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GROUND WATER PROTECTION STRATEGY FRAMEWORK FOR MINNESOTA

June, 1983

Prepared by

Minnesota Pollution Control Agency
Solid and Hazardous Waste Division
Program Development Section

Ground Water Protection Strategy Framework For Minnesota

June 1983

Prepared by staff of the

Minnesota Pollution Control Agency
Solid and Hazardous Waste Division
Program Development Section

Foreword

The Minnesota Pollution Control Agency/United States Environmental Protection Agency (MPCA/USEPA) Agreement for Fiscal Year 1981 identified the need for Minnesota to develop a comprehensive ground water protection strategy. As lead agency in development of water quality management programs required by Section 208 of the Clean Water Act (P.L. 92-500), the MPCA received a grant (USEPA Grant No. P005627011) to assist Minnesota in developing a ground water protection strategy framework. This framework report summarizes the findings and recommendations for the 29 month project period, February 1, 1981, through June 30, 1983.

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Statement of Purpose

In reviewing this document, it is important to keep in mind the perspective from which it was written. It represents the final work product of a group of staff in the Solid and Hazardous Waste Division (SHWD) who were assembled for the expressed purpose of reviewing existing ground water programs, assessing the magnitude and extent of ground water contamination in the state and, through a series of consultant studies, evaluating the efficacy of existing Minnesota Pollution Control Agency (MPCA) review, permitting and monitoring policies for several types of facilities in terms of ground water impacts. The last phase of the review was to formulate a ground water protection strategy framework and recommend a method of implementation. Chapters One through Eight comprise a compendium of that review effort and document the basis of the strategy framework which is presented in Chapter Nine.

All suggestions and recommendations in the technical sections represent staff positions and may or may not evolve into official policy. The scope of this report is so broad that it is not reasonable to expect a full-scale endorsement of its recommendations by either the MPCA administration or the MPCA Board at this time. It will be a primary function of the Program Development Section of SHWD to more fully develop issues raised in the report and, as appropriate, bring them to the MPCA for official adoption. This may take the form of either policy statements or rules. It is anticipated that the report's greatest usefulness to the MPCA administration will be as a reference when developing work plans establishing priorities and determining the necessary allocation of limited resources to accomplish MPCA goals.

Acknowledgements

This report would not have been possible without the valuable assistance of the Ground Water Protection Strategy Work Group, which reviewed and constructively criticized many portions of this report. In addition to meeting as a group about quarterly between July, 1981, and June, 1983, the following members were frequently asked to comment and provide ideas in the face of crowded schedules and responsibilities to their own programs:

Hal Anderson/Ron Nargang - Minnesota Soil and Water Conservation Board

Linda Bruemmer - Minnesota Water Planning Board

Mike Convery - Minnesota Department of Health

Paul Davis - Minnesota Pollution Control Agency, Division of Water Quality

Al Frechette - Scott County Environmental Health Office

Mark Have - U.S. Geological Survey

Marcel Joseau - Metropolitan Council

Memos Katsoulis - Minnesota Waste Management Board

Larry Landherr - Minnesota Pollution Control Agency, Rochester Regional Office

Bruce Olsen - Minnesota Geological Survey

Nancy Onkka - Minnesota Environmental Quality Board

Joe Thomas/Roxanne Sullivan - Minnesota Department of Transportation

Sarah Tufford /Dennis Beissel - Minnesota Department of Natural Resources, Division of Waters

Cindy Wakat/Ray Giese - U.S. Environmental Protection Agency, Region V Office, Chicago

Tom Clark - Minnesota Pollution Control Agency, Chairperson

Acknowledgements (continued)

Recognition is given to the consultants to the MPCA who contributed many hours toward completion of the site-specific studies described in Chapter 7 of this report. E.A. Hickok and Associates, Wayzata, Minnesota was the consultant for the two landfill studies. Braun Environmental Laboratories, Eden Prairie, Minnesota was consultant for studies of the two industrial impoundments, two spray application systems, community drainfield system and rapid infiltration system. The U.S. Geological Survey was consultant on the tailings basin study. The cooperation of the responsible parties for the study sites is both acknowledged and appreciated.

Special mention should be made of the contributions of Linda Bruemmer, Minnesota Waste Planning Board toward the writing of Chapter 2, Minnesota Ground Water Resource Overview. Much of the information contained in this chapter will become part of an informational publication describing the ground water resource in Minnesota and being prepared cooperatively by MPCA and the Water Planning Board. Janeen McAllister of the Department of Energy, Planning and Development and Nancy Onkka of the Minnesota Environmental Quality Board assisted with preparation of the sections on ground water data sources. Len Nelson assisted with drafting the graphics for the report. Gordon Meyer and John Holck provided editing, ideas and general support. Finally, but by no means least, the patience of Roberta Wells who typed and assisted with editing of the text is gratefully acknowledged.

List of Acronyms for Agencies Referenced in This Report

MPCA - Minnesota Pollution Control Agency

MDH - Minnesota Department of Health

MDNR - Minnesota Department of Natural Resources

MWPB - Minnesota Water Planning Board

MGS - Minnesota Geological Survey

MDOT - Minnesota Department of Transportation

MDA - Minnesota Department of Agriculture

MWMB - Minnesota Waste Management Board

MEQB - Minnesota Environmental Quality Board

DEPD - Department of Energy, Planning and Development

SWCB - Soil and Water Conservation Board

USGS - United States Geological Survey

USEPA - United States Environmental Protection Agency

Ground Water Protection Strategy Framework for Minnesota

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CHAPTER 1

EXECUTIVE SUMMARY AND RECOMMENDATIONS

Introduction

The growing demand for the development of ground water for irrigation, industrial, commercial and drinking water supplies along with the increased detection of ground water contamination currently focus attention on this resource throughout the world. Yet, for all this recent attention, many misconceptions remain regarding its occurrence, movement and vulnerability to contamination. Over 97 percent of all fresh water on earth is ground water. Despite this abundance, the amount of ground water that can be economically brought to the surface in wells is limited. Ground water moves much slower than surface water. Once degraded, ground water may require many years for natural processes to purify it.

Minnesota's water resources consist of both surface and ground water. Although best known for its "10,000 lakes," Minnesota is highly dependent on ground water. About two of every three Minnesotans use ground water as a high quality source of drinking water. Increasingly, ground water supplies in Minnesota are threatened by a variety of contamination sources including waste impoundments, underground fuel tanks and pipelines, landfills, animal feedlots, unregulated hazardous waste storage or dump sites, salt storage piles and many other land use practices. While a relatively small percentage of available ground water has been degraded, incidents of contamination are widespread and are not limited to industrialized or densely populated areas.

This report summarizes the findings and recommendations of a 29-month study to provide background on Minnesota's ground water resource, its use and its abuse.

In cooperation with other federal, state and local agencies involved with ground water management, the Minnesota Pollution Control Agency (MPCA) has developed a set of program goals and a plan of action to help determine that the quality of Minnesota's ground water will be ensured for many years to come. These goals and plan of action form the framework of a ground water protection strategy, which will have long-range implications as far as development of the state's ground water protection programs are concerned. The plan of action will help assure that Minnesota continues to respond to immediate ground water problems, begins to anticipate problems and fosters a transition to a broader preventative strategy. The MPCA recognizes the importance of maintaining a clear and abundant source of ground water for all Minnesota citizens. The results of this report will not only provide guidance to future MPCA ground water protection programs, but will strengthen the ability of all ground water agencies in the state to prioritize and target most effectively the use of limited program resources toward areas most in need of regulatory and management attention.

The goal of the MPCA Ground Water Protection Strategy work plan has been to establish the framework for the development of comprehensive ground water protection policies and procedures which are consistent with existing state and federal requirements, yet specific to the needs of Minnesota and formulated with a firm technical basis. The framework was developed through review and analysis of newly and previously collected site-specific ground water data, ambient ground water quality information and summary of existing ground water programs, regulations and data. In addition, a work group was formed, comprising individuals familiar with the technical aspects of the ground water resource, whose charge was not to set policy, but to assist in developing technically-sound recommendations to serve as a basis for establishing MPCA policies in the area of ground water quality protection.

Background

The MPCA/USEPA Agreement for Fiscal Year 1981 identified the need for Minnesota to develop a comprehensive ground water protection strategy. The state recognized this need. As lead agency in development of water quality management programs required by Section 208 of the Clean Water Act (P.L. 92-500), the MPCA received some limited grant money to assist Minnesota in developing a comprehensive ground water protection strategy.

Previous activities undertaken by MPCA relative to ground water protection have included adoption of rules establishing use of ground water for potable water supply as the highest priority use, prohibition of injection for waste disposal, and provision of a general policy of non-degradation for ground water protection. Several other state agencies have developed rules to address certain aspects of ground water protection. These include rules for water well construction and potable water supply systems (Minnesota Department of Health - MDH); ground water appropriation (Minnesota Department of Natural Resources - MDNR); and rules for general environmental impact review (Environmental Quality Board - EQB). The Water Planning Board (WPB) provides statewide water and related land resources planning. The Minnesota Geological Survey (MGS) develops maps and technical data regarding the state's aquifers. In addition, several sets of technical criteria and project review programs have been implemented by various state and local agencies which have the sole or partial purpose of ground water protection. However, little effort to date has been expended to make comprehensive policies and procedures. By developing a framework as described in this report and incorporating knowledge gained through investigative activities and available through review and analysis of other existing programs, a more definitive and comprehensive strategy to protect Minnesota's valuable ground water resource will result.

The MPCA/USEPA Agreement for Fiscal Year 1981 identified as a integral part of a successful ground water protection program the need for the state to develop a priority determination system for ground water quality problems and a methodology for isolating the cause and identifying appropriate mitigative or preventative measures. Currently the state does not have an adequate ground water sampling activity to determine possible area-wide quality problems, although various recently implemented ambient ground water monitoring programs have begun to provide this data. Without such information, it is difficult to properly allocate limited resources to meet the most critical needs.

Previous work in this area is also fragmented, including ground water sampling through the above-mentioned ambient ground water monitoring program designed by the U.S. Geological Survey (USGS) for MPCA and the ongoing contaminated site investigations conducted by MPCA, as well as data generated by the MDH, MGS and MDNR monitoring programs. Preliminary results from these activities suggest, however, that ground water problems are generally site specific, and only limited instances have been documented where more broad regional problems exist (i.e., southeast Minnesota). Therefore, in obtaining a data base for a statewide ground water protection strategy, analysis of data from site-specific investigations was thought to provide the most immediately needed and useable information.

Categories of potential study sites were based on two major factors. First, it was felt that there was a need to study facilities having high loading rates to the ground water, and therefore, the greatest potential to impact ground water quality. Second, there was a need to study facilities for which the majority of MPCA permit decisions will need to be made in upcoming years. In addition, sites were to be chosen from among permitted facilities believed to employ good design and management practices as well as sites having suspected or known ground water contamination.

Based on these criteria, among others, six categories of facilities were selected for which studies were authorized by the MPCA Board. These are: community septic tank drainfields; industrial spray irrigation sites; municipal rapid infiltration systems; industrial impoundment/waste disposal areas; mixed municipal waste (sanitary) landfills; and mining waste tailings basins. A total of nine site-specific hydrogeologic studies was conducted by three consultants to MPCA. Through the operation of monitoring programs at the selected facilities, the effectiveness of facility design and management practices was determined. This information was then used in the framework to suggest areas worthy of review and monitoring, and areas where existing procedures are effective and need no further modifications before incorporation into an overall program.

This report is built around the Ground Water Protection Strategy Work Plan and the October, 1982 amendment as approved by USEPA. It is divided into nine parts or chapters which discuss an overview of the ground water resource in Minnesota; existing state ground water programs and data bases; ambient ground water quality in Minnesota; an assessment of ground water contamination in the state; site-specific ground water quality monitoring programs; disposal system site assessments; underground injection in Minnesota; and, finally, the ground water protection strategy framework itself. Several of these efforts have produced more detailed background reports which are available from MPCA. These include publications on the Minnesota ground water resource, ambient water quality and data interpretation, statewide ground water contamination assessment, the site specific consultant reports, and procedures for site-specific ground water monitoring.

Recommendations

1. Data base management: MPCA should in cooperation with other ground water management agencies, develop an automated ground water data management system to provide information necessary for evaluating immediate ground water impacts and making decisions, to assemble and use pertinent ambient and site-specific data, and to prevent potential problems from occurring by guiding MPCA regulatory program operations.
   a. A coordinated effort among ground water management agencies to acquire ground water data is needed. Interagency cooperative data gathering programs should be considered to eliminate duplicated efforts and help ensure that the data acquired is usable and reliable.
   b. The progress recently made toward developing coordinated data storage should be continued so that ground water management agencies may have access to more data than that which they alone acquire;
   c. There should be an interagency effort to share in the analyses of ground water data and apply the information so gained toward improvements in individual agency ground water management programs.
   d. Coordination of ground water data management should extend to the day-to-day operations of regulatory programs within the ground water management agencies to minimize conflicts in water use and potential gaps in water resource protection that can lead to ground water degradation.

e. MPCA should continue to implement the in-house effort now underway to examine and improve its data management systems, including those for ground water.

2. Ambient ground water quality: MPCA should investigate the feasibility of developing a ground water classification system which recognizes the high ambient quality of Minnesota's ground water, the sensitivity of certain aquifers in the state to degradation, and the necessity of protecting critical recharge areas.

   a. MPCA's ambient ground water quality monitoring data is sufficient to begin to define the chemical characteristics of Minnesota's principal aquifers. As MPCA begins collecting the second round of samples from the established monitoring wells more time should be allocated to a well-by-well analysis to eliminate wells without sufficient well construction and/or geologic information; to select, well by well, which water quality parameters could be eliminated without jeopardizing the intent of the program; to locate any candidate wells to replace wells without sufficient construction and/or geologic data; and finally, to select wells within areas and aquifers where insufficient data currently exist.

   b. Some time should be spent looking at other data sources for water quality information. Expanding the data base wherever possible would be beneficial to justifying specific parameter standards applicable to statewide situations.

   c. An ambient ground water monitoring program is necessary to assist MPCA in measuring the success or failure of ongoing ground water protection programs. The fundamental question of how the MPCA defines the "natural quality" or "natural state" is at the root of maintaining an ambient ground water quality monitoring program. Unless the MPCA constantly monitors the state's ground waters, any attempt at defining the "natural" quality of our waters is impossible. And if the staff cannot reasonably define the "natural" quality of our ground waters, the only remaining alternative is to provide the citizens of Minnesota protection to drinking water standards only.

d. The ambient program requires a seasonal technician to collect samples. The ambient ground water quality monitoring program involves data collection, data storage and publication of an annual report. Unlike the surface water monitoring program, the ground water program involves data analysis. Currently, data analysis, publication of the annual report and developing program modifications are all expected to be accomplished in less than half a man-year. These responsibilities are full time tasks.

3. Ground water contamination assessment: Current programs dealing with assessment in cleanup of unregulated or uncontrolled land uses which may impact ground water should be refined. As a part of this process, MPCA should continue to inventory and prioritize activities for which the potential to degrade ground water is either known or suspected.

a. Because of the large number of unpermitted dump sites and the expense of installing monitoring systems and analyzing samples from these systems, a review and prioritization of all known dump sites (inactive and active) in the state should be undertaken. This review should build on previously-conducted inventories such as those for surface impoundments (1979) and open dumps (1980).

b. Additional site-specific investigations of uncontrolled sites in different hydrogeologic settings especially sensitive to ground water contamination should be conducted. Results of such studies should be applied to ongoing site response activities to assist in developing protocols for hydrogeologic investigations.

c. Most land use activities having the potential to contaminate ground water in Minnesota are now either being regulated or have regulations in the process of being developed. An exception may be in the requirements for underground storage tanks. Rules for underground tanks should be developed and should include methods for preventing and detecting leaks.

d. Product handling and waste disposal practices of applicators and dealers of pesticides and fertilizers should be reviewed, particularly as they relate to equipment cleaning and rinsate control. Where these practices are found to be poor, ground water monitoring should be undertaken to detect or describe the extent of the problem.

e. Efforts to assess and minimize potential for ground water contamination due to deicing chemicals are best directed toward improving storage practices at those state, county and municipal storage facilities where they are found to be inadequate.

f. MPCA should have a clearly defined set of priorities to insure that unregulated or uncontrolled facilities which pose the greatest threat receive the appropriate commitment of resources. Priorities should follow in a sequence beginning with those incidents where there is a known threat to public health:

   - Investigate and mitigate where necessary any possible known contamination incidents where there is a threat to public health.

- Investigate problems where suspected contamination poses a threat to public health.
- Investigate potential areas of contamination where there is a threat to public health.
- Investigate and mitigate where necessary any possible known contamination problems which pose a threat to the environment but where there is no recognized threat to public health.
- Investigate suspected problems which pose a threat to the environment.
- Investigate potential problems which pose a threat to the environment.

4. <u>Site-specific ground water quality monitoring</u>: Implementation of the requirements of the MPCA draft ground water monitoring procedures manual should receive a high priority. Vigorous and consistent enforcement of the monitoring requirements should follow. Ground water quality monitoring programs for specific categories of sites each have a separate set of needs. These may be summarized as follows.

   a. Mixed municipal waste (sanitary) landfills:
      - Staff should be designated whose primary responsibility is data review and interpretation.
      - Implementation of a quality assurance program and standardization of monitoring system requirements should receive a high priority.

   b. SDS/NPDES facilities:
      - Staff should be designated whose primary responsibility is data review and interpretation.
      - A consolidated ground water data base should be established to include monitoring locations, monitoring requirements, well construction

information, water quality data, and requirements of a quality assurance program.

c. Uncontrolled hazardous waste facilities:

- A quality assurance program should be implemented.
- Centralized files should be developed, along with a computerized water quality data base.

d. Sites of spills/leaks:

- Hydrologic expertise should be available to assist Water Quality Division Emergency Response Unit staff.
- Spills data should be computerized to facilitate project tracking and water quality data review.

5. Disposal system site assessments: Based on results of the nine site assessments conducted as a part of the framework plan, review should be conducted of rules for permitting, operating, and monitoring those facilities having the greatest potential to impact ground water resources, especially mixed municipal waste (sanitary) landfills, industrial spray fields and impoundments, and large drainfield systems.

a. Landfills:

- Mixed municipal waste landfills should not be located in local ground water recharge areas.
- Landfills should be constructed to limit infiltration to the greatest extent possible.
- Control of leachate migration is important to limit potential for ground water contamination as a result of landfill operation.
- Even lacking evidence of problems, older permits should be periodically reviewed and necessary changes made (i.e., ground water

diversion, leachate collection, monitoring network upgrading, etc.) to minimize the impact these sites may have on ground water.

- Regardless of hydrogeology, landfills may pose a threat to ground water quality. The potential for landfill leachate to contribute significantly to the load of inorganic constituents in the ground water is well known and is emphasized by the site-specific studies. Landfill monitoring systems should be upgraded to include monitoring for volatile organic compounds as well. Implementation of requirements of the draft ground water monitoring procedures manual would make this mandatory.
- Ground water studies should be conducted on several selected demolition debris landfills to document their perceived non-problem status.

b. Drainfields:

- Large drainfields do impact ground water, particularly for mobile constituents such as chloride and nitrate.
- Drainfields should be designed carefully with consideration given to restricting loading rates, the volume of sewage discharged to a system, and construction of systems within a specified ground water separation distance in highly permeable soils.
- For large drainfields, pressure distribution has a greater capacity to control effluent loading and should be considered to minimize ground water impacts while extending the life of a system.
- Placement of monitoring devices at drainfield systems is critical, particularly ensuring that background monitoring wells are placed far enough away from a loading area beyond the influence of any effluent migration in both the unsaturated and saturated zones.

- Ground water and soil samples at drainfield sites should be monitored for conductivity (or TDS), chlorides, ammonia-nitrogen and nitrate-nitrogen, at a minimum.

c. Spray irrigation systems:

   - Water quality problems associated with spray irrigation systems are generally limited to chlorides and TDS. Adequate treatment is normally provided for nitrate-nitrogen, biological oxygen demand and pH. Impacts of chlorides and TDS can normally only be reduced by decreased loading rates.
   - Site-specific hydrogeology is critical to determining potential ground water impacts from proposed spray irrigation systems. Sites with limiting hydrogeology may require restrictions such as establishing loading rates based on consumptive use of cover crops. Chloride is another limiting parameter upon which to establish loading rates.
   - Buffer zones are important around spray irrigation systems to protect existing and potential drinking water sources from mounding which is likely to occur as a result of continued loading of these systems.
   - Management practices, such as supplemental use of fertilizers, implementation of runoff controls and use of loading and resting cycles, may have significant impacts on ground water quality beneath spray sites.
   - Monitoring systems at these sites should include conjunctive use of wells and lysimeters. Because of their small area of influence and poor performance under certain field and climatic conditions, lysimeters should not be substituted for wells in ground water impact studies.

- Current program requirements for parameters and frequency of analysis are adequate and should be continued for spray irrigation systems.

d. Rapid infiltration systems:

- Rapid infiltration systems can create significant mounding effects that reduce the treatment below basins and may reduce hydraulic capacity if a mound extends to basin surfaces. Proposed infiltration systems should be divided into separate infiltration areas so that an entire area may be rested to allow time for mounds to dissipate before reuse.
- Ground water quality results depend to a great extent on effluent quality. Loading/resting cycles are effective in reducing nitrates and, to some degree, chloride, conductivity and TDS. Loading/resting cycles for rapid infiltration systems should be designed based on an acceptable level of chloride in ground water downgradient of a site.
- Ground water effects from infiltration systems may be minimized by designing basins or infiltration areas so that they are narrow with the longer sides normal to ground water flow.
- The primary restriction to infiltration is cold weather. A minimum of four months of basin storage should be provided for systems in northern Minnesota. This may be reduced where warmer effluent, climate and/or bare basin surfaces are present.
- Specific ground water monitoring requirements concerning well placement, frequency of sampling and parameters are necessary. Wells should be placed so that the highest point of a mound can be measured

to determine when loading should be terminated. Monitoring should be scheduled so that wells are sampled when basins adjacent to them are being loaded. Monitoring parameters depend on the nature of the wastewater, but may include nitrate- and ammonia-nitrogen, phosphorus, biological oxygen demand, chloride, bacteria, conductivity (or TDS) and possibly, heavy metals.

e. Industrial impoundments:

- A systematic review of the need for ground water monitoring at industrial impoundments as a followup to the Surface Impoundment Assessment should be conducted.
- Strong consideration should be given to sampling for volatile hydrocarbon compounds at industrial impoundments. Both of the study sites at Waseca and Red Wing showed presence of organic compounds in the ground water even though none of the measured organics were believed to be present in the waste stream nor were they listed on hazardous waste disclosures provided by the companies. Many of the detected volatile hydrocarbon compounds have wide application in industrial settings, even if not directly used in the manufacturing process.

f. Mining impoundments:

- Taconite tailings basins should receive a relatively low priority for long-term ground water monitoring based on the results of this and other monitoring data on active and non-active tailings basins.
- MPCA should encourage continuation of the water quality portion of the tailings basin study being done by the USGS.

6. <u>Emerging ground water issues</u>: A strategy to address emerging issues in ground water protection in Minnesota such as ground water source heat pumps, underground injection control (UIC), aquifer thermal energy storage, natural resource development, and irrigation systems should be established.

   a. If final UIC rules issued by USEPA are modified from earlier proposals to provide more incentives for the states to assume primacy for the program, it is recommended that Minnesota reevaluate its decision not to seek primacy to determine the feasibility of assuming the UIC program.

   b. It is desirable to have one agency responsible for the enforcement of a single regulation concerning, in whole or in part, underground injection. It is recommended that MPCA have sole regulatory responsibility on the utilization of injection. MDH would continue to regulate injection relative to the proper construction of wells.

   c. There is need to generate more information on heat pump systems by providing greater flexibility in existing statutes and regulations. It is recommended that MPCA support the study and utilization of ground water source heat pumps and reinjection as a disposal method through a state supported program.

7. <u>Ground water quality management and policy considerations</u>:

   a. Coordination at all levels of government (federal, state, regional and local) is essential to the successful development and implementation of any ground water protection strategy. Ground water problems are, by their nature, complex and institutions dealing with activities affecting ground water are numerous.

b. The quantity and quality of ground water are so inextricably linked that efforts to protect or enhance quality must be coordinated with activities of governmental units responsible for managing the quantity of ground water use. For the same reason, ground water management efforts must be coordinated with surface water quality management programs.

c. To support the process of ground water protection, a priority must be assigned to gathering scientific knowledge of ground water contamination and better defining the nature of the state's ground water resource.

d. Certain land use activities do and will degrade ground water quality; a strict non-degradation policy is neither possible nor feasible everywhere. Recognizing this, a process must be established to enable the public to participate in and eventually accept appropriate decisions regarding the siting of polluting activities and remediation of existing ground water problems.

e. The state should encourage new and innovative approaches to ground water protection by emphasizing reduced pollutant volumes, increased recycling and treatment of wastes prior to disposal.

f. Although some totally new ground water initiatives ultimately might be necessary, the existing structure of operating programs already contains much of the essential management framework. The focus of future program evaluation should be to adjust these programs to ensure that ground water will receive equal emphasis with surface water in all water management areas.

g. Since ground water is not distributed equally, since uses vary from one locality to another, and since ground water is more naturally-protected in some areas than others, any statewide ground water protection effort must acknowledge and be sensitive to regional differences.

h. To the extent that available resources allow, financial assistance for program development efforts and dissemination of information on means of solving ground water problems are activities which federal agencies should continue.

i. To provide a plan of action for moving ahead that is consistent with overall program goals, MPCA should implement a three-part approach to address ground water protection needs for the state built around site-specific response on critical ground water contamination incidents; implementation of a strong, consistent regulatory compliance activity through ongoing programs of enforcement and facility review; and fostering a transition to a broad, preventative strategy which emphasizes audit of existing ground water protection efforts to anticipate and prevent future problems and to target most effectively the use of limited program resources toward areas most in need of regulatory and management attention.

CHAPTER 2

MINNESOTA GROUND WATER RESOURCE OVERVIEW

Introduction

The growing demand for the development of ground water for irrigation, industrial, commercial, and drinking water supplies along with the increased detection of ground water contamination currently focus attention on this resource throughout the world. Management of any ground water supply must be supported by a basic understanding of the occurrence, movement, and composition of the ground water resource. The purpose of this chapter is to provide specific information about use and quality of ground water in Minnesota, and to outline the state's statutory, regulatory, and operational policies which affect its use and abuse.

In order to provide the correct perspective on the importance of ground water as a source of fresh water, a brief overview of the world supply and distribution of water is useful. Approximately 97 percent of the earth's water is salt water in the seas and oceans. The remainder is water which occurs on or below the land surface and amounts to only 2.8 percent of the total supply. The land surface supply of water is distributed as follows:

- 2.14 percent ice caps and glaciers
- 0.61 percent ground water to 13,000 feet
- 0.009 percent fresh water lakes
- 0.008 percent saline lakes
- 0.005 percent soil moisture
- 0.0001 percent rivers

In addition, 0.001 percent of the total supply is found in the atmosphere at any given time (Fetter, 1980).

It is apparent from these figures that available fresh water is quite limited and that the main source of supply which is available for human consumption and use is the fresh water from surface and underground sources. Surface sources include lakes, streams, drainage areas, and holding reservoirs; underground sources include surficial and bedrock aquifers from which water is obtained by wells and springs. At present, ice caps and glaciers are not considered as readily available sources of water.

The worldwide importance of ground water is evident in the estimate that over 97 percent of the available fresh water supply is ground water. The total amount of ground water has been estimated at 2,607,200 trillion gallons, not all of which is obtainable from the geologic formation in which it is contained (UOP-Johnson, 1974). Some of the water is too deep to recover economically and some cannot be withdrawn from the formation in which it is found because it is held too tightly in the rock. But even considering the obtainable amount of ground water, it would exceed all the available supplies of fresh surface water found in lakes and streams. The ground water resource then becomes an immeasurably valuable resource for present use and future generations. The worldwide distribution of fresh water is, of course, not uniform and can be misleading in comparison to its occurrence in Minnesota. From estimates of water availability in Minnesota made from 1976 data, 8.8 percent is ground water and 91.2 percent is surface water (Kanivetsky, 1979a).

The Minnesota Picture

The natural availability and quality of ground water in Minnesota is determined by its geologic history. Ground water generally occurs in uneven, layered sequences of rock materials at varying depths below the land surface. The geologic units which commonly contain ground water are the layers of bedrock and the unconsolidated deposits. Geologic and hydrogeologic maps are available from the Minnesota Geological Survey (MGS) (Kanivetsky, 1979b; 1979c) as is the more site-specific geological information from which the maps are derived.

The basement rocks, usually igneous or metamorphic rocks, are the oldest and hardest layer of rocks and underlie the porous and permeable bedrock formations. Above the bedrock, the loose, unconsolidated sand, gravel, and clay occur in varying thicknesses and form the visible land surface. The basement rocks generally do not contain ground water. They are dense and hard, and seldom have open spaces capable of holding water--except perhaps in cracks and crevices created by differential earth movements. In areas of the state where the basement rocks occur at or very near the land surface, for example in Lake, Cook and parts of St. Louis, Carlton, and Pine counties, there is a good possibility that even small supplies of ground water may not be available. Fractures and cracks in the basement rocks may be interconnected to provide some open storage space for ground water but it is rare to have significant yields of water over large areas. Exceptions are a few known sites where there are extensive interconnected fracture systems and thick porous zones between basement rocks.

In southwestern Minnesota, the basement rock is composed of a very old layer of hard, cemented sandstone called quartzite. This area includes most of Rock and Pipestone counties and parts of Nobles, Lincoln, Murray, and Jackson counties. Although these rocks are generally so hard and dense that they would not be considered major aquifers, they are locally important because they may be the only source of water supply in this part of the state.

The most important source of ground water in Minnesota is the porous and permeable bedrock of the eastern two-thirds of the state, consisting of one to five major water-yielding sandstone and limestone aquifers. The Twin Cities are located within this geologic setting. These layers of sandstone and limestone are separated by relatively impermeable layers of shale and siltstone of varying thicknesses which confine the ground water under artesian conditions.

Figure 2-1 is a geologic column of the major bedrock aquifer systems in Minnesota. The column shows the order in which these units may be found underground. Not all units are present at all locations due to uneven deposition and pre-glacial and post-glacial weathering and erosion. The more familiar names are the Jordan, St. Peter, and Hinckley Sandstone aquifers, each of which provides a moderate to high yield of relatively good quality water. These rock units are generally named for the location in the state where they have been identified as surface outcrops. The individual bedrock aquifers in the system are up to 350 feet thick and yield more than 2,500 gpm to wells where they are deepest and thickest in the Twin Cities area and in southeastern Minnesota.

The southeastern corner of Minnesota is underlain by gently dipping sedimentary rocks which feature prominent beds of limestone and dolomite. The bedrock is normally fractured and contains numerous cracks, crevices, channels, and caves. "Karst" is the geologic term for this land area. It is characterized by streams which disappear into the ground or which lose most of their flow underground;

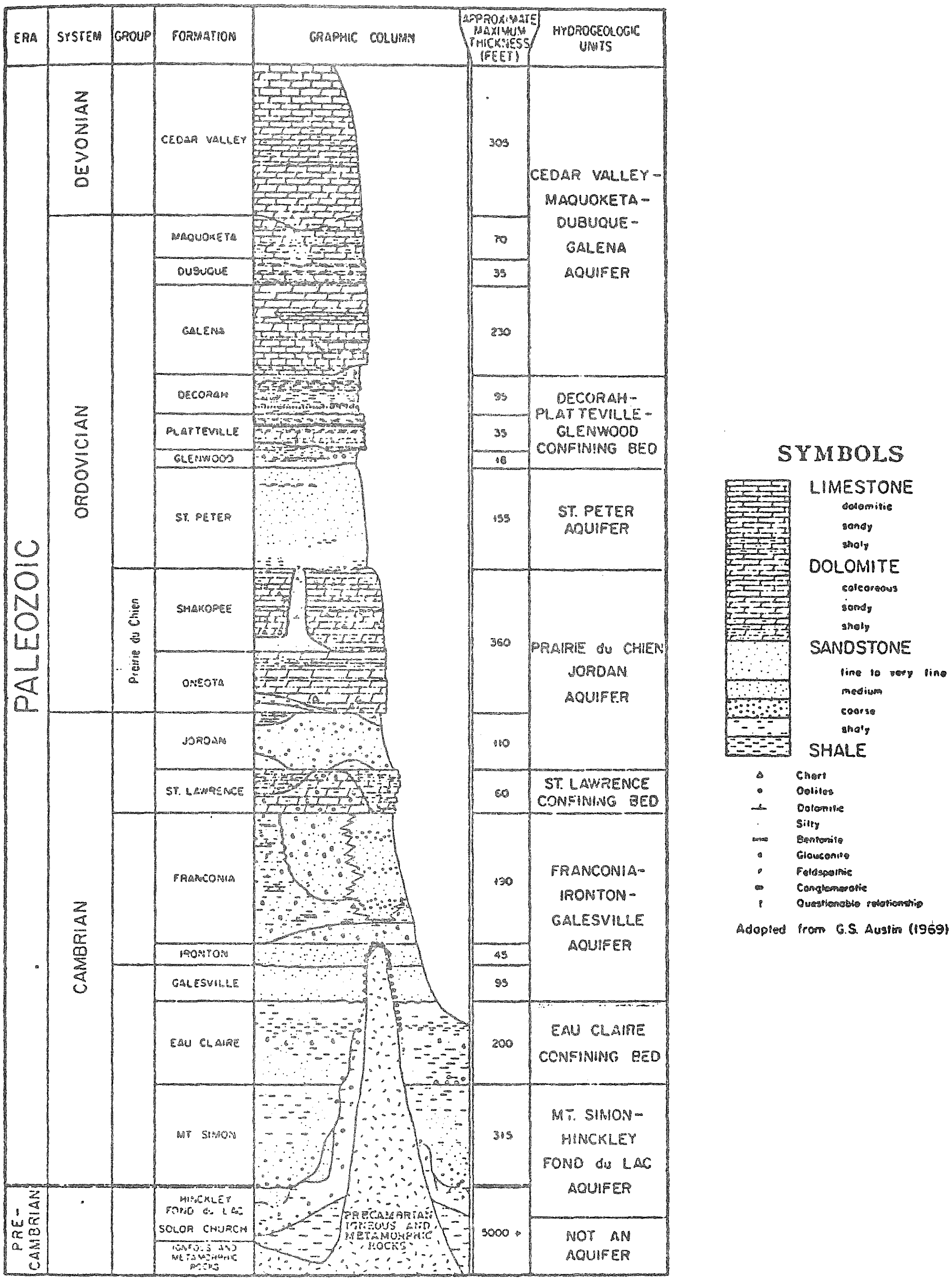


Figure 2-1: Sequence of bedrock aquifer systems and confining beds for southeastern Minnesota (Kanivetsky and Walton, 1979)

valleys which have no surface outlet; caves, springs, and circular depressions called sinkholes. The ground water system is particularly vulnerable to contamination in this part of Minnesota because the near surface bedrock deposits have little or no glacial drift cover. Both biological and chemical surface contaminants can enter the ground water through sinkholes and travel swiftly into open channels for considerable distances with little or no filtration, adsorption, and/or chemical reaction. The quality of the shallow ground water is often the same as the surface water in the area.

Much of the southwestern quarter and extreme western edge of the state contain scattered remnants of the sedimentary bedrock. These rocks generally consist of mixtures of loose sands, sandstones, siltstones, and shales, usually varying in thickness from 10 to 20 feet. They commonly have short term yields of less than 50 gpm. Along the western border, yields are generally less than 10 gpm, but they do reach as much as 100 to 200 gpm in a few areas.

Unconsolidated layers and lenses of sand, gravel, silts, clays, and boulders cover the bedrock or basement rock over practically all of the state except where the basement rocks or porous bedrock are found at the land surface. They provide a major portion of the ground water for individual households in the state. These sand and gravel aquifers can be divided into two major types: surficial sands and gravels which are located at the land surface and buried sands and gravels which generally occur as lenses at varying depths. These commonly were deposited by glacial meltwater along ice-contact areas, or as beach ridges along the edges of ancient glacial lakes. The surficial sands and gravels can be more easily located and developed because of their shallow depths.

Buried sand and gravel lenses located at various depths below the land surface are much more difficult to locate than surficial deposits. They are extremely variable in thickness and yield because they generally occur as lenses of sand and gravel of varying size and shape within great masses of clayey and silty glacial deposits. Known lenses are generally less than 50 feet thick and yields are often less than 100 gpm.

Yields from unconsolidated and bedrock aquifers vary considerably throughout the state. However, in most areas, ample ground water for household use is readily available. Except for the hard rock areas of the northeast, the dense clay areas of the Red River Valley, and scattered areas where bedrock occurs at the surface, ground water sources are generally adequate for municipal and industrial uses as well.

Quality of Minnesota's Ground Water Resource

As water availability varies both geographically and with depth, the water quality also changes across the state. The dissolved material in water consists mainly of carbonates, bicarbonates, chlorides, sulfates, phosphates, nitrates, calcium, magnesium, sodium, and potassium with traces of iron and manganese. A dissolved solids concentration of less than 500 mg/l is generally satisfactory for domestic and many industrial uses (UOP-Johnson, 1974; USEPA, 1977). Water over 1000 mg/l usually contains sufficient minerals to cause taste and corrosion problems. Figure 2-2 shows the distribution of the average dissolved solids in Minnesota ground water which can be used as an indicator of its chemical quality. The map does not reflect the generally much lower levels of dissolved solids found in the surficial deposits. The usefulness of a water supply must be based on the concentration of the individual ions rather than the total concentration of all substances which total dissolved solids shows.

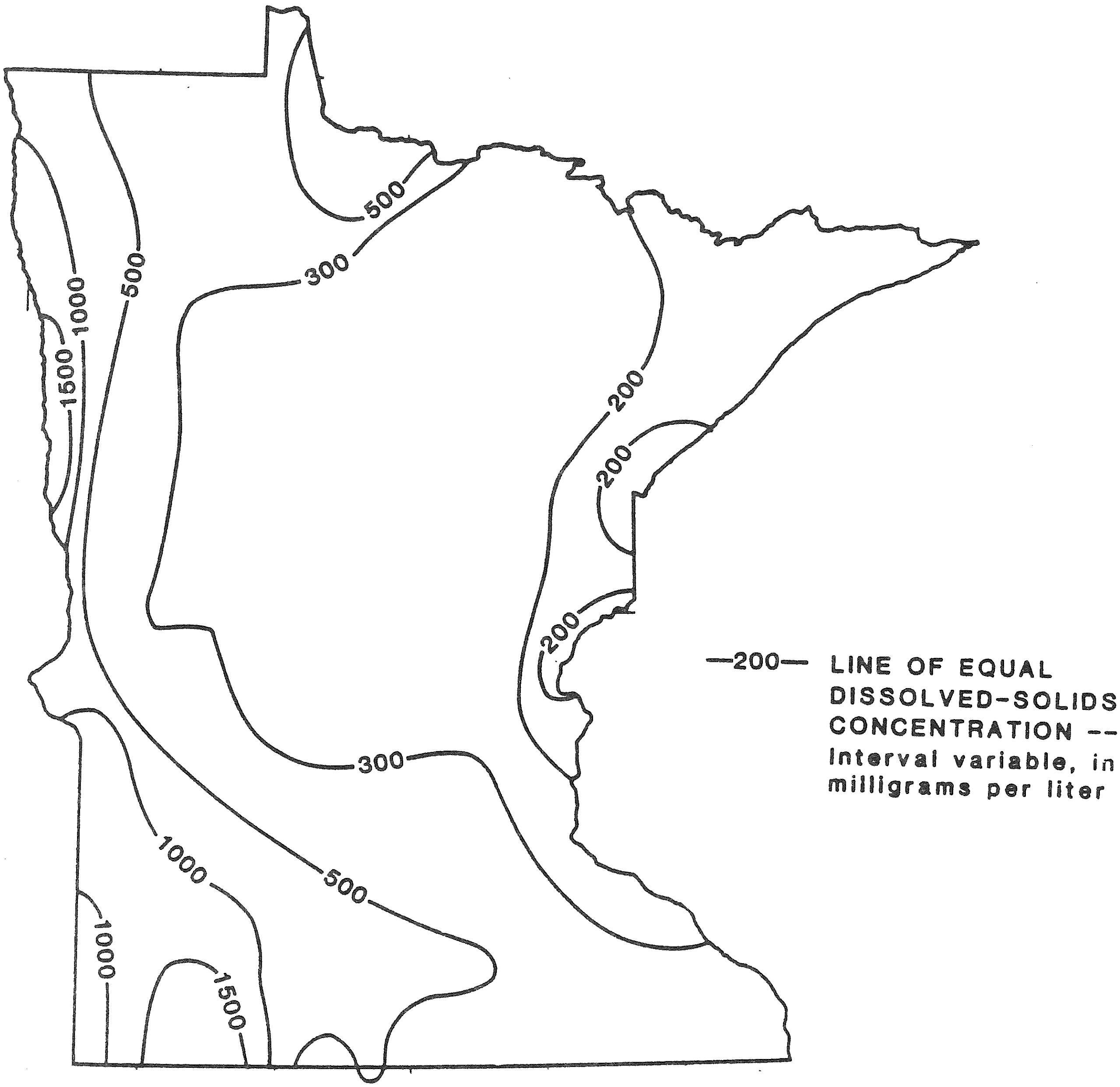


Figure 2-2: Generalized distribution of mean dissolved-solids concentration of ground water in Minnesota (Adolphson, Ruhl and Wolf, 1981)

Hardness depends on the concentration of calcium and magnesium in the water. It does not present a health hazard but can cause economic problems. Hard water tends to deposit a scale on pipes, water heaters, and boilers reducing flow and heating efficiencies. Soap does not clean as effectively in hard water. Ground water is usually hard water because the rocks and soils which contain the water also contain large amounts of calcium and magnesium, so it is a naturally-caused source of "pollution." Bicarbonate and carbonate content contribute to alkalinity --the capacity to neutralize acid. Alkalinity is used to help characterize water quality although there are no drinking water standards for alkalinity because it has no recognized health effects.

Sulfate-rich rocks in the western edge of the state leach sulfate into the ground water. This ground water can have a laxative effect on people unaccustomed to consuming high sulfate water. Sodium bicarbonate also occurs in water but does not contribute to permanent hardness. Sodium is very soluble so it does not form scale like calcium or magnesium. In fact, most ion exchange water softeners use salt to convert calcium and magnesium carbonate to a sodium form which is called soft water. Waters with high sodium chloride (salt water) also occur and are undesirable for most uses. (Sea water contains about 19,000 ppm; 19,000 ppm = 19 percent.)

Monitoring and an informed knowledge of the natural quality of the ground water will help identify any changes in the quality due to the contamination by land-surface activities. Unnatural chemicals, when found, can then hopefully be traced to their origin, once it has been determined that they are not normally present.

Quantity of Minnesota's Ground Water Resource

Methods of estimating the total amount of the ground water in Minnesota provide results which vary widely. Assumptions for any estimates must be made and can change the estimates dramatically. Primary assumptions involve the amount of ground water discharging naturally to the surface waters, the average annual recharge rates, and the location of aquifer boundaries both vertically and horizontally. Two estimates which have been made, 1.1 to 2.0 trillion gallons (Kanivetsky, 1979a) and 330 trillion gallons (Ross, 1976), illustrate the point. These estimates of total ground water do not represent the amount of water which can practically be withdrawn. This may be even a more complex calculation. The estimates do however provide a general framework within which ground water resources must be managed. Ground water distribution varies widely across the state, just as water quality does, so generalizations lose their importance.

Accurate information on the extent of ground water supplies in high-use areas is necessary for effective ground water management. In most high-use areas, there is adequate knowledge of surficial glacial drift aquifers (near-surface sand and gravel deposits) and of consolidated bedrock aquifers. There is less information available on the size, shape, yield characteristics of unconsolidated buried drift aquifers (pockets of sand and gravel containing water buried at some depth and surrounded by heterogeneous, relatively impermeable glacial deposits which do not yield water), in high-use areas and in areas of growing demand. In some areas of Minnesota (e.g., the western part of the Minnesota River basin and in the Red River basin), unconsolidated buried drift aquifers are the only good source of ground water supply.

The importance of ground water in Minnesota is reflected in the state's reliance on it for drinking water, industrial production, food processing, and irrigation. In 1976, ground water was 14 percent of the total water withdrawn. By 1980, ground water accounted for 21 percent of the state's total water withdrawal (228.4 billion gallons of ground water out of a total of 1,109.6 billion gallons water withdrawn.) Most ground water is for high purpose usage, i.e., municipal water supplies and commercial use. The majority of surface water usage is for cooling water, so the figures for ground water usage become even more impressive.

Water use in Minnesota for 1980 is shown in Figure 2-3 and was estimated from pumpage reported to the MDNR, Division of Waters, agricultural statistics, and population data. Water use within the state was divided into five major categories:

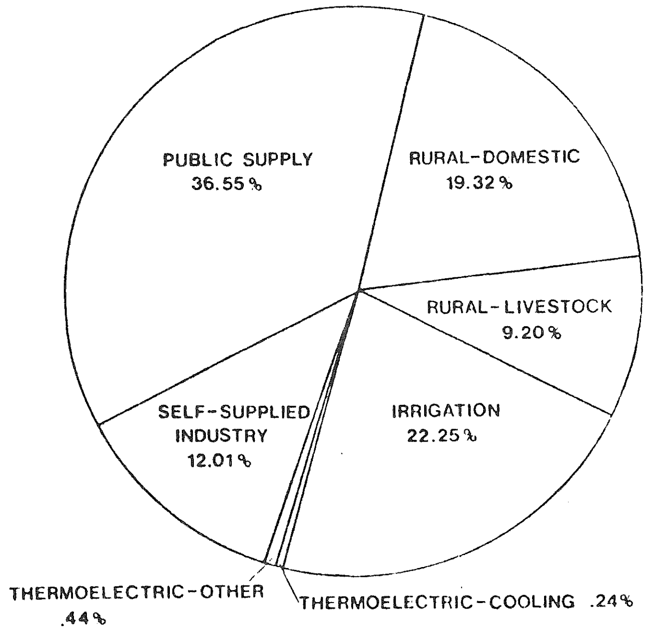
1. Public water supply;
2. Rural domestic and livestock;
3. Irrigation;
4. Thermoelectric power generation; and
5. Self-supplied industrial use.

Water usage was tabulated separately for ground water and surface water sources for these five categories. Public water supplies account for 36.6 percent of the total amount of ground water withdrawn. Rural water use is the second largest category of ground water withdrawal at 28.5 percent of the total ground water use. Rural water usage can be further subdivided into domestic and livestock uses. Domestic water use accounts for 19.3 percent of the ground water withdrawn; livestock watering accounts for 9.2 percent. Surface water is

Figure 2-3: Minnesota Water Use - 1980 (MDNR, 1982)

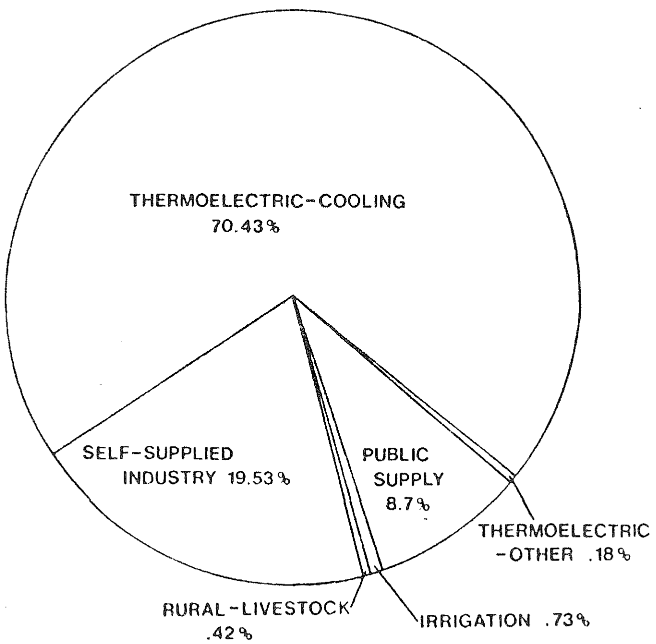
GROUND WATER WITHDRAWN-1980

Total= 228.4 Billion Gallons



SURFACE WATER WITHDRAWN-1980

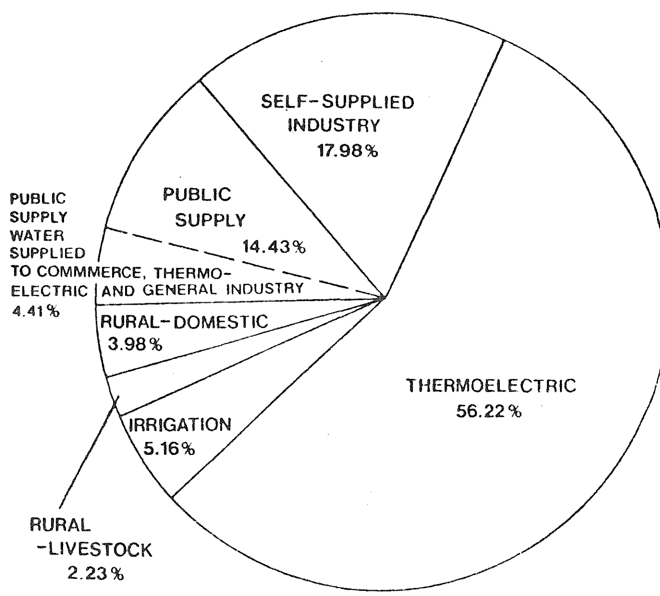
Total= 881.2 Billion Gallons



TOTAL WATER CONSUMED:

GROUND WATER AND SURFACE WATER

Total= 1,109.6 Billion Gallons



rarely used for rural domestic purposes. Irrigation water use also comprises a large portion (22.3 percent) of ground water withdrawals and is growing rapidly.

To reiterate the point that ground water plays a central role in Minnesota's water supply picture as compared to the entire United States, Table 2-1 presents summary comparisons of United States ground water use and Minnesota ground water use by percentages. The water use statistics are taken from a variety of sources (U.S. Water Resources Council, USGS, and MDNR); the main purpose in presenting them is to show the high reliance on ground water for public and rural water supply in Minnesota compared to a much lower reliance nationwide.

When the number of individual permits rather than the sheer volume of water use is examined, ground water appropriations emerge as being even more significant in the Minnesota water use picture. For example, 63 percent of the water withdrawn by municipal water treatment plants in 1976 came from wells. However, 93 percent of all the municipal systems use ground water. The figures may seem a bit anomalous but that is because major cities such as Minneapolis, St. Paul, and Duluth use surface waters.

Despite the generally positive picture of demand and supply, there are significant cautions. Localized shortages can occur either due to well interference or to water quality problems. The potential for this to occur is greatly amplified where users are concentrated. Shortages can also occur when the capacity of the water supply system cannot keep up with the demand, generally falling short during peak use periods. Adequacy of the capacity can be somewhat adjusted to the economics of meeting the marginal demand and also to the definition of acceptable uses, for example, sprinkling bans. In some cases,

Table 2-1: Summary Comparison of Ground Water Use
United States and Minnesota

GROUND WATER - UNITED STATES
USE
1950 - 1975

USE	Percent of Total 1950	1960	1970	1975
Irrigation	62	68	66	69
Industry	18	13	15	14
Public Supplies	12	13	14	13
Rural Supplies	8	6	5	5
TOTAL	12.4	18.3	24.8	19.9 trillion gallons per year

GROUND WATER - MINNESOTA
USE
1970 & 1980

USE	Percent of Total 1970	1980
Irrigation	2	22
Industry	46	12
Public Supplies	26	37
Rural Supplies	25	29
TOTAL	0.21	0.23 trillion gallons per year

however, the system may simply be unable to sustain pumping at desired rates. Major natural occurrences, such as the drought of 1976 and 1977, cannot be accurately predicted and can also cause unanticipated problems.

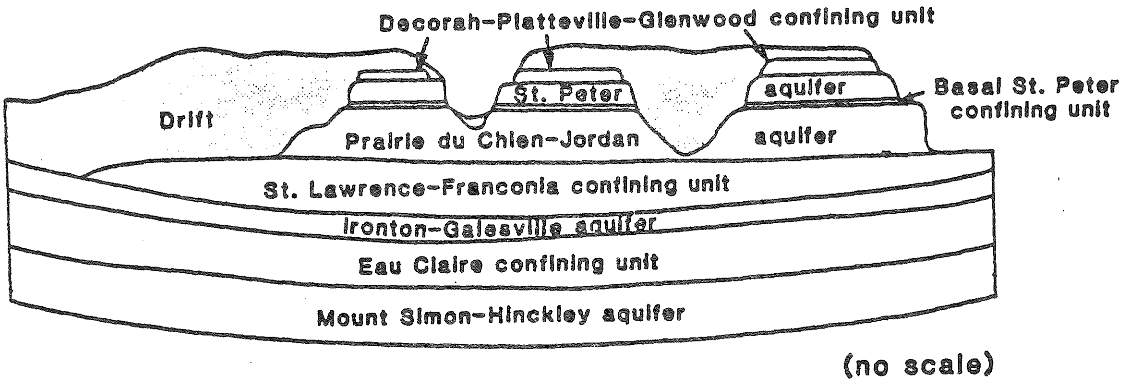
Ground Water Management in the Twin Cities Area

An example of how the information on geology, water quality, water quantity, and supply and demand are used to define and ultimately manage ground water resources is the current study headed by the USGS entitled, "Appraisal of the Ground Water Resources of the Twin Cities Metropolitan Area, Minnesota." The project is being carried out with the cooperation of the Metropolitan Council, the MDNR, and the MGS. The report "Preliminary Evaluation of the Ground Water Flow System Process in the Twin Cities Metropolitan Area, Minnesota" outlines the data gathering process and describes a preliminary ground water flow model for the area (Guswa, Siegel and Gillies, 1982).

Based on the present level of understanding of the water-bearing characteristics of the geologic units that underlie the seven-county metropolitan area, nine hydrogeologic units are now recognized. Figure 2-4 illustrates the vertical distribution of these units as a simplified hydrogeologic section. These nine hydrogeologic units are not uniformly present across the entire Twin Cities region. Bedrock valleys dissect the area, filled partly or totally with drift or recent river deposits. These valleys complicate the ground water flow by providing hydraulic connections between deeper bedrock formations and surficial deposits and the major rivers. They also cause local recharge or discharge which differs from the general regional flow.

Fortunately, the ground water resources of the Twin Cities Metropolitan Area are abundant. Average ground water withdrawal in the area was estimated to be about

Figure 2-4: The vertical distribution of the nine hydrogeologic units of the Twin Cities area in simplified cross-section. (Guswa, Siegel and Gillies, 1982)



168 million gallons per day for 1971 through 1977. The majority of the water is withdrawn from the Prairie du Chien-Jordan aquifer. In 1980, 867 out of 991 appropriation permits in the Twin Cities Metropolitan Area were for ground water withdrawal.

Since 1890, ground water withdrawals have caused water level declines in the Prairie du Chien-Jordan and Mt. Simon-Hinckley aquifers of approximately 90 and 200 feet, respectively. Water levels in the Prairie du Chien-Jordan are lowered an additional 65 feet during summer when pumping is greatest, but the water levels recover during the winter. Extensive pumping in the downtown areas for air conditioning in the summer is a major factor in the lowering of ground water levels.

Although the long term water level declines appear to have stabilized by 1978, the demand on the ground water resource is increasing. For example, the city of St. Paul is developing ground water for supplemental municipal supply. At present, approximately 25 percent of the supply is ground water, with a goal of reaching 50 percent ground water. An important benefit of ground water is that its quality and temperature are consistent, making water treatment less costly and more predictable.

Regulatory Framework for Ground Water Management

The legal framework within which Minnesota manages its ground water resources is comprised of common law, federal and state laws and resultant regulatory programs. Common law, evolving from court decisions and opinions, separates ground water into two distinct divisions, underground streams and percolating water. No connection to surface flow is recognized. Although these assumptions are hydrologically incorrect, the distinction is maintained in the courts.

Five levels of government are potentially involved in the decision making which affects water and related land resources. Federal, interstate, state, regional, and local government entities oversee ground water management through an assortment of laws, regulations, compacts, plans, strategies, and ordinances.

The federal laws which have an impact on ground water define national water quality standards or attempt to protect ground water from land surface activities which may lead to its contamination. Minnesota has adopted standards and established state programs to carry out the federal programs for the majority of these federal environmental laws. The majority of the laws and amendments that provide the federal government with the tools to deal with ground water pollution problems were passed in the 1970's. In some cases, the effect on ground water is implied and untested:

- The Clean Water Act of 1972 (PL 92-500) gives USEPA jurisdiction over ground water quality but the authority is somewhat ambiguous. Numerous states have outlined ground water elements in their Water Quality Management Plans under Section 208 of that act. Land application of effluents from wastewater treatment plants is regulated under this law.
- The 1974 Safe Drinking Water Act (SDWA-PL 93-523) gives USEPA the authority to set water quality standards for drinking water, to establish standards for the control of underground injection of wastes, and to designate aquifers as sole sources of drinking water in specific areas. Sole source designation requires special review of projects with federal funding in that area to insure that the ground water quality will not be degraded.
- The 1976 Resource Conservation and Recovery Act (RCRA-PL 94-580) was

designed to improve solid waste disposal practices, to regulate hazardous wastes from their generation to disposal; and to establish resource conservation as the preferred solid waste management approach.

- The Toxic Substances Control Act of 1976 (TOSCA-PL 94-469) and the 1972 amendments to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA-PL 92-516) require inventories to be kept of assorted chemicals and control their use. These laws indirectly protect ground water by controlling potential contaminants.
- The Comprehensive Environmental Response, Compensation, and Liability Act (Superfund-PL 96-510) was passed in 1980, creating the authority and providing limited financial resources to act immediately to prevent the spread of ground water contamination.

Each of these laws sets out control of hazardous substances, of actions such as the manufacture or transport of toxics, or of the disposal operations such as injection wells or landfills. The federal presence in the area of ground water protection enhances existing state enforcement authority, facilitates public acceptance of state programs, and attempts to achieve consistent performance among the states. In some cases, the federal law allows direct transfer of authority to the states for enforcement of programs.

Interstate water management has generally focused on surface water use and quality until recently. In 1982, two court cases were heard which dealt with interstate appropriation of ground water. In July 1982, the U.S. Supreme Court overturned a Nebraska law which was being used to deny an appropriation permit along the Colorado-Nebraska border (Sporhase v. Nebraska). The court opinion stated that the Nebraska law which required a reciprocal appropriation, placed a greater burden on interstate transfers of water than intrastate transfers. In a similar decision, the U.S. District Court, citing Sporhase, overturned a New Mexico ruling forbidding El Paso, Texas, from appropriation permits (January 17, 1983 - El Paso v. New Mexico). Ground water appropriations, until these decisions, have been left to state jurisdiction but with increased competition for water, the federal commerce law has been used as the basis for sending these cases to the federal courts.

The legal principle on which Minnesota water law is based is called the American Reasonable Use Doctrine of Riparian Rights. Under this doctrine, each landowner has the right to make reasonable, beneficial use of water available adjacent to or underneath his property. Reasonable, beneficial use provides for, but does not necessarily deal with water quality concerns.

Ground water law has not yet developed satisfactory answers to a number of recurring problems in the management and administration of aquifers. One difficulty is determining the extent to which the owner of a ground water right has or should have a right to the maintenance of artesian pressure or underground water levels. Another is the extent to which aquifers should be depleted, mined, or even exhausted and the extent to which this use interferes with the rights of others. A third is the extent to which ground and surface water supplies can be integrated for management purposes so that interconnecting sources of supply can be utilized for a fair administration of existing rights (Seinwell, 1977).

In the evaluation of state laws, rules, and procedures of public water resource management and regulation, the Minnesota Water Planning Board (MWPB) identified

16 state agencies and boards which administer over 80 water related programs in Minnesota (1979a). The primary statutory responsibilities and regulatory programs for ground water fall within three agencies: the Minnesota Department of Natural Resources (MDNR), the Minnesota Department of Health (MDH), and the Minnesota Pollution Control Agency (MPCA). The division of authorities among these agencies places control and conservation of water use in the MDNR; health-related and domestic supply matters in the MDH; and pollution control functions within the MPCA. While this division of authority seems clear conceptually, it lends itself to great interdependence among the agencies, and potentially, to gaps or overlap in authority.

Table 2-2 summarizes the legislative authorities relating to ground water management in Minnesota. The earliest provisions of the state's statutes dealing with water are found in Minnesota Statutes, Chapter 105. Since the enactment of this statute in 1947, the legislature continued to seek development of a water policy for the state. General charge and control over the waters of the state and of their use, sale, leasing, and other disposition is given to the Commissioner of the MDNR. Appropriation permits are required of all users except for domestic use serving under 25 persons and annual pumpage must be reported.

Water Quantity Regulation

The regulation of water quantity is carried out through the MDNR's appropriation permit program (6 MCAR §§ 1.5050-1.5058). At present the MDNR has approximately 5,300 active permits in the state. The MDNR maintains a data base on water use based on over 10,000 appropriation permits recorded since the program's inception in 1947.

Table 2-2 Legislative Authorities Relating to Ground Water Management

Area of Authority	DNR	MDH	PCA	OTHER
1. General	M.S. 105.38(2) Policy to control use in order to conserve and utilize the waters of the state.	M.S. 144.05 State's official health agency including environmental health matters.	M.S. 115.03(1) To administer and enforce all laws relating to the pollution of any waters of the state.	MGS - General Laws of Minnesota 1872, Ch. XXX, Sec. 2 To provide a complete account of the mineral kingdom. EQB. M.S. 116C.04 WPB. M.S. 105.401 SWCB. M.S. 40.02(4) DPS. M.S. 12.02 MDA. M.S. 17.03
2. Conservation				
a. General	M.S. 105.39(1) Water conservation program for guiding issuance of permits for use. M.S. 105.405 Water supply management for long-range ...seasonal requirements including quality and quantity needs M.S. 105.51 DNR authorized to prevent waste by well owners.	M.S. 144.35 to preserve domestic water supplies from pollution. M.S. 144.383 To insure safe drinking water. M.S. 156A.01 To reduce and minimize waste.	M.S. 115.03(1) To establish reasonable pollution standards for any waters of the state.	M.S. 116D.02 State Environmental Policy.
b. Critical or Emergency Periods	M.S. 105.41(2a) Modification of permits endangering domestic supply. M.S. 105.418 Conservation of public water supplies during periods of critical water deficiency.	M.S. 144.34 Protect sources of domestic supply from pollution which could endanger public health. M.S. 144.383 Emergency plans and orders to protect public when a decline in quality or quantity creates a serious health risk.	M.S. 116.101 Hazardous waste control and spill contingency plan. M.S. 116.11 Emergency powers to direct discontinuance or abatement of pollution endangering health and welfare.	DPS M.S. 12.03(4) Emergency services to prevent, minimize, and repair injury and damages resulting from disasters. MDA. M.S. 18A.37 Procedures to contain and control pesticides in an emergency.

5. Data Collection & Management a. Information Systems Development	M.S. 105.39(6) DNR in cooperation with other state agencies shall establish and maintain a statewide system to gather, process and disseminate information on availability, distribution quality, and use of waters of the state.	M.S. 156A.07 May establish procedures for coordinating water well data collection for geologic and water resource mapping to assist in development of a state water information system.		Laws of Minnesota, 1977, Ch. 446, Sec. 20(4) To complete a statewide data bank of waterwell logs and compilation of data obtained from current drilling activities.
b. Collection Reporting & Monitoring	M.S. 105.40(10) Written approval of Waters Director required for state and local water data collection contracts with federal government. M.S. 105.41(2) Owner or manager of every installation for water appropriation to file requested information to DNR. M.S. 105.41(4) Requirement for measuring and recording quantity used. M.S. 105.41(5) Annual pumpage reports required. M.S. 105.416(2) Information requirements for class B irrigation appropriation permit applications. M.S. 105.51 Reports of well logs and pumping tests required of drillers.	M.S. 144.383 Board to conduct, or contract with local boards for sanitary surveys and investigations of operation and service. M.S. 156A.05(2) Establishment of a system for reporting on wells drilled by licensed contractors. M.S. 156A.05(3) Inspection of wells drilled, or being drilled. M.S. 156A.07 Submission of verified reports by licensed contractors with copies to DNR, MGS, and SWCD's. Establishment of procedures and criteria for submission of data.	M.S. 115.03 To gather the data and information necessary in administration and enforcement of pollution laws. M.S. 116.101 Hazardous waste plan to include information reporting system.	MDA. M.S. 31.54 Supply source and quality data collection relating to packing plant approval. MDA. M.S. 32.392 Supply source and quality data collection relating to dairy plant approval. DOT. M.S. 161 Collection of undisturbed lorings data for highway construction and development.
6. Coordination and Assistance	M.S. 105.49 Personnel from PCA, MDH and local governments to cooperate in monitoring and enforcement.	M.S. 156A.03 Consultation with DNR and PCA in development of standards for design, location, and construction of waterwells. M.S. 156A.07 May establish procedures for coordinating well data collection with other state and local agencies.	M.S. 115.06(3) Cities, towns, counties, sanitary districts, public corporations, and other governmental subdivisions to cooperate in obtaining compliance and to enforce requirements within their jurisdictions. M.S. 116.05 State departments to cooperate and to assist Agency in performance of its duties.	

Table 2-2 (continued)

3. Regulation	M.S. 84.57 Permits for underground storage of gases or liquids. M.S. 105.41 Appropriation and use of waters permits. M.S. 105.418 Public water supply restrictions based on DNR rules for critical periods. M.S. 105.41(3) Abandonment of wells of specified size to comply with DNR recommendations.	M.S. 114.12 Regulations relating to disposal of sewage, pollution of waters, sanitation of resorts. M.S. 144.35 Charge to preserve water supply sources from pollution as may endanger public health. M.S. 144.383 Safe Drinking Water regulations for supply development and management. M.S. 156A.03 Regulation and licensing of drillings construction and abandonment of water wells to release and minimize waste.	M.S. 115.03 Regulation to control or abate water pollution. M.S. 116.101 Hazardous waste management regulation.	EQB. M.S. 116C.23 Environmental permits coordination. M.S. 116D.04 Environmental impact statements MDA. M.S. 18A.25 Pesticides regulation. M.S. 31.54 Water supplies of packing plants. M.S. 32.392 Approval of dairy plants including water supplies and disposal of wastes.
4. Planning	M.S. 105.39(1) Development of a water conservation program to guide the issuance of use permits. M.S. 105.403 Statewide framework and assessment water and related land resources plan, including water supply and quality needs. M.S. 105.41(1a) Requirement of permit consistency with state, regional, and local water and related land resources plans.	M.S. 144.383 To develop an emergency plan to protect the public when a decline in quality or quantity creates a serious health risk. M.S. 145.918 To establish a planning process for development of community health services plans.	M.S. 116.10 Long range annual plan and program for implementation of pollution control policies. M.S. 116.101 Statewide hazardous waste management plan, and including a spill contingency plan.	EQB. M.S. 116C.07 Annual preparation of a long range plan and program for the effectuation of state environmental policy. WPB. M.S. 105.401 Preparation of a framework water and related land resources plan.

7. Regional and Local Roles	M.S. 105.41 Permit consistency with local and regional plans is required provided these are consistent with state plans. M.S. 105.41(1b) Local or regional processing of permits authorized with conditions. M.S. 105.416(1) SWCD's as a source of ground water data. M.S. 105.416(3) SWCD recommendations on adequacy of soil and water conservation measures of proposed water uses for irrigation. M.S. 105.418 Public water supply authorities to adopt and enforce restrictions during critical periods. Consistent with DNR rules. M.S. 105.44(8) SWCD's may make recommendations on compatibility of permit applications with comprehensive SWCD plans. M.S. 105.49 County and municipal cooperation in monitoring and enforcement.	M.S. 144.12 County and local health officers may be required to make investigation enforce regulations under supervision of Board. M.S. 144.383 Local boards of health may contract with state Board for water supply testing. M.S. 145.031 One or more counties, and cities may enter into formal agreements to perform functions of state Board. M.S. 145.911 Local administration of community health services under State guidelines and standards. M.S. 145.92 Plan review by regional development commissions or Metropolitan Council.

Prepared by: Minnesota Water Planning Board, Water Management Work Group, 1979b, in Management Problems and Alternate Solutions, MWPB Draft Technical Paper 14.

The statutes set priorities for water appropriation in the state. They are as follows:

1. Domestic supply, excluding industrial and commercial uses of municipal water supply;
2. Any use of water that involves consumption of less than 10,000 gallons per day. For the purposes of this section, "consumption" shall mean water withdrawn from a supply which is lost for immediate further use in the area;
3. Agricultural irrigation, involving consumption in excess of 10,000 gallons per day, and processing of agricultural products;
4. Power production, involving consumption in excess of 10,000 gallons per day;
5. Other uses involving consumption of 10,000 gallons per day. (Minnesota Statutes, Chapter 105.41).

The system of water use priorities came under scrutiny in the case of the Crookston Cattle Company v. MDNR (December 1980). The city of Crookston was changing its source of water supply from the Red Lake River to wells. The change was recommended by the MDH because the city's water treatment plant needed extensive renovation and the city felt in switching to ground water, maintenance costs would be considerably lower than for a surface water system.

The Crookston Cattle Company applied for water appropriation permits for 12 irrigation wells in the vicinity of the four municipal wells. The MDNR refused the permit until the company could prove that their withdrawal would not affect the municipal supply. The Minnesota Supreme Court supported the MDNR's position based on the facts that (1), municipal use is first priority and agricultural irrigation is third and (2), riparian rights are subordinate to the rights of the public and are subject to state regulation. The MDNR's refusal to give a permit to the Crookston Cattle Company was not an absolute refusal, rather a conditional one requiring proof that the third priority use would not have a deleterious effect on the municipal supply.

Two other subdivisions within Chapter 105 specifically mention ground water. Minnesota Statutes, Chapter 105.416 defines special requirements for water appropriation permits for irrigation from ground water. If the application is submitted for wells in an area of the state where the MDNR does not have adequate information on ground water availability, well, aquifer, pumping, and general quality data are required with the application.

Minnesota Statutes Chapter 105.51 defines general operational constraints which the MDNR can set. "For the conservation of underground water supplies of the state, the commissioner is authorized to require the owner of wells, especially flowing artesian wells, to prevent waste" (Subdivision 1).

Water supply conflicts are anticipated in the future but may be avoided through MDNR work to develop the technical capability to delineate, quantify, and evaluate the state's ground water resources. Past projects focused on mapping of high capacity wells (irrigation, commercial, industrial, and municipal wells with greater than eight-inch diameters), observation well data collection and mapping, and determination of aquifer hydrologic parameters.

The quantity of ground water pumped by permittees is submitted to MDNR annually. In addition to the pumpage report, water levels are measured in an observation-well network. The MDNR and USGS cooperate in the collection of data from 17 continuous recorders and from 15 weekly, 84 monthly, and 153 bimonthly tape measurements of water-table wells. The Minnesota observation-well network was decreased from 357 wells in 1981 to 269 in 1983 (federal fiscal year). Data from selected wells are plotted on monthly high, low, and mean levels for the period of record to aid in the description of seasonal fluctuations (USGS, 1982).

Water Quality Regulation

A related charge to protect ground water is assigned to the MDH. The purpose of Minnesota Statutes, Chapter 156A, Water Wells and Exploratory Borings, is "to reduce and minimize the waste of ground water resources within the state by reasonable legislation in licensing drillers or makers of water wells and the regulation of exploratory borings in Minnesota and to protect the health and general welfare by providing a means for the development and protection of the natural resource of underground water in an orderly, sanitary, and reasonable manner."

The MDH Water Well Construction Code provides a preventive approach to water quality if a well is properly drilled and maintained, it is less likely to act as a conduit for contamination. The Division of Environmental Health requires water well construction through the Code which has been in effect since July 1974. This code (7 MCAR § 1.210-1.224) has provisions for: (1) licensing water and exploratory well drillers and registering monitoring well engineers; (2) delineating location and construction requirements of wells depending on the geology of the site and existing sources of contamination; (3) requiring the submittal of a well log and a water sample for each new or reconditioned well; (4) requiring proper sealing and abandonment of wells if the well is no longer in use, contaminated, or the source of contamination; and (5) prohibiting the use of a well for disposal of surface water, near-surface water, or ground water or any other liquid, gas, or chemical. The well construction rate is about 10,000 per year.

In 1981, the legislature added a limited program which allows a specific number of permits to be granted for the reinjection of ground water and ground water thermal exchange devices, commonly called ground water heat pumps (Minnesota Statutes 156A.10).

The MDH also oversees public water supply regulations which were adopted to carry out the Safe Drinking Water Act in Minnesota. (Minnesota Statutes, Chapter 114.381 and 7 MCAR § 1.145-1.150.) Public water supplies currently serve about 1.7 million Minnesotans. The objectives of the program are:

1. To achieve all monitoring requirements as defined by the Minnesota Safe Drinking Water Regulations;
2. To identify all community and non-community supplies in the state;
3. To enforce drinking water quality standards (maximum contaminant levels);
4. To see that records are maintained and public notice takes place when standards are violated; and
5. To inspect each community supply once ever 15 months.

The third agency in the triad that oversees ground water is the MPCA. MPCA's statutory charges pertaining to ground water are very general and, consequently, have the potential to allow comprehensive programs. Quite simply, Minnesota Statutes, Chapter 115 directs the MPCA "to administer and enforce laws relating to pollution of any waters of the state" and Minnesota Statutes, Chapter 116 requires the MPCA to promote solid waste disposal control, hazardous waste control, and have a spill contingency plan.

The MPCA operates according to rules aimed at controlling pollution. Minnesota Rule 6 MCAR § 4.8022 (WPC-22) gives the MPCA authority to preserve and to protect the underground waters of the state by preventing any new pollution and by abating existing pollution. Other MPCA rules which provide for ground water protection address sewage sludge landspreading (6 MCAR § 4.6101-4.6136), hazardous waste facilities (6 MCAR § 4.9001-4.9010), sanitary landfills (Minnesota Rule SW-6 and SW-12), and septic tanks and drainfields (6 MCAR § 4.8040). Permits are required for the operation of disposal practices and facilities which could impact ground water quality. MPCA programs to protect ground water quality are discussed in detail later in this report.

CHAPTER 2

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CHAPTER 3

SUMMARY OF EXISTING STATE GROUND WATER PROGRAMS AND DATA BASES

Ground Water Programs Introduction

The Minnesota Water Planning Board (MWPB) has identified 16 state agencies and boards which administer more than 80 water-related programs in Minnesota. (MWPB, 1979; 1983). In 1979, there were 14 local agencies, seven interstate agencies and five regional (intrastate) agencies dealing directly with water resources in Minnesota. In addition, 12 federal agencies were found to directly affect water resources management in the state. The focus of this chapter will be on state agency involvement with ground water protection. Responsibilities and programs of other institutions in Minnesota dealing with ground water protection may be found in publications such as those by USGS (1982) and the Metropolitan Council (1983).

Of the over 80 water-related programs administered by state agencies, 54 have direct bearing on ground water and related management programs (Table 3-1). Fourteen of the 16 agencies and boards at the state level have at least some involvement in ground water resources. Of these, however, three agencies (MDH, MDNR and MPCA) account for about 75 percent of the ground water programs. As a means of cataloging and describing state agency ground water programs, the resources of the Department of Energy, Planning and Development (DEPD) through its Systems for Water Information Management (SWIM) were used. SWIM is currently funded by the Legislative Commission on Minnesota Resources (LCMR).

Systems for Water Information Management (SWIM)

The purpose of SWIM is to link together users of all Minnesota water resource data with those agencies and institutions that collect, store and use such data.

TABLE 3-1

MINNESOTA GROUND WATER AND RELATED MANAGEMENT PROGRAMS

ENVIRONMENTAL QUALITY BOARD

Environmental Impact Assessment	Critical Areas
Program Review and Policy Conflict Resolution	Pipeline Routing and Power Plant Siting
Permit Coordination	Environmental Policy Planning

ENERGY, PLANNING, AND DEVELOPMENT

Land Management Information Center

Systems for Water Information Management

POLLUTION CONTROL AGENCY
-Division of Water Quality-

Water Quality Management Planning	NPDES Permits Program
Standards Development	State Disposal System Permits
Municipal Sludge Disposal	Agricultural Waste Unit
Emergency Response Unit (Spills)	

-Division of Solid and Hazardous Waste-

Site Response Section	Solid and Hazardous Waste Facility Review
Hazardous Waste Generator Program	Ground Water Surveys Ambient Monitoring
Solid and Hazardous Waste Facility and Transportation Permits	Solid and Hazardous Waste Program Development
Underground Injection Control	

NATURAL RESOURCES
-Division of Waters-

Water Appropriation Permits	Underground Gas and Liquid Storage Permits
Ground Water Hydrology	
Information Systems Development	

TABLE 3-1 (continued)

MINNESOTA GROUND WATER AND RELATED MANAGEMENT PROGRAMS

UNIVERSITY OF MINNESOTA
-Minnesota Geological Survey-

Hydrogeologic Mapping (Statewide)

Water Well Drillers Logs Database

Hydrogeochemistry Mapping

High Capacity Well Database (HICAPS)

-Department of Geology and Geophysics-

Research and Mapping of Karst in Southeastern Minnesota

WATER PLANNING BOARD*

Statewide Framework Water and Related Land Resources Plan

Coordination of State Water Resources Management

SOIL AND WATER CONSERVATION BOARD

Oversight of Soil and Water Conservation Districts

WATER RESOURCES BOARD

Water Policy Conflict Resolution

Watershed District Formation and Plan Review

SOUTHERN MINNESOTA RIVERS BASIN BOARD

Regional Water and Related Land Resources Planning

Coordination of Natural Resources Management

WASTE MANAGEMENT BOARD

Hazardous Waste Management Plan

Solid Waste Management

Siting of Hazardous Waste Facility

PUBLIC SAFETY
-Division of Emergency Services-

Emergency Water Supply Services

*Effective July 1, 1983, the Water Planning Board is merged with the Environmental Quality Board

TABLE 3-1 (continued)

MINNESOTA GROUND WATER AND RELATED MANAGEMENT PROGRAMS

HEALTH
-Division of Environmental Health-

Water, Exploratory, and Monitoring Well Construction

Safe Drinking Water Program

Occupational Health*

Environmental Field Services*

Analytical Services (Laboratory)

Health Risk Assessments

Hotels, Resorts, and Restaurants*

TRANSPORTATION

Undisturbed Boring Program

Soil Engineering Program

AGRICULTURE

Dairy Division*

Agronomy Services Division
(Pesticide and Fertilizer Licensing)

Food, Meat, and Poultry Division*

*Activities include surveillance of water supplies

Information contained in the SWIM data base includes that which is both surface and ground water related. A SWIM Users Committee, made up of representatives from user agencies, meets about monthly to coordinate development of individual water data bases through a centralized user service bureau, the Land Management Information Center (LMIC) of DEPD. Again, both ground and surface water interests are represented on the committee. One of the work products of the committee has been a catalog of water data sources in Minnesota (MWPB and DEPD, 1981).

The catalog of water data sources was compiled from the master SWIM reference file, which contains detailed information on over 150 data collections. The reference file describes each of these collections in approximately one page of purpose, content, reports, parameters measured, data format, geographic coverage, agency contact persons, and availability. Currently, no separate catalog of data sources relating specifically to ground water is available. However, with the assistance of LMIC, it is possible to access (for a small fee) the SWIM reference file and request a sort of the data sources based on key word descriptors. For the purposes of this report, a compilation of all data sources listing "ground water" as a descriptor was requested. The result was a summary of 28 general program areas within seven state agencies which have primary responsibilities for ground water management in Minnesota. An outline of these agencies and their related ground water programs is given below. It is believed that these programs account for over 90 percent of all state agency ground water programs administered in Minnesota. Appendix A to this report contains a detailed catalog of ground water data sources in Minnesota.

1. Minnesota Department of Agriculture (MDA)

   A. Dairy industries division: industrial private water supply

   B. Food, meat and poultry inspection program: private industrial water quality

   C. Pesticide control program

      1. Data on licensing and registration

      2. Data on spills and emergencies and reported misuses

2. Minnesota Department of Health (MDH)

   A. Analytical services: soil and water quality

   B. Ground water quality information system

      1. Water well log data base

      2. Ground water quality

   C. Health risk assessment: ground water quality

   D. Safe Drinking Water Act

      1. Water quality monitoring

      2. Inventory of public water supplies

   E. Southeast Minnesota Ground Water Study (karst study): ground water quality data

3. Minnesota Department of Natural Resources (MDNR)

   A. Heavy metals leaching studies

   B. Iron range information system (IRIS): water related data

   C. Mineland reclamation program (permit to mine)

   D. Mineral exploration registration: bore hole data

   E. Peat study

      1. General description

      2. Ground water quantity

F. Ground water program

1. Aquifer characteristics and tests

2. Observation well data base

3. High capacity well inventory

a. Irrigation wells

b. Municipal wells

G. Water use program

1. Appropriation permit files

2. Appropriation permit mailing list

3. Water appropriator's annual pumpage records

4. State water use estimates

4. Minnesota Department of Transportation (MDOT)

A. Ambient water quality program

1. Water quality chemical parameters

2. Stream flow

B. Project development and wetland initiation--environmental impact assessment: wetland and land type classification

C. Soil engineering program: Soil profile

D. Undistrubed boring program

1. Field boring logs

2. Laboratory log and test results

3. Auger boring notes

5. Minnesota Geological Survey (MGS)

A. Water well and engineering test boring programs

1. Water well log data base

2. Engineering test boring logs

3. Water chemistry analyses data base

6. Minnesota Pollution Control Agency (MPCA)

   A. Hazardous waste management regulatory program

      1. Generator's waste disclosure and evaluation of waste generated

      2. Waste storage information

      3. Waste storage site monitoring

      4. Hazardous waste disposal facility permit applications

      5. Spills in transit data

      6. Uncontrolled sites and RCRA inspections

   B. Land application of wastewater program

   C. Ambient ground water quality monitoring program

   D. Sludge disposal program

      1. Sludge analyses

      2. Solids disposal plan

      3. Soil data

      4. Routine monitoring

   E. Solid waste inventory and monitoring system (SWFIMS)

      1. Characteristics of each monitoring well

      2. Water quality monitoring data

      3. Data from solid waste facility permit application

   F. Agricultural waste pollution control program: feedlot program

   G. National pollution discharge elemination system (NPDES) and state disposal system (SDS) permits: water quality monitoring

7. Minnesota Department of Energy, Planning and Development (DEPD)

   A. Regional copper-nickel study

Ground Water Data Bases - Introduction

With the emergence of ground water as a key issue in environmental protection and resource management in Minnesota, the number and complexity of ground water data bases, both manual and computerized, being developed by state agencies has grown rapidly in recent years. The Minnesota Environmental Quality Board (MEQB) staff is currently compiling a list of ground water data bases which includes both computerized systems and manual files. MEQB proposes a classification of data bases related to ground water into four categories:

1. ground water use data summary
2. ground water quality data summary
3. geologic data summary
4. surface features data summary

The MEQB listing contains information on 29 data bases, 18 computerized and 11 in manual files. These have been summarized on the following pages by categories as shown above. Following the discussion of data bases within each category is a table (Tables 3-2, 3-3, 3-4 and 3-5) which lists the agency maintaining the data base, the areas of Minnesota covered by the data base, the number of wells in the data base, and the status of the data base in terms of which statewide, centralized data base management system the individual data base is a part or is proposed to be a part. Currently, these data base management systems include SWUDS (State Water Use Data System) and the computer facilities of LMIC.

Ground Water Use Data Summary

A. Computer Data Bases:

1. National Water Use Data System (NWUDS) (MDNR-USGS)

Content: Contains surface and ground water use data for MDNR's 8,000 appropriation permit holders, including location, annual water use and appropriation limits, and an index of other agency numbers for that permit.

Data: For each permit: permit holder; MDNR permit number; location (township, range, section, 40-acre parcel, county, confidence level, watershed district, latitude, longitude, topographic quadrangle, whether location is field checked); use; source code and number; permit data (permitted pumping rate, annual appropriation and irrigated acreage; number of installation on permit; population served, municipal percentage supplied to commerce and industry; special provision flag; (complaint flag); other agency numbers (old MDNR permit, Health municipal ID, NPDES, USGS site ID, MGS unique well number); discharge water body, discharge rate, and months of discharge; reported annual pumpage (annual pumpage, crop irrigated, crop acreage, measurement accuracy); for each well: locations, installation code and reported pumpage data if available.

Coverage: 33 counties in northwest Minnesota and Twin Cities are available. Southeast Minnesota counties to be next priority for entry. 1979 and 1980 water use data.

Comments: This will become the State Water Use Data System (SWUDS). Not all data is reported for each well or each permit. Variations in use of installation number in system often makes identification of specific well difficult. Excludes many wells since permits are not required for domestic wells serving less than 25 persons or annual appropriations less than 10,000 gallons per day and totaling less than one million gallons per year. Also, some qualified wells do not have permits.

2. High Capacity Wells--Catalog of Agency Numbers (HICAPS) (MGS)

Content: For high capacity wells (finished casing diameter of at least eight inches used for non-domestic purposes) and municipal wells with smaller casing diameters, HICAPS contains a catalog of agency numbers, location data and certain data on well construction, aquifer and use.

Data: Location (quadrangle name, whether field located, township, range, section 2½ acre parcel, county), whether in WELL-LOG data base, well name, well use (8 types), finished well diameter, top aquifer, bottom aquifer, catalog of numbers (MGS samples, MPCA-GWQ, newest MDNR permit, oldest MDNR permit, USGS Site ID, MDH municipal ID, MSGS unique number, MGS NURE sample) remarks.

Coverage: Over 5,000 wells in Minnesota. About 100 wells in southeast Minnesota, many of them in Olmsted and Mower counties.

Comments: HICAPS now complete for state; quarterly updating is proposed. HICAPS is at LMIC; programming to analyze and map data has been completed. To be part of SWUDS.

3. Reported Water Pumpage (Pump 78-81) (MDNR)

Contents: Contains data on reported monthly surface and ground water pumpage for installations under MDNR water appropriation permits.

Data: pumpage (monthly, yearly), permit number, source, location.

Coverage: Statewide, for all reporting permit holders. Over 8,000 permits statewide. About 200 reporting in 1980 for southeast Minnesota. Data is available for 1978-1981; 1982 data will be entered shortly.

Comments: See earlier comments on NWUDS. Also, not all water pumped out is actually consumed; some is discharged to surface water. Since the MDNR permit number contains the year of issuance, this data can be used to track location of new ground water appropriators.

4. Observation Well Water Level (MDNR)

Content: Contains data on water levels, aquifer and well construction for observation well network in the state.

Data: Location of well, name of observer, unique well number, well construction data, geologic log, period of record, frequency of measurement, aquifer being measured, well elevation, well depth, method of measurement, actual water levels, type of aquifer (confined or unconfined), topographic setting, well name, county name.

Coverage: About 1,200 wells, of which less than 600 have been monitored recently. Frequency of reading varies, from several times a month to once a year.

Comments: Many of these are part of the USGS observation well network (GWSI); USGS can prepare hydrographs for these wells. MDNR is currently considering transfer of the data base to LMIC: existing MDNR software to develop groundwater hydrographs needs debugging before use. Period of record varies from well to well.

5. High Capacity Well Inventory: Irrigation Wells (MDNR)

Contents: Data on location, construction, geology, aquifer(s) used and other data for irrigation wells.

Data: See NWUDS.

Coverage: 1,000 irrigation wells.

Comments: This data base was never finalized or completely error-checked; it will become part of SWUDS.

B. Manual Data Files:

1. USGS RASA Study Data for Southeast Minnesota

Contents: Historical water use data for major appropriations as part of the Regional Aquifer Systems Analysis (RASA) program.

Data: Regional water use.

Coverage: For the Twin Cities and Rochester, USGS collected and assessed the historical ground water use data necessary for the RASA program and the Metropolitan Council ground water assessment computer model. For other southeast counties in the RASA study area, the data was collected but never analyzed. A report on municipal water use since 1880 is in press.

Comments: USGS estimates that it would take four to five weeks to analyze and computerize this data. This data includes major ground water users who do not have MDNR permits.

2. Appropriation Permit Sites (MDNR)

Contents: Data on use, appropriation limits, source, geology, location, etc., for wells subject to MDNR permits.

Data: Location, pump type, pumping schedule, measurement method, pumping rate, annual volume, life of project, well depth, well log data, well diameter, aquifer test results, other wells in area, use of well (if irrigation: crop type and acreage, soil type, slope; if public water supplies: population served, water treatment, commercial/industrial users, emergency plan, other users), limits to appropriation (annual amount, pumping rate, special permit provisions), disposition of application.

Coverage: Statewide; all permits.

Comments: Pertinent data from these files are being included in NWUDS and SWUDS.

3. Reported Water Pumpage Records (MDNR)

Contents: Data on monthly pumpage from surface and ground water and use for MDNR permit holders.

Data: See Reported Water Pumpage (Pump 78-81)

Coverage: Statewide; all reporting permit holders since 1952.

Comments: None

TABLE 3-2

GROUND WATER USE DATA SUMMARY

Computer Data Bases	Agency	Coverage	No. Wells	Status
NWUDS	MDNR-USGS	33 counties		SWUDS, GWIS
HICAPS	MGS	state	5,600	SWUDS, GWIS
PUMP 78-81	MDNR	state	5,000	SWUDS
Observation well	MDNR	state	1,200 total <600 active	Maybe to LMIC
Irrigation wells	MDNR	state	1,000	SWUDS
Manual Data				
Appropriation permit files	MDNR	state	8,000	
Reported pumpage	MDNR	state	4,000+/yr	
USGS RASA data	USGS	SE MN		

C. Reports:

1. USGS Water Use Estimates. These estimates include: a) every five years since 1960 for the 10 major watersheds in the state; b) for the metropolitan area, data on specific uses for every year from 1970-1979; c) for the RASA study in the Twin Cities area and Rochester, data on specific users for every decade from 1880-1960. The first set of estimates have been published. The other sets are in draft report form. The USGS does not provide projections for future water use.

2. MDNR 1980 Water Use Almanac. This report lists reported monthly water pumpage in 1980, water source and location for reporting MDNR permit holders. This is basically a report of 1980 PUMP, in three report formats. There are less than 150 reporting ground water users in southeast Minnesota.

3. Water Planning Board 1976 Water Use Estimates. The Water Planning Board (WPB) estimated 1976 and 1980 water use for the major watersheds in Minnesota.

4. MGS Ground Water Yield Estimates. The MGS estimated ground water yields throughout the state in 1979 for the WPB. Three estimation methods were used to develop figures for the 39 watersheds.

5. USGS Hydrologic Atlases. USGS has prepared hydrologic atlases on surface and ground water in the 39 major watersheds in the state. These atlases have general maps showing direction of ground water flow, ground water quality, ground water use, ground water yield, etc., and also list more specific data.

D. Computer Programs:

Metropolitan Council USGS Ground Water Model. The Metropolitan Council and the USGS have spent three years developing a computer model of the aquifers in the metropolitan area. The model will be used by the Metropolitan Council to assess the impacts of several ground water use scenarios in preparation of a ground water management plan. The model will be done shortly; the results of the scenarios will be available in late 1983.

Ground Water Quality Data Summary

A. Computer Data Bases:

1. Ambient Ground Water Monitoring Program (STORET) (MPCA)

Content: Ground water quality data on over 45 parameters for each of the 400 wells or springs in MPCA's ground water quality (GWQ) program.

Data: Well location, well owner, aquifer, well construction, water quality parameters, which generally include the following parameters. Measured in the field: pH, temperature, specific conductivity, field alkalinity as $CaCO_3$. Measured in the lab: nitrogen, fluoride, silica, total hardness as $CaCO_3$, total alkalinity, chloride, sulfate, sodium, potassium, nitrate, nitrite nitrogen, total kjeldahl nitrogen, total phosphorus, total organic carbon, phenol, total coliform, fecal coliform, dissolved solids, total volatile solids, total cadmium, total copper, total chromium, total iron, total lead, total manganese, total mercury, total zinc, total arsenic, total boron, selenium, barium, cyanide, nickel, fecal streptococci, chemical oxygen demand, organics.

Coverage: About 400 wells/springs statewide - chosen to provide an acceptable understanding of ambient conditions in the bedrock and surfical aquifers. 66 stations are in southeast Minnesota.

Comments: Sampling frequency is once every five years for most wells. Most wells have been sampled once. The data is stored in the USEPA's STORET water quality data bank. STORET also contains the WATSTORE water quality data from USGS.

2. Solid Waste Facility Inventory and Monitoring System (SWFIMS) (MPCA)

Content: Site characteristics, monitoring well characteristics and water quality monitoring data for land disposal facilities with permits from MPCA's Solid and Hazardous Waste Division.

Data: Location, responsible party, well construction, water quality parameters. Water quality data generally includes chloride, pH, conductivity, NO_3 and COD, although there are more parameters for some sites.

Coverage: About 150 of the 237 permitted facilities monitoring wells.

Comments: The water quality data comes from facility operators via many private labs, so the accuracy varies. MPCA is currently considering a proposal to transfer this system to LMIC.

3. Southeast Minnesota (8 County) Computerized Well Test Project (8 Counties and Agricultural Extension Service Southeast Office).

Content: Water quality data on domestic wells (nitrate, coliform, etc.) in the eight southeast Minnesota counties with karst geology.

Data: Likely to include owner, well depth, well age, last date tested, last date repaired, location of water supply, date and time of sample, sampler, reason for sample, lab number, coliform bacteria, nitrate nitrogen, notes, recommended action.

Coverage: Propose to begin computerizing the March well samples analyzed at the Olmsted County lab, using an IBM personal computer. Will run for about a year, then evaluate. County level and multi-county level statistical analyses will be done. These are voluntary samples, so the data is not statistically valid. Care must be taken so that the location data is accurate enough so that mapping and comparison with other data can be done.

4. NURE Water Chemistry Analyses (MGS)

Content: Geology and geochemical analyses useful in predicting ground water movement as part of the DOE National Uranium Resources Evaluation (NURE).

Data: Radio-isotope measures, dissolved oxygen, water temperature.

Coverage: About 5,000 wells in western and central Minnesota.

Comments: No data for southeast Minnesota.

B. Manual Data Files

1. Surface Features Data (MPCA)

Content: Data on surface features with the potential to contaminate ground water and which require a MPCA permit or MPCA review. Examples include feedlots, hazardous waste disposal sites, mixed municipal waste (sanitary) landfills, disposal ponds for industrial waste, etc.

Data: Varies.

Coverage: Statewide

Comments: These are generally manual records. Projects requiring land disposal permits have been included in SWIFMS (discussed earlier).

2. Water Supplies for Dairy, Food, Meat, and Poultry Facilities (MDA)

Content: Water quality data for water supplies for dairy industries and food, meat and poultry facilities.

Data: Coliform, nitrates, data on facility.

Coverage: Over 8,000 dairy operations and over 1,000 food, meat and poultry facilities in the state.

Comments: Records are destroyed after five years. Sampling frequency varies according to type of facility.

3. Public Water Supply Sites (MDH)

Content: Water quality data on public water supplies.

Data: Temperature, coliform organisms, total solids, turbidity, color, hardness, alkalinity, pH, iron, manganese, chloride, residual chlorine, sulfate, fluoride, nitrate, nitrite nitrogen, calcium, sodium, potassium, magnesium, arsenic, barium, chromium, cadmium, lead, mercury, selenium, silver, zinc, copper, nickel, total organic carbon, ammonia nitrogen, organic nitrogen, phenol, oil, grease, endrin, lindane, methoxychlor, toxaphene, 2, 4-D, 2, 3, 5-TD (silvex), radiochemicals, volatile organics, polynuclear aromatic hydrocarbons.

Coverage: About 2,000 supplies statewide.

Comments: The finished water quality is monitored daily to weekly, although in many cases there have been supplemental investigations on the raw water supply. Records may go back as far as the turn of the century. The data is stored in manual files, but they should be relatively easy to access.

4. Abandoned Wells (MDH)

Content: Water quality data on wells proposed for abandonment ("capping").

Data: Total dissolved solids, alkalinity, iron, chloride, fluoride, nitrate, nitrite, sodium, specific conductance at 25 degrees centigrade, magnesium as $CaCO_3$, barium, cadmium, selenium, zinc, nickel, ammonia nitrogen, organic nitrogen, hardness, pH, manganese, sulfate, total phosphorus, calcium as $CaCO_3$, potassium, arsenic, chromium, lead, silver, copper, TOC, phenol (using MBTA method), total cations, total anions, polynuclear aromatic hydrocarbons (using high performance chromatography).

Coverage: 30-40 selected wells, mostly in metropolitan area where new construction is proposed for site.

Comments: MDH has estimated 1-4 abandoned wells/active well/township in southeast Minnesota (1979 study), or about 10,000 total. Many of these wells were not abandoned properly. Temporarily idle wells are not considered abandoned, so won't be capped or otherwise protected.

5. Water Well Records (MDH)

Content: Well-log data (well construction and driller's description of geology) and an MDH analysis of water quality for new water wells.

Data: Water well contractor's certification, well use, drilling method, casing, screen, well head completion, well grouting, pump type, source of possible contamination, subsurface formation hardness, formation color, formation depths, well depth, static water level, pumping level, coliform, nitrates, public land survey description, distance to nearest road intersection.

Coverage: All water wells drilled in state since 1975 are required to have well log filed with MDH; 50-60 percent actually do. About 40-50,000 logs have been filed.

Comments: 1977-1980 well construction data was computerized (GWQIS); MGS then field located many of the wells and interpreted the geology, and used the data in the MGS WELL-LOG computer data base. Other records are in manual files. Water quality data is not in GWQIS, but rather is filed with the well log. The MDH lab has computerized the results, but by lab sample number - which is contained on the water quality analysis sheet in the manual file; the computerized lab results are not retained permanently. (An earlier effort to computerize water quality data was apparently unsuccessful; the tape still exists, but there is little information on extent of data, amount of error-checking, format, etc.)

TABLE 3-3

GROUND WATER QUALITY DATA SUMMARY

Computer Data Bases	Agency	Coverage	No. Wells	Status
STORET (GWQ)	MPCA-EPA	State	400	
STORET (WATSTORE)	USGS	State		
SWFIMS	MPCA	State	150 sites	Maybe to LMIC
SE Well Test Data	U, SE counties	SE MN	1,000/yr.	Proposed
NURE Data	MGS	W, C	5,000	
Manual Data				
Surface features permit files	MPCA	State		
Water supply files	MDA	State		
Public water supply files	MDH	State	2,000	
Abandoned wells	MDH	State	50	
New well files	MDH	State	40,000+	

C. Reports:

1. Underground Injection Control Program (USGS for USEPA).

   Content: Geologic, hydrologic and water quality data for the major aquifer formations in the state, as part of USEPA's program to determine baseline aquifer quality.

   Data: Two plates containing maps for each formation, showing generalized maps of geohydrology (overlying deposits, surface contour, line of equal thickness, potentiometric surface) and water quality (lines of equal concentration of calcium, magnesium, sodium, bicarbonate, chloride, sulfate, dissolved solids). Maps are about 1:500,000 scale. Tables and charts are also provided.

   Coverage: Maps cover the portions of the state where the formations are present. In southeast Minnesota, the St. Peter, Ironton-Galesville, Prairie du Chien, Jordan, and Cedar Valley-Makoqueta-Galena formations are shown.

   Comments: Geohydrologic data is from the RASA study. The water quality data is from WATSTORE, STORET, MDH municipal well data and USGS hydrologic data.

2. Ambient Ground Water Monitoring Program (STORET) (MPCA).

   Results of MPCA's ambient network are published annually. Reports for data collected in 1978, 1979 and 1981 are still available. The report for data collected in 1981 also includes a section on data analysis. The report for data collected in 1982 will be available about July 1, 1983.

3. Special Studies:

   Several special studies have been completed on southeast Minnesota water quality, including:

   Minnesota Department of Health. Problems Relating to Safe Water Supply in Southeastern Minnesota. 1976; also, January, 1979.

   Minnesota Department of Health, Division of Environmental Health. History of Problems Relating to Safe Water Supply in Southeastern Minnesota. January 1981 (mimeo).

   St. Ores, J., E.C. Alexander, Jr., and C.F. Halsey. Ground Water Pollution Prevention in Southeast Minnesota Karst Region. University of Minnesota Agricultural Extension Service Bulletin 465. 1982.

   Singer, R.D., M.T. Osterholm, and C.P. Straub. Ground Water Quality in Southeastern Minnesota. University of Minnesota Water Resources Research Center Bulletin 109. October, 1982.

D. Computer Programs:

MPCA investigations at Reilly Tar and Chemical Plant, a Superfund project to assess contaminant spreading. LMIC computer facilities are being used for the study; computerized geologic fence diagrams for cross-sections have been developed.

Geologic Data Summary

A. Computer Data Bases:

1. NWUDS - Ground Water Data Base (MDNR-USGS)

Content: Well construction and geological data for wells in National Water Use Data System (NWUDS), those wells covered by a MDNR appropriation permit.

Data: For each permit and well: location (as in NWUDS), well status, well type, multiple/single aquifer, aquifer test, well log type, water level flag, year constructed, well driller, well depth-LSD, well depth-MSL, well depth source casing (material, diameter, cased from MSL, cased to MSL), opening (type, material, diameter, slot-gauge, opening top, opening bottom), pump (type, power source, capacity, horsepower, lowest intake level, data installed), aquifer (lithology, stratigraphy, overlying material, top MSL, bottom-MSL), driller's pumping test (date, length, static level, pumping water level, rate), water level measurements (date, water level-MSL), remarks.

Coverage: Same 33 counties as NWUDS. Southeast Minnesota will be entered next.

Comments: This will become the SWUDS-GWDB. The data is not complete for many wells. The installation numbering system is the same as for NWUDS. General aquifer types are used, not detailed MGS aquifer designations. See NWUDS comments in discussion of ground water use data.

2. Subsurface Geology Data Base: Water Wells (WELL-LOG) (MGS)

Contents: Contains geologic data on materials encountered during well construction, water levels, and location for water wells whose drillers filed well logs with the MGS.

Data: MGS unique well number, owner, address, location (county, township, range, section, 2½ acre parcel quadrangle name, UTM location, field location method), elevation, elevation source, depth, chemical data availability, pumpage test (static water level, date, lengths, gpms, drawdowns), top aquifer, bottom aquifer, data source, well use (8 standard codes), all casing types and depths, sources of possible contamination (feet, direction, type); screen (make, type, diameter slot/gauge, length set between which depths), pump (manufacturer's name, model number, h.p., volts, length of drop pipe, capacity, type), geologic data (for each formation encountered: driller's description, color, hardness, top of unit, MGS' interpretation of stratigraphic unit and lithology).

Coverage: Over 80,000 manual records for wells throughout the state; over 10,000 are in the computer data base (WELL-LOG) or keypunched for entry.

Comments: Well drillers submit well logs for only about half of the wells drilled. Geologic data varies in accuracy since the interpretation depends on well driller's data. Although well location is generally field-checked by MGS, accuracy varies. Computerization was halted this biennium due to funding problems. The well logs are the basis for geologic information in Minnesota. To be included in SWUDS. Fence diagrams displaying area stratigraphy can be made at LMIC; the MPCA superfund project required this capability.

3. Visible Karst Features (University of Minnesota Geology Department)

Content: Number of visible karst features per section, as shown on source maps.

Data: Number per square mile of sinkholes, karst springs, karst seeps, stream sinks, stream sieves, cave entrances visible on USGS topographic maps, aerial photos and SCS maps.

Coverage: Houston, Olmsted and Fillmore counties are computerized in LMIC; Winona and Wabasha counties are available in manual form and on a personal computer.

Comments: The latter two counties were not put in LMIC. The infrequency of karst features in these areas meant that karst features were often not specified in source maps so data accuracy was less than acceptable. Note that field work often turns up even more features.

4. High Capacity Well Inventory: Municipal Wells (MDNR)

Content: Data on location, construction, geology, aquifer(s) utilized and other data for municipal wells that can produce greater than 70 gpm.

Data: Well identification (county, municipality, well number, aquifer(s) used), location (township, range, section, quarter-quarter-quarter section), MGS unique well number, application data (number, file number), well contact person and address, drilling firm, license number, well specification (depth, altitude-MSL, drop pipe length, date drilled, casing type and diameter, depth, screen diameters and depth, pump type, pump power type and pump average discharge), aquifer test data (static water level, test date, tester, static and dynamic water levels, duration, pump rate, transmissivity, storativity, specific capacity), well log (lithology and stratigraphy for each layer, depth), comments.

Coverage: 3,000 municipal wells in the state.

Comments: This data base was never finalized or completely error-checked; it will become part of SWUDS.

B. Manual Data Files:

1. Subsurface Geology Data Base: Water Wells (MGS)

See earlier discussion under computerized data bases. About 10,000 of the 80,000 water well records have been computerized. Many of the remaining wells have been coded for entry, but have not been added to the computer data base.

TABLE 3-4

GEOLOGIC DATA SUMMARY

Computer Data Bases	Agency	Coverage	No. Wells	Status
NWUDS-GWDB	MDNR-USGS	33 counties		SWUDS
WELL-LOG	MGS	40+ counties	10,000+	SWUDS
Visible Karst	University	3 SE counties	-	LMIC
Municipal Wells	MDNR	State	3,000	SWUDS
Manual Data				
New Water Well Logs	MGS	State	80,000+	

C. Reports

1. Regional Geology in Southeast Minnesota MGS. A series of 1:500,000 scale maps of southeast Minnesota prepared by the MGS for the USGS Regional Aquifer Systems Analysis study. Maps include depth to bedrock; and structural contours, potentiometric surface and thickness of the major aquifers and aquicludes.

2. USGS Regional Aquifer Systems Analysis (RASA) Study. The RASA study involves a study of the geologic, hydrologic and geochemical data on the six-state regional aquifer systems, to evaluate regional ground wter development. Maps include: (1) the MGS base maps discussed before; (2) summary maps at 1:500,000 scale showing the extent of aquifers and aquicludes, drift thickness, recharge ("mound") areas, flow patterns of recharge areas, and two water quality maps; and (3) final maps in report, generally at a scale of 1:1 million. The RASA study area includes southeast Minnesota and the Twin Cities area. Three reports will be issued.

3. MGS County Geologic Atlases. The MGS has begun preparation of detailed county geologic atlases in Olmsted and Fillmore counties, on an "as time is available" basis. The atlases will contain a series of geologic and hydrogeologic maps very useful for local and state officials. Well log data will form the basis for the maps. "The Scott County atlas, already completed, has been used extensively in the siting process for landfills.)

4. Potential Sinkhole Areas in Southeast Minnesota, SCS. A 1:500,000 scale map showing areas with high moderate and low potential for sinkhole development prepared by the USDA Soil Conservation Service.

5. Geologic Map of Minnesota: St Paul Sheet, Bedrock Geology, MGS. A 1:250,000 scale map showing the first bedrock unit in the southeastern quarter of Minnesota.

6. MGS Geologic Maps of Minnesota. A series of maps showing quaternary geology (1:500,000), bedrock geology (1:1 million), bedrock topography (1:1 million), depth to bedrock (1:1 million), and bedrock hydrogeology (1:500,000). Working maps at a larger scale are available for some of these maps.

Surface Features Data Summary

A. Computerized Data Bases:

1. Solid Waste Information Management System (SWIFMS) (MPCA). See earlier discussion on SWIFMS in the ground water quality section. SWFIMS contains location and information on about 150 facilities that require permits form MPCA's Solid Waste Division

2. 1969 Land Use (LMIC). LMIC contains a file of dominant land use in 1969 for each 40 acre parcel in the state. This data could be used to calculate the potential effect of agricultural practices (e.g. application of pesticides and N-fertilizer) in areas with sensitive geology.

3. 1970, 1980 Census Data (LMIC). LMIC has 1970 and 1980 census data for each minor civil division (MCD) in the state. This data can be used to identify population-based trends with surface implications (e.g. rural septic systems).

4. Gravel Pits (LMIC). LMIC has some data on gravel pits. Gravel pits generally intercept the water table, so they become access points of pollutants.

B. Manual Data Files:

1. MPCA Permit Files (MPCA). MPCA maintains files for surface features with contamination potential that require MPCA permits. Feedlots are one example. For certain types of features like dumps, MPCA developed master lists of the features and the major problems at each site.

2. Other Activities (Local Units). Many surface features with contamination potential are under the jurisdiction of local units of government. Individual septic systems are one example. Other activities or features, like agricultural practices, are not regulated.

TABLE 3-5

SURFACE DATA SUMMARY

Computer Data Bases	Agency	Coverage	No. Wells	Status
SWFIMS	MPCA	State	150 sites	
1969 Land Use		State	40 acres	LMIC
Gravel Pits	MDOT	State		LMIC
1970, 1980 Census Data	DEPD	State	By MCD	LMIC
Manual Data				
Permit Files (landfills, MPCA feedlots, etc.)	MPCA	State		
Other Activities	Local Units	Local		

C. Reports:

1. Assessment of Ground Water Contamination in Minnesota (MPCA) MPCA has prepared a report on a variety of surface activities which have the potential to contaminate ground water (see Chapter 5).

2. MDH Estimate of Abandoned Wells in Southeast Minnesota. In its 1979 report to the LCMR on southeast Minnesota, the MDH estimated the number of abandoned wells. Improperly abandoned wells provide a means for surface pollutants to enter surficial and bedrock aquifers.

Recommendations

1. A coordinated effort among ground water management agencies to acquire ground water data is needed. Interagency cooperative data gathering programs should be considered to eliminate duplicated efforts and help ensure that the data acquired is usable and reliable.

2. The progress recently made toward developing coordinated data storage should be continued so that ground water management agencies may have access to more data than that which they alone acquire.

3. There should be an interagency effort to share in the analyses of ground water data and apply the information so gained toward improvements in individual agency ground water management programs.

4. Coordination of ground water data management should extend to the day-to-day operations of regulatory programs within the ground water management agencies to minimize conflicts in water use and potential gaps in water resource protection that can lead to ground water degradation.

5. MPCA should continue to implement the in-house effort now underway to examine and improve its data management systems, including those for ground water.

CHAPTER 3

REFERENCES

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CHAPTER 4

AMBIENT GROUND WATER QUALITY IN MINNESOTA

Purpose and Scope

In October, 1977, the MPCA developed a proposal to establish and maintain a statewide network for monitoring ground water quality in Minnesota and asked the USGS to assist in its design. An interagency agreement was signed which resulted in design of a monitoring program consisting of over 400 wells and springs (Hult, 1979). The purpose of this monitoring program is to better define baseline (ambient) conditions and evaluate major trends in ground water quality on a statewide basis by resampling the network wells in approximately five-year intervals.

Field sampling was initiated by the MPCA in early 1978. The program currently consists of 360 wells or springs located throughout Minnesota (Figure 4-1). Wells and springs were selected to be representative of each of 12 major aquifer groups found in Minnesota (Table 4-1). This list is in substantial agreement with previous classifications published by the USGS (Adolphson, Ruhl and Wolf, 1981). Several minor stratigraphic units or only locally important aquifers have not been included in the MPCA classification in Table 4-1. These are the Platteville Limestone, present in portions of southeast Minnesota between the Galena Dolomite and St. Peter Sandstone; the Red River-Winnipeg aquifer, located in approximately the same position stratigraphically in extreme northwest Minnesota; and the Proterozoic metasedimentary aquifer, a low yielding aquifer which underlies Cretaceous rocks in parts of north-central Minnesota. As Table 4-1 indicates, the number of wells sampled per aquifer was based primarily on well yields within each of the aquifers. A compilation of ambient ground water quality data for the previous calendar year is published annually

Figure 4-1

GROUND WATER QUALITY MONITORING NETWORK 1982

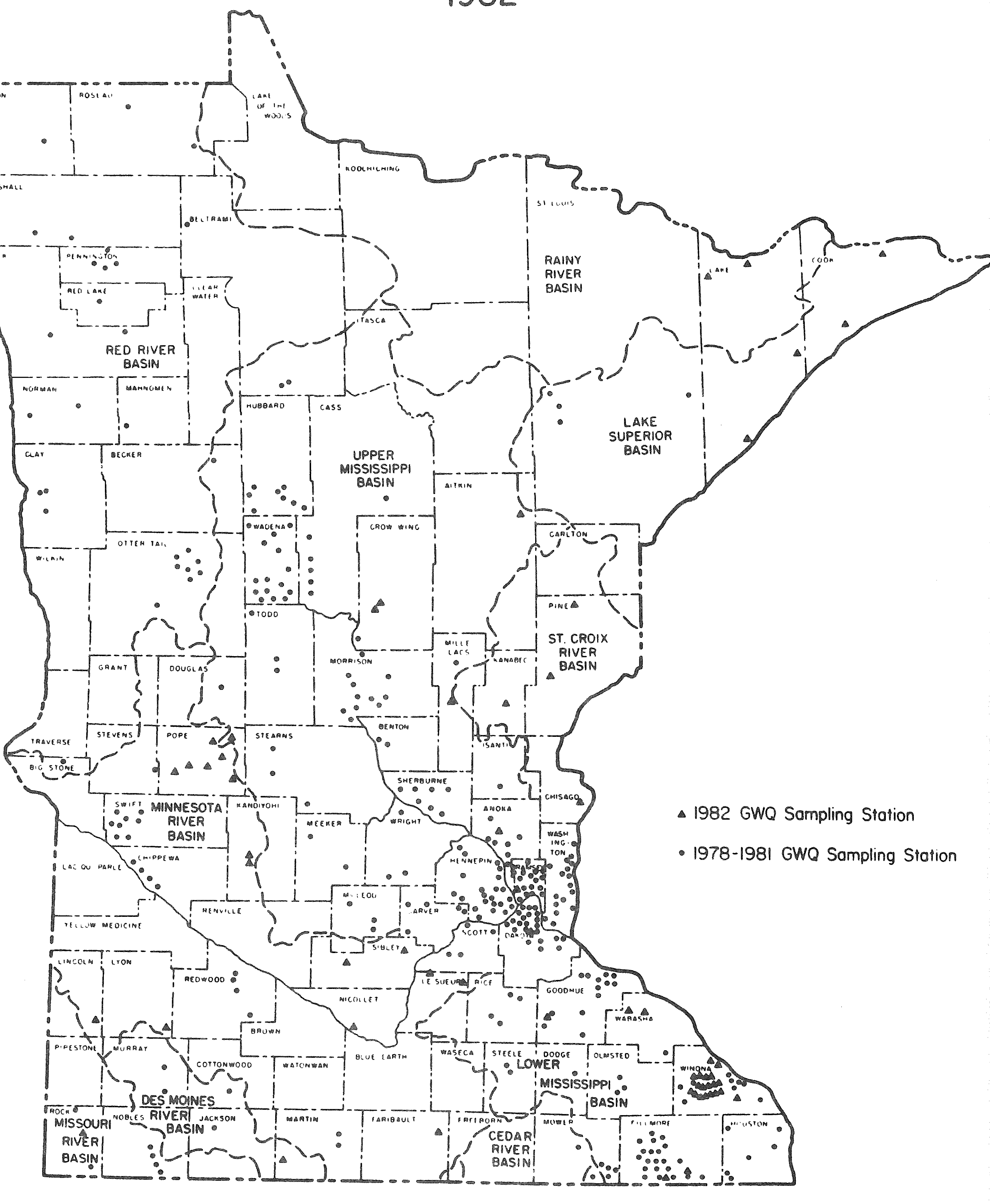


TABLE 4-1: GENERALIZED STRATIGRAPHIC AND HYDROGEOLOGIC UNITS, WELL YIELDS AND NUMBER OF AMBIENT NETWORK WELLS FOR PRINCIPAL AQUIFERS IN MINNESOTA

Erathem	System	Stratigraphic Unit	Hydrogeologic Unit	Well Yield (gal./min.)	No. of Network Wells
Cenozoic	Quaternary	Glacial drift	Surficial Sand	10-3,000	88
			Buried Sand	10-1,000	58
Mesozoic	Cretaceous	Cretaceous rocks, undifferentiated	Cretaceous, Undifferentiated	10-25	5
Palezoic	Devonian	Cedar Valley Limestone	Upper Carbonate	200-500	25
	Ordovician	Maquoketa Shale Dubuque Formation Galena Dolomite			
		St. Peter Sandstone Prairie du Chien Group	St. Peter	10-100	9
			Prairie du Chien-Jordan	300-2,700	82
	Cambrian	Jordan Sandstone			
		Franconia Formation Ironton Sandstone Galesville Sandstone	Franconia-Ironton-Galesville	40-400	25
		Mt. Simon Sandstone	Mt. Simon-Hinckley-Fond du Lac	500-2,000	39
Precambrian	Precambrian	Hinckley Sandstone Fond du Lac Formation			
		North Shore Volcanic Rocks	North Shore Volcanics	25-100	-
		Sioux Quartzite	Sioux Quartzite	10-450	3
		Biwabik Iron Formation	Biwabik Iron Formation	250-1,000	2
		Precambrian rocks, undifferentiated	Precambrian, Undifferentiated	10-150	4

[After Kanivetsky (1978) and Adolphson, Ruhl and Wolf (1981)]

(MPCA, 1983) which summarizes data collected for 1982 is in preparation. Previous volumes have been published for 1978, 1979, 1980 and 1981. Design and operation of MPCA's ambient program are summarized by Clark and Trippler (1982).

Selection of Network Wells

In addition to meeting the purpose and scope discussed above, individual wells or springs selected for the ambient network were chosen so as to meet as many of the following criteria as possible:

1. In conjunction with available data, the well or spring should provide a statewide overview of ground water quality with respect to naturally occurring constituents and contaminants.
2. Wells or springs should be selected to include all principal aquifers, with an emphasis proportional to present use and availability of alternative water supplies.
3. The network as a whole should be integrated with other water resources data networks and projects.
4. The network should provide data on water quality for studies of regional significance, such as those associated with areas of karst or extensively irrigated areas.

Network Operations

Minnesota's ambient ground water quality monitoring program consists of 360 wells and springs, with at least one station in 68 of Minnesota's 87 counties, (Figure 4-1). The goal of the program is to have 400 quality sampling sites which will be sampled once every five years. A good site is a well with a detailed well log including comprehensive construction data and a complete geologic description of the formations or rock types encountered during drilling. Also, ambient stations should not be located in or near known contamination sources.

An attempt is being made to place at least one sampling station in each county. During the five-year sample rotation cycle, a representative number of samples is collected each year throughout the state, avoiding sampling in one or two isolated areas in any given year. In addition, the principal aquifers in the state are being sampled in accordance with productivity and use of the aquifers. Aquifers with higher yields and more wells receive increased sampling (Table 4-1). Note that in Table 4-1, only 340 network wells are indicated. This is because several multiaquifer wells and wells without logs were sampled early in the program. These wells are being dropped from the program as substitutes are found. Results from these wells were not included in data interpretation.

All samples were handled and analyzed in accordance with methods approved by the U.S. Environmental Protection Agency (USEPA). Laboratory services were provided by the Minnesota Department of Health (MDH), Section of Analytical Services. The resulting data were entered into STORET, the USEPA computerized national water quality data bank.

Field Procedures

Determinations are usually made in the field for alkalinity, temperature, pH, and conductivity. The final conductivity measured in the field is mathematically converted to the standard of 25°C. In addition, field observations are usually made for flow, color, odor, turbidity, and location of possible sources of pollution. The actual collection, preservation, and analyses of water samples are done in accordance with Standard Methods for Examination of Water and Waste Water, 15th Edition (1980), and/or recommendations of USEPA. MPCA has sampled natural ground water discharges or wells equipped with motor-driven pumps. Observation or monitoring wells have not been sampled in the ambient program due to time and equipment constraints and such wells' usual proximity to potential sources of contamination. However, these wells are sampled as a part of MPCA's regulatory compliance program (see Chapters 6 and 7).

Standardized field procedures were developed to insure a uniformly representative sample from each site. The MPCA uses two procedures for collecting samples, one for wells and the other for springs. When sampling a well, water is drawn from the operating system as close to the well head as possible, with continuous measurement of water temperature, pH, and conductivity. This is accomplished by directing a two to five gpm flow through an insulated pipe into an insulated tank equipped with probes attached to field instruments. All field instruments are calibrated before and after sampling. The calibration is essential to maintaining a high degree of quality control. While a continuous flow is directed through the tank, the instruments are read at five-minute intervals until three consecutive and identical sets of readings are obtained. At this time the system is considered to be reasonably stabilized. The tank and hose are then removed, and all samples are collected from the tap that was used to feed water to the tank. The final step in the sampling process is flame treating the tap prior to collection of bacteriological samples.

The sampling of springs is done by placing the temperature, pH, and conductivity probes directly into the flow. Only one reading for these parameters is taken from a point as close as possible to the place where the water emerges. This is also the point where samples are collected. Where the flow in a well, cistern, or spring is extremely limited, water samples and an extra two liter and one liter bottle of water are collected from a point as close to the well head or point of origin as possible. A field reading for temperature and conductivity is obtained from the water in the extra two liter container; pH is measured from the extra one liter container.

Program Review and Modification

During 1978 through 1980, filtering equipment was used in the field to process samples for certain dissolved constituents. The parameters filtered were potassium, sodium, sulfate, fluoride, silica, calcium, magnesium, and boron. Field filtering was terminated after 1980. Prior to sampling in 1981, a statistical analysis comparing filtered against unfiltered parameters showed no significant differences in the data (Table 4-2). The potential for sample contamination, the extra time involved in sample collection, the need for additional bottles, and increased analytical and shipping costs all contributed to the conclusion that the added expense and time involved did not justify collecting field filtered samples for dissolved constituents. However, in regulatory compliance sampling from narrow-diameter wells, where the water may be contaminated or contain suspended solids, field-filtration is an important part of sample preparation.

Data Interpretation

Ground water is commonly classified by chemical type based on relative concentration in milliequivalents of principal cations and anions. Classification provides a basis for grouping waters of similar types and evaluating chemical processes which may affect water quality. There are many ways of graphically displaying the chemical composition of ground water. The Piper diagram (Piper, 1944) is one graphical method which allows the cation-anion relationship of many samples to be represented on a single graph and has

TABLE 4-2

COMPARISON OF TOTAL VERSUS DISSOLVED PARAMETERS

Parameters (mg/l) (STORET Code)	Number of Samples	Mean ($\bar{x}$)	Standard Deviation	Test of[1] $\bar{x}_1 = \bar{x}_2$	Maximum	Minimum
(00910) Ca as $CaCO_3$, Total	375	186.7	102.6	0.37	780	10
82368 Ca as $CaCO_3$, Diss	292	183.8	96.6		710	10
(00920) Mg as $CaCO_3$, Total	375	107.4	57.4	1.09	420	10
(82369) Mg as $CaCO_3$, Diss	292	102.7	53.4		350	10
(00929) Na, Total	77	21.7	43.5	-0.04	234	1.4
(00930) Na, Diss	291	21.9	45.0		370	1.4
(00937) K, Total	77	2.7	2.7	-0.28	15.5	0.5
(00935) K, Diss	291	2.8	2.9		31.	0.5
(00951) F, Total	62	0.21	0.15	0	0.95	0.1
(00950) F, Diss	298	0.21	0.26		3.1	0.1
(00956) Si, Total	60	16.9	5.8	-0.12	31.	6.8
(00955) Si, Diss	298	17.0	6.3		39.5	1.6
(00945) SO_4, Total	77	77.3	191.0	1.14	1300.	5.0
(00946) SO_4, Diss	299	51.4	107.9		800.	5.0
(01022) B, Total (ug/l)	62	205.9	533.8	0.83	4000.	50
(01020) B, diss (ug/l)	295	148.6	236.5		1300.	50

$$^1Z = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

where: a = 0.05 (level of significance)
$\bar{x}_1$ = mean of the total parameters
$\bar{x}_2$ = mean of the dissolved parameters
s_1 = standard deviation of the total parameters
s_2 = standard deviation of the dissolved parameters
n_1 = number of samples of the total parameters
n_2 = number of samples of the dissolved parameters

been used in this study as an aid in organizing and interpreting raw chemical data from the Minnesota ambient monitoring program.

The natural chemical quality of ground water in Minnesota has been previously discussed by Winter (1974) and Adolphson, Ruhl and Wolf (1981). There are six major water quality types present in the state's principal aquifers, with the calcium-magnesium-bicarbonate type dominant. In the eastern three-fourths of the state, water in the near surface aquifers is low in sulfate because most of the readily available sulfate minerals have been leached from these aquifers. Calcium-magnesium-bicarbonate ground water therefore generally occurs in recharge areas in the upper part of the ground water flow system. In some areas of the state it overlies water of other types. An example of this occurrence can be seen in northwestern Minnesota where sodium-bicarbonate water is found in Cretaceous sediments underlying buried glacial drift. Sodium-chloride type ground water is also found in large areas of extreme western Minnesota, especially within and adjoining the Red River Valley. The source of sodium chloride for these aquifers is generally thought to be Cretaceous and Paleozoic bedrock aquifers in the eastern Dakotas which are hydraulically connected, under higher head potential, to the Minnesota aquifers. In some areas, this water is high enough in dissolved solids to be unpotable. Sodium-chloride waters also occur in small areas of southeast Minnesota underlain by Precambrian red clastic rocks and in Precambrian basalt flows along the north shore of Lake Superior.

Other water quality types which are locally important in Minnesota include calcium-magnesium-chloride water in parts of extreme northwest Minnesota, sodium-sulfate water in Cretaceous sediments southwest of the Minnesota River, and calcium-magnesium-bicarbonate-sulfate water in parts of southwestern

Minnesota, where a source of sulfate-rich minerals, such as gypsum and iron sulfide, is available in the glacial drift.

The basis of the Piper diagram analysis of Minnesota's ground water for this study is the 12 major aquifer groups listed in Table 4-1. Detailed plots of five of these aquifers were not attempted because of insufficient data. They are the Cretaceous, Undifferentiated; the Sioux Quartzite; the Biwabik Iron Formation; the North Shore Volcanic Rocks; and the Precambrian, Undifferentiated. Data from these aquifers has, however, been included in calculation of statewide mean values of selected inorganic parameters (Table 4-3). As the ambient monitoring program expands or additional observations are made at existing stations, these aquifers will be plotted and analyzed as discussed below. Two aquifers, the Upper Carbonate and the St. Peter, have twelve and nine wells respectively, for which data are available (13 of the 25 Upper Carbonate samples shown on Table 1 are surface water from springs). These aquifers have been analyzed using Piper diagrams and although the data appear to indicate specific patterns of dominant chemical characteristics, the small number of observations allows only tentative conclusions about these aquifers at this time.

The following discussions will focus on three principal aquifers in Minnesota having different characteristics and illustrating several ways in which graphical presentation can be used to assist in ground water data interpretation.

The Buried Sand aquifer showed the greatest scatter of data points of any of the aquifers for which Piper diagrams were plotted (Figure 4-2). However, as with most

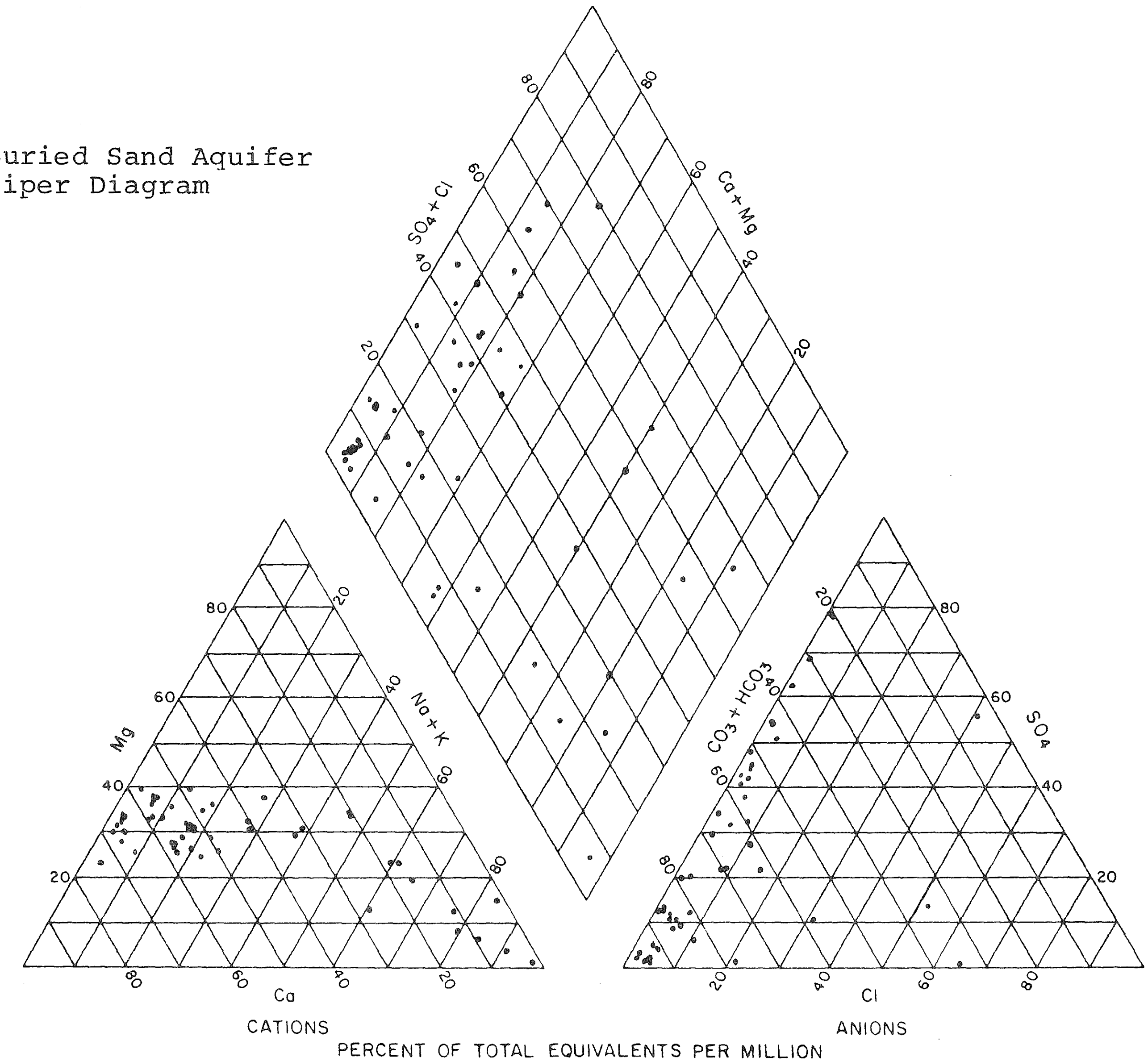
TABLE 4-3

MINNESOTA'S AMBIENT GROUND WATER QUALITY

Parameter	Sample Number (n)	6 MCAR § 4.8014 Standard	State Ground Water Quality Average ($\bar{x}$)
Arsenic, as As	107	10 ug/l	2.85 ug/l
Chloride as Cl	376	250 mg/l	19.51 mg/l
Copper as Cu	223	1000 ug/l	19.55 ug/l
Fluoride as F	298	1.5 mg/l	0.21 mg/l
Iron as Fe	359	300 ug/l	1230.14 ug/l
Manganese as Mn	359	50.0 ug/l	154.16 ug/l
Nitrate (NO_3) as N	388	10 mg/l	2.56 mg/l*
Phenol	200	1 ug/l	<2.0 ug/l
Sulfate as SO_4	299	250 mg/l	51.39 mg/l
Total Dissolved Solids (TDS)	360	500 mg/l	404.75 mg/l
Zinc as Zn	360	5000 ug/l	120.40 ug/l
Barium as Ba	222	1000 ug/l	92.33 ug/l
Cadmium as Cd	359	10 ug/l	0.13 ug/l
Chromium as Cr (total)	359	50 ug/l	1.90 ug/l
Lead as Pb	361	50 ug/l	8.39 ug/l
Selenium as Se	222	10 ug/l	1.95 ug/l
Silver as Ag	23	50 ug/l	0.04 ug/l

*Value represents NO_2 + NO_3 as N

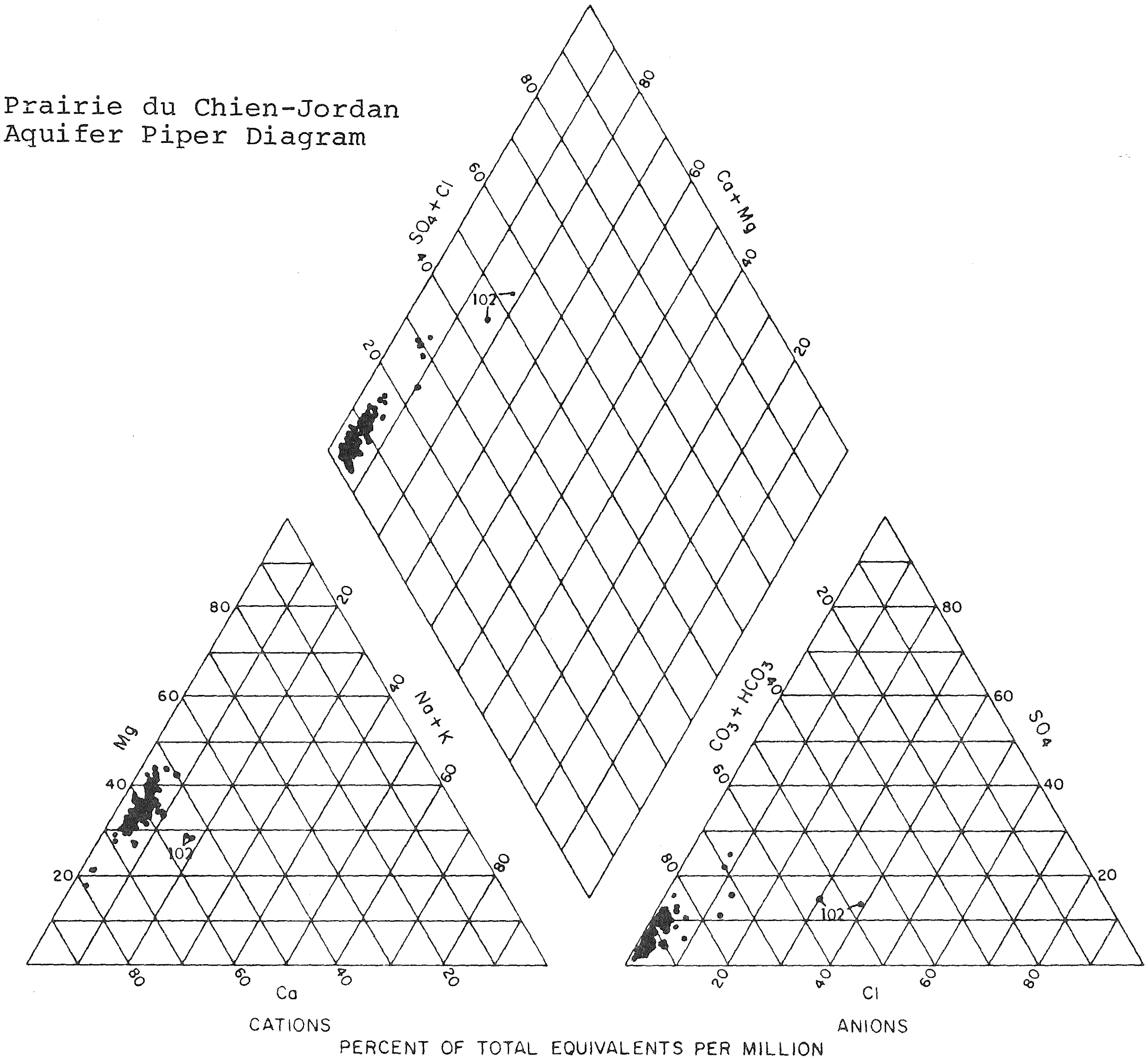
Figure 4-2: Buried Sand Aquifer Piper Diagram



of the principal aquifers, water in the Buried Sand aquifer is dominated by calcium and bicarbonate. From the coordinate point of approximately 25 percent calcium, 30 percent magnesium and 45 percent sodium plus potassium, there is an apparent linear drop in both calcium plus magnesium as the percentage of sodium plus potassium increases from 45 percent to more than 95 percent. The Buried Sand aquifer anion configuration shows a strong inverse relationship between bicarbonate and sulfate. With the exception of one sample, when the percentage of chloride increases above 10 percent, the percentage of bicarbonate is always greater than that of sulfate. With the small population of samples containing greater than 20 percent chloride, conclusions are tentative; however, it appears that percentages of chloride and bicarbonate are also inversely related, and without a corresponding increase in sulfate.

The Prairie du Chien-Jordan aquifer data, in contrast to the Buried Sand aquifer data, cluster very tightly in both the cation and anion diagrams, with few exceptions (Figure 4-3). Only one well had more than 10 percent sodium plus potassium. The cation data as a whole clustered around 60 percent calcium, 35 percent magnesium and 5 percent sodium plus potassium. The anions clustered between 85 to 95 percent bicarbonate, 0 to 3 percent chloride, and 2 to 12 percent sulfate. A few observations fell outside this range, but the majority of points stayed within the area mentioned. For example, station GWQ0102 has been sampled twice and both samples showed high nitrates and relatively high chlorides suggesting possible contamination from a septic tank, drainfield, or a small cattle feedlot in the vicinity of the well. This demonstrates the utility of the Piper diagram as it allows one to identify wells in a given aquifer which may be influenced by a source of contamination. The Prairie du Chien-Jordan aquifer is almost totally dominated by calcium-magnesium and carbonate-bicarbonate.

Figure 4-3: Prairie du Chien-Jordan Aquifer Piper Diagram



No other aquifer plotted exhibited such a tightly-clustered distribution in both the cations and anions. With 85 observations, the relationships displayed on the Piper diagram indicate a very consistent pattern and a strong reliability is associated with the aquifer's ionic characteristics.

Analysis of data from the Fraconia-Ironton-Galesville aquifer shows a small cluster of points in an area where calcium and magnesium have an almost equal share of the cations measured (Figure 4-4). The cation ratio for the centroid of this cluster is approximately at 53 percent calcium, 45 percent magnesium, and 2 percent sodium plus potassium. In addition to the above-mentioned cluster, there is a scatter of points toward an increasing component of sodium plus potassium. GWQ0290 is plotted only to show another beneficial use of the Piper diagram. After the data were plotted, the question arose as to why that particular site should be so dominated by sodium plus potassium while the other data were dominated by calcium and magnesium. Discussions with the well owner revealed that the samples from an outside faucet had run through a water softener prior to collection. The well owner was unaware that water in his outside faucet was being softened. Future samples will be collected ahead of the water softener and the past data will be deleted from any statistical or graphical analysis.

Space does not allow a complete discussion of aquifer-specific and parameter-specific ground water quality characterizations. Persons interested in more details regarding data interpretation are referred to Appendices A, B and C of the 1981 ambient program report. However, data from these appendices has been summarized for certain principal aquifers in Table 4-4. Interestingly, the St. Peter aquifer showed the greatest number of parameters having maximum mean values, with seven. The Buried Sand aquifer had six parameters with maximum means. Surprisingly, the Surficial Sand aquifer, nearest to the sources of most

Figure 4-4: Franconia-Ironton-Galesville Aquifer Piper Diagram

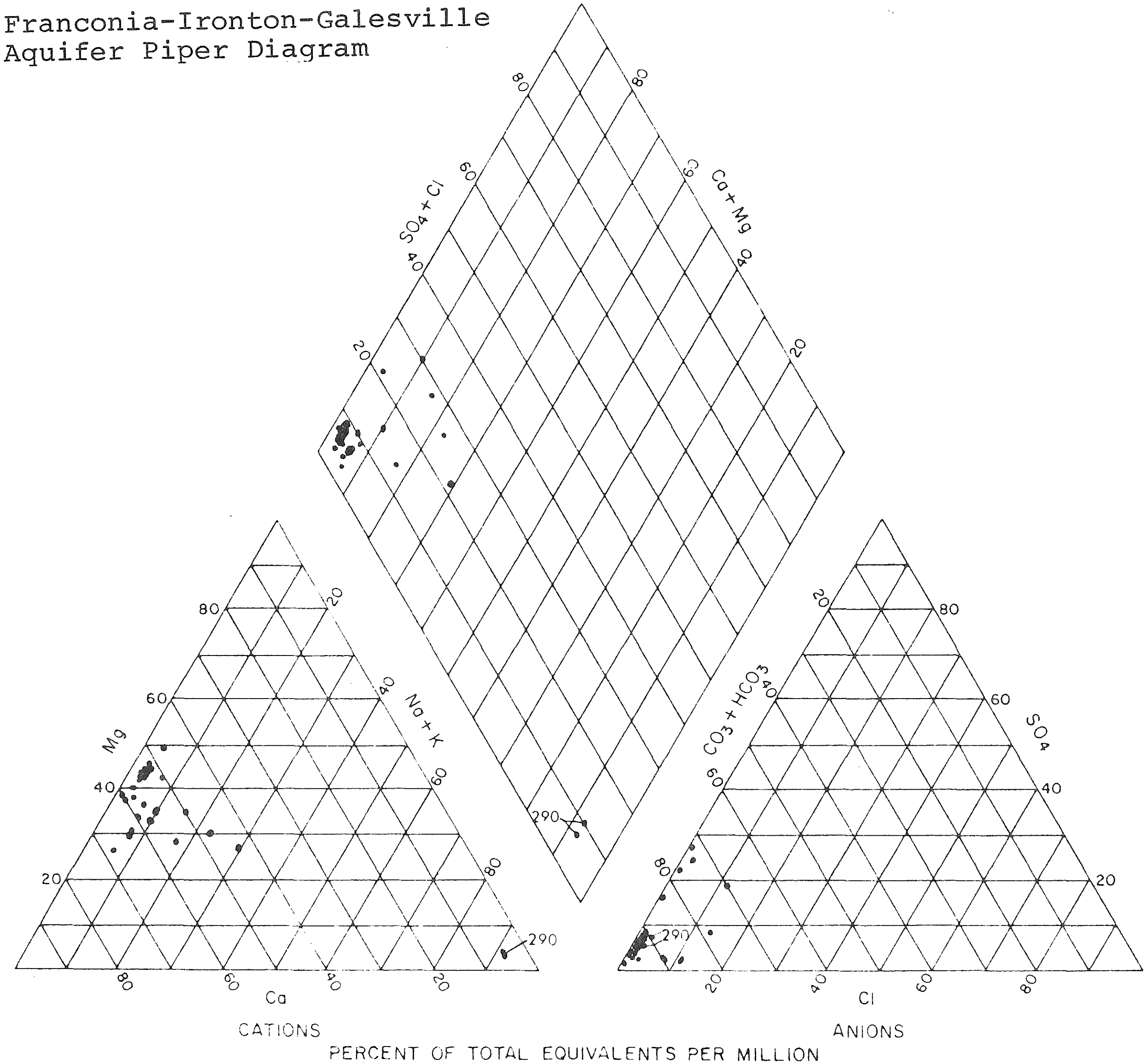


TABLE 4-4: MAXIMUM AND MINIMUM MEAN VALUES FOR SELECTED INORGANIC PARAMETERS FROM PRINCIPAL AQUIFERS IN MINNESOTA

Parameter	Surficial Sand (78)	Buried Sand (50)	Upper Carbonate (25)	St. Peter (9)	Prairie du Chien -Jordan (75)	Franconia-Ironton -Galesville (23)	Mt. Simon-Hinkley -Fond du Lac (33)
Temperature	-						+
Field Conductivity		+			-		
Field pH	-			+			
Field Alkalinity	-	+					
Nitrate	+			-			
TOC				+	-		-
Calcium		+				-	
Magnesium	-	+					
Sodium		+		-			
Potassium			-	+			+
Chloride						-	+
Sulfate		+			-		
Copper	+		-				
Iron				+	-		
Lead				+	-		
Manganese				+	-		
Nickel		-					+
Zinc				+			-

( ) = Number of Aquifer Samples; "+" = Maximum Mean Value; "-" = Minimum Mean Value contamination, showed four minimum means. As expected, however, the nitrate mean was highest in the Surficial Sand. The Prairie du Chien-Jordan aquifer, which underlies the St. Peter, had six minimum means. Four of these--iron, lead, manganese and TOC--showed maximum mean values in the overlying St. Peter. The trend of most parameter means was to decrease with depth, although temperature, pH, potassium and nickel reverse this trend. Mean temperature increased in every principal aquifer with depth.

Data Application

Currently, the ambient ground water quality monitoring program has the following number of well samples from major aquifers:

	Observations (n)
1. Glacial Outwash	
a. Surficial Sand	89
b. Buried Sand	62
2. Cretaceous	5
3. Upper Carbonate	12
4. St. Peter	11
5. Prairie du Chien-Jordan	97
6. Franconia-Ironton-Galesville	54
7. Mt. Simon-Hinckley-Fond du Lac	50
8. Sioux Quartzite	3
9. Biwabik Iron Formation	2
10. Precambrian Rocks, Undifferentiated	4
	389*

*The number of observations may exceed the number of wells per aquifer group because some wells have been sampled more than once. This list does not contain observations from 33 stations which are springs of unknown origin, multi-aquifer wells which will be deleted from the system, or wells of unknown origin because insufficient construction or geologic data are available at this time.

The ambient program will fill the existing gaps in major aquifer data during 1983. Wells finished in the St. Peter, Upper Carbonate, and Cretaceous aquifers will be the focus of the sixth sampling year in addition to repeat sampling of the wells established in 1978. In the interim, other sources of data are available. The U.S. Geological Survey (USGS) is in the final stages of publishing a series of documents which will address water quality criteria for major Minnesota aquifers. Sufficient inorganic data are available through the USGS and the ambient program to justify setting inorganic ambient levels for the St. Peter through the Mount Simon-Hinckley-Fond du Lac. Two other sources of data are the Minnesota Department of Health (MDH) and Department of Natural Resources (MDNR).

Enough data are available to justify consideration of developing either a ground water quality classification system or aquifer-specific water quality criteria. Statistical theory assumes that 30 or more independent samples are sufficient to represent a normal distribution. For example, the standard Chi-Square Distribution Table lists a population range from 1 to 30. The Students' t-Distribution and f-Distribution lists the population (n) from 1 to 30, then jumps to 40, 60, 120, and finally, infinity (Selby, 1971). The point in noting these tables and their corresponding "n" is that they graphically show the relatively insignificant reliability differences which exist between sample populations with 30 observations and a population of infinite size.

More observations always contribute to a stronger data base, but statistically, any number over 30 should provide a sufficient base upon which to reliably predict subsequent sample values. Increasing "n" (population size) decreases the probability of error at a geometrically decreasing rate. That is why the tables generally list the degrees of freedom for only 40, 60, 120 and infinity observations, after 30 observations have been achieved.

MPCA, through the legislative mandate contained in Minnesota Statutes, is directed "to make such classification of the waters of the state as it may deem advisable." [Classification of Water, Minnesota Statutes 115.03 (b); also see, Standards of Quality and Purity, Minnesota Statutes 115.42-115.44, Subdivision 1-4 (with minor revisions), and Minnesota Statutes 116.07, Subdivision 4.] Each of these citations provides the authority needed to establish ground water standards.

Minnesota Rules 6 MCAR §§ 4.8014, 4.8015 and 4.8022 provide for a level of ground water protection adequate to protect public health. Rules 6 MCAR §§ 4.8014 4.8015 specifically form classes of domestic consumption waters. Rule 6 MCAR § 4.8022, by definition, classes all underground waters as potable waters. It protects such waters by reference back to Rules 6 MCAR §§ 4.8014 and 4.8015 D.1.a.-d. or by either a non-degradation clause (c.) or a natural origin clause (d.8.).

Minnesota Rule 6 MCAR § 4.8022 has two provisions which could be used in lieu of the standards in Minnesota Rules 6 MCAR §§ 4.8014 and 4.8015 D.1.a.-d. to abate pollution. They are paragraphs C. (non-degradation), and D.8. (standards). The MPCA has had a non-degradation clause in its rules since 1967. That clause has not been applied in any compliance or enforcement action because MPCA has yet to develop an applied definition for non-degradation. That leaves paragraph D.8. which simply states that if the natural background can be shown to be higher than Minnesota Rules 6 MCAR § 4.8014 D.1.a.-d., then the background level becomes the standard. It should be noted that Minnesota Rules 6 MCAR § 4.8014 and 4.8015 A.7. are written with a clause which allows existing standards to be set aside if it can be shown that the natural background is "reasonably definable and normally higher than standards."

This is also the essence of Minnesota Rule 6 MCAR § 4.8022 D.8. However, Minnesota Rules 6 MCAR §§ 4.8014 and 4.8015 A.7. continue from a relaxing of the standards to also include a clause which allows stricter standards when it can be shown that the natural level is lower than the standards. Minnesota Rule 6 MCAR § 4.8022 contains its stricter standards clause in paragraph C. labelling it "non-degradation." Therefore, Minnesota has adopted as its ground water quality criteria, "the mandatory and recommended requirements of the Public Health Service Drinking Water Standards for 1962." With that in mind, a few examples of how actual ambient quality of Minnesota ground water relates to these standards are offered.

Zinc is an example of a parameter where the difference between the statewide ambient mean value and the ground water standard is large. The only realistically enforceable ground water standard the MPCA can now apply for zinc is 5 mg/l. Any other value would require extensive research and study at a given site to show the "natural" or "original" levels are either lower or higher than the 5 mg/l of zinc as specified in Minnesota Rule 6 MCAR § 4.8014 D.1.a. Establishing aquifer standards would eliminate the need for the MPCA to prove at every new site what the natural levels are before setting permit requirements or taking enforcement action. For example, the ambient monitoring program collected 26 samples in southeastern Minnesota from emerging springs and found a mean zinc value of 1.3 ug/l or 0.0013 mg/l. The drinking water standard in Minnesota Rules 6 MCAR §§ 4.8014 and 4.8015 is almost 4,000 times higher than the measured background in this example. The state average for zinc in ground water, independent of aquifer type, is 0.12 mg/l or over 40 times lower than the standard (Table 4-3). The St. Peter's average zinc value is three times higher than the next highest zinc value for an aquifer. The average zinc concentration for the St. Peter is less than one-tenth of the drinking water standard.

The only parameter in Minnesota Rule 6 MCAR § 4.8014 D.1. which is close to a statewide average under current conditions without treatment is total dissolved solids (TDS). The standard for TDS is 500 mg/l and the state's average is 404.75 mg/l. State-wide mean values for other parameters are between 3 and 1,000 times lower than the established standards, except for iron and manganese which regularly exceed the drinking water criteria for untreated waters. The standard for iron is 0.3 mg/l with an average for all Minnesota ground waters at 1.23 mg/l. The standard for manganese is 0.05 mg/l with a statewide ground water average at 0.15 mg/l. These parameters are the only exception to the rule that Minnesota's ambient ground water is far superior to the current drinking water standards. Table 4-3 shows the parameters for which the ambient program has data, the drinking water standard, the number of samples analyzed per parameter, and the statewide average (mean) for all sites independent of aquifer type.

The establishment of aquifer-specific quality criteria will define the current "ambient" or existing "natural" state of the ground water. With the passage of each year, man's activities have an influence on the quality of ground water. Changes in the physical composition of ground water are being recognized already in the upper aquifers. Most of those changes can be attributed to man's ignorance, neglect or intentional disregard for sound land use practices. Every day redefines a new "natural" status of our ground water. Without a clear definition of "natural" ground water conditions today or soon, the "natural" quality of ground water could continue to decline until only the domestic consumption numbers contained in Minnesota Rules 6 MCAR §§ 4.8014 and 4.8015 would be available to define acceptable ground water quality.

The ambient ground water quality monitoring program used in conjunction with other available data can adequately define aquifer-specific ground water quality criteria. More sampling is needed and the ambient program must eliminate a few poor wells and substitute good reliable sites in their place. The ambient ground water quality monitoring program has provided the MPCA with excellent data and provides a sound framework to continue this work.

Future Studies

In the future, analysis of data from Minnesota's ambient ground water quality monitoring program will include an examination of the spatial distribution of wells within the state and how this correlates with their ionic composition. As stations with more reliable well logs are located and sampled, the chemical quality will be examined to determine how depth affects ground water characteristics within each major aquifer group. Use of multivariate analyses is being investigated to allow MPCA to make better use of the well log and chemical quality information collected so far.

Expansion of the ambient program data base to include analyses for organic compounds began in 1981. Because of the expense associated with these analyses, the number of wells sampled for organic compounds has been limited. However, a grant from the Legislative Committee on Minnesota Resources (LCMR) may allow MPCA to expand this effort, beginning in July 1983.

Summary

The Minnesota ambient ground water quality sampling program being conducted by MPCA has completed its fifth year of sampling. Over 360 wells and springs from 68 of Minnesota's 87 counties and representing 12 principal aquifers have been sampled and analyzed for 38 physical, bacteriological and inorganic parameters. A limited number of organic analyses have also been done.

When statewide mean values are examined, quality of natural ground water in Minnesota is generally good, meeting water quality standards for drinking water by several orders of magnitude for certain parameters. However, statewide mean values for iron and manganese exceed drinking water standards.

As the number of samples per aquifer increases, the techniques and extent of data interpretation will also expand. Sufficient data now exist from certain principal aquifer groups to establish quality criteria for ground water for those aquifer groups. Despite the lack of large sample populations, several aquifers, most notably the Prairie du Chien-Jordan aquifer, have a high degree of predictability. For these aquifers, water quality criteria will have a high degree of reliability. Others, such as the Buried Sand aquifer, show a variation in water quality throughout the state. In these areas defining water quality criteria are still possible, but the degree of predictability will be diminished by the variation in each parameter.

The distinctions between aquifers are demonstrated by analyzing how each aquifer progresses from calcium-magnesium-bicarbonate dominance to various degrees of scatter toward the other major cations and anions investigated. Most aquifers are calcium-magnesium dominant in the cations and carbonate-bicarbonate dominant in the anions.

Recommendations

1) The establishment of aquifer-specific ground water criteria is an essential element in the MCPA's ability to protect the state's high quality ground water resource. The ambient monitoring program is providing staff with a body of highly reliable ground water data from throughout the state. Like the surface water monitoring program, statistically valid numbers on a variety of parameters

are available to apply to daily problem-solving tasks. The ambient data, with the support of USGS data, can define the principal characteristics of Minnesota's major aquifer groups.

2) The ambient ground water quality monitoring program should have a clearly stated goal or objective and adhere to that goal. For example, the initial goal was to sample all the wells recommended by USGS and collect almost all the water quality data suggested by USGS. An examination of the data and the recommended parameters indicated that certain parameters should be dropped and some sampling techniques modified for expediency and cost savings. Statistical analysis showed certain parameters were unnecessary in both the total and dissolved form. The total value reliably approximates the dissolved value for most ambient ground water situations.

The USGS designed the ambient ground water quality monitoring program so that it could fulfill one of four possible objectives: point sampling, point monitoring, site-specific monitoring, and regional monitoring (Hult, 1979). The ambient program has been used for all four objectives so far, but budget constraints may reduce the scope of the ongoing program. It is therefore necessary to closely evaluate which aspects of the program must be maintained.

The ambient program is being currently operated largely as a regional monitoring program. However, last year, a considerable amount of time was committed to a point monitoring study in Winona County. This shift in program objectives subverts the primary objective of the principal program and makes data analysis more difficult.

3) As MPCA begins collecting the second round of samples from the established monitoring wells, more time should be allocated to a well-by-well analysis to

eliminate wells without sufficient well construction and/or geologic information; to select, well by well, which water quality parameters could be eliminated without jeopardizing the intent of the program; to locate good candidate wells to replace wells without sufficient construction and/or geologic data; and finally, to select wells within areas and aquifers where insufficient data currently exist. This task alone could consume one man-year effort for the next 3-5 years. Voluminous well log files exist at USGS, MGS, MDH, and MDNR. All these agencies' files should be reviewed for the best possible wells.

4) Some time should be spent looking at other data sources for water quality information. Expanding the data base wherever possible would be extremely beneficial to justifying specific parameter standards applicable to statewide situations.

5) The process of developing a statewide ground water protection strategy is ongoing. Without an ambient ground water monitoring program in place and operational, it will be difficult to measure the success or failure of the strategy as it is implemented.

6) The argument has been made by some that standards are not necessary because each situation will be unique or at least different enough so that site specific investigations will determine background levels of parameters in the ground water. That statement implies that because a few sites may deviate from the norm, defining "real" ground water characteristics for the majority of situations is not possible or at least not realistic. Sites will vary, but the variability should be definable and a well-written regulation could address that variability.

One fundamental problem with the non-degradation clause in Minnesota Rule 6 MCAR § 4.8022 is that some situations do not lend themselves to a definition of natural background levels. Spills, massive industrial contamination sites, and large impoundments of mining waste tailings, for example, may make the establishment of natural conditions economically or temporarily impossible. These "real world" situations have already altered the ground water in various degrees. Any attempt at <u>post facto</u> ground water assessment often precludes the ability to determine natural background from man-induced change.

The fundamental question of how the MPCA defines the "natural quality" or "natural state" is at the root of maintaining an ambient ground water quality monitoring program. Unless the MPCA constantly monitors the state's ground waters, any attempt at defining the "natural" quality of our waters is impossible. And if the staff cannot reasonably define the "natural" quality of our ground waters, the only remaining alternative is to provide the citizens of Minnesota protection to drinking water standards only.

7) The surface waters of Minnesota have been monitored since 1955. That program was, and is, an essential part of the MPCA Water Quality Division's responsibility to protect and safeguard against pollution of the state's surface waters. It is questionable whether MPCA's ground water staff will be able to operate its on-going programs, assess ever-changing environmental conditions, and relate new proposals to actual ground water conditions without a viable ambient monitoring program. The ambient program is a major source of the ground water data available to the MPCA. The program is just beginning to develop meaningful analyses of the individual aquifer information, to digest the data and transform it into useful forms.

8) The program requires a seasonal technician to collect samples. This monitoring network collects almost as much data annually as the Water Quality Division's surface water monitoring program which is staffed by a half-time Senior Pollution Control Specialist, full time Pollution Control Specialist, and a seasonal Pollution Control Technician.

The ambient ground water quality monitoring program involves data collection, data storage and publication of an annual report. Unlike the surface water monitoring program, the ground water program involves data analysis. Currently, data analysis, publication of the annual report and developing program modifications are all expected to be accomplished in less than half a man-year. Many aspects of the original design are still being revised to meet changing directions and needs of the MCPA's ground water program. These responsibilities are full time tasks. For this very reason, a seasonal technician is needed to collect samples, store and retrieve data, and assist in the ambient program development effort now underway as a part of the ambient monitoring network assessment.

CHAPTER 4

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CHAPTER 5

ASSESSMENT OF GROUND WATER CONTAMINATION IN MINNESOTA

Introduction

The number of ground water contamination incidents nationwide that has come to light in recent years have heightened everyone's awareness of the effects of improper waste handling and disposal practices on human health and the environment.

Past efforts directed towards assessing the magnitude and extent of ground water contamination have largely been reactions to problems which had already resulted in contamination of drinking water supplies or surface waters. These efforts will likely continue for some time as we suffer the consequences of previous improper waste handling and disposal practices. However, much manpower and financial resources are now being directed toward improving disposal practices and seeking out contamination problems before they cause irreparable damage to the environment or threaten public health and safety.

Several significant pieces of federal legislation have been enacted in the last decade for the control of waste nationwide. These Acts required the U.S. Environmental Protection Agency (USEPA) to develop and administer programs related to wastes in general and hazardous waste in particular, and in many cases to aid the individual states in developing their own programs. Several of the environmental programs currently being developed or administered in Minnesota are the results of those Acts which include the following:

- Clean Air Act as Amended, August 1977, PL 95-095. Sets standards for hazardous air pollutants;

- Federal Water Pollution Control Act Amendments of 1972, PL 92-500. Also known as the Clean Water Act. Prohibits the discharge of pollutants in significant amounts into navigable waters of the United States;
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), PL 96-510. Commonly referred to as "Superfund," this Act addresses problems due to past uncontrolled disposal of hazardous waste and established procedures for future control of hazardous waste. Provides limited funding for cleanup of hazardous waste facilities;
- Safe Drinking Water Act of 1974, PL 93-523. Authorizes the USEPA to set maximum contaminant levels for public drinking water supplies;
- Resource Conservation and Recovery Act of 1976 (RCRA), PL 94-580. Requires the USEPA to institute a national program to control hazardous waste;
- Federal Insecticide, Fungicide, and Rodenticide Act as Amended, 1972 (FIFRA), PL 92-516. Authorizes the USEPA to regulate registration, treatment, disposal and storage of all pesticides, including labeling requirements.

In order to efficiently seek out and investigate those problems which are likely to be of greatest concern, it is first necessary to have an understanding of the types of facilities which are likely to cause contamination problems. Second, it is necessary to identify those specific facilities where ground water contamination is known or suspected to have occurred.

The sources of ground water contamination inventoried or discussed in this chapter are those which contain constituents known to have caused contamination in the past, either in Minnesota or elsewhere. This does not imply that a certain source will cause contamination or even that the possibility is likely, only that given the right (or perhaps more correctly, wrong) combination of circumstances, ground water contamination could occur.

Several sources discussed, such as individual septic systems, are impossible to inventory because of the extremely large number of sites. There are also categories in which there ought to be a more complete inventory, but because there are no regulatory programs or the programs are not a very high priority, the number of sites can only be estimated.

This chapter has been condensed, in part, from a comprehensive report assessing ground water contamination in Minnesota (MPCA, 1983). That report contains detailed appendices listing sources of known or suspected ground water contamination. The reader desiring more site-specific information is referred to this report.

Areas Vulnerable to Contamination

The potential for contaminating the ground water is dependent upon many factors, one of which is the geology of the area in which a potential site is located. As discussed in Chapter 2, there are several areas in the state where the geology is such that the ground water is particularly vulnerable to contamination. These are shown in Figure 5-1 and are discussed in more detail below.

Twelve to 14 specific aquifer groups are generally defined in Minnesota (see Chapters 2 and 4). They can be grouped into four broad categories.

- Precambrian igneous and metamorphic rocks;
- Cretaceous sandstones and shales;
- Paleozoic sandstones, limestones and dolomites;
- Glacial drift.

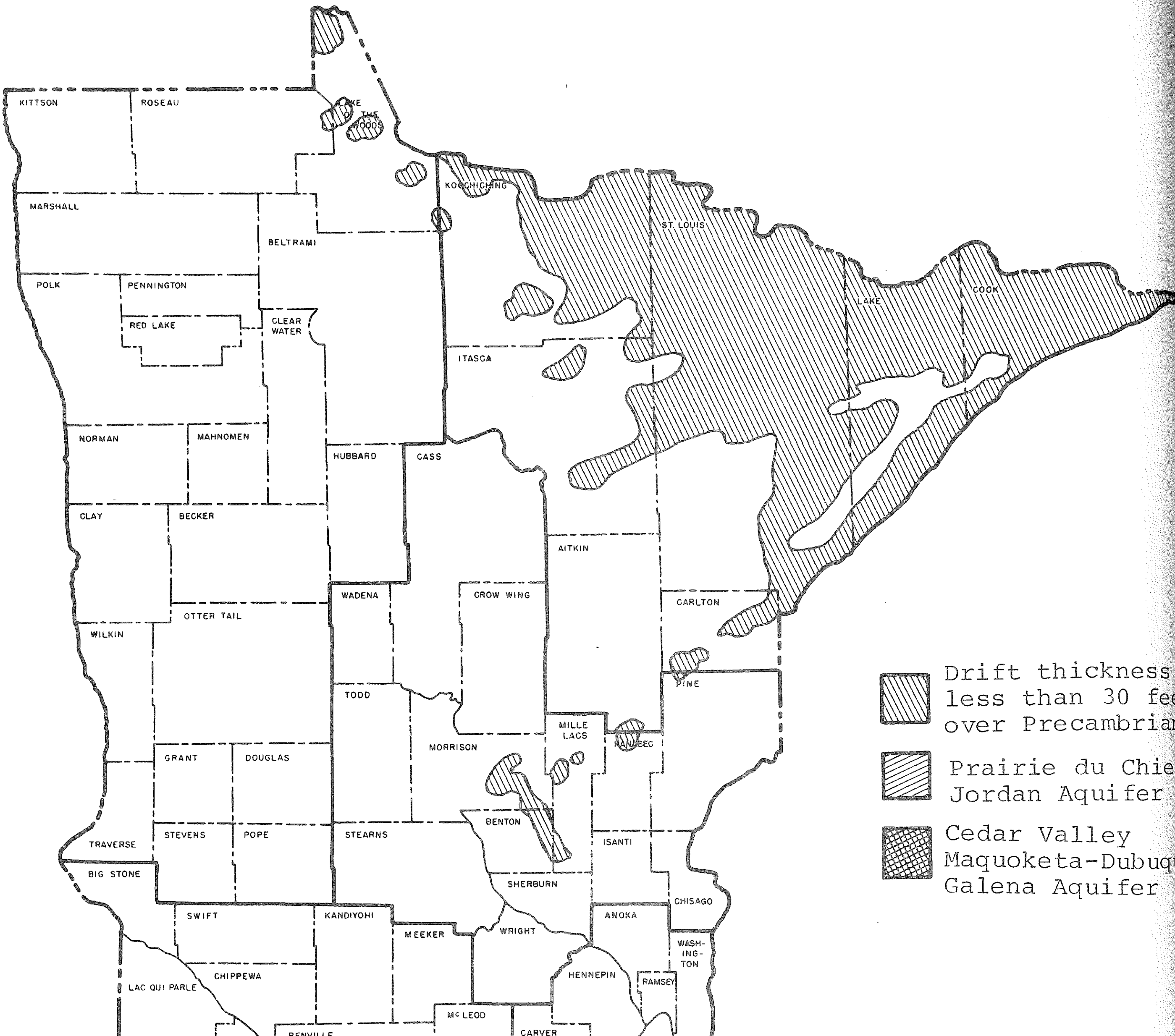


Figure 5-1: Areas Particularly Vulnerable to Ground Water Contamination

Ground water occurs in the pore spaces between the sand, silt, and clay particles in the glacial drift and in the Paleozoic and Cretaceous sandstones. This allows for some attenuation of contaminants in water moving down through the soils or in the aquifers. In the Precambrian igneous and metamorphic rocks and the Paleozoic limestones and dolomites, the ground water occurs in cracks and fissures in the rocks. In the igneous and metamorphic rocks only very small quantities of water are usually present, but they are often the only source available. Larger supplies are generally available from the limestones and dolomites, partly because the rock is more soluble and therefore the cracks and fissures are enlarged by water flowing through them, and partly because they are often highly fractured. In both cases, however, there is little or no attenuation of contaminants in the water as it flows through the cracks and fissures down to the water table or within the aquifer. Therefore the ground water can be easily contaminated, especially where there is little or no glacial drift over the fractured rocks to provide protection. In addition, contaminants in fractured bedrock aquifers can also migrate farther.

There is generally less than 30 feet of drift over the Precambrian rocks in the Arrowhead region of northeast Minnesota. In the southeast part of the state the drift is often very thin or entirely absent, with only a thin layer of wind blown silt over the limestone and dolomite bedrock. The latter area is referred to as a karst area. It is characterized by disappearing or losing streams, blind valleys, sinkholes, caves and springs. Although these features are most strongly developed in Fillmore and Olmsted counties, limestone and dolomite form the upper bedrock surface in much of southeastern Minnesota and these features may develop where the drift is thin.

Figure 5-1 outlines the area in the Arrowhead region which generally has only a thin layer of drift over the igneous and metamorphic bedrock and the karst area in southeast Minnesota. In general the eastern and northern parts of the karst area are the more vulnerable to contamination. The reader should keep these two areas in mind when considering the distribution of sources of contamination in the state and the potential consequences of contaminant migration in these areas.

As discussed in Chapter 4, an ambient ground water quality monitoring network consisting of 360 wells and springs has been established by MPCA in order to describe the general quality of the ground water in the state's principal aquifers and to build a data base to examine long range trends in ground water quality. The data from this network have been valuable in investigating known and suspected sources of ground water contamination in Minnesota. Expansion of the system and future sampling include programs designed to examine long term changes in water quality in industrialized areas and in areas where agricultural activity and the use of agricultural chemicals is particularly intensive.

Introduction of Contaminants to the Ground Water

Contaminants can enter the ground water in several ways, either by infiltrating through the soils from the surface or near surface, by direct injection into the ground water from the surface, or by a combination of the two.

Infiltration of Contaminants: When discussing sources of ground water contamination, there are several recurring factors which determine the magnitude of the potential for contamination and the consequences of this process. These are:

- Volume and type of contaminant;
- Texture and composition of the soils and bedrock;
- Depth and rate of movement to the water table;
- Hydrologic regime.

All of these factors are interdependent to a certain degree and, in general, the worst incidents of ground water contamination occur when all of the factors are less than ideal.

Fine grained materials such as silt and clay and even fine sand can filter bacteria from water passing through them. In addition, clay can remove contaminants by ion exchange and adsorption. Chemical complexing and precipitation may also remove some contaminants. The greater the clay content of a soil, the greater its capacity to exchange ions and adsorb contaminants, thus reducing the potential for contaminants to reach ground water. Clays are not the only soil component responsible for ion exchnge and adsorption, however. Organic matter, soil minerals, oxides and hydrous oxides can all act to remove contaminants.

As the grain size of a soil becomes larger and the clay content decreases, the capacity of a soil to remove contaminants is reduced. Therefore, sand and gravel have very little attenuation capacity and afford little or no protection to the ground water.

The amount and nature of the contaminant itself is also very important. Many materials, particularly some heavy metals, are adsorbed onto clay particles and undergo ion exchange. However if a large concentration of contaminants is present, they may exceed the attenuation capacity of the soils. Landspreading of sludges and contaminated soils from spills or other activities takes advantage of the attenuation capabilities of a soil by spreading out the contaminated material at rates which do not exceed the capacity of the soil to absorb the contaminants. Once attenuated, many organic materials then undergo further chemical and biological degradation, thereby renewing the soil's capacity to attenuate contaminants.

The thickness of the soil and the rate of movement of contaminants to the water table are other important factors. The smaller the attenuation capability of a soil, the greater the thickness needed to remove the contaminants prior to their entering the ground water. A fine grained soil with a higher clay content will remove more contaminants than a sandier soil of the same thickness. This process can also be extended to lateral movement of contaminants in the ground water. Contaminants in coarser soil will be transported farther from a source.

The ability of soils to attenuate organic contaminants and the effects of chemicals on the soils is not well understood. There is growing evidence that some chemicals may have an adverse effect on certain soils, causing them either to lose some of their attenuation capability or to break down structurally. For this reason, the notion that the presence of clay liners or natural clay bodies will effectively deter all contaminant transport should be tempered with caution.

A high rate of infiltration through a waste and surrounding soil may cause a ground water mound to build up beneath a site. This can have several consequences. The mound could grow so high as to be in contact with the waste and cause increased leaching of contaminants. It could also alter the ground water flow pattern in the area. This is particularly true with leaking surface impoundments which have a continuous supply of water or other liquid and a high hydraulic head, which increases the amount of seepage and the rate of infiltration. Mounding may also occur beneath landfills and dumps, large drainfields, and rapid infiltration and seepage basins.

The hydrologic regime is very important in considering the potential consequences of contamination. If the site is located in a recharge area, the potential for the spread of contamination in the ground water is greater than if it is in a discharge area. If the ground water discharges to surface water, the turbulent action of the surface water and the high flow rates will often dilute the contaminants to harmless levels. This is not intended to condone this practice, but rather to suggest it as a consideration in evaluating sites.

Direct Injection of Contaminants:

Contamination can be introduced into an aquifer in more direct ways than infiltration through the soils to the water table. These include:

- Improperly constructed, maintained and abandoned water wells, monitoring wells, and soil borings;
- Underground injection wells;
- Dry wells.

Water Wells: Improperly constructed or maintained wells can serve as conduits for contamination to reach an aquifer that otherwise would not be impacted. This can be a significant problem for wells in areas subject to flooding or located near sources of contamination. If the well casing is damaged or does not extend enough above the surrounding land surface, it could allow flood waters or contaminants to flow down inside the casing. If an open annular space is present or if the material used to backfill around the casing is very permeable the contaminant could flow down around the outside of the casing. Minnesota Rule 7 MCAR § 1.220 contains standards for water well construction in the state.

Regulations for proper well locations including those in floodplains and near sources of contamination are contained in 7 MCAR § 1.217. Wells installed for the purpose of monitoring contamination are exempt from the separation requirements, however, extra caution must be exercised in construction to ensure that they do not become pathways for contamination to reach the water table.

Abandoned wells can also become a pathway for contamination to reach ground water. Over a period of years, abandoned well casings may corrode or become damaged. They may also be used for the unauthorized disposal of wastes. Rules pertaining to the proper maintenance, repair, and abandonment of wells are contained in 7 MCAR § 1.218.

Underground Injection Wells: Underground injection is the direct injection of a liquid into the subsurface through a well. The USEPA Underground Water Source Protection Program also known as the Underground Injection Control (UIC) program designates five classes of injection wells.

Class	Use
I.	Wells used by generators of hazardous waste or owners and operators of hazardous waste management facilities and other industrial and municipal disposal wells which inject beneath the lowermost formation containing, within one-fourth mile of the well, an underground drinking water source.
II.	Wells associated with oil and gas production and hydrocarbon storage where the hydrocarbons are liquid at standard temperature and pressure.
III.	Wells used in the extraction of minerals including mining of sulfur, solution mining of salt or potash, and insitu production of uranium or other metals.

Class	Use
IV.	Wells used by generators of hazardous waste or of radioactive waste, or by owners or operators of hazardous waste management or radioactive disposal sites that inject hazardous and radioactive wastes into or above a formation used as a drinking water source, within one-fourth mile of the well; wells used by generators of hazardous waste or owners or operators of hazardous waste management facilities to inject in an area not specifically classified.
V.	Wells not included in Class I, II, III, or IV. Wells in this classification applicable to Minnesota include return wells used in conjunction with ground water heat pumps, return wells used to inject water previously used for cooling, drainage wells used to drain surface fluid, cesspools with open bottoms or perforated sides, or septic system wells used to inject wastes from business establishments or community systems (except for those that have solely sanitary wastes and serve less than 20 people per day), dry wells used to inject wastes, and radioactive waste disposal wells other than Class V.

No Class I, III, or IV wells are known to exist in Minnesota. Injection of any substance below the water table is prohibited by Minnesota Rule 6 MCAR § 4.8022, although a variance may be obtained. Several Class II wells are being used or planned to inject natural gas for storage purposes. This program is regulated by the Minnesota Department of Natural Resources (MDNR). Nine Class V injection wells are known to exist in the state. A description of these locations is contained in the contaminated site report (MPCA, 1983). A discussion of the regulatory basis for the UIC program in Minnesota is contained in Chapter 8.

Dry Wells: Dry wells are also referred to as leaching pits or seepage pits. They are not, as the name might suggest, water wells which have gone dry. They are used for disposal of septic tank effluent when standard systems are not feasible. Dry wells are regulated by Minnesota Rule 6 MCAR § 4.8040. Another structure also referred to as a dry well or sump is sometimes used to drain perched water from an area for dewatering or to relieve moisture problems. A large diameter hole is drilled or dug through the low permeability confining layer and backfilled with a more permeable material such as sand. Perched water can then drain into the lower unsaturated zone. This may also allow contamination in the perched layer to travel to the lower aquifer as discussed below.

Interaquifer Contamination: When an aquifer becomes contaminated, there is the danger that the contaminants may spread to other aquifers. This can occur by several of the means described previously, such as improperly constructed, maintained, or abandoned wells or the use of dry wells or sumps for drainage. Wells which are open to more than one aquifer do exist, although prohibited by Minnesota Rule 7 MCAR § 1.220 H.4. These multi-aquifer wells are a potential means of interaquifer contamination. For example, multi-aquifer wells were partly responsible for spreading contamination to underlying aquifers at the Reilly Tar and Chemical Facility in St. Louis Park, which has been designated by the MPCA as Minnesota's highest priority hazardous waste facility for cleanup.

High capacity wells such as municipal and industrial supply wells and agricultural irrigation wells can cause changes in hydraulic head allowing contaminants to move from one aquifer to another or in a direction they would not move under natural conditions. If there is connection between two or more aquifers, withdrawal of large amounts of water from an uncontaminated aquifer could induce recharge from a polluted aquifer. Caution should be exercised in locating wells near potential sources of pollution or in locating wells in clean aquifers below aquifers known to be contaminated.

Many high capacity wells are located in high yielding alluvial aquifers adjacent to rivers and large streams. Although ground water flow is generally toward these surface waters, withdrawl of large quantities of water can induce recharge of the alluvial aquifer from the surface water body. If the quality of surface water is poor, the quality of the ground water in the vicinity of the high capacity well may be degraded. Figure 5-2 illustrates several of the previously described routes of contaminant movement.

Potential Sources of Contamination

Waste Disposal Activities:

Landfills: Landfillng is one of the most common methods of waste disposal. It is also one of the most significant sources of ground water contamination. Old landfills and dumps were generally located in those areas for which there was no competitive land use. This "out of site--out of mind" attitude frequently led to waste disposal in abandoned sand and gravel pits and wetlands, both of which are numerous in Minnesota. It has only been in the past few years that the danger of these disposal practices has become widely apparent.

Landfills or dumps are often classified by the type of waste received as either industrial, demolition debris, or mixed municipal refuse (sanitary) landfills. There is no clear distinction between a dump and a landfill although the term landfill has come to imply that some measure of site selection, design, and operational control has been implemented at the site. While it may be true for more recently developed sites, the idea that many of the old sanitary landfills do not pose any environmental problems, particularly as they relate to ground water, is one which should be entertained with a great deal of caution.

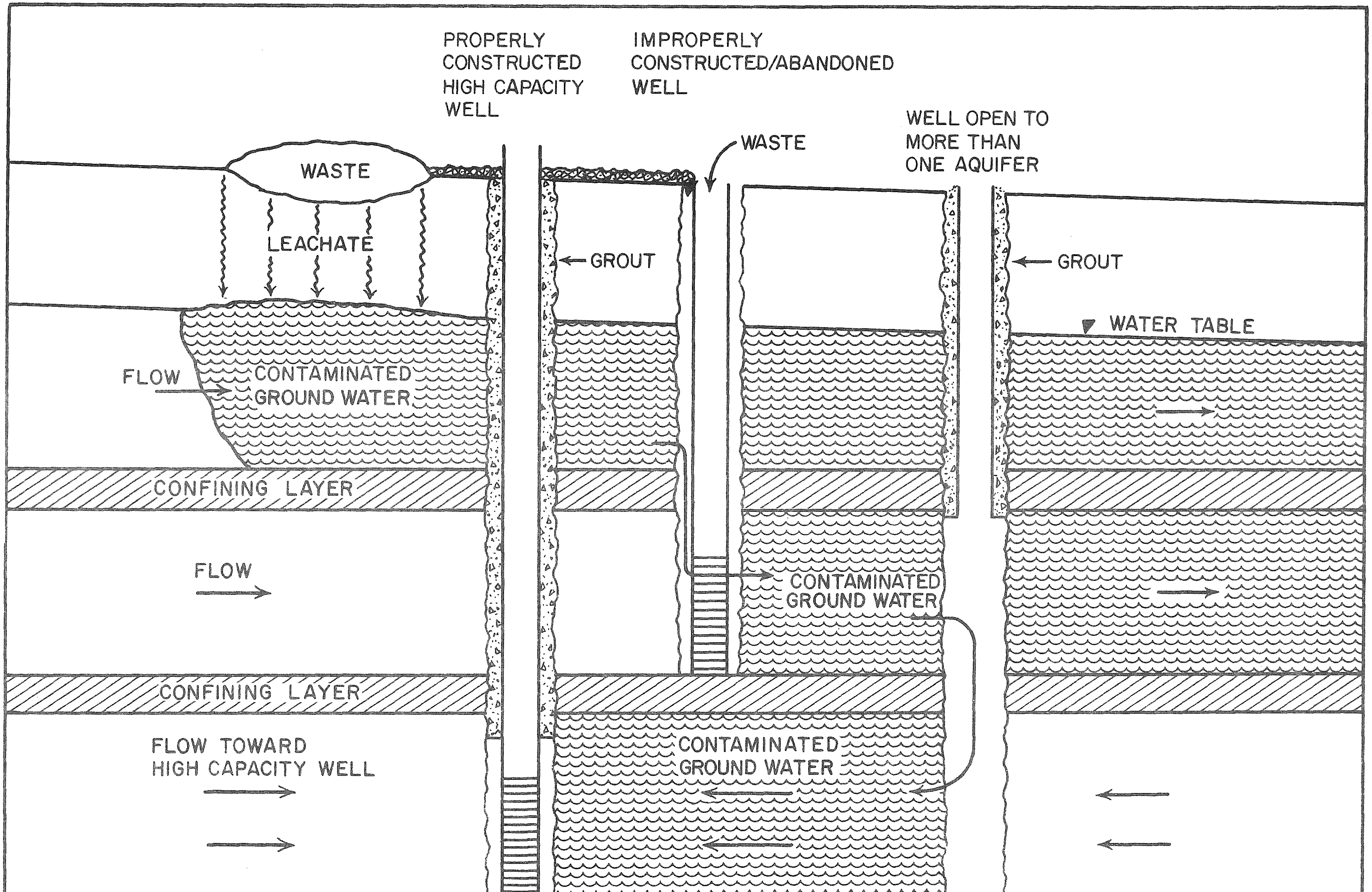


Figure 5-2: Possible Routes of Contaminant Movement

The potential for landfills and dumps to contaminate the ground water is dependent upon a complex relationship among several factors. These include:

- Type and volume of materials in the landfill;
- Physical and chemical properties of the host soils;
- Hydrology of the site;
- Design and operational history of the landfill.

The type and volume of materials deposited in sanitary landfills and dumps are extremely variable. Consequently the type and concentration of contaminants leached from the waste are also highly variable. Analysis of leachate from sanitary landfills in Illinois gives an indication of the types and variability of concentrations of contaminants in the leachate (Cartwright, Griffin and Gilkeson, 1977 and Clark, 1975). Tables 5-1a and 5-1b show the results of these analyses.

Ground water contamination from demolition debris landfills is generally believed to be relatively insignificant, however there is a danger that material other than the normally expected concrete, steel, wood and plaster may also be included in the waste. For instance, if an old industrial or commercial site is being demolished, the effort may not be made to exclude any residual waste or contaminated debris from the landfill.

Ground water contamination from industrial landfills can be a very significant problem. The type of contaminants present depends on the type of industrial activity and is therefore highly variable. However industrial landfills frequently contain many organic compounds as well as toxic metals and other inorganic contaminants.

Leachate is generated by the percolation of water through the waste, either from

TABLE 5-1a

CHEMICAL ANALYSIS OF LANDFILL LEACHATE AT DUPAGE, ILLINOIS

Na	748.	mg/l
K	501.	mg/l
Ca	46.8	mg/l
Mg	233.	mg/l
Cu	<0.1	mg/l
Zn	18.8	mg/l
Pb	4.46	mg/l
Cd	1.95	mg/l
Ni	0.3	mg/l
Hg	0.0008	mg/l
Cr	<0.10	mg/l
Fe	4.2	mg/l
Mn	<0.1	mg/l
Al	<0.1	mg/l
NH_4	862.	mg/l
As	0.11	mg/l
B	29.9	mg/l
Si	14.9	mg/l
Cl	3484.	mg/l
SO_4	<0.01	mg/l
PO_4	<0.1	mg/l
COD	1340.	mg/l
Organic acids	333.	mg/l
Carbonyls as acetophenone	57.6	mg/l
Carbohydrates as dextrose	12.	mg/l
pH	6.9	
Eh	+7 mv	
Conductivity	10.20	umhos/cm

Source: K. Cartwright, R.A. Griffin, and R. H. Gilkeson, Ground Water, 15 (1977):294-305.

TABLE 5-1b

MEAN AND RANGE OF VALUES OF CHEMICAL CONSTITUENTS OF 45 LANDFILL LEACHATES FROM ILLINOIS

Parameters	Observed Range (mg/l)			Observed Extremes (mg/l)	
	N	$\overline{Y}$	S	High	Low
Calcium (Ca)	32	686	553	2300	100
Magnesium (Mg)	32	284	258	1102	68
Sodium (Na)	31	380	259	1100	25
Potassium (K)	31	204	172	740	2.4
Ammonia (NH_3-N)	42	167	172	670	1.23
Iron (Fe)	44	402	473	1920	13.5
Chloride (Cl)	45	616	382	1820	75
Sulfate (SO_4)	36	379	458	2000	0
Hardness	39	2093	1794	6500	420
COD	44	7171	6792	26000	28

N = number of samples $\overline{Y}$ = mean of samples S = standard deviation of samples

Source: T. P. Clark, Ground Water, 13 (1975):321-31.

outside the landfill or from liquid or semi-liquid waste deposited in the landfill. External sources of moisture include direct precipitation on the landfill, surface run-on which enters the landfill, or ground water flow through the waste. All of these external sources are functions of the local hydrology, which in humid regions is almost always conducive to leachate production. The effects of the host soils in protecting the ground water from the leachate produced was previously discussed.

The design and operation of a site can impact the potential for ground water contamination in that each controls, to a certain extent, the amount of water which enters the landfill, the amount of leachate which leaves the site and the types of waste accepted. Proper sloping of landfill surfaces and diversion of surface flows can minimize infiltration, as can the proper compaction and covering of the wastes with low permeability materials. Because it is practically impossible to totally eliminate infiltration and leachate production in humid areas, engineering solutions to preventing leachate from reaching the ground water by use of liners and leachate collection systems and other methods are being attempted. These designs are relatively new, however, and long term effectiveness of the different designs, types of liners and operating conditions is largely unknown.

Approximately 1,421 landfills and dumps are known to exist in Minnesota. These sites were inventoried by MPCA in 1980 as a part of the Open Dump Inventory for the USEPA. These sites are listed in the Contaminated Site Report (MPCA, 1983). They included all known sites, whether open and operating or closed. Figure 5-3 shows the distribution of these landfills and dumps within the state. Their distribution is somewhat even with two obvious exceptions, Itasca and St. Louis

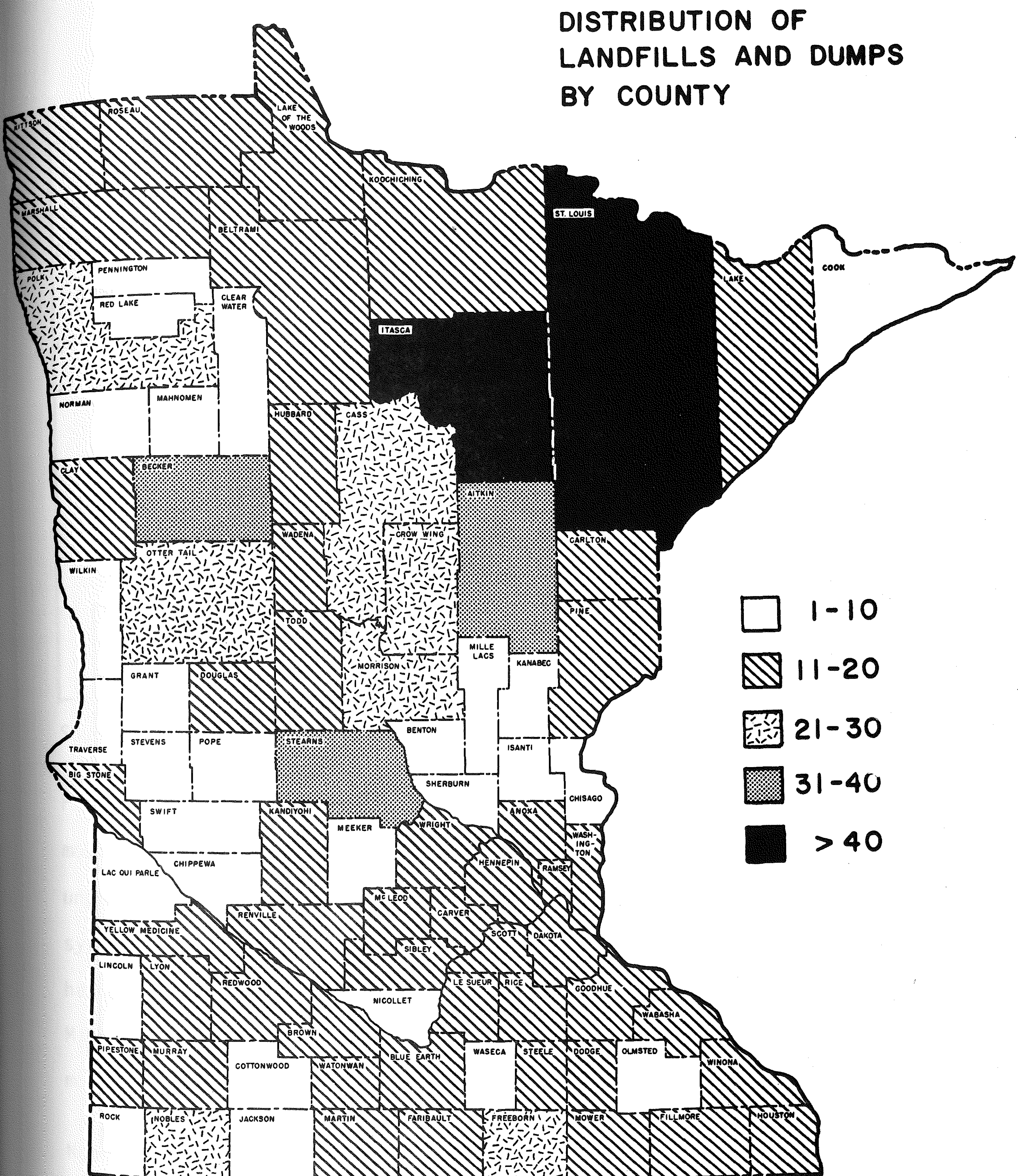

DISTRIBUTION OF
LANDFILLS AND DUMPS
BY COUNTY
1-10
11-20
21-30
31-40
>40
KITTSON
ROSEAU
LAKE OF THE WOODS
KOOCHICHING
MARSHALL
BELTRAMI
ST. LOUIS
LAKE
COOK
POLK
PENNINGTON
RED LAKE
CLEAR WATER
ITASCA
NORMAN
MAHNOMEN
HUBBARD
CASS
CLAY
BECKER
AITKIN
WADENA
CROW WING
CARLTON
WILKIN
OTTER TAIL
TODD
PINE
MILLE LACS
KANABEC
MORRISON
GRANT
DOUGLAS
BENTON
TRAVERSE
STEVENS
POPE
STEARNS
ISANTI
BIG STONE
SHERBURN
CHISAGO
SWIFT
KANDIYOHI
ANOKA
MEEKER
WRIGHT
WASH-ING-TON
CHIPPEWA
HENNEPIN
RAMSEY
LAC QUI PARLE
McLEOD
CARVER
RENVILLE
YELLOW MEDICINE
SCOTT
DAKOTA
SIBLEY
LINCOLN
LYON
REDWOOD
LE SUEUR
RICE
GOODHUE
NICOLLET
WABASHA
BROWN
PIPESTONE
MURRAY
COTTONWOOD
WATONWAN
BLUE EARTH
WASECA
STEELE
DODGE
OLMSTED
WINONA
ROCK
NOBLES
JACKSON
MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
HOUSTON

Figure 5-3

counties, with 64 and 180 sites respectively. Both of these counties are quite large and have many small scattered communities as well as a large seasonal fluctuation in population due to their many lakes and resorts. This makes centralized refuse collection difficult and, as a result, the sites of many operating dumps are scattered throughout the two counties. A total of 127 solid waste disposal permits have been issued by the MPCA for sanitary landfills in accordance with Minnesota Rules 6 MCAR §§ 4.600-4.6012. By contrast, there are at least 1,274 dumps in the state which have operated or are still operating without Solid Waste Permits. The type and status of the permitted facilities is given in Table 5-2. Status of unpermitted dumps is given in Table 5-3.

TABLE 5-2

PERMITTED SOLID WASTE MANAGEMENT FACILITIES

Type of Facility	Status[1]	
	Operational	Closed
Sanitary landfill	103	16
Modified sanitary landfill	8	0
Demolition debris landfill	26	8
Transfer station	17	4
Industrial disposal/management sites	25	4
Wood/leaf recycling site	6	2

[1] Seventeen permits were issued but the sites have never been used. Two permit numbers have been retired and are incorporated under a third number.

TABLE 5-3

STATUS OF UNPERMITTED DUMPS

Number of Dumps	Status
169	Either operating without a permit or not operating but no steps have been taken to properly close the facility. Contamination potential estimated to range from medium to high.
155	Facilities identified as having a medium to high contamination potential which have recently been closed or are on compliance schedules to upgrade or close.
247	No longer in use but not closed in complete accordance with solid waste rules. Contamination potential unknown.
444	Closed in complete accordance with solid waste rules. Contamination potential unknown.
259	Status unknown--either too remote or too small to locate. Contamination potential unknown.

Source: MPCA, Minnesota Open Dump Inventory, April, 1981 Update

Fifty-one of the permitted landfills are operating with inadequate ground water monitoring systems or without systems altogether. Nearly all of the 1,274 unpermitted sites either operated or are still operating without monitoring systems. As a result, MPCA has virtually no idea what impact these sites have had on the ground water. However, a grant from the Legislative Commission on Minnesota Resources (LCMR) will allow MPCA to instrument 15 dump sites with monitoring devices to assess the impacts they may be having on ground water.

Nearly one-fourth of the permitted sanitary landfills, those sites which might be presumed to be more environmentally sound, have demonstrated ground water contamination problems, either from inorganic or organic contaminants. There may be more, but due to the absence or inadequacy of the monitoring systems at nearly half the locations, contamination, if it exists, goes undetected. Given these problems with the permitted sites, it is likely that many unpermitted, unmonitored sites are also contaminating ground water. The Oakdale Hazardous Waste Dump is a good example of an unpermitted dump which has caused serious ground water contamination.

Ground water sampling and analysis at the sanitary landfills has generally focused on inorganic contaminants. More recent programs have included analysis for organic compounds, and they are being found in ground water at many landfills. During the summer of 1982, ground water samples were collected by the MPCA and analyzed for organic contaminants at 18 permitted sanitary landfills, three of which were closed. Leachate samples were collected at five additional sites and given the same analysis. Ground water at 13 of the 18 sites contained organic contaminants. At 9 of those 13 sites the ground water was known to have been contaminated by inorganic constituents, but at the remaining four sites contamination had not been previously detected. Ground water at 5 of the 18 sites showed neither organic nor inorganic contamination. Leachate at all five sites where it was collected contained organic contaminants. A more detailed discussion of organic compounds in landfill leachate is contained in Chapter 7.

Many of the above sites were specifically targeted for organic analysis based on known inorganic contamination and/or operational, siting and other problems. Therefore, extrapolation of the percentage of sites that might be contaminated by organics on a statewide basis appears unjustified. However it does appear that ground water contamination by organic compounds is not an isolated phenomenon and deserves greater attention.

The origin of the organics in the landfills may be from one or more of the following sources:

- Disposal of large quantities of hazardous wastes by individual hazardous waste generators:
- Disposal of smaller quantities by many of the smaller hazardous waste generators;
- Disposal of household quantities of hazardous wastes in municipal refuse and decomposition of materials containing hazardous substances.

The latter source is difficult or impossible to control or eliminate. Control of the first two sources is one of the goals of programs being developed under RCRA and state hazardous waste programs. Although the problem of organic compounds in landfills and dumps is certainly a statewide problem, the distribution of manufacturers and hazardous waste generators (Figures 5-7 and 5-8) suggests that the landfills and dumps in the metropolitan area and southeast Minnesota may have received more significant amounts of hazardous waste than other areas of the state and, considering the vulnerability of the ground water in some areas of this region, may deserve special attention.

Based on the above discussion, following are specific recommendations for future action regarding waste disposal facilities.

1. The adequacy of the ground water monitoring systems at all the permitted solid waste disposal facilities should be determined and systems should be installed or upgraded where necessary.
2. Because of the extremely large number of unpermitted dump sites and the

expense of monitoring system installation and sample analyses, a systematic review and prioritization of all known dump sites in the state based on the previously discussed factors relating to ground water contamination should be undertaken.

3. A ground water sampling program for organic contaminants should be developed and implemented at those dumps and landfills which have the greatest potential for contaminating drinking water supplies.
4. A ground water study should be conducted on several selected demolition debris landfills to document their perceived non-problem status.

Surface Impoundments: Surface waste impoundments are natural depressions, artificial excavations, or diked areas which are used to store, process or dispose of a waste material in a liquid or semi-liquid state. Ground water contamination from surface impoundments depends on the volume and type of waste, the permeability of the lining (if any) and the underlying soils, the adsorption and ion exchange capacity of the soils, depth to the water table and the degree of treatment the waste receives prior to discharge to the impoundment. Serious ground water contamination problems exist in Minnesota where untreated hazardous wastes were discharged to unlined impoundments located on porous soils.

Under a grant from the USEPA, MPCA conducted the Surface Impoundment Assessment (SIA) in 1979. The impoundments inventoried were in one of four categories: industrial, municipal, agricultural, and mining. The inventory included any operating or abandoned impoundment that had a diameter greater than its depth. It did not include those lined with concrete, asphalt or steel. A total of 2,733 impoundments was inventoried in the four categories. All of the municipal sites were assessed on their ground water contamination potential. Seventy percent of the industrial sites, 50 percent of the agricultural impoundments and

10 percent of the mining impoundments were also assessed.

The SIA scoring system rated the depth to ground water, transmissivity of the aquifer, water quality and waste type. Because the water quality of the state is generally very good, the scores for water quality are nearly all exactly the same. In addition, the scores for waste type for municipal impoundments and agricultural impoundments is also identical in nearly all cases. Therefore the relative rankings for each type of site are good indicators of the geologic characteristics of the sites. The higher the scores for the sites (maximum 29) the poorer the geologic conditions. Because the waste characteristics for industrial impoundments vary considerably, this generalization cannot be extrapolated to include that category.

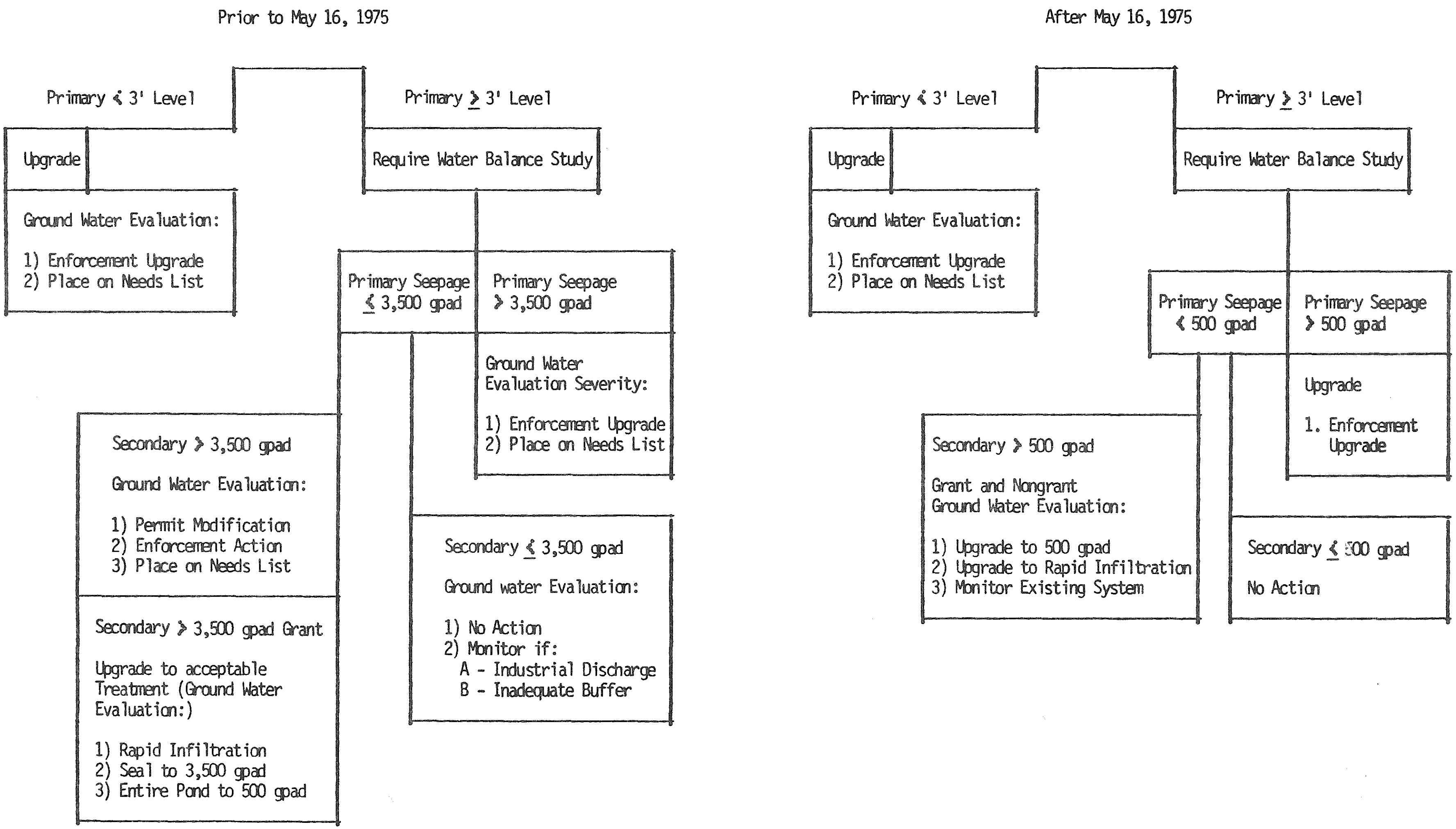
The cause of ground water contamination from impoundments is excessive seepage. The degree of contamination depends on the previously referenced factors. The Water Quality Division of the MPCA has established a procedure for investigating the potential for ground water contamination by impoundments. The procedure is outlined in Table 5-4.

Municipal Impoundments: This category included not only municipal wastewater impoundments but also those at mobile home parks, campgrounds, motels and other facilities large enough to have their own treatment systems. There were 864 impoundments at 380 sites when the SIA was conducted (Figure 5-4). Thirteen abandoned impoundments at 11 sites were also inventoried. The current inventory (MPCA, 1983) contains 415 sites, an addition of 35. The number of sites abandoned since the SIA was conducted is unknown.

Ground water contaminants associated with municipal impoundments include soluble salts (primarily chlorides), nitrogen compounds, phosphorous, BOD, COD and under

TABLE 5-4

Procedural Flowchart
Nondischarging Ponds



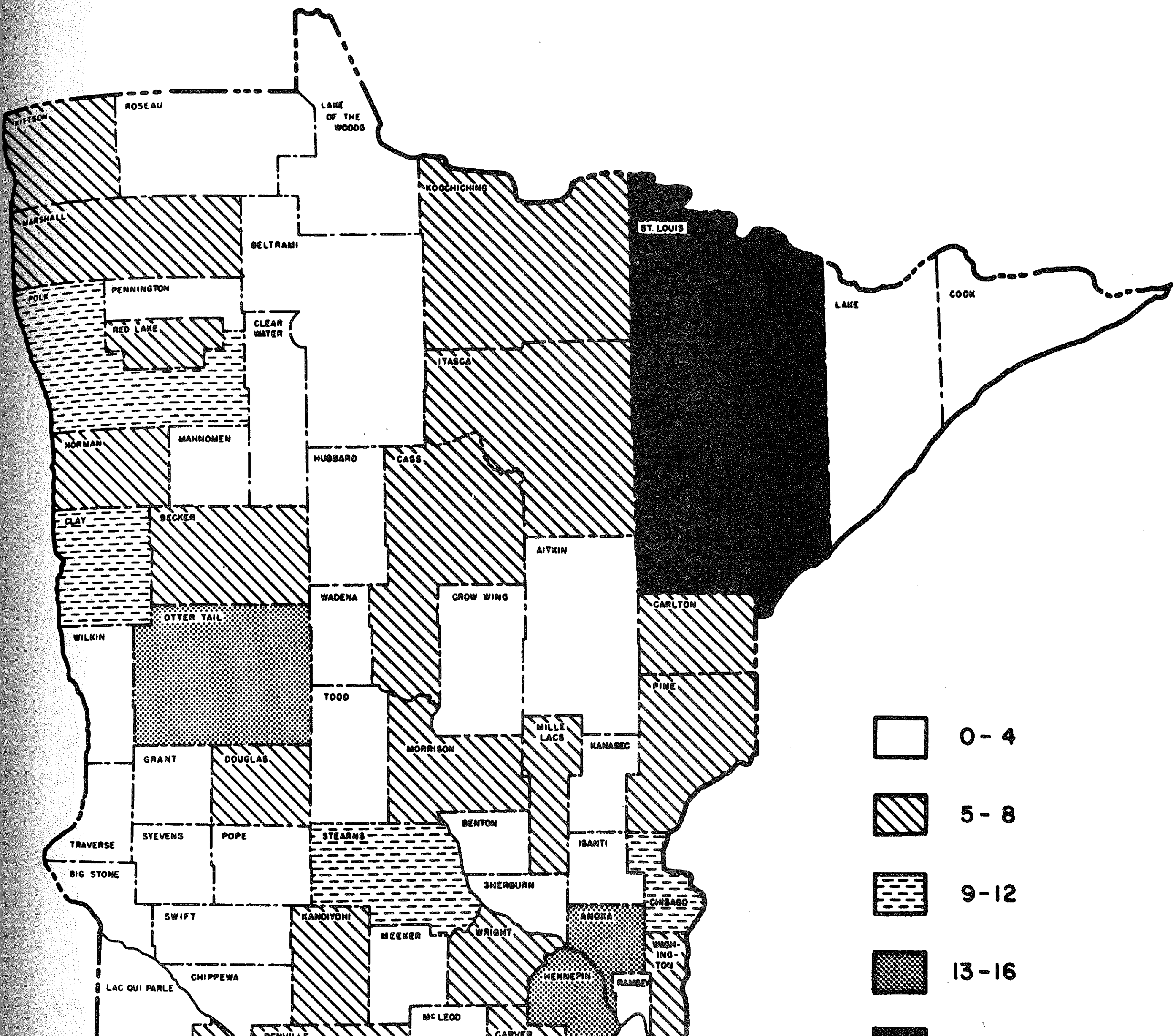


Figure 5-4: Distribution of Municipal Impoundments

certain conditions, coliform bacteria. Industries which discharge to municipal wastewater systems may also contribute a variety of contaminants including organics and heavy metals.

There are approximately 100 municipalities which have ponds that do not discharge to surface waters or that discharge infrequently. While this may be an indication of excessive seepage, it could be due to other factors such as over design of the pond which allows more evaporation and reduces the need to discharge. The list of communities and the design discharge, the average percent of design flow over the past four years, and SIA step 5 and step 6 ratings are contained in the Contaminated Site Report (MPCA, 1983).

Industrial Impoundments: Ground water contamination from industrial impoundments is more difficult to categorize because of the wide variety of industrial contaminants. The SIA identified 154 facilities with active industrial impoundments and 29 with abandoned impoundments. Table 5-5 shows the type of industries discharging to surface impoundments in Minnesota and the percent of the total based on their Standard Industrial Classification. The inventory of industrial impoundments is contained in the Contaminated Site Report along with the SIA step 5 ratings (MPCA, 1983). Figure 5-5 shows the location of the active and abandoned industrial surface impoundments in the state.

Animal Feedlots and Agricultural Impoundments: By far the largest number of impoundments in the state is in the agricultural category. Contaminants from feedlots include nitrogen compounds, phosphorous, chlorides, coliform bacteria and high TDS, BOD, and COD. In addition to the geologic and hydrologic considerations, the potential for ground water contamination is determined by the size of the feedlot (number of animal units) and the procedures for handling

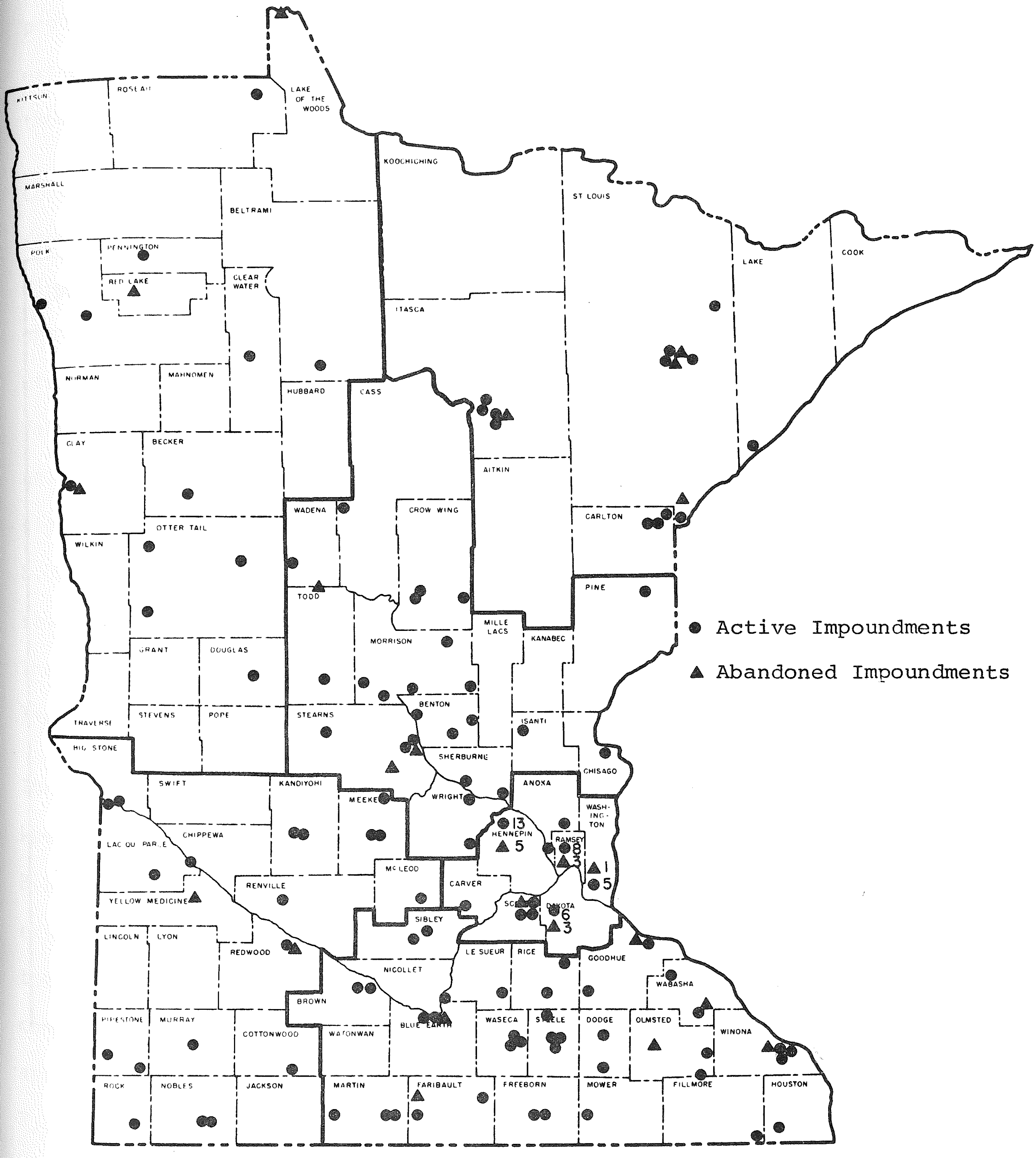


Figure 5-5: Location of Industrial Surface Impoundments

TABLE 5-5

TYPE OF INDUSTRIAL SITES WITH SURFACE IMPOUNDMENTS

SIC	DESCRIPTION	NUMBER OF SITES	PERCENT OF TOTAL
20	Food and food products	67	38.7
49	Utilities	19	11.0
28	Chemicals	15	8.7
34	Fabricated metals	9	5.2
32	Stone	8	4.6
24	Lumber and wood	8	4.6
29	Petroleum	5	2.9
33	Primary Metals	4	2.3
40	Railroads	4	2.3
14	Non-metallic mining	3	1.7
51	Wholesale trade (non-durable)	3	1.7
72	Laundering	3	1.7
16	Heavy construction	2	1.2
26	Paper and allied products	2	1.2
35	Non-electrical machinery	2	1.2
36	Electrical machinery	2	1.2
50	Wholesale trade (durable)	2	1.2
13	Oil and gas	1	0.6
22	Textiles	1	0.6
25	Furniture	1	0.6
30	Rubber and plastics	1	0.6
31	Leather	1	0.6
37	Transportation	1	0.6
39	Miscellaneous manufacturing	1	0.6
45	Airlines	1	0.6
46	Pipelines	1	0.6
MISC		6	3.5

Source: MPCA, 1980

the manure generated. Although cattle are usually thought of as being the main problem because of the amount of manure each animal produces, there are many extremely large poultry and egg production facilities having hundreds of thousands of turkeys or chickens.

Contamination can result from either direct infiltration of contaminants at the feedlot, infiltration of contaminants from waste collected and improperly disposed of or infiltration of wastes held in impoundments. Feedlot operators are required to handle the manure generated in such a manner as to prevent the creation of a pollution hazard. Minnesota Rules 6 MCAR §§ 4.8051-4.8052 set forth the regulations for the control of waste from livestock, poultry and other animal feedlots. The number of permits issued by the MPCA has increased significantly since the SIA was conducted in 1979. There were approximately 8,000 permitted facilities of which more than 1,500 were known to have waste storage areas constructed such that they were considered surface impoundments. The numbers are now estimated to be approximately 13,000 and 3,500 respectively. The total number of feedlots estimated to exist statewide is approximately 90,000.

Three types of "permits" are currently issued to feedlot operators by the MPCA. Where a potential pollution hazard does not exist as defined by 6 MCAR § 4.8051 B.19. a certificate of compliance is issued. Where a potential pollution hazard exists but can be remedied within ten months, an interim permit is issued. If the hazard cannot be corrected within ten months, a permit is issued which contains conditions and requirements to insure compliance with applicable rules and regulations. Since December 1979 when the current rules became effective, 2,223 certificates or interim permits have been issued. Only 13 permits have been issued. Prior to that date 10,744 permits were issued under Minnesota Rules SW-51 through SW-61. The number of interim permits in force is constant at approximately 225, however the specific sites change as they come into compliance with current rules and are issued certificates of compliance. A comprehensive list of the feedlots and an updated list of agricultural impoundments is currently being developed by the Agricultural Unit of the Water Quality Division.

Mining Impoundments: Mining activities in Minnesota include numerous sand and gravel pits statewide, building stone quarrying in several areas across the center of the state, and iron ore mining, primarily in north-central and northeast parts of the state. The mining impoundments inventoried during the SIA were restricted to those associated with iron ore mining, although several impoundments associated with building stone quarrying were included in the industrial category.

Iron ore mining has historically occurred in large deposits in the Mesabi district, the Cuyuna district and a few scattered deposits in Fillmore County in southeast Minnesota. In the latter two areas, the mines are largely abandoned. There were 54 facilities with active impoundments and 104 locations with abandoned locations inventoried. Nearly all are in Itasca and St. Louis Counties. A list of the mining impoundments can be obtained from the Surface Impoundment Assessment (MPCA, 1980).

Ground water contamination due to the use of surface impoundments by the iron-mining industry has not been observed in Minnesota. However where these mines, pits or impoundments have been used as refuse dumps, problems can develop. One significant ground water contamination problem has developed at an MPCA-permitted landfill located at an abandoned iron-ore mining site in Fillmore County. Other examples of landfills located at abandoned mining sites include the city of Crosby Landfill on the Cuyuna Range and the East Mesaba Landfill on the Mesabi Range. Figure 5-6 shows the approximate location of the principal ore bodies and the number of active and abandoned impoundments in the counties.

Manufacturing and Hazardous Waste Generation: Hazardous waste is unavoidably generated during the manufacturing of many common materials such as metals, paints, plastics, pesticides, chemicals, petroleum and a wide variety of other products we rely on in our daily lives. It is also produced by non-manufacturing activities such as hospitals, laboratories, utilities, and dry cleaners.

There are approximately 6,000 manufacturers in Minnesota. Their distribution throughout the state is shown in Figure 5-7. It is estimated that manufacturing and other activities produce approximately 174,000 tons of hazardous waste annually in Minnesota (MWMB, 1983). Approximately 60,000 tons is waste oil. As suggested by the distribution of manufacturers, hazardous waste generation is not equally distributed throughout the state, but rather is concentrated in the Twin Cities metropolitan area. One-third of all the hazardous waste generated in the state is in Hennepin County, one-third in the other six metropolitan counties, and one-third in the remaining 80 out-state counties (Lie, 1982). One-half of the hazardous waste generated in the out-state area is generated in the southeastern corner of the state which includes the karst areas (Barr, 1979). The remaining 17 percent is equally divided among the other areas of the state. Table 5-6 lists the number of manufacturing facilities in the state within each Standard Industrial Classification (SIC) and the estimated amount and percent of the total hazardous waste generated within each classification. A list of manufacturing facilities in Minnesota is published annually by the Nelson Name Service of Minneapolis.

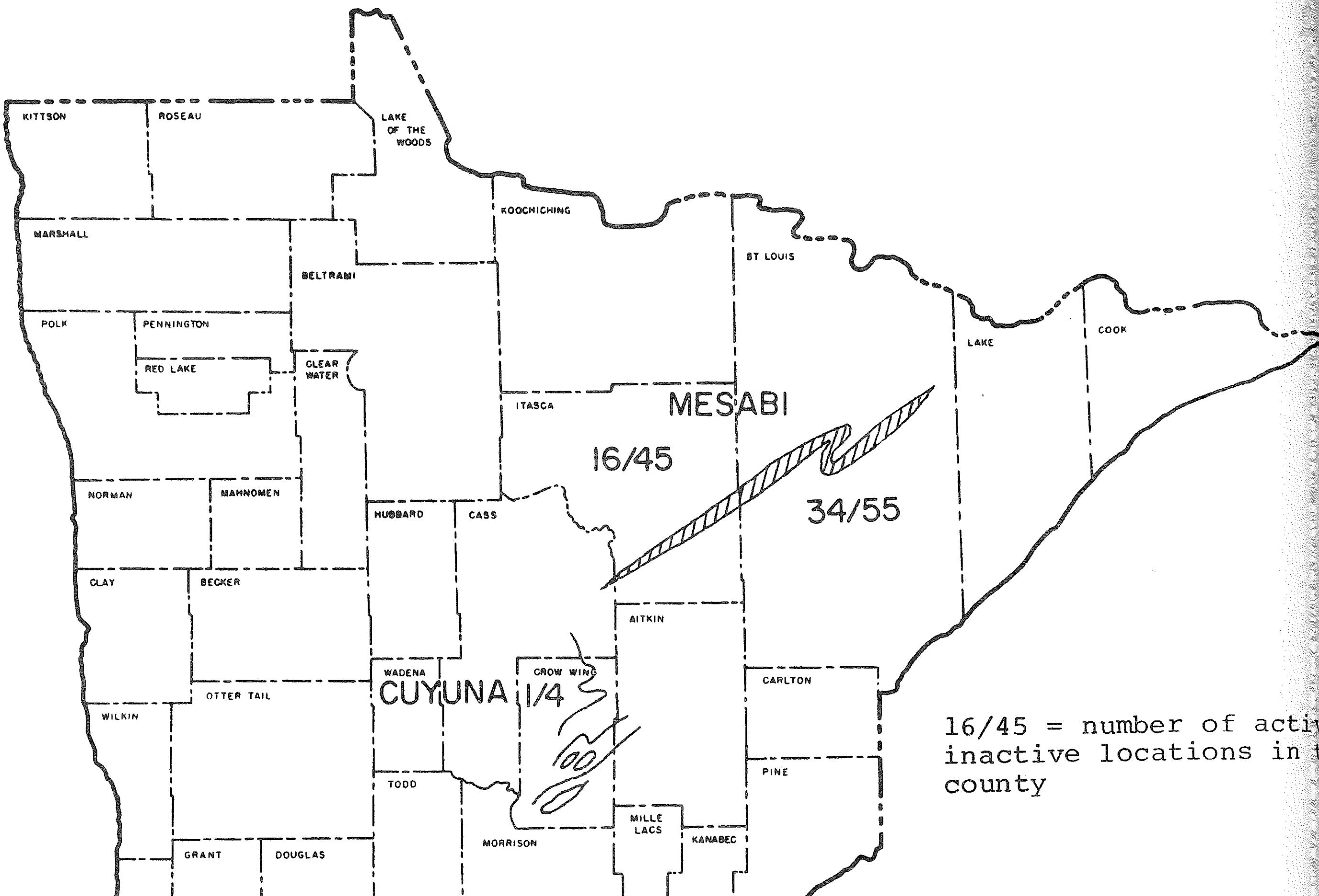


Figure 5-6: Iron Mining Impoundments

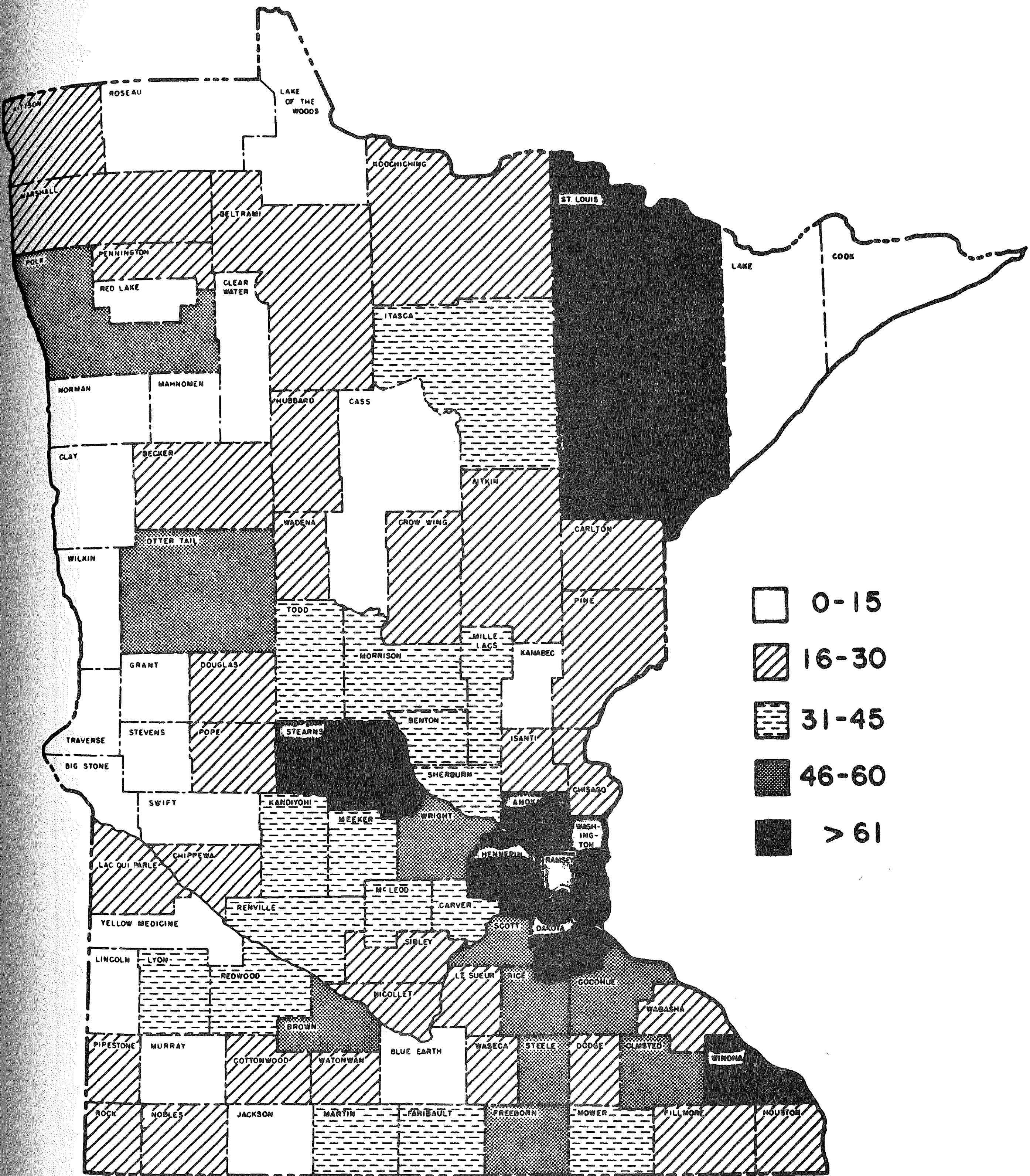


Figure 5-7

MANUFACTURING SITES

TABLE 5-6

HAZARDOUS WASTE GENERATION IN MINNESOTA

SIC	Description	Number of Establishments(1)	Tons/Year(2)	Percent Total
25	Furniture	74	1,000	0.5
26	Paper and allied products	1,024	2,100	1.2
27	Printing	243	5,500	3.1
28	Chemicals	31	16,900	9.7
29	Petroleum	148	12,100	6.9
30	Rubber and plastics	23	11,800	6.7
31	Leather	350	1,200	0.6
33	Primary metals	562	5,600	3.2
34	Fabricated metals	1,450	12,700	7.3
35	Non-electrical machinery	295	9,500	5.4
36	Electrical machinery	183	6,300	3.6
37	Transportation equipment	188	5,400	3.1
38	Instruments	370	700	0.4
39	Miscellaneous manufacturing		1,300	0.7
40	Railroads		1,500	0.8
49	Utilities		700	0.4
55	Auto dealers--service stations		3,100	1.7
80	Health services		800	0.4
99	Other (3)		75,100	43.2

(1) Minnesota Department of Energy, Planning and Development (1981)
(2) Minnesota Waste Management Board (1983)
(3) Other includes unspecified industries agriculture and generally distributed waste sources.

In order to effectively manage hazardous wastes, Congress enacted the Resource Conservation and Recovery Act of 1976 (RCRA), PL 94-580. Subtitle C of RCRA gives USEPA authority to develop a nationwide program to regulate hazardous waste practices from the time the waste is generated until its final disposal (cradle to grave). Specific criteria for carrying out RCRA are contained in the Code of Federal Regulations 40 CFR parts 260 to 266 and 122 to 124. Each state is encouraged to develop its own program following USEPA guidelines.

The major provisions under RCRA for controlling hazardous waste are:

- Definition of hazardous waste;
- Manifest system to track hazardous waste from its generation to its final disposal;
- Standards for hazardous waste generators and transporters;
- Permit requirements for facilities that treat, store, or dispose of hazardous waste;
- Requirements for state hazardous waste programs.

Anyone who generates or transports hazardous waste or owns or operates a facility that treats, stores or disposes of hazardous waste must notify the USEPA and the state. Generators must receive an identification number. Over 2000 firms or individuals in Minnesota have filed notifications under RCRA or state hazardous waste rules (6 MCAR § 4.9001-4.9010). Figure 5-8 shows their distribution in the state. It is estimated that there are as many as 5,000 generators in the state.

Federal regulations provide exemptions from many of the requirements for generators of small quantities of hazardous waste as well as that which is used, reused, recycled or reclaimed, such as waste oil. Current Minnesota rules do not contain any such provisions. Although firms in these categories are not

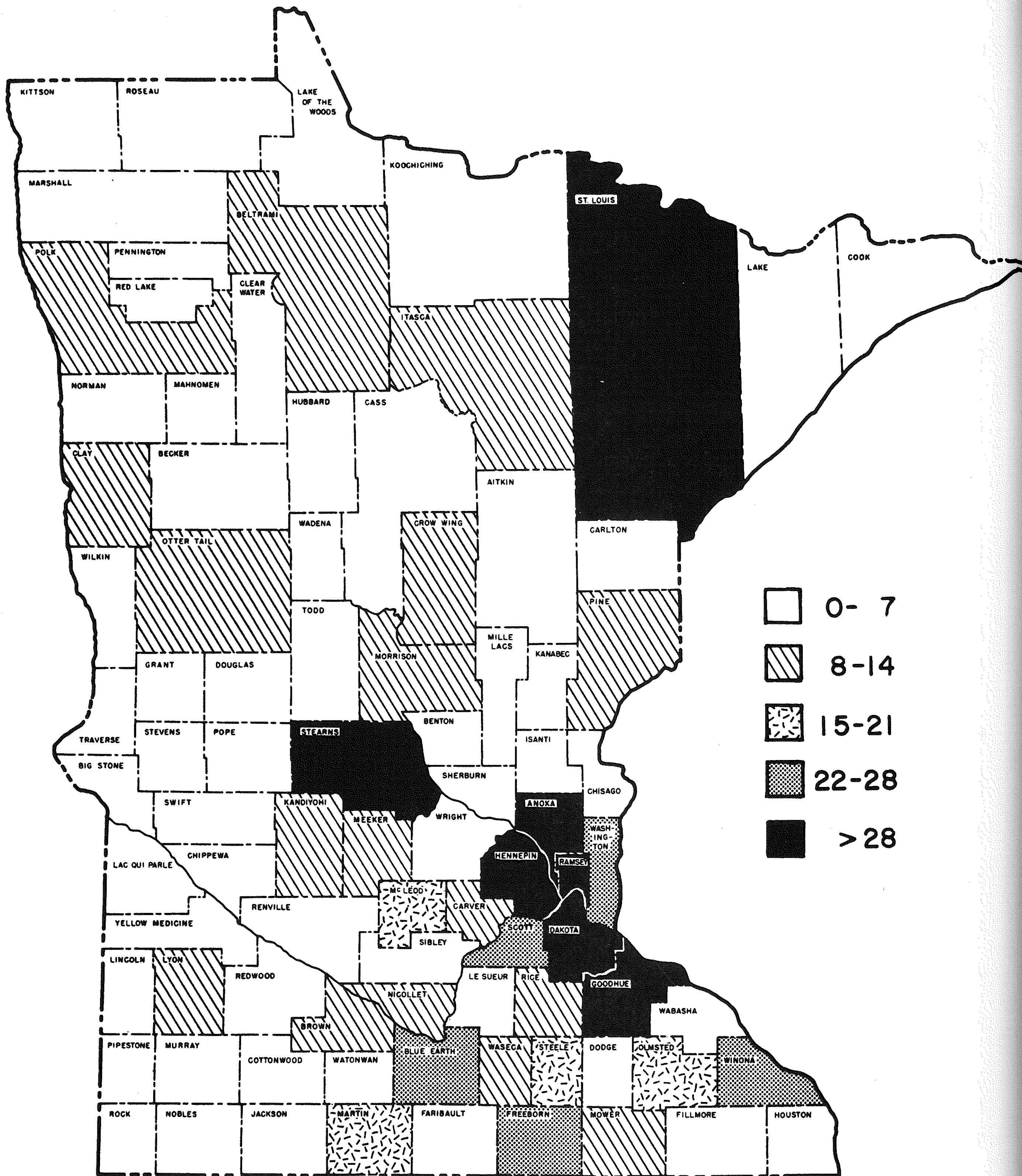


Figure 5-8
HAZARDOUS WASTE GENERATORS

required to file federal notifications they must apply for an USEPA identification number and file a notification with the state. The number of hazardous waste generators under state regulations is therefore larger than under federal regulations.

Owners and operators of facilities that treat, store, or dispose (TSD) of hazardous wastes must receive a permit to operate such a facility. Generators who accumulate waste on their property for more than 90 days are considered to be storing it and must therefore obtain a facility permit. There are currently 139 firms in Minnesota which are considered TSD facilities and which must therefore obtain permits. Most are simply storing it for transportation to hazardous waste management facilities. Figure 5-9 shows their distribution in the state. Anyone transporting hazardous waste must:

- Receive an USEPA identification number;
- Comply with the manifest system for tracking hazardous waste;
- Deliver the entire quantity of hazardous wastes to the facility designated by the generator on the manifest;
- Retain a copy of the manifest for three years;
- Comply with U.S. Department of Transportation regulations pertaining to reporting discharges or spills;
- Clean up any hazardous waste discharged during transportation.

There are currently 272 firms in Minnesota which have notified as transporters of hazardous wastes.

The potential for ground water contamination by hazardous waste depends upon the type and volume of wastes, the methods of handling or disposing of them, and the characteristics of the disposal sites. There are many thousands of different hazardous wastes. The major catagories identified in Minnesota include

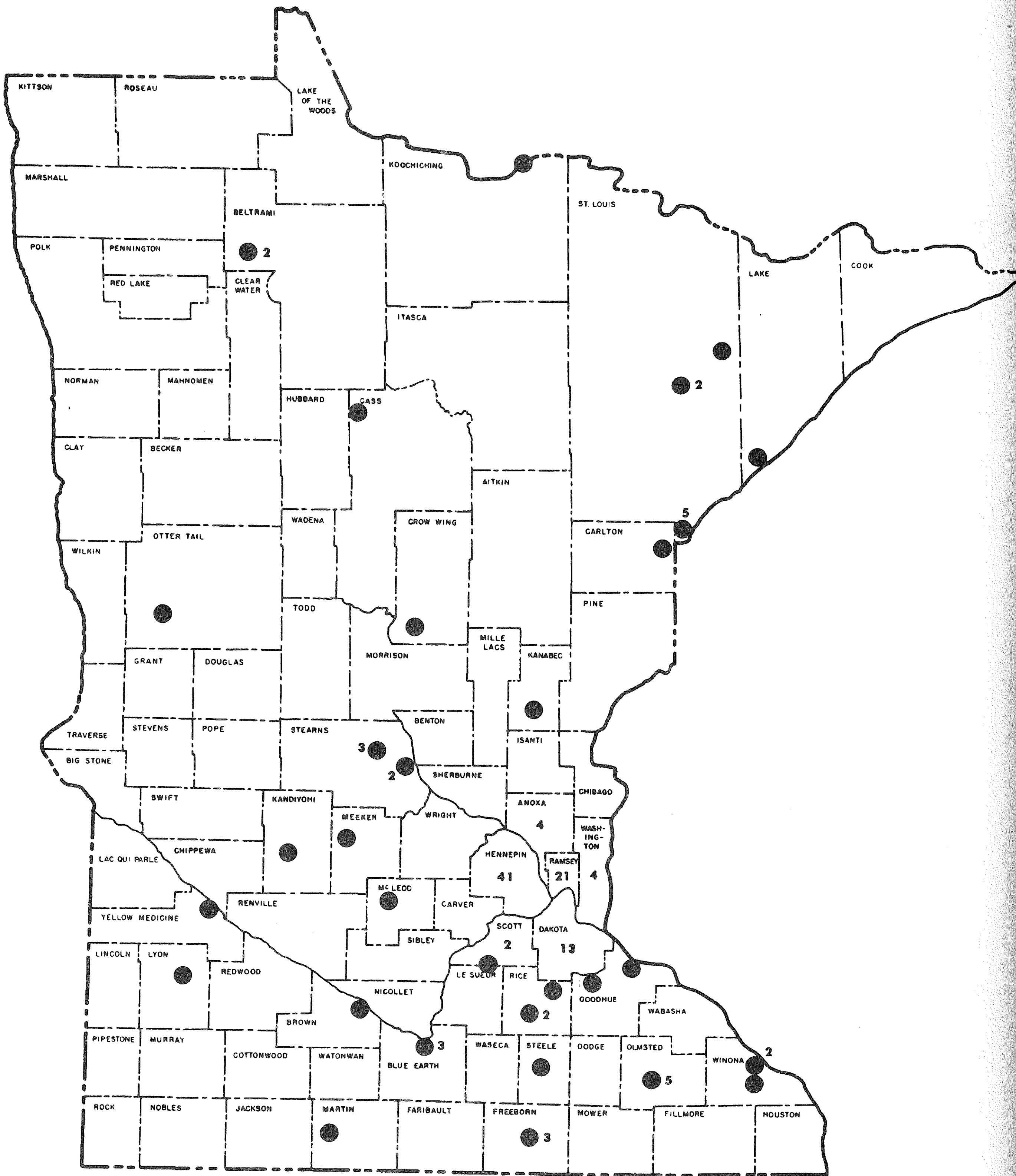


Figure 5-9: Distribution of Hazardous Waste Treatment, Storage and Disposal Facilities

solvents and organic solutions, oils and greases, heavy metals solutions and inorganic residuals, and cleanup residuals. These four categories include 75 percent of the total hazardous waste generated (MWMB, 1983).

The methods by which these wastes have been disposed of include:

- Shipment to processing, recovery, or containment facilities;
- Disposal or processing on site;
- Disposal in sanitary sewer systems;
- Disposal in sanitary landfills or unregulated (open) dumps.

The information being gathered through the notification program and on-site inspection to assure compliance with RCRA and state regulations can be used not only in present and future hazardous waste management but also as a tool in investigating past disposal practices. The Solid and Hazardous Waste Division of MPCA maintains a current inventory of all hazardous waste generators, transporters and treatment storage and disposal facilities in the state.

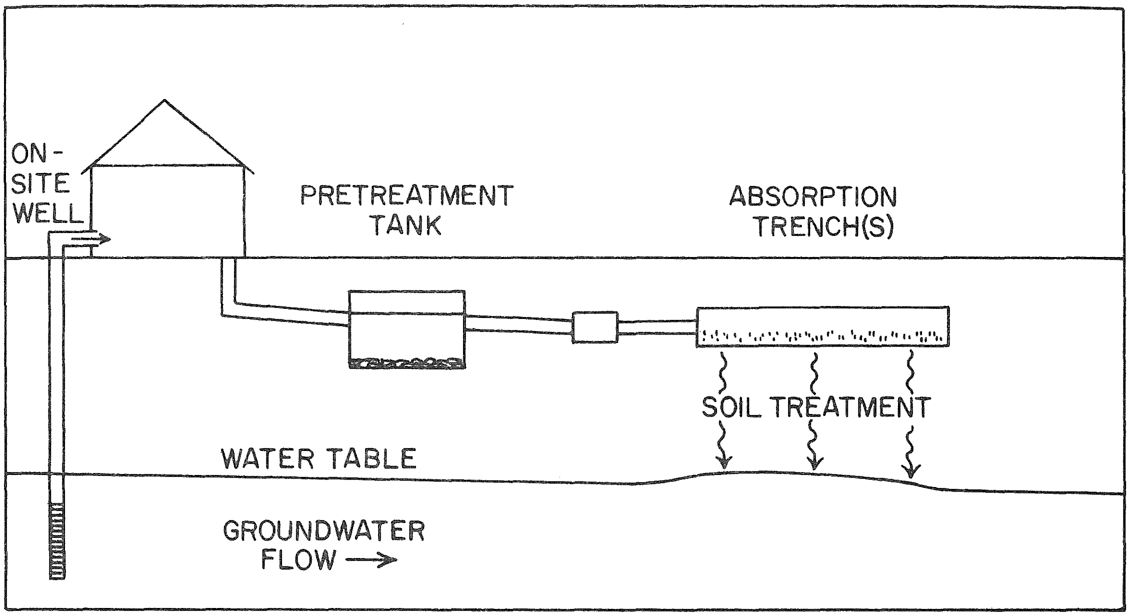
Septic Systems: Approximately one-third of the homes in Minnesota have individual sewage treatment systems commonly referred to as septic systems. These systems function by natural decomposition of the waste on the site where it originates. Properly designed, sited, and operated septic systems will have a life span of 20 to 50 years and will provide treatment of the waste water, while at the same time protecting the ground water. Improperly designed, sited or operated systems may fail and cause serious ground water contamination. Even properly functioning systems rely on some dilution of nitrates and other constituents in the ground water and have a slight impact. Nitrate contamination of the ground water is the most common result of septic system failure. If the soils are very porous, there may be little or no treatment of the liquid and the quality of the ground water may approach that of raw sewage. In one extreme example, viral contamination of a downgradient well was attributed to a septic system over a gravel aquifer. If a system fails in an isolated rural area, the only effect may be contamination of the on-site drinking water well. However, many populated areas exist where there is no common sewage collection and treatment. These include areas around popular lakes, suburban areas beyond the reach of the central municipal sewage system, and smaller municipalities with no central system. In lake areas, improperly operating systems may also affect the water quality in the lake. In areas that do not have common sewer systems, it is also likely that there is not a central water supply system and a general degradation of the ground water may cause contamination of shallow domestic wells. Zoning authorities have begun to address these problems by requiring greater setbacks from lakes and larger lots for building new homes.

The MPCA has identified 230 municipalities in the state which have no municipal sewer systems (MPCA, 1982). The potential for a general degradation of the ground water in these areas depends on the type of soils, the density of the population, and the number of failing systems. Municipalities without sewer systems are listed in the Contaminated Site Report (MPCA, 1983).

The septic system is relatively simple and inexpensive, consisting of two components, an underground holding tank and a soil filter, usually a drainfield. Figure 5-10 depicts a typical system. Wastewater first flows to the tank where it separates into liquid and solids. Bacteria decompose the solids in the tank, becoming either a sludge which settles to the bottom of the tank, or a scum which floats. The liquid portion flows from the tank to the drain field where it undergoes further treatment by filtering and biological decomposition.
By the time the effluent reaches the water table it is considerably improved in quality. The contaminants that remain are diluted to usually harmless levels.

FIGURE 5-10

DISPOSAL OF HOUSEHOLD WASTES THROUGH A CONVENTIONAL SEPTIC TANK-SOIL ABSORPTION SYSTEM



In order to reduce contaminants before they reach the water table, both parts of the system must be operating properly. For the tank to provide proper settling and biological activity it must be pumped periodically to maintain the necessary depth of water. If too much sludge builds up, untreated wastes may begin to flow to the drainfield and clog the soil pores, resulting in failure of the entire system. If the drainfield is undersized or too close to the water table or if the soil is too course, there may be little or no attenuation of contaminants in the liquid.

Even systems that are properly designed and kept pumped at recommended intervals can cause ground water contamination if homeowners place materials down the drains that can kill the organisms providing biological decomposition of the wastes in the septic tank or soils beneath the drainfield. These materials include paints, solvents and cleaning agents, pesticides, and some so-called septic tank cleaners. Besides damaging the system, these materials themselves are potential ground water contaminants.

As indicated, septic tanks must be periodically pumped to ensure proper treatment of the wastes. The improper disposal of the pumped septage can also lead to ground water contamination. Minnesota Rule 6 MCAR § 4.6006 prohibits the dumping of septage in sanitary landfills. MPCA guidelines encourage the utilization of septage as fertilizer on crop, pasture, or forest land or, if necessary, disposal at wastewater treatment plants under the supervision of the operator. Although the state does not issue permits or regulate septage hauling and spreading, some counties do. In any case, the appropriate county authority should be contacted before applying septage to the land.

Minnesota Rule 6 MCAR § 4.8040 sets forth the minimum standards and criteria for the design, location, installation, use and maintenance of individual sewage treatment systems. These rules are generally administered and enforced by local units of government. Individual sewage treatment systems which serve a single facility generating more than 15,000 gallons per day must conform to Minnesota Rule 6 MCAR § 4.8040 and obtain a State Disposal System (SDS) Permit from the MPCA. The same is true for collector systems which serve 15 dwellings or generate 5,000 gallons per day, whichever is less.

Land Application of Liquid Wastes: Land application of liquid wastes is the application of wastewater onto the land at a contolled rate for treatment through the biological, physical and chemical processes of plants and soils. The three major processes in use are slow rate, rapid infiltration, and overland flow.

The slow rate method involves the application of wastewater to a vegetated land surface. Application is usually by irrigation, either ridge and furrow, border strip flooding or sprinkling. Nitrogen removal and hydraulic loading are often the controlling factors for slow rate design. Potential contaminants include nitrogen, dissolved solids, trace elements and organics and microorganisms.

Rapid infiltration involves wastewater application to moderately and highly permeable soils through basins or by sprinkling. Vegetation is usually not planned. The major objective of the rapid infiltration process is wastewater treatment through filtration and ground water recharge. Suspended solids, BOD, and fecal coliform bacteria are almost completely removed. Ground water contaminants may include nitrates, dissolved solids, trace elements and organics and microorganisms.

Overland flow systems apply wastewater at the upper reaches of grass covered slopes and allow it to flow over the surface to collection ditches. It is best suited to sites with relatively impermeable soils. The treatment objectives are either to achieve secondary effluent quality when applying screened raw wastewater, primary effluent or treatment pond effluent or removal of nitrogen, BOD and suspended solids. Ground water contamination from overland flow systems is generally unlikely because of the impermeable soils.

Combinations of these systems may provide additional treatment. Use of these systems in Minnesota may require operational modifications or wastewater storage capability during extremely cold weather. Properly designed and operated systems will generally not have any significant impact on the ground water. Figure 5-11 shows schematically of the hydraulic pathways for the different systems. The inventory of municipal land application sites, large septic tank and

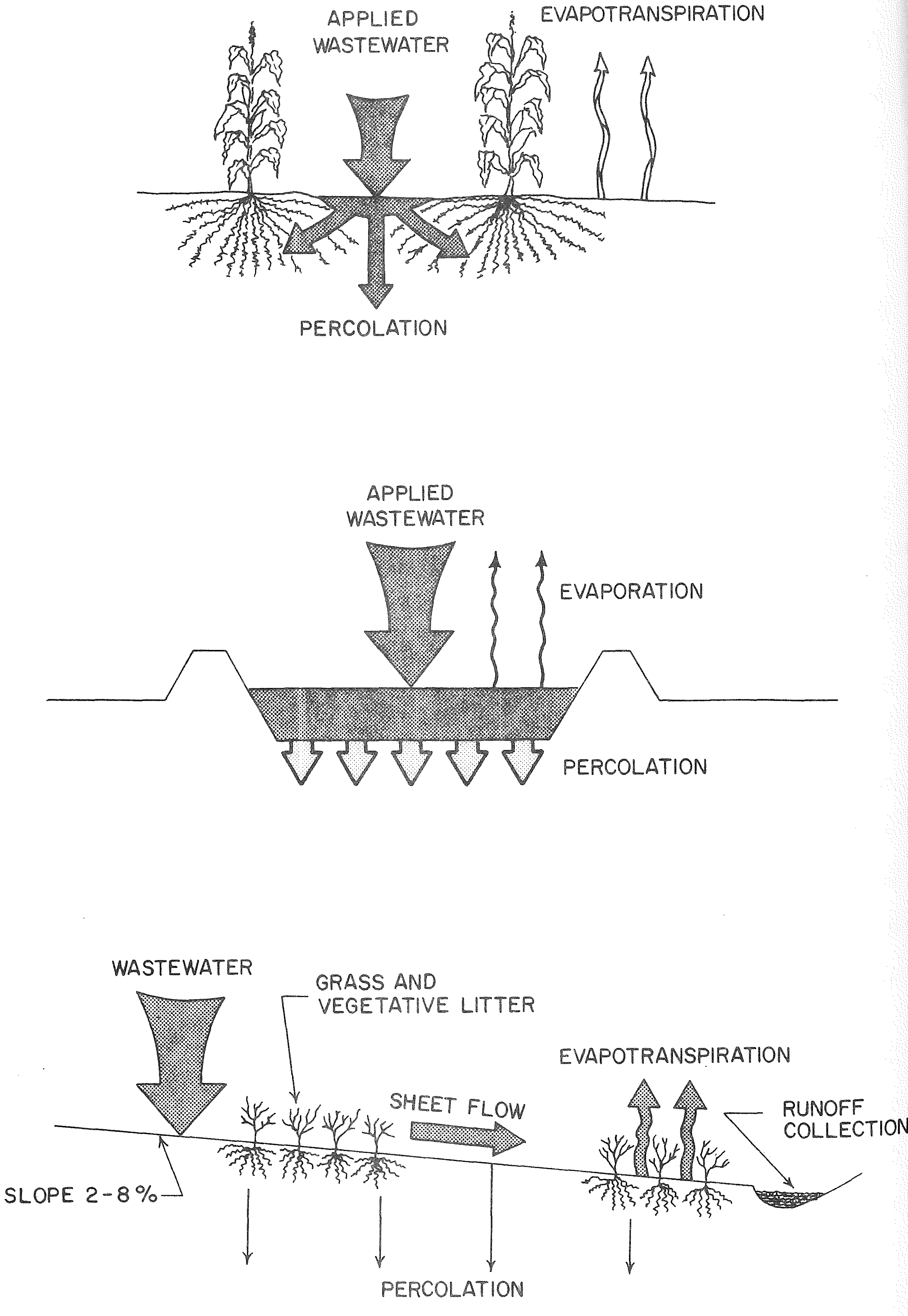


Figure 5-11: Hydraulic Pathways for Applied Wastewater

drainfield systems industrial systems are contained in the Contaminated Site Report (MPCA, 1983).

Municipal and Industrial Sludge Disposal: National efforts to clean up surface waters and air have led to a significant increase in the amount of sludge generated at municipal and industrial wastewater treatment plants and by the removal of particulate and gaseous matter from stacks and ventilators at power plants and industrial facilities. The type of contaminants in industrial sludges depends on the specific industry and vary considerably. The contaminants in municipal sludges represent those found in normal household sewage as well as a composite of materials being discharged to the system by local industry. In industrialized areas such as the Twin Cities these contaminants may include nitrogen, phosphorous, PCBs, organic priority pollutants, and heavy metals such as cadmium, lead, zinc, copper, nickel, chromium and mercury. Table 5-7 contains an average sludge cake analysis from the Metropolitan Waste Control Commission (MWCC) Metro Wastewater Treatment Plant, the largest in the state.

The removal of contaminants from waste streams to preclude surface water and air pollution presents an increased potential for ground water contamination from the disposal of the sludges. Contamination may result from the loading of heavy metals and other constituents at rates which the soils cannot absorb, or from chemicals not removed in the treatment process.

Because municipal sludge contains nitrogen, phosphorous, and potassium, it is an attractive supplemental fertilizer and soil conditioner for farm land. Demonstration projects have shown that controlled landspreading of sludge does not contaminate ground water. Controlled landspreading is the application of the sludge at rates which allow the metals to be absorbed onto soil particles and nutrients to be taken up by the plants thus protecting the ground water.

TABLE 5-7

AVERAGE FILTER CAKE CHARACTERISTICS
MWCC METRO PLANT, SECOND QUARTER, 1982

Constituent	Number of Observations	Average Concentration (mg/kg dry)
Solids %	90	25.0*
Volatile Solids %	90	50.9
Total Kjeldahl Nitrogen	77	34,540
Ammonia Nitrogen	77	570
Total Phosphorus	77	14,890
Copper	13	830
Nickel	13	140
Lead	13	440
Zinc	13	1,470
Cadmium	76	39
Chromium	13	1,030
Potassium	13	1,090
Mercury	3	2.5
PCB	2	1.2

* wet weight basis

Source: MWCC Interim Sludge Disposal Program Quarterly Report; April-June, 1982

Minnesota Rules 6 MCAR §§ 4.6101-4.6136 regulate the utilization or disposal of sewage sludge. The rules provide for two types of landspreading areas: a landspreading site and a landspreading facility. A landspreading facility is land used for sewage sludge landspreading that is owned, rented, or leased by the political subdivision generating the sewage sludge. A landspreading site is one that is not owned, rented, or leased by the political subdivision generating the sludge. These are generally farms which use the sludge as a supplemental fertilizer and soil conditioner.

Besides ownership, the principal difference between a site and a facility is that a site has limits on the cumulative amount of heavy metals which can be landspread on a particular area and a facility does not, so long as certain pH and crop restrictions are maintained. For this reason, permitting and monitoring requirements are more stringent for a facility, and stipulations regarding present and future land use for growing crops are placed on facilities which exceed specified levels of heavy metals, particularly cadmium. An SDS permit must be obtained to operate a landspreading facility. A letter of approval is needed to operate a landspreading site.

Approximately 300,000-350,000 dry tons of municipal sewage sludge are generated in Minnesota annually. Approximately 80 percent of that is generated by one plant, MWCC Metro Wastewater Treatment Plant. Consequently the MPCA letter of approval and permitting programs are focused on the MWCC and landspreading in the Twin Cities metropolitan area. All of the wastewater treatment plants in the state were required to be in compliance with the sewage sludge management rules by May 1983.

Methods of disposal of industrial sludges depend on their physical and chemical characteristics. Industrial sludges which are classified as hazardous waste must be disposed of according to state and federal hazardous waste rules. Those which are not hazardous may be disposed of in industrial or municipal landfills under appropriate conditions or may be landspread.

Unauthorized Waste Disposal: The unauthorized disposal of a waste is that which takes place in violation of state and/or federal solid and hazardous waste regulations. It may take the form of disposal 1) on the site where it is generated, 2) at unauthorized landspreading sites, 3) in landfills and dumps from which it is specifically excluded because of its physical or chemical properties, or 4) randomly at sites which are not normally disposal areas. While the potential for ground water contamination may be equally great in all cases, the latter may be the most dangerous of the three. By their very nature, random sites are difficult to locate until they manifest themselves in contaminated water wells, basements, or surface waters. Furthermore, when these problems are identified it is often difficult, sometimes impossible, to identify the type of waste and/or responsible party. These latter sites are undoubtedly located throughout the state but most of the more dangerous ones are probably located near the more industrialized areas as indicated previously.

Unauthorized on-site disposal and unauthorized disposal of wastes in landfills and dumps is somewhat more predictable and may be discovered through routine inspections and ground water monitoring systems, where present. Of the 61 sites currently on the Hazardous Waste Site Response Section log of hazardous waste contamination sites, 64 percent are the result of on-site disposal, 19 percent from disposal of hazardous waste in known landfills and dumps and 17 percent from disposal in random dump sites. Table 5-8 lists these sites and the types of waste disposed of and found in the ground water. Figure 5-12 shows their locations.

Ten of these sites are currently on the National Priorities List making them eligible for "Superfund" monies for study and cleanup. The Minnesota legislature has recently passed state superfund legislation (May 1983) which will allow the MPCA to take action on many of the lower priority sites.

The goal of the programs being developed and administered under RCRA and other federal and state laws is the elimination of the unauthorized disposal of toxic hazardous wastes. Through the review of hazardous waste disclosures and on-site inspections, information is being gathered which will aid in discovering many previously-used unauthorized and unregulated disposal areas. Another significant potential source of information concerning these types of sites is the general public. Cooperation of individuals who have knowledge or suspicions of unauthorized waste disposal should be encouraged. The MPCA maintains a hazardous waste hotline on which actual or suspected problems may be reported.

Non-Disposal Activities:

Spills and Bulk Storage of Liquids: The spillage of liquid substances during transportation, storage, or use represents a potential source of ground water contamination. The potential depends on the type and volume of liquid released, the manner in which it is stored, transported or released to the environment, and the physical characteristics of the spill site.

The MPCA receives approximately 850 reports of spills each year. Figure 5-13 represents the distribution of the type of material and the volumes spilled as

TABLE 5-8

SITE RESPONSE UNIT HAZARDOUS WASTE INVESTIGATION SITES

0 = Known/Suspected Waste Disposal X = Ground Water Contaminant

Hazardous Waste Facility	Volatile Hydrocarbons/ Solvents	Inks/ Dyes	Metals	Paint/ Paint Sludge	Plating Wastes	PAH/Nitrogeneous Heterocycles/PCP		Acids/ Caustics	Petroleum/ Petroleum By-Products	Radioactive Wastes	Pesticides	PCBs	Miscellaneous
						Coal Tar Distillation/ Coking	Wood Preservation						
Ironwood SLF.	0/X												Resins
FMC	0/X		0	0	0								
Isanti Solvent Sites	0/X	0		0				0/X	0/X			0	Resins
LeHillier/Mankato	0/X												Possibly Arsenic
TCAAP	0/X		0	0	0			0	0	0			Ammunition
Oakdale Dump	0/X		X	0				0	0				
Reilly Tar and Chem. Co.						0/X	0/X						
South Andover	0/X	0	X	0					0/X				
Burlington Northern							0/X		0/X				
Consolidated Cont. Corp.	0/X	0	X	0			0/X	0			0		Ash
Hastings Dump	0/X				0			0					
Hibbing Kitzville	0/X												
Joslyn Mfg. and Supply							0/X		0/X				
Koppers Coke						0/X							
MacGillis and Gibbs			0/X*			0	0/X						*Metals from spill/ground water quality improving
National Lead			0/X										
Nutting Truck and Caster	0/X		0	0	0			0					
St. Regis Wheeler							0/X		0/X				Arsenic
Washington County SLF.	0/X	0		0			0		0				
Waste Disposal Eng. SLF	0/X	0	X	0	0			0/X	0/X		0/X		
Airco								0/X					
Arrowhead Ref.			X					0	0/X			X	
Boise Cascade	0		0	0									
Duluth A.F.B.	0									0	0		
DM and IR Rwy.	0			0	0			0	0			0	
Ford Motor Company	0/X		X	0					0			0	

TABLE 5-8 (continued)

0 = Known/Suspected Waste Disposal X = Ground Water Contaminant

Hazardous Waste Facility	Volatile Hydrocarbons/ Solvents	Inks/ Dyes	Metals	Paint/ Paint Sludge	Plating Wastes	PAH/Nitrogeneous Heterocycles/PCP		Acids/ Caustics	Petroleum/ Petroleum By-Products	Radioactive Wastes	Pesticides	PCBs	Miscellaneous
						Coal Tar Distillation/ Coking	Wood Preservation						
Maple Plain Dump	0/X			0									
N.W. Refinery								0	0/X				
General Mills	0/X												
Hopkins Ag. Chem.	0										0/X		
Interlake Inc.						0							
Marvin Windows	0/X			0									
MGK	X												
Metronics (Boise)						0/X	X						
Metals Reduction Inc.			0/X					0					
Minnegasco	X					0/X			0/X				
Morris Arsenic Site			X								0		
Onan (Boise)						0/X	0/X						
PCI, Inc.	0/X												
Perham Arsenic Site			X								0		
Rice Street Site	0/X								0				
3M Chemolite	0/X			0				0				0?/X	
Tonka Corp.	0			0				0	0				
Trio Solvents	0/X												
Union Scrap			0					0					
U.S. Steel						0/X							
Wadena Arsenic Site			X								0		
Sam Weisman and Sons	0								0/X			0/X	
White Bear Lake Dump	X			0									
Windom Municipal Dump	0/X			0									
Ashland Oil Co.								0	0/X				
Ashland Pine Cunty								0	0				
Hutchinson Tech. Inc.	0/X				0								
Ritari Post and Pole							0/X						
3M-Kerrick	0/X			0						0			Resins
Whittaker Corp.	0			0									
Winona SLF.	0	0		0				0	0				Phenolic Resin
U.S. Navy (Fridley)	0/X											0	
Kurt Mfg.	X												
Agate Lake	0												
Honeywell	0/X										0/X		

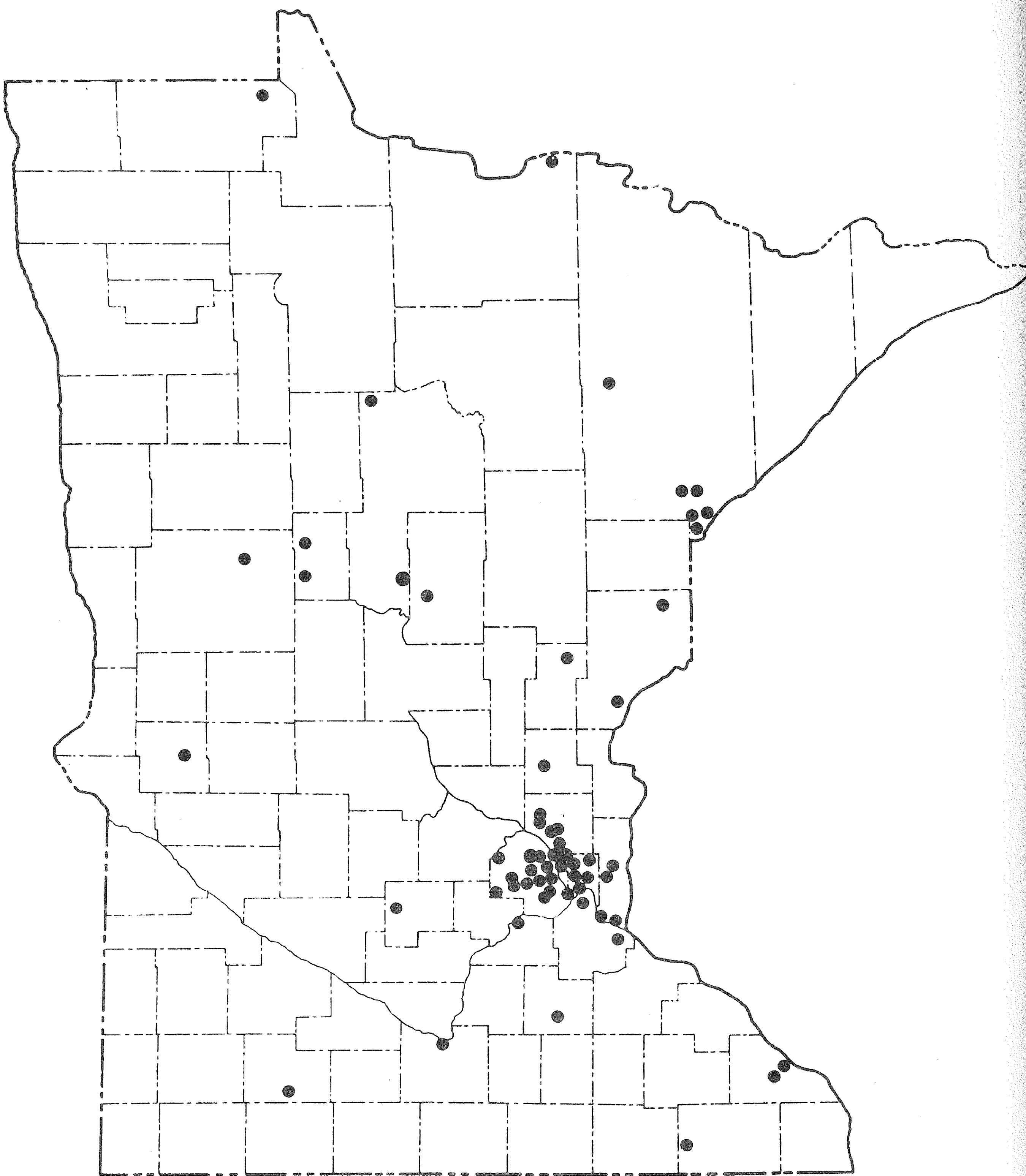


Figure 5-12: Site Response Unit Hazardous Waste Investigation Sites

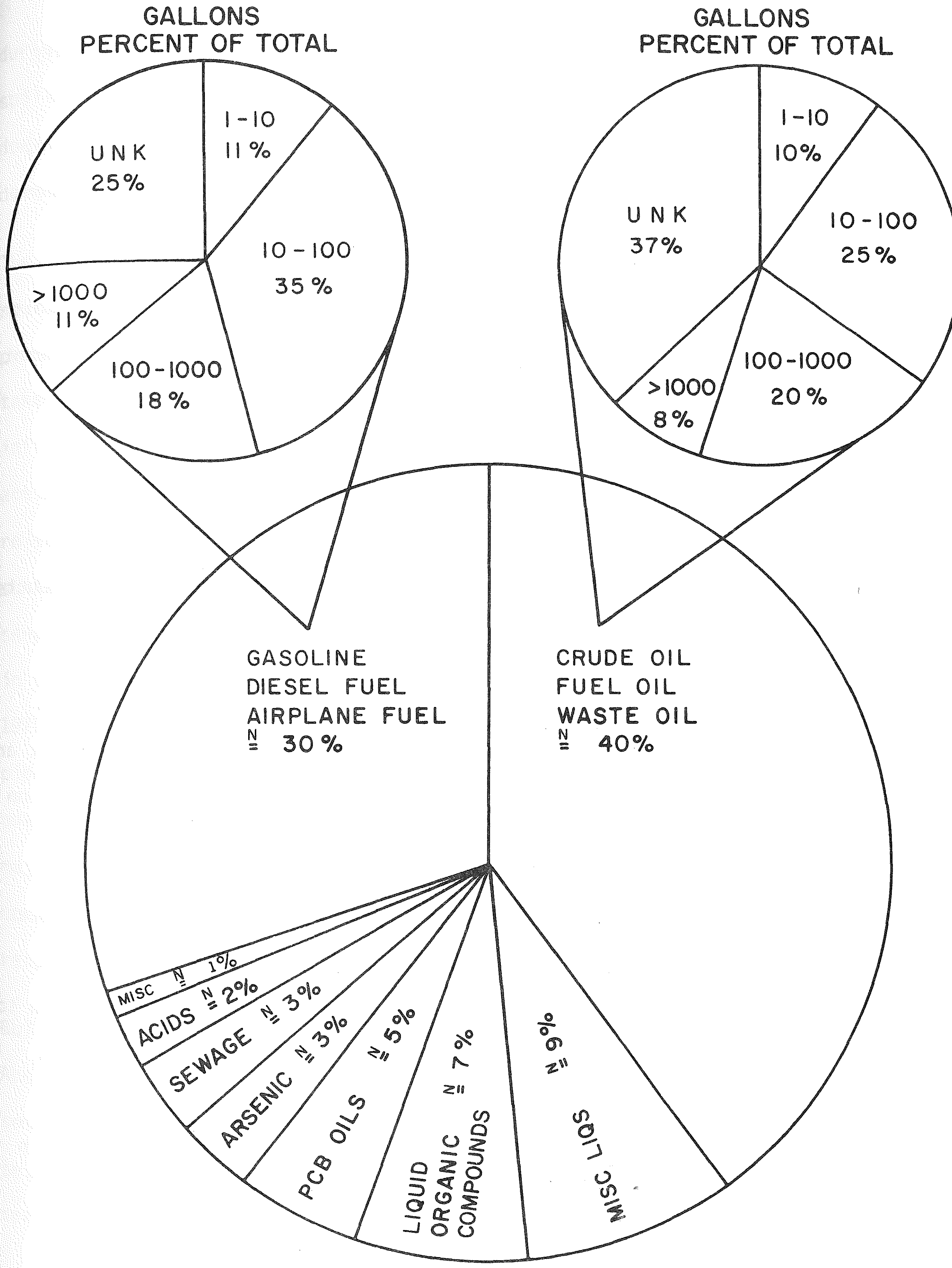


Figure 5-13: TYPE OF MATERIAL SPILLED AND PERCENT OF TOTAL

reported to the MPCA during a three year period (1978-1980). Approximately 70-80 percent of the spills involve petroleum products, primarily fuels of various types. In addition to the potential for ground water contamination, fuels and other chemicals which infiltrate the subsurface will release vapors and present both explosion and health hazards from fumes.

The transportation of liquid substances in bulk occurs either in a continuous stream (pipeline) or in discrete volumes (truck, railcar, or barge). Minnesota ranks fifth in the nation with 128,540 miles of streets and highways. Transportation of liquids on these roads presents a potential source of contamination should these vehicles be involved in an accident. There are currently 1,600 registered petroleum transporters with a capacity of 3,000 gallons or more. The MDOT estimates that 1,000,000 loads of petroleum products are transported over the roads each year in Minnesota.

There are 6,526 miles of class I and 443 miles of class II rail trackage in Minnesota. The potential for accidents depends in a large part on the track and equipment condition. Morrison (1982) described the ground water contamination and cleanup of a 1978 train derailment in Michigan.

If an accident does occur during transportation the potential for ground water contamination depends on the type of liquids and volume spilled, the type of soils at the accident site, and the response time in preventing infiltration to the water table through product recovery. Efforts to prevent spillage from reaching surface waters may increase the potential for infiltration to the ground water by damming up large pools which can then infiltrate the soil. In addition to spills from accidents, there is also the potential for spillage during the transfer of products from storage to transport or vice versa. If spillage occurs infrequently, the material will usually be adsorbed or broken down in the soils. However if spillage occurs repeatedly at a site it may develop into a serious problem.

The transportation of petroleum products by pipeline is a significant potential source of ground water contamination. Pipelines generally operate under high pressure and leaking liquids will often surface rapidly. Steps can usually be taken immediately to limit the amount of product lost. Even if there is infiltration to the water table, contamination can be limited by rapid remedial action. Far more insidious however is the slow undetected leak which may release tens of thousands of gallons of liquids to the ground water before it surfaces or manifests itself in contaminated wells, basements, ground surface seeps or surface waters. There are approximately 3,250 miles of major pipelines in the state. Over half a million gallons were lost from pipeline leaks in both 1979 and 1980. Serious soil and ground water contamination from a leaking pipeline in a residential area of Maplewood, a Twin Cities suburb, has forced abandonment of several homes. Figure 5-14 indicates the routes followed by the major lines. The MPCA does not currently have authority to regulate construction or testing of pipelines. MPCA action is limited to after-the-fact response and enforcement.

Bulk storage of liquid occurs either in above-ground or below-ground tanks. Above-ground storage tanks range in size from very small to extremely large, sometimes containing several million gallons. Below ground storage tanks are seldom larger than a few tens of thousands of gallons. The typical gasoline service station has on the average, 20,000 gallons of product in below-ground

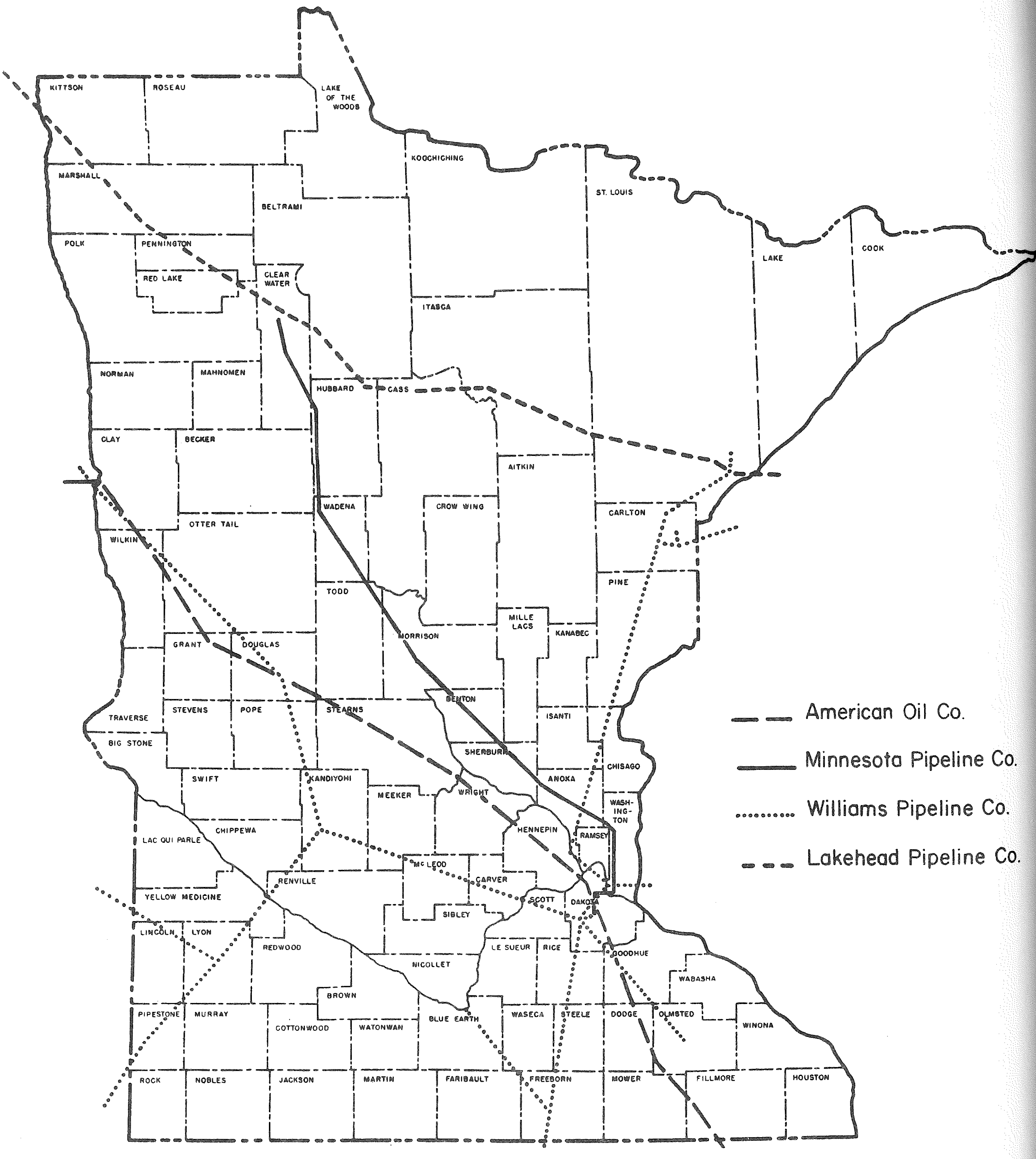


Figure 5-14: Major Pipeline Routes

storage. The major causes of storage leaks are either corrosion of steel tanks, leaking fittings or cracking of fiberglass tanks resulting from improper installation, shifting soils or puncture from gauge sticks.

An MPCA permit is required by Minnesota Rules 6 MCAR § 4.8004 to store above ground "any liquid material which might cause pollution of any waters of the state if mixed therewith." If the liquid to be stored is flammable, the facility plans must be approved by the state fire marshall. There have been approximately 640 permits issued statewide for above ground storage facilities, which is approximately 45 percent of the estimated number of existing facilities. Having a permit is, of course, no guarantee that spills will not occur. However it will generally ensure that the facility has been constructed so as to minimize the amount of environmental (and other) damage that may result from spillage. In addition, facilities operating without necessary permits may be more reluctant to report spills which do occur. This will preclude a rapid response which might limit the amount of damage resulting from the spill. In 1980 and 1981 there were 43 reported leaks from above-ground storage tanks with an estimated loss of 300,000 gallons.

There are an estimated 4,000 underground bulk storage sites in Minnesota. Leakage from the underground storage of liquids, mostly petroleum products, is potentially far more damaging than that from above ground storage for two reasons. First, there is no containment structure as with many above ground tanks and second, the volume of liquid which can be lost from an underground storage tank is not limited to the volume of the tank. If the leak is small enough and the turnover (use) of the liquid in the tank rapid enough, the leak may continue unnoticed for a long time until it manifests itself in contaminated wells, basements or surface waters. A large volume of product may be released which may contaminate a large area prior to being noticed, similar to a slow pipeline leak.

There is currently no rule pertaining to underground storage of liquid products in Minnesota although the MPCA does have statutory authority to regulate underground storage. The state fire marshall's office does review plans for new construction of all flammable liquid storage sites including underground sites. Because there are no permitting program or rules for underground storage facilities it is not possible to actively seek out or identify existing or potential problems. Time is spent reacting to problems that have already occurred, rather than discovering them before they become difficult to manage or preventing them altogether.

In 1980 and 1981 there were 135 reported leaks from below-ground storage tanks in Minnesota with an estimated total loss of 378,000 gallons. Studies in Michigan and Illinois have indicated that 25 to 50 percent of all underground tanks are leaking. If this is true in Minnesota, there are an estimated 1,000 to 2,000 underground tanks which are currently leaking and may be contaminating the ground water to one degree or another.

The Water Quality Division of MPCA is currently reviewing Minnesota Rule 6 MCAR § 4.8004. Their recommendations for revision can be generalized as:

1. The requirements for above-ground tanks should be made more specific and the administration of the rules should be given higher priority.
2. The regulation should encompass underground storage tanks and include methods for preventing and detecting leaks.
3. Some means to more actively ensure that pipelines are adequate to prevent

leaks and are in compliance with all federal requirements must be established.

Agricultural Chemicals: Agricultural chemicals include both fertilizers and pesticides. The latter term includes insecticides, herbicides, fungicides, rodenticides and other chemicals with specific targets. There are approximately 7,000 such products registered for use in Minnesota. These chemicals have a wide variety of chemical and physical characteristics and therefore, their toxicity and effects vary considerably.

There are currently 1,700 commercial pesticide applicators, 1,463 non-commercial applicators, and 544 restricted-use pesticide dealers in Minnesota. Their distribution in the state is indicated in Figures 5-15 and 5-16. Rules pertaining to the use of pesticides are contained in Minnesota Rule 3 MCAR § 1.0338. They are administered by the Minnesota Department of Agriculture (MDA).

Ground water contamination by pesticides and fertilizers is both a point source and non-point source problem. Point source problems are usually the result of poor handling or disposal practices at specific locations while non-point source problems are due to the widespread use or misuse of these products. The latter problem is often very complex and nearly impossible to control short of banning a product or class of products from use, as with DDT. As an example, Union Carbide discontinued the sale of Temik (TM) in eastern Long Island because of underground aldicarb contamination due to sandy soils and shallow water tables.

The following are examples of activities related to pesticide handling and residue disposal that can cause ground water contamination:

- Improper handling or disposal of wastes or products generated during the manufacturing or formulation of pesticides and fertilizers. The

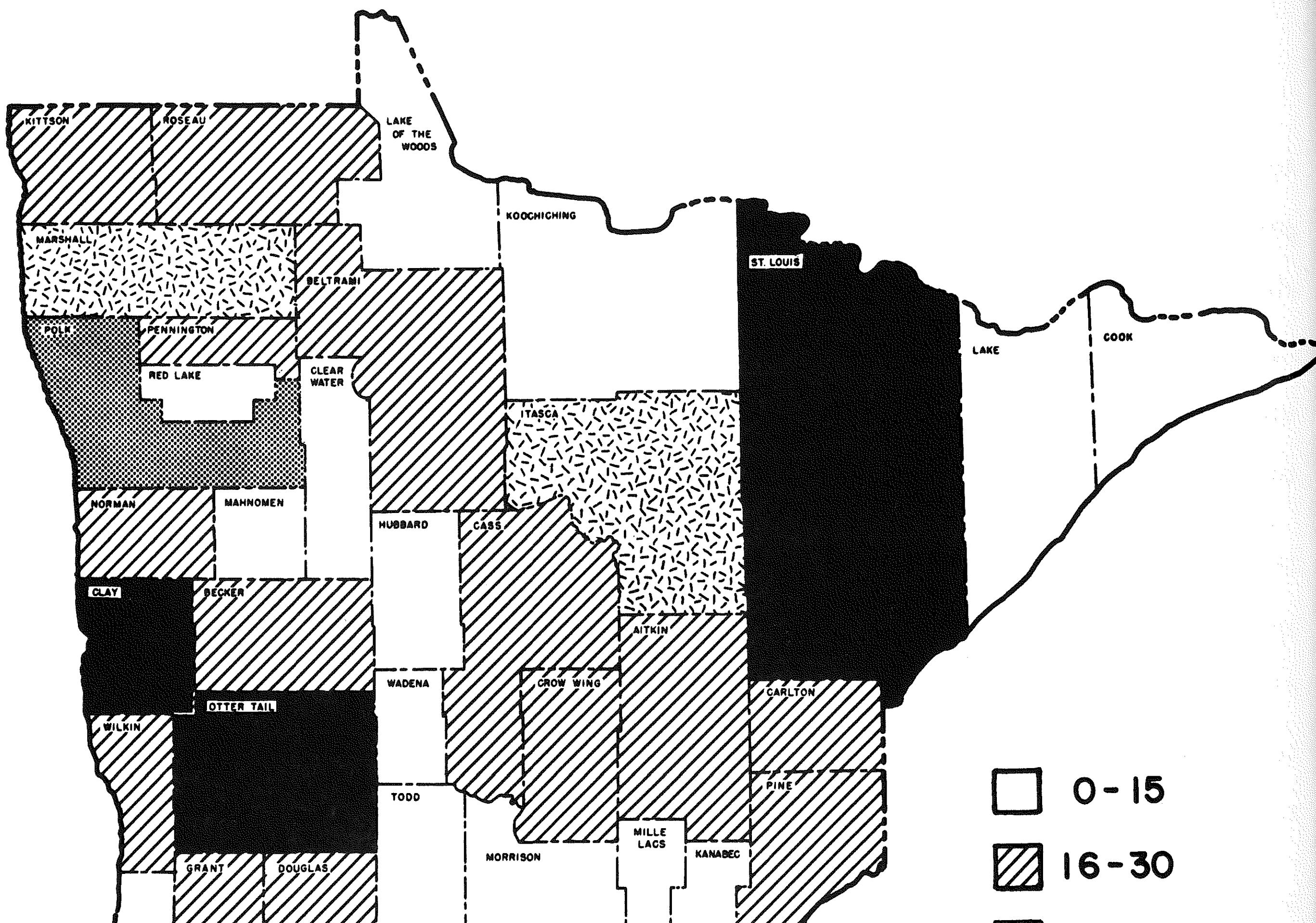


FIGURE 5-15 DISTRIBUTION OF COMMERCIAL AND NON-COMMERCIAL PESTICIDE APPLICATORS

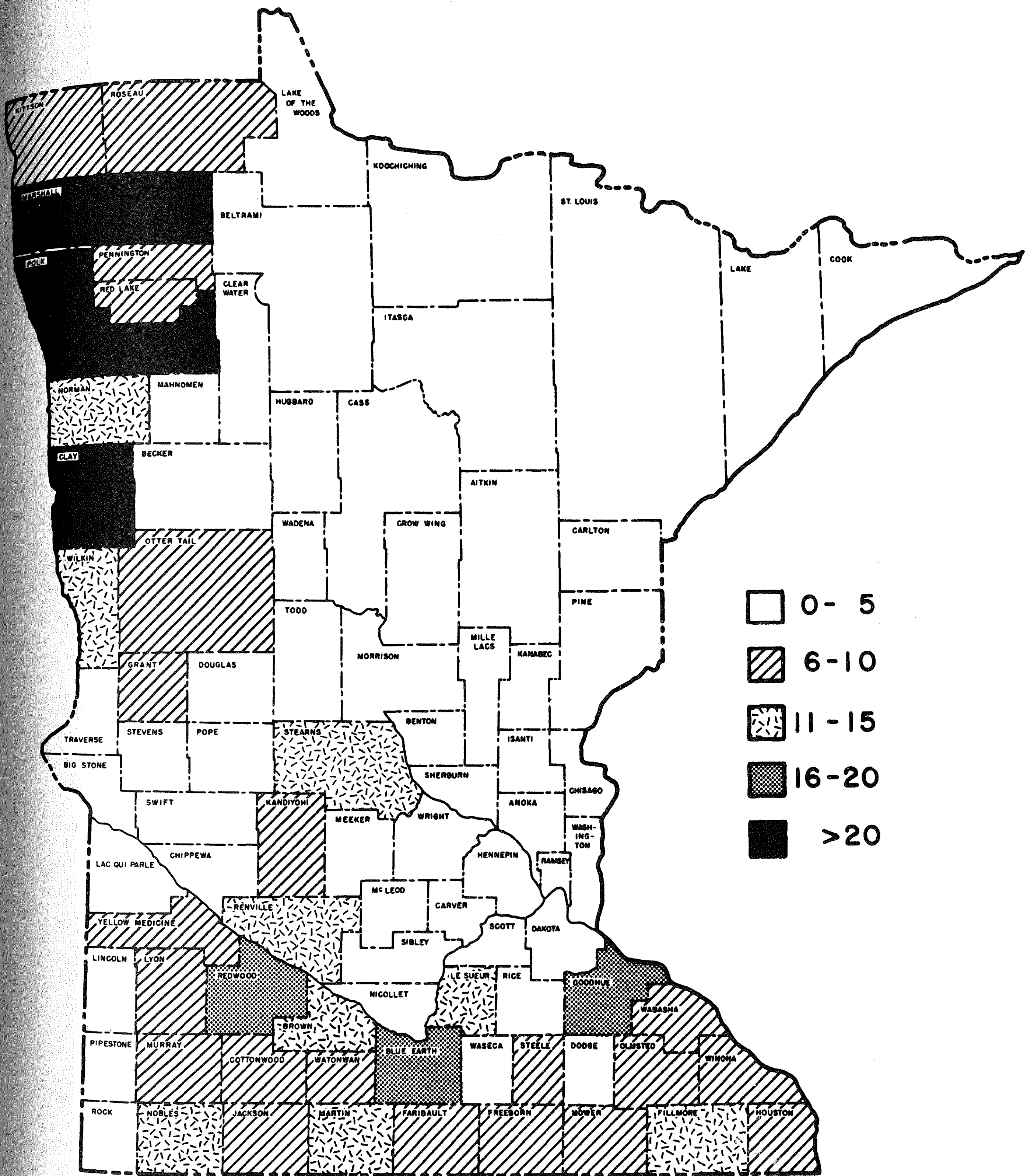


FIGURE 5-16 DISTRIBUTION OF RESTRICTED-USE PESTICIDE DEALERS

indiscriminate dumping of wastes on-site or in dumps and inadequate landfills is a serious threat to the ground water.

- Disposal of incompletely rinsed containers. Even after the contents of containers are emptied into sprayers they contain residual amounts of the product. This residual material can leak from the containers after they are disposed of and contaminate the soils and ground water. This problem can be particularly acute in the karst areas where containers are often dumped in sinkholes. It is recommended that the containers be triple rinsed and the rinse water be used as diluent in the spray tanks. The rinsate should be properly handled. It is estimated that if all of the containers used in Minnesota were properly rinsed, the rinsate itself would represent 20 percent of all the hazardous waste generated in the out-state areas (Barr, 1979).
- Runoff from storage, mixing, loading or container and spray tank cleaning areas. This runoff can infiltrate the soils and cause ground water contamination. Even properly controlled runoff and rinsate can be a problem if underground collection tanks leak to the ground water.
- Fires. A fire at a facility with large amounts of product present can cause contamination if a large amount of water is needed to control the fire. Barr (1980) describes soil and ground water contamination resulting from a fire at Howe, Incorporated in a pesticide and fertilizer storage building in Brooklyn Center. Emergencies such as this are handled by the Agricultural Chemical Emergency Response Team composed of representatives of six state agencies lead by the representative of the MDA.
- Direct injection. Backsiphoning of fertilizers and pesticides from spray

tanks into the well providing the water for dilution and application will contaminate the ground water. Tanks which are being filled should never be left unattended. Check valves should be provided to guard against possible backsiphoning.

- Application and use. Improper application and use of these chemicals can cause widespread problems. Even where properly applied, poor tillage practices may allow for excessive erosion and consequent runoff of these chemicals. Application of excessive nitrogen fertilizers may result in nitrogen moving down through the soils to the ground water.

The potential for ground water contamination to occur depends on the volume and concentration of chemicals released, their mobility and persistence, the physical and chemical properties of the soils and geology and the hydrology of the site. The more serious point source problems are apt to occur when large volumes of materials are improperly handled by commercial and non-commercial applicators and dealers.

In order to assess the impact on the ground water due to pesticides and fertilizers, the following recommendations are made:

1. Inspect the commercial and non-commercial applicators and dealers and review their product handling and waste disposal practices particularly as it relates to equipment cleaning and rinsate control. Where these practices are found to be poor, ground water monitoring should be undertaken to detect or describe the extent of the problem.
2. Expand the number of wells and/or list of monitoring parameters in the ambient ground water monitoring network to include heavily used chemicals in appropriate regions of the state. Use of this system in cooperation with other agencies or individuals who have responsibilities or interests

in this area will lead to a better understanding of the extent of problems that may exist.

3. Encourage/require periodic testing of wells located where these products are mixed, or where tanks are rinsed.

Salt Storage and Application: The stockpiling and application of deicing salts, primarily sodium chloride, can have a detrimental impact on the environment and health as well as roads, bridges, and automobiles. The primary threat to the ground water comes from inadequate storage of stockpiles of salt and sand mixed with salt. There have been no known cases of ground water contamination in Minnesota due to the application of deicing salts, although studies in New England have shown that high salt usage has caused ground water contamination.

There have been numerous documented cases of ground water and surface water contamination caused by runoff from inadequately stored stockpiles of deicing salts. One study estimated that if all storage inadequacies were eliminated, over 80 percent of the reported cost to the environment from the use of deicing chemicals would be eliminated. There are no Minnesota rules which regulate the storage of deicing chemicals, although there may be local ordinances.

In October 1977, MDOT established a policy regarding storage of salt and sand/salt mixtures in order to reduce the potential for ground water and surface water contamination near its stockpile sites. This policy is based on recognized best management practices and requires that:

1. All salt and sand/salt mixtures be placed on bituminous pads which must be sloped to prevent surface water from draining through the stockpiles;
2. All salt piles be covered with polyethylene if not stored in a shed, and

all sand/salt mixtures be moved to empty salt sheds or covered during spring and summer;

3. Any runoff from the stockpiles be contained.

This policy has been widely implemented by MDOT district engineers and area maintenance supervisors.

There are currently 217 sites to which MDOT has salt delivered during the fall and winter (MPCA, 1983). Of the 217 sites, 180 have some type of storage shed(s). At the remaining 37 sites, the salt piles are kept covered with polyethylene at all times and sand/salt mixtures are kept covered during the non-use months. Slightly less than half of the 37 sites do not have bituminous pads. Nearly half of the 37 sites are in the two metropolitan maintenance districts which probably have the largest stockpiles. Regardless of the care exercised in the storing and handling of the stockpiles, the potential for varying degrees of ground water contamination near the stockpile sites exists. Figure 5-17 shows the locations of MDOT delivery locations statewide. MDOT may build small temporary stockpiles at other sites as needed, but they are removed after the spreading season. A survey conducted by the Minnesota House Committee on Transportation, Science and Technology revealed the following about county and municipal storage practices:

	Counties Responding	Storage Method (Percent)**		
	Percent Number	In Building	Under Tarp	In Open
County	77 (66)*	51	13	36
Municipal	54 (52)	38	11	51

*Lake of the Woods County did not use any salt.
**Percent of storage sites where this method is used.

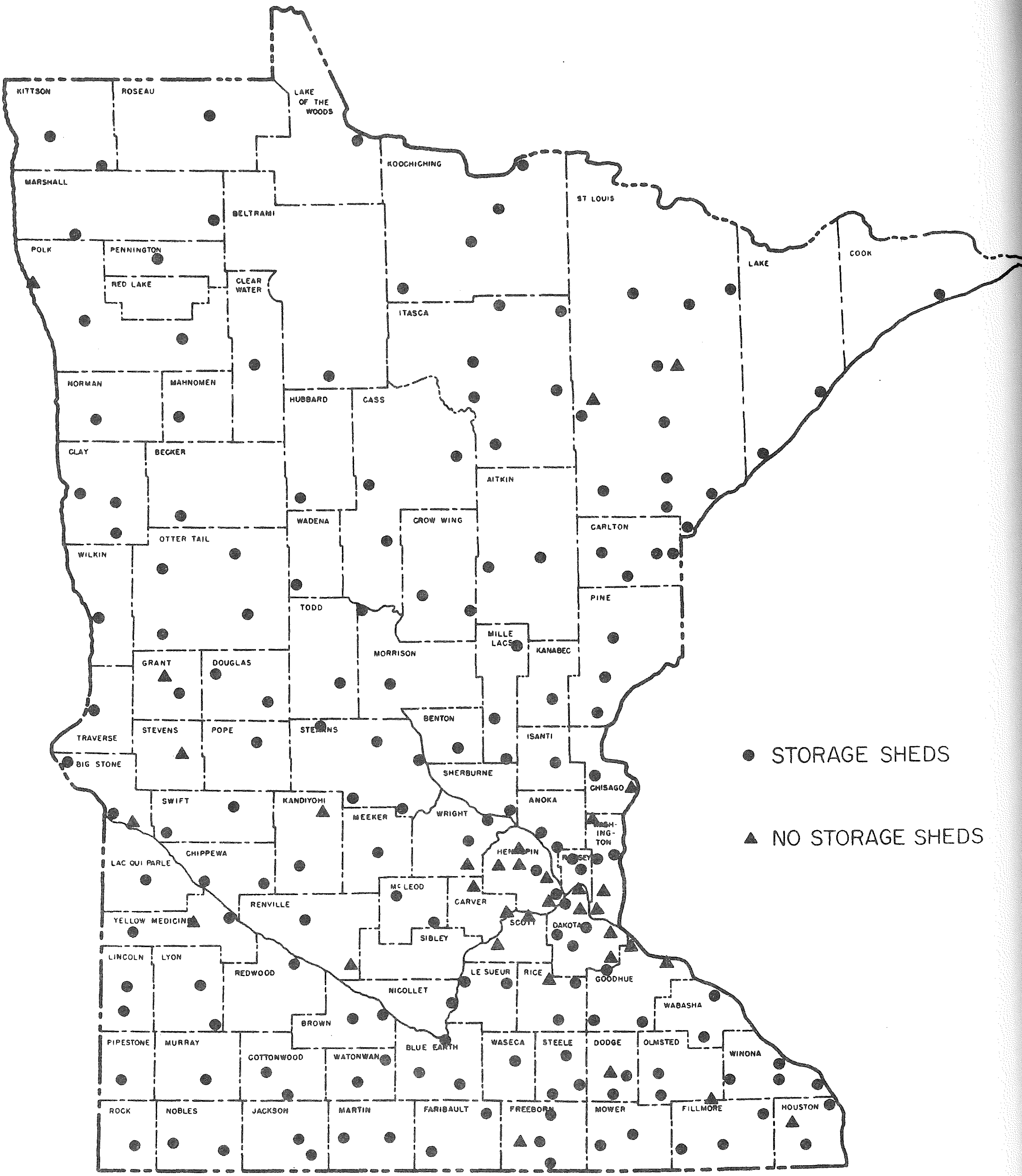


Figure 5-17: Minnesota Department of Transportation Salt Delivery Sites

The pollution potential from county and municipal salt storage should be considered high because of the large percentage of open uncovered sites. Even though there has been no known ground water contamination in Minnesota due to the application of deicing chemicals, this problem has been documented in Massachusetts. The Minnesota Legislature enacted Statute 160.215 in 1971 in an attempt to minimize damage from application of deicing chemicals. The statute established guidelines for the application of deicing chemicals. MDOT believes that their current application rates and procedures are in compliance with the established guidelines and cannot be significantly improved given current technological and fiscal constraints without a detrimental decrease in the level of service provided. MDOT does continue research in an attempt to improve its ice removal practices. County and municipal practices are many and varied and a detailed discussion of them is beyond the scope of this report. Based on the available information, it appears that efforts to assess and minimize the potential for ground water contamination due to deicing chemicals would be best directed towards improving storage practices at those state, county, and municipal storage facilities where they are found to be inadequate. A comprehensive survey of counties and municipalities would be necessary to determine locations and adequacy of storage sites. If there is only one site for each of the municipalities over 5,000 population and three sites per county, there would be 359 sites which would have to be assessed. The addition of the MDOT sites, which are believed to be generally satisfactory, would bring the total to approximately 586 sites. Approximately 20 percent of these 586 sites are estimated to be totally inadequate and would require additional action such as implementation of MDOT storage policies at all levels of government.

Priorities and Investigations

The MPCA has identified many hundreds of sites where ground water contamination has occurred or is likely to occur. Because of the large number of sites which is known to exist and because the MPCA must also maintain staff to develop regulations and permit new facilities to preclude or minimize the possibility of future ground water problems, the fiscal and personnel resources of the MPCA are being increasingly stretched. Accordingly, it is desirable to develop a priority system for investigating known or potential sources of ground water contamination so as to maximize use of limited resources. The following is an example of such a priority system:

Priority	Action
1	Investigate and mitigate where necessary and possible known contamination incidents where there is a threat to public health.
2	Investigate problems where suspected contamination poses a threat to public health.
3	Investigate potential areas of contamination where there is a threat to public health.
4	Investigate and mitigate where necessary any possible known contamination problems which pose a threat to the environment but where there is no recognized threat to public health.
5	Investigate suspected problems which pose a threat to the environment.
6	Investigate potential problems which pose a threat to the environment.

Recognizing the need to address those problems where the threat to public health is considered very serious, the MPCA established a Hazardous Waste Site Response Section within the Solid and Hazardous Waste Division to investigate on a priority basis those sites where that threat is known or strongly suspected to exist. The MPCA also maintains an Emergency Response Team in the Water Quality Division to respond to emergencies involving the spillage of hazardous materials, most frequently petroleum products, where an immediate response can frequently limit the amount of environmental damage and preclude the development of a more widespread problem that could eventually threaten public health.

Maintenance of these functions is essential. At the same time an increased commitment to investigating seemingly lower priority problems, those where only a mildly suspected or potential problem exists, is necessary. All of the currently existing major problems were small and manageable at some time in the past and it is seen as necessary that a more systematic approach be taken to investigating at least on a preliminary basis those sites which are mildly suspected or have the potential to adversely affect the public health and the environment.

Conducting investigations of ground water contamination incidents can be both expensive and time consuming. A "cookbook" approach to conducting these investigations is not possible because of the variability of the problems and the amount and type of information available at any particular time. There is however a logical progression which can be traced through any complete investigation which allows a decision to continue the investigation to be made at several points during the investigation. These decisions are made after various phases of an investigation are complete and certain objectives or goals are achieved. They are as follows:

Phase I. Objective: Determine whether or not a potential problem appears significant enough to warrant the installation of ground water monitoring wells or the sampling of nearby water supply wells.

Phase II. Objective: Determine whether or not contamination of the ground water has occurred or is likely to occur if no action is taken.

Phase III. Objective: Define the total extent of contamination, the potential consequences of leaving the source of contamination in the ground, and the feasibility of removal of the waste and restoration of the aquifer.

Phase IV. Objective: Remove the source of contamination and restore the quality of the aquifer

Phase I: The installation of ground water monitoring wells is usually expensive and frequently accounts for the largest percentage of investigative costs. Their installation must be justified. Phase I involves the collection of a sufficient amount of information to determine whether installation is necessary. The information needed includes a preliminary determination of:

1. Type and amount of waste present;
2. Geology and hydrology of the site;
3. Potential impact of the source on water supplies.

This information may be obtained from a complete review of all MPCA files, on-site inspections, interviews with people familiar with the site, and current and historical records of other state agencies, and water well drillers. At this time it is also desirable to identify the party responsible for the problem for future enforcement purposes.

With this preliminary information in hand, the investigator(s) should be able to make a determination as to whether ground water monitoring is necessary. If further action appears unwarranted and the facility is closed, the files can be removed from the mainstream. If the facility remains active, files should be kept current and the facility kept on the list of active sites being investigated. If ground water monitoring appears justified, then the investigation will proceed to Phase II. The site would now be considered a suspected source. Once this point is reached it may be necessary to rank sites because there may be too many to immediately take to Phase II.

Phase II: Phase II is intended to allow the investigator to determine whether contamination of the ground water has, in fact, occurred. This involves the following:

1. Installation of ground water monitoring wells;
2. Sampling of monitoring wells and/or nearby supply wells;
3. Analyses of collected data.

Phase II requires a refinement of much of the data collected in Phase I. In order to properly locate monitoring wells, detailed information on the hydrogeology of the site and the methods of transport of expected contaminants is required. For instance, some contaminants such as gasoline will float on top of the water table while others may sink to the bottom of the aquifer. If the well screens are improperly located, the contaminated plume may not be detected. Sampling programs must also be tailored to the specific site and require a thorough knowledge of waste constituents and volumes. Unfortunately, the latter is often the most difficult area to define, especially for landfills and dumps which frequently contain more than household refuse. There is often little or no information available.

MPCA procedures for obtaining approval for monitoring systems should be followed. Figure 5-18 indicates the flow of the approval process. If no contamination is detected, then a routine monitoring program can be established and the results periodically reviewed. If contamination is detected, then the investigation will proceed to Phase III and the site is moved into the category of known contamination.

Phase III: Phase III is intended to determine the extent and potential consequences of the contamination. If nearby supply wells are contaminated or if it is shown that this is likely to occur in the future, alternate supplies or contingencies should be established. Phase III will generally require an extensive hydrogeologic study of the area which has been or may be impacted. Results of Phase III can be used in the development of Phase IV.

Phase IV: Phase IV involves removal of wastes and restoration of the aquifer if feasible. There are incidents where the wastes are readily identifiable and relatively easily removed. In cases such as this, it may be desirable to remove the waste as soon as possible (during Phase I for example) and then proceed to determine if there have been any adverse effects. In the case of landfills and dumps, removal may be impractical, in which case, other mitigative measures must be considered. Based on the results of Phase III it should also be determined whether restoration of the aquifer is necessary or possible and if so, to proceed with that.

Financial Responsibility:

As stated earlier the responsible party should be identified as early as

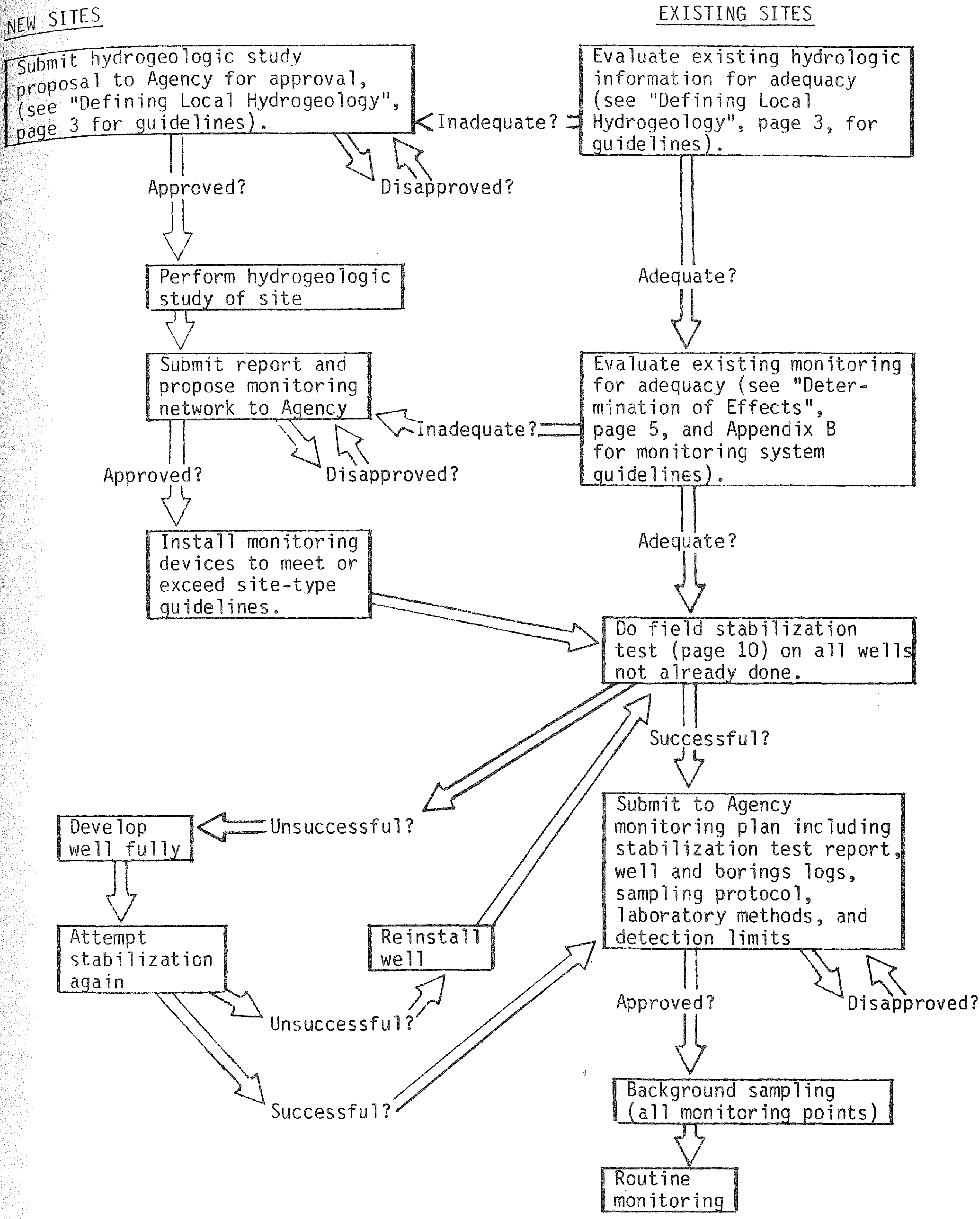


Figure 5-18: Flowchart for Obtaining MPCA Approval for a Ground Water Monitoring System

possible. Studies needed in Phases II through IV are very expensive and most regulatory agencies do not have the financial resources to conduct them when they are necessary. These ground water impact studies must be generally done at the expense of the responsible party. Even when responsible parties are identified however, they may prove uncooperative and cause long delays in resolving a problem. Time lost in postponing investigative and remedial action only compounds the problem by allowing continued spreading of contaminants. In cases where the responsible party is uncooperative or where none can be identified the state superfund bill will allow investigation and cleanup to proceed without unnecessary delay.

Summary

This report was prepared as part of the ground water protection strategy framework being developed by the MPCA in conjunction with other state agencies. Potential sources of ground water contamination in Minnesota are identified, their impact on the ground water is discussed and they are enumerated where possible and practical.

A clear picture of the overall extent of ground water contamination in Minnesota does not exist. The primary reason is that statewide ground water monitoring programs at waste disposal and other facilities are relatively new and a long-term source of data from which to draw information and base conclusions is unavailable. Existing regulations for ground water monitoring programs at waste disposal facilities are generally vague, sometimes ignored or poorly implemented and infrequently enforced. As the general awareness of the effects of waste handling and disposal on ground water has increased, ground water monitoring requirements have been given a higher priority, both in permitting new facilities and in enforcing requirements for existing facilities. There are, however, many existing waste disposal and treatment facilities both abandoned and operating for which no ground water monitoring data exist. An increased emphasis on the implementation and enforcement of ground water monitoring programs would be needed to fully assess the extent to which these facilities have contaminated ground water.

A systematic approach to characterizing the ambient quality of ground water in the state's principal aquifers has been undertaken by the MPCA in the past five years. Results indicate that concentrations of those parameters for which primary drinking water standards exist are significantly less than those standards, some by order of magnitude. However, in some areas, contamination of these same aquifers is resulting from both waste disposal activities and non-disposal activities. The type and extent of this contamination varies considerably. It may be relatively minor, affecting no more than a small area around an old rural dump to widespread, serious incidents forcing closure of certain municipal wells, as in the St. Louis Park and New Brighton suburbs of the Twin Cities. Contamination of ground water may even occur regionally, due to a unique geologic environment and involving many sources of contamination which individually may present only a minor problem, but when viewed collectively take on a greater significance. The karst area of southeast Minnesota is an example of a part of the state where regional ground water quality degradation is a concern. Finally, there is the danger of potential widespread degradation of ground water in areas such as the seven county Twin Cities metropolitan area where a plethora of industrial and other facilities exist which have the potential to contaminate the ground water.

Waste disposal facilities which can contaminate the ground water include landfills and dumps, surface waste impoundments, agricultural feedlots, land application systems for municipal and industrial wastes, individual and community septic systems, sludge disposal areas for municipal and industrial wastewater treatment facilities and other miscellaneous facilities. Nondisposal activities which may cause ground water contamination include spills and leakage of liquid material (frequently petroleum products) during transportation and storage and the improper handling, storage or use of pesticides and fertilizers, as well as road deicing salt. Table 5-9 summarizes the facilities known or estimated to exist in Minnesota which may have the potential to contaminate ground water. Figure 5-19 depicts this information graphically.

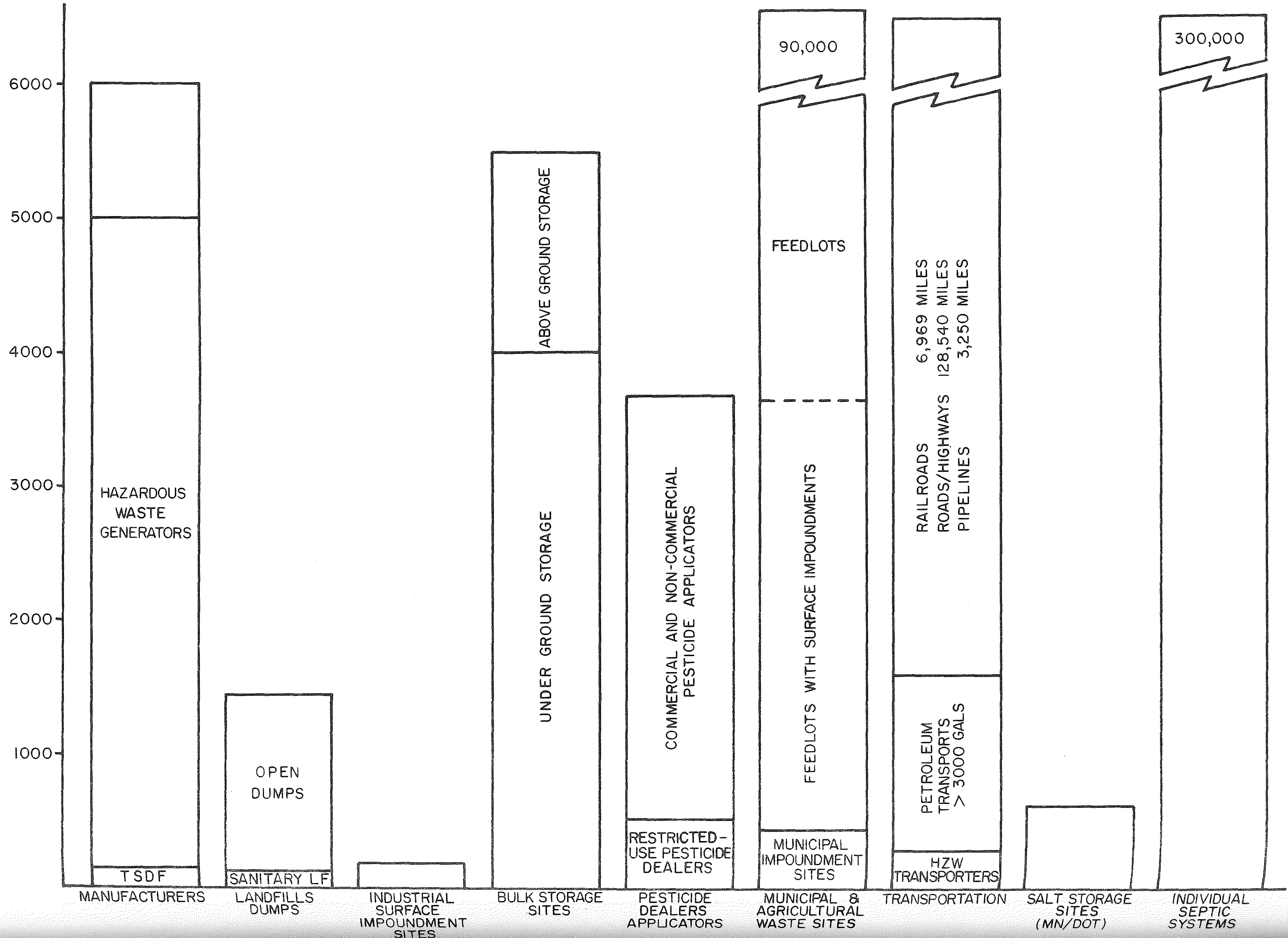
The distribution of some of these facilities holds as much significance as their numbers. Approximately two-thirds of all the hazardous waste produced in the state is generated in the seven-county Twin Cities metropolitan area and about 17 percent is generated in the southeastern part of the state. It is likely that landfills and dumps in these parts of the state have received a greater amount of hazardous waste than in other areas. In addition, the amount of on-site disposal of waste and location of random disposal areas is also likely to be greater in these areas. The distribution of hazardous waste sites under investigation by the MPCA follows this pattern. More than half of the 61 sites currently under investigation are in the seven-county Twin Cities metropolitan area. The distribution of landfills and dumps in the state is relatively even, although the size of these facilities tends to be larger near the more heavily populated areas. Municipal waste impoundments and salt storage stockpiles also tend to be somewhat evenly distributed statewide.

TABLE 5-9

POTENTIAL SOURCES OF GROUND WATER CONTAMINATION IN MINNESOTA

Type of Facility	Number of locations
Manufacturing	6000
Hazardous Waste Generators	5000
Hazardous Waste Treatment, Storage and Disposal Facility	139
Landfills and Dumps	
Sanitary Landfills	127
Unregulated Dumps	1274
Surface Waste Impoundments	
Industrial	173
Municipal	415
Agricultural	3500
Mining	158
Land Application and Large Septic Tank/ Drainfield Systems	
Industrial	60
Municipal	163
Individual Septic Systems	300,000
Bulk Liquid Storage	
Above Ground	1500
Under Ground	4000
Agricultural	
Feedlots	90,000
Commercial and Noncommerical Pesticide Applicators	3,163
Restricted - Use pesticide Dealers	544
Salt Storage	
MnDOT	217
County/Municipal	359
Transportation Lines	
Pipe Lines	3,250 miles
Streets and Highways	128,540 miles
Raillines	6,969 miles
Municipal Sludge	300,000-350,000 tons 1,000 sites

Figure 5-19: Potential Sources of Ground Water Contamination in Minnesota



Relatively few of the facilities listed in Table 5-9 have ground water monitoring systems specifically designed to detect contamination should it occur. Some of the categories do not require permits and even some of those which do, have no ground water monitoring requirements. Only about five percent of all the landfills and dumps in the state have adequate ground water monitoring systems. These are nearly all at permitted facilities, although only about half the permitted mixed municipal waste (sanitary) landfills have adequate systems. Virtually none of the unregulated dumps have or had any monitoring. As such, there is little or no information on the effect these old dumps have had on the ground water.

Ground water monitoring at facilities with surface waste impoundments is largely tied to seepage rates. A study of municipal impoundments has shown that a seepage rate of less than 500 gallons per day per acre of primary pond will provide adequate protection for the ground water (Hickok, 1978). However many industrial contaminants such as solvents will migrate even through very low permeability soils. Although hazardous waste regulations now require total containment of hazardous wastes discharged to surface impoundments, many existing facilities were not constructed to these standards. A preliminary review of the potential for ground water contamination from surface impoundments was conducted in 1979. Follow-up was initiated on those sites which had the highest contamination potential, however, a complete review of all industrial impoundments is needed.

Ground water monitoring requirements for larger septic systems are poorly defined. Design criteria being applied are those developed for individual systems and questions concerning the effectiveness of the larger systems still exist. Because more of these systems are being proposed, there is a need for a comprehensive review of design criteria and monitoring requirements.

A regulatory program for underground storage of liquids which do not fall under hazardous waste regulations is urgently needed. The MPCA currently has no regulatory program for these facilities although revision of the current regulation for above ground storage to include under ground storage is underway. Studies have indicated that 25 to 50 percent of all underground storage tanks leak. If this is true in Minnesota, there may be 1000 to 2000 locations where this is currently occurring. A higher priority should also be given to the permitting of above ground storage facilities. Currently only about 45 percent of the existing facilities in Minnesota have permits.

The greatest problem affecting ground water quality in Minnesota may be the unregulated and unauthorized disposal of hazardous wastes. As previously stated, MPCA is currently investigating 61 sites on a high priority basis. Ten of these sites are on the national priority list of sites eligible for federal "superfund" money. At nearly 60 percent (36) of these sites, the ground water is contaminated by volatile hydrocarbon compounds. Most of the problems exist as a result of on-site disposal of the hazardous material. Approximately 40 percent of the sites are evenly divided between known off-site landfills and dumps and random, previously unknown disposal areas.

Recent sampling of landfill leachate and ground water at many landfills where there is no known history of disposal of industrially generated hazardous wastes has also revealed the presence of many of these organic compounds. A systematic approach to investigating the 1,421 landfills and dumps in the state to determine the extent of these problems is needed, as is a more concerted effort to identify many of the currently unknown locations where disposal of these wastes has taken place.

Through programs being developed as a result of recent federal and state legislation, the tools exist to prevent future occurrences of the problems Minnesota is currently experiencing. It is obvious, however, that a considerable future commitment of resources is needed to effectively address the consequences of past waste disposal practices.

CHAPTER 5

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CHAPTER 6

SITE-SPECIFIC GROUND WATER QUALITY MONITORING PROGRAMS

Introduction

Although monitoring of ground water quality is primarily a Minnesota Pollution Control Agency (MPCA) responsibility, such monitoring does take place within several other agencies in the state. The Department of Health (MDH) regularly monitors public water supplies to determine their compliance with requirements of the Safe Drinking Water Act of 1974 (P.L. 93-523). The Department of Natural Resources (MDNR) has historically participated in cooperative agreements with the U.S. Geological Survey (USGS) for area or regional aquifer assessments which have included analysis of ground water quality sampling results. Recent examples of such programs may be found in USGS publications by Miller (1982), Myette (1982) and Guswa, Siegel & Gillies (1982). The Minnesota Geological Survey (MGS) has coordinated several water quality studies. One large program conducted recently included results from 5000 wells in Minnesota sampled as part of the U.S. Department of Energy's National Uranium Evaluation (NURE) study. In addition, MGS has a cooperative program with MDH whereby MGS collects samples for MDH which are run by the MDH lab for standard water chemistry parameters. MGS then runs radioisotope studies on these same samples. The Department of Agriculture (MDA) and Minnesota Department of Transportation (MDOT) also conduct limited ground water quality monitoring in support of their respective programs. Finally, there are several well-equipped county health laboratories which analyze ground water samples in support of programs within their areas of jurisdiction. St. Louis and Olmsted Counties are two such examples.

MPCA Ground Water Quality Monitoring Programs

At present, MPCA operates four site-specific ground water monitoring programs in addition to the ambient programs discussed in Chapter 4. These are:

1. Landfill monitoring required by Solid Waste permits
2. Monitoring of impoundments and land application sites required by State Disposal System (SDS) or National Pollutant Discharge Elimination System (NPDES) permits,
3. Monitoring of uncontrolled hazardous waste sites required by the Site Response Section of the Solid and Hazardous Waste Division (DSHW).
4. Monitoring of spills and leaks required by the Emergency Response Unit of the Water Quality Division (DWQ).

Problems resulting from a lack of consistently applied quality assurance requirements may be common to each of the above monitoring programs. These problems may include poor or improper well construction, inconsistent or inadequate sampling techniques and poor laboratory quality control. Steps are being taken to correct these problems, and these are discussed in detail later in this chapter.

The most important output resulting from this element of the Ground Water Protection Strategy Work Plan is a ground water monitoring guidance manual (MPCA, 1983) which sets out criteria for well construction, sampling techniques, laboratory quality assurance and recommended monitoring programs for a variety of site-types.

Another problem shared by at least the first two programs has been a lack of consistency in application and approach by MPCA. Changes in emphasis within DSHW, particularly, have been frequent within the last three years. These shifts in philosophy have caused the monitoring programs to appear to be disorganized to the regulated community. There is a strong need for an extended period of stability, to allow the programs to operate consistently and to allow their weaknesses to surface and be corrected.

Permit-Required Landfill Monitoring/Recommendations: The permitted landfill monitoring program is managed by the DSHW Regulatory Compliance Section. Minnesota Rule SW-6 (2) requires that sanitary landfills monitor ground water, but this requirement has not been uniformly applied. Most landfill monitoring systems are not adequate for the early detection of leachate, but many will function for the eventual detection of leachate. Other monitoring systems focus on monitoring water supply wells surrounding landfills, thus providing some degree of protection to local water users. A few sites have no monitoring at all. This lack of uniformity in monitoring is due to changing requirements as technology progresses, and changes of staff and monitoring philosophy over the years. Finally, there is no routine program for the monitoring of the over 1400 closed, partially-closed or open solid waste disposal sites which operate or have operated in Minnesota at one time.

Site permittees are responsible for the collection and analysis of the samples. They submit the data to Regulatory Compliance section staff who maintain manual data logs. Data review and interpretation occurs at this time. The data then goes on to the clerical staff who are responsible for data entry into the Solid Waste Facility Inventory and Monitoring System (SWFIMS), a computerized data base for solid waste permit information and water monitoring data. It is maintained currently in the University of Minnesota computers, and is described in more detail in Appendix A to this report.

Specific recommendations for improving the landfill monitoring program include:

1. implementation of a quality assurance program,
2. standardization of monitoring system requirements,
3. vigorous and consistent enforcement of the above requirements to be coupled with definitive rules for ground water protection, and
4. designation of staff whose primary responsibility is data review and interpretation.

<u>SDS and NPDES Permit Monitoring/Recommendations</u>: Ground water monitoring may also be a requirement of SDS or NPDES permits. Initial review of these projects is handled by the Technical Review Section of DWQ. If their review reveals the potential for significant ground water impacts, the project is sent to the hydrologists of DSHW, who set monitoring requirements. This extended review procedure leads to delays and inefficiencies, which are often complicated by the unfamiliarity of SHWD staff with waste water treatment and disposal systems.

The monitoring systems at many such sites are adequate to detect seepage or changes in water quality. However, the files are incomplete or difficult to locate, which makes review of the data submitted time-consuming and frustrating. Much work is needed to get the monitoring data for these sites organized. Review of the routine ground water monitoring data is handled by the DWQ. The data is maintained in manual files by the Enforcement Section of that Division, and is not computerized.

Since little emphasis has historically been placed on quality control, permittees required to monitor ground water are often not familiar with the correct procedures and methodologies for monitoring. Quality assurance is therefore a problem in this program, much as it has been in the solid waste site monitoring program.

The effectiveness of this monitoring program would be improved by:

1. Addition of ground water hydrologists to MPCA staff who are familiar with design and operation of these systems and responsible for their ground water quality data analysis and interpretation.
2. Establishment of a consolidated data base containing:
   a. monitoring locations,
   b. monitoring requirements,
   c. well construction details, and
   d. water quality data.
3. Computerization of the information in 2. above,
4. Implementation of a quality assurance program, and
5. Vigorous and consistent enforcement of the monitoring requirements, to be coupled with detailed rules for ground water protection.

Uncontrolled Hazardous Waste Site Monitoring/Recommendations: In 1980, a Hazardous Waste Site Response Unit (SRU) consisting of investigative and technical positions, was established within DSHW to locate and begin cleanup of uncontrolled hazardous waste sites. These sites are generally unregulated disposal sites which have taken hazardous wastes in the past. Serious ground water contamination has resulted from many such practices. The unit has recently been expanded to a section within DSHW and given added positions and responsibilities.

A major portion of the section's responsibilities involves ground water monitoring.

Most of the data they work with is generated by the parties responsible for the dumping, and therefore they often experience the same problems with quality assurance as the other programs. To deal with these problems, they often split samples with the responsible parties for analysis by the MDH. This is a costly program, especially when dealing with organic contaminants. Other problems frequently encountered are those of improperly constructed wells and poor sampling techniques, both of which could be substantially corrected by the implementation of a quality assurance program.

The ground water data generated from this program is maintained manually in notebooks and is not computerized. Each staff person maintains the files for the individual sites for which he or she is responsible. There is no centralized filing system for this group, making access to ground water quality information difficult.

Recommendations for improving this program include:

1. implementation of a quality assurance program, and
2. development of central files, and a computerized water quality data base.

<u>Monitoring of Spills and Leaks/Recommendations</u>: Cleanup of spills and leaks of petroleum materials and PCB's is the responsibility of the Emergency Response Unit of DWQ. Due to the limited number of waste types and cleanup projects dealt with by this unit, quality assurance is not felt to be as great a problem in this program as in the others.

Staff of this unit are quite experienced in spill containment and cleanup. A possible weakness of the spills program is the absence of trained hydrologists in the unit. Long-term or widespread leaks may affect more than the uppermost aquifer, and great care must be taken to ensure that the deeper aquifers are protected and rehabilitated if necessary. Specialized training is needed to provide the necessary level of expertise.

Data collected by the group is maintained in centralized manual files, and is not computerized. This program has been long-running and fairly stable in management. The recommendations made to improve the program are:

1. Addition of hydrologists to the staff, or moving the unit to a part of the MPCA where hydrologists are available, and
2. Computerization of the data to facilitate project tracking and water quality data review.

Ground Water Monitoring Guidance Manual

The problems with quality assurance and lack of consistency in programs emphasize the need for MPCA to provide guidance to the regulated community. One of the outputs of the Ground Water Protection Strategy Work Plan is the manual "Procedures for Ground Water Monitoring: Minnesota Pollution Control Agency Guidelines" (MPCA, 1983). It is a technically oriented document for use by hydrologists, geologists and engineers responsible for designing or upgrading on-land disposal systems. The topics covered include:

- source of quality control,
- objectives of monitoring,
- monitoring system design,
- monitoring well construction and sampling,
- installation and sampling of lysimeters,
- collection of surface water and drinking water samples,
- field measurements,
- establishing a sampling protocol,
- laboratory requirements,

- reporting requirements, and
- guidelines for monitoring various types of disposal sites.

It is hoped that, by having guidelines on these various topics available for distribution, better communication of MPCA's objectives regarding ground water monitoring will be established in the regulated community. The document will also provide guidance to MPCA staff who deal with monitoring programs, enabling MPCA to present a unified approach to ground water monitoring.

Current research and publications formed the cornerstone to development of the manual. Staff input was obtained through an initial questionnaire, then formal and informal review and comment periods on several draft versions of the document. Review and comment was also solicited from many persons outside MPCA including the Ground Water Protection Strategy Work Group, MDH staff and many independent consultants.

Issues in Ground Water Monitoring/Recommendations

Several areas of ground water monitoring are controversial and deserve further attention. Recommendations made in the ground water monitoring procedures manual should be tried, and, as appropriate, become firm policy which is rigorously and consistently applied. Key issues include:

1. Monitoring objectives -- It is often not clear to the regulated community that monitoring is not an end in itself. A clear position needs to be taken, emphasizing that monitoring is simply a yardstick to be used to measure the effectiveness of engineered pollution abatement

projects. Follow-up corrective-action must be taken when contamination is observed.

2. Monitoring network design -- Currently, there is little consistency in the placement of the monitoring devices intended for the detection of contamination. Detection monitoring, that is, monitoring at the closest possible point to the downgradient edge of the waste management area, is the most stringent approach of any applied. This policy, if consistently applied to all sites, would greatly enhance the effectiveness of monitoring systems statewide.

3. Monitoring requirements -- Inconsistency in monitoring requirements among facilities leads to confusion in the regulated community regarding MPCA requirements. Site-type requirements for monitoring parameters and frequency of sampling should be established and consistently applied.

4. Quality assurance -- As pointed out in the program descriptions earlier in this chapter, quality assurance in monitoring is a major problem facing MPCA. MPCA programs are impacted by the programs of MDH, specifically the monitoring well construction rules currently being written and the much-needed certification procedure for chemistry laboratories, similar to the program operated for the certification of bacteriological tests under the Safe Drinking Water Act (PL 93-523). MPCA involvement in these programs is essential, and to date has not been rigorously sought. In addition, the MPCA needs to provide clear guidance to the regulated community as to who may collect samples and what procedures they should follow.

The latter three issues are addressed in the guidance manual, which may aid in fostering uniformity in the areas needing consistency. The manual, however, contains only recommendations and does not have the force of rules. A rigorous and consistent approach toward application of recommendations is necessary. Rule revisions to upgrade the recommendations to requirements should be considered at a later date.

The first issue, that of monitoring objectives, must be dealt with in another format. Once contamination is discovered to be leaving a facility, the need is evident to ensure that ground water will be protected. For example, ponds which leak in quantities great enough to affect surrounding water quality should be re-sealed to lower the rate of leakage. Leachate should be collected, so that landfills do not have an opportunity to leak. A policy should be set as to what set of factors triggers follow-up action. If the MPCA begins a policy of requiring cleanup of polluting facilities, greater ground water protection and public confidence will result.

Monitoring network design is one of the most critical factors in monitoring effectiveness. The move toward detection monitoring would be a great improvement. Upgrading of many monitoring systems is necessary. A policy of unilaterally requiring upgrade of systems for all facilities (as over a two-year period) would be very controversial, however. A less controversial approach would be to require upgrading of sites individually as permits come up for review. In either case, upgrading of the monitoring network should be the first step before increasing any other monitoring requirements.

A corollary to monitoring network design is determining the characteristics of the aquifers potentially affected. There are tests which can be conducted on monitoring wells which give information as to aquifer characteristics and proper sampling protocol. These tests have not been required in the past, but are included in the new guidance manual. By consistently requiring these tests to be done, the MPCA would improve the value of the monitoring data submitted.

The tests discussed in the manual are the stabilization test and the recovery rate test. In the stabilization test the well is pumped at a steady rate and temperature, pH and specific conductance measured at five minute intervals until three successive readings yield essentially equivalent values. Water levels are also measured at five minute intervals, and the cumulative volume of water removed from the well is recorded. Information gained from the stabilization test includes data on yield characteristics and drawdown for the aquifer, and also provides a basis for establishment of a sampling protocol for each individual well. Stabilization testing is done at each well in MPCA's ambient monitoring program, a more detailed discussion of which is given in Chapter 4.

The recovery rate test is to be used for wells where the recharge rate is too low to allow the use of a continuously-pumped stabilization test. Water levels are measured, the well casing is emptied of water and water level readings are taken at regular intervals until the initial pre-evacuation water level is reached. Temperature, pH and specific conductance are measured at the start and finish of the test. From this test, the rate of recovery and aquifer yield characteristics can be determined.

In an attempt to foster uniformity in monitoring requirements among like facilities, Appendix B of the guidance manual sets out basic guidelines for the number of monitoring points, parameters to be tested and frequency and duration of sampling. The number of monitoring points is intended as a minimum, to be adjusted as site conditions dictate.

MPCA believes it is necessary to provide waste-specific information on contamination to protect the state's aquifers from widespread degradation. Under this approach, less emphasis is placed on choosing parameters for their significance to human or animal health. If vigorous and effective follow-up action is taken to upgrade facilities once the data show contamination to be leaving the site, human and animal health will be protected. The reader is directed to the last section of this chapter on selection of monitoring parameters and to the draft manual for specific guidelines.

Guidelines on parameters for non-routine landfill monitoring represent a departure from the sole reliance upon indicators. Since landfills contain such a variety of wastes, many compounds with possible human health impacts may be present in landfill leachates. For that reason, an expanded list of parameters (notably metals and volatile organics) are recommended at the first sampling and every other year after that, so that background levels and trends or increases can be tracked over time.

The requirement for the biennial analysis of volatile organics is the most controversial item on the expanded list. This is because the test is costly ($90 - $200 per sample depending on the laboratory chosen, at current costs), and drinking water standards for the compounds included in a volatiles scan have not been firmly established. Yet many of the compounds are priority pollutants, some are carcinogens, and the MPCA has been developing a data base which shows that all landfill leachates contain at least some of these compounds. The most commonly found compounds (in greater than 50% of the leachates tested) include: acetone; 2-propanol; benzene; toluene; ethyl benzene; xylenes; methylene chloride; 1,1-dichloroethane; trans-1,2-dichloroethylene and 1, 1, 2-trichloroethylene. A recent study at a landfill in a clay-rich environment (Hickok, 1983) shows that while metals may be attenuated, organics are not retained by clay soils (see Chapter 7). Therefore, requiring volatiles to be analyzed provides a greater degree of protection to aquifers and water supplies.

In the past, most facilities were required to collect samples on a quarterly basis. The guidance manual now recommends sampling three times a year (April, July and October) at landfills, quarterly sampling at large drainfields and site-by-site determination for other types of facilities. The reason for the cut back on landfill monitoring is the fact that leachate is generated when precipitation infiltrates the landfill cover. Frozen soil prevents this from happening in the winter, so leachate generation will decline. Large drainfields, by contrast, have high loading rates to ground water in all seasons of the year, so quarterly monitoring is required.

Three topics dominate the issue of quality assurance in ground water monitoring programs. These topics are:

- monitoring well construction
- sample collection, and
- sample analysis

Monitoring well construction is a critical issue. Improperly constructed wells can obscure the meaning of analytical results and potentially jeopardize ground water quality by providing conduits for the transport of contaminants to lower levels. The MDH is writing regulations governing the construction of monitoring wells, under the statutory authority provided by Minn. Statutes 156A.03.

Sample collection is another important topic. Currently the MPCA has no statutory or regulatory authority to require that samples be collected by trained operators or trained laboratory personnel or consultants. Neither is there any voluntary training program in the state currently for instruction in the collection of samples. A small part of the MPCA operator training and certification program is devoted to monitoring, but, by its nature, the course content is quite basic. The overall monitoring program would benefit if facility operators and/or permittees utilized persons with appropriate expertise to collect samples. Since analytical results from improperly collected samples can be quite confusing and misleading, special emphasis needs to be placed on this area of ground water monitoring. The guidance manual discusses the various techniques in detail, but face-to-face training to all involved would be much more effective.

Of equal concern to quality assurance in sample collection is quality assurance in laboratory analysis. The best way to establish a regulatory framework to deal with this issue will be to set up a state certification program for the certification of chemistry laboratories. A similar program is currently operated under the MDH for certification of bacteriological laboratories under the Safe Drinking Water Act and has done much to improve quality assurance when bacteriological tests are required.

Ground Water Monitoring Parameter Justification

The final topic of concern in this chapter is justification of monitoring parameter selection. Although Appendix B of the draft monitoring manual specifies monitoring parameters for a variety of waste management facilities, it is appropriate to use mixed municipal waste (sanitary) landfills as an example both because of the number of landfills with monitoring systems in-place and because of the strength of landfill leachate relative to that generated by other waste management systems.

Landfill leachate is generated when water percolates through a landfill, dissolving soluble components of the refuse and flushing out any liquids present. Leachate is much more concentrated than municipal wastewater and varies significantly from site to site, over time, and even from place to place in a landfill depending on the type and age of wastes deposited. It presents a complex matric which commonly contains elevated levels of toxic metals and organic compounds. The levels of toxic metals and organics are often higher than maximum limits set for these components.

As well as being harmful to human and animal health, leachate is a highly repulsive liquid, characterized by strong odor, dark color, and a thick foamy texture. Its presence would not long be tolerated in receiving streams or water supplies, even if the limits for individual constituents were not surpassed.

Due to Minnesota's humid climate, innate landfill design limitations, and past or ongoing landfill operational problems, leachate is expected to be produced at all Minnesota landfills. For that reason, monitoring is required in the MPCA regulations governing landfills. The MPCA has a policy of requiring that each landfill monitor for parameters indicative of leachate contamination, rather than monitoring for all parameters with possible health significance.

Selection of Monitoring Parameters: Generally, the choice of parameters to be monitored is based upon selection of those parameters which will serve as indicators of contamination from the waste types disposed at a site. This should provide waste-specific information on contamination to protect the aquifer from widespread degradation. Historically, no emphasis has been placed on choosing parameters for their significance to human or animal health. If vigorous and effective follow-up action is taken to upgrade facilities once the indicators show contamination to be leaving a site, human and animal health will be protected.

Guidelines on parameters for landfill monitoring represent a departure from sole reliance upon indicators. Since landfills contain such a variety of wastes, many compounds with possible human health impacts may be present in landfill leachates. For that reason, an expanded list of parameters (notably metals and volatile organics) are to be analyzed at the first sampling and every other year thereafter so that background levels and trends or increases can be tracked over time.

The expanded list of parameters for landfill monitoring in the manual includes:

Alkalinity	Manganese, Dissolved
Ammonia Nitrogen*	Mercury, Dissovled
Arsenic, Dissolved	Nitrate+ Nitrite, as N*
Cadmium, Dissolved	pH*(1)
Calcium, Dissolved	Potassium, Dissovled
Chemical Oxygen Demand (COD)*	Sodium, Dissolved
Chloride*	Specific Conductance*(2)
Chromium, Total Dissolved	Sulfate*
Copper, Dissolved	Suspended Solids, Total
Dissolved Solids, Total	Temperature*(2)
Iron, Dissolved*	Volatile Organics(3)
Lead, Dissolved	Zinc, Dissolved
Magnesium, Dissolved	Water Elevation*(4)

*Parameters recommended for routine monitoring.

(1)Two measurements: in field, immediately after obtaining sample and in laboratory.
(2)As measured in field.
(3)Halogenated and non-halogenated, purge-and-trap method.
(4)As measured in field before pumping or bailing.

Historically, the routine parameters included pH, specific conductance, chloride, COD and either ammonia or nitrate. Iron and sulfate have been added to the list, and both ammonia and nitrate-nitrite are now to be required. An expanded list of parameters which did not include volatile organics had previously been required when a new well was put into service, but was not required regularly thereafter. Temperature and water elevations had been and continue to be required.

Use of Indicators: An example of a test which had long been used successfully as an indicator of contamination from domestic wastes is the fecal coliform test. The organisms specifically detected in this test are Escherecia coli (E. coli), which are present in human and animal excrement in great numbers. They are considered harmless in and of themselves. Also present in excrement are various pathogenic organisms including many types of bacteria, viruses and other parasites, which are not harmless.

Testing for E. coli is more simple and less costly than testing for the pathogens. E. coli are often more abundant in the intestinal tract and more persistent in the environment than are many of the pathogens. Since E. coli is specifically an intestinal organism, it is not found in waters not contaminated with fecal materials. These facts make the fecal coliform test valuable as an indicator of water contamination from domestic wastes. When E. coli are present, it is assumed that intestinal pathogens may also be present.

A similar philosophy can be applied to landfill leachate indicators. Elevated levels of the indicators in downgradient wells may not be inherently harmful. However, the levels of toxic compounds may also be increasing and therefore be greater cause for alarm. Limits for toxic compounds are much lower than for the indicator parameters.

Due to the variability of leachate characteristics, a wide range of indicators is necessary to provide a reliable tool for detection of leachate. Some of the indicators chosen are general parameters which give information on a wide range of constituents. The others are chosen for their specificity and sensitivity to particular waste constituents. Use of all these parameters together provides the reviewer not only with specific information needed but also some rudimentary quality control data to judge its accuracy.

Previous monitoring requirements specified quarterly monitoring in the months of January, April, July and October. Under the newly-proposed requirements for the draft monitoring manual, the monitoring schedule would more closely follow the major hydrologic events of spring thaw, evapotranspiration peak and the autumn dry season. This would mean sampling in April (or May in extreme northern areas) after the frost leaves the ground, July when evapotranspiration values are greatest, and October to represent the autumn dry season.

The five indicators included in the past requirements left gaps in the areas of metals and forms of nitrogen and sulfur. Since the types of wastes disposed and decomposition processes occurring in the landfill vary from site to site it may be necessary to go beyond the basic five parameters to ensure that leachate will be detected. MPCA staff recognized the need to keep the costs of monitoring at a reasonable level. Deletion of the winter quarter sampling requirement gave the MPCA more flexibility in setting monitoring requirements, and the three additional parameters were added to yield more complete ground water information.

<u>How Indicators are Chosen</u>: Desirable characteristics for landfill leachate indicators include the following.

1. Availability: the indicators should typically be abundant in landfill leachates.
2. Mobility and persistence: The indicators should be capable of moving through the soils without ion-exchange, sorption, and chemical reactions.
3. Contrast: The indicators should be significantly more abundant in leachate than in ground water.
4. Ease of analysis: Test methods for the indicators should be relatively low-cost and uncomplicated.

(from Clark and Piskin, 1977).

Table 6-1 shows concentrations of various constituents for Minnesota leachates, leachate data from Illinois leachates, ambient ground water data and drinking water standards. Volatile organics are dealt with later.

The Minnesota leachate data is based on a maximum of seven leachate samples, taken from seeps, ponds or collection systems. Some of the leachates are diluted with ground water or surface water runoff. The Illinois data base contains a maximum of 119 leachate analyses from 54 landfills. These samples also were collected from seeps, ponds and collection systems. Differences between Minnesota and Illinois data can stem from the following:

1. Relative size of the database,
2. Greater industrialization in Illinois,
3. More frequent codisposal of industrial wastes in Illinois, and
4. Inclusion in the Illinois data base of sites utilizing coal strip mine wastes as cover. The leachates from the coal mine wastes are generally quite acidic and contribute to greater potential for the leaching of metals.

Table 6-1

Parameter	Minnesota Leachates Range	Minnesota Leachates Mean	Illinois Leachates Range	Illinois Leachates Mean	Ambient Ground Water All Aquifer Mean	Ambient Ground Water Surficial Sand Mean	Drinking Water Standards
Alkalinity, mg/l			0-13,500	2,062	256	217	
*Ammonia, mg/l as N	0.15-410	142	1.8-1,250	158			
Arsenic, ug/l	5.4-26	14.0	0-40	1.09	2.8	3.6	10/50[1]
Cadmium, ug/l	0.52-30	16.2	0-1,160	100	0.13	0.33	10
Calcium, mg/l			23-3,050	635	187	186	
*COD, mg/l	1,100	1,100	63-70,740	7,996	8.2	7.6	
*Chloride, mg/l	99-1,000	425	31-4,350	773	19.5	11.4	250
Chromium, ug/l	8.3-110	48.3	0-22,500	580	1.9	0.85	50
Copper, ug/l	26-160	76	0-1,100,000	25,200	19.5	28.6	1,000
Dissolved Solids, mg/l			990-594,000	20,240	404	361	500
*Iron, ug/l	5,100-1,300,000	370,485	90-42,000,000	697,000	1,230	1,800	300
Lead, ug/l	5.8-370	162	0-6,600	430	8.4	2.6	50
Magnesium, mg/l			12,000-1,102,000	260,000	107	91.3	
Manganese, ug/l	2,500-93,000	26,920	0-678,000	27,500	154	252	50
Mercury, ug/l			0-30	1.2	.24	.22	2
*Nitrate + Nitrite, mg/l	0.04	0.04	0-1.8	0.46	2.6	3.7	10
*pH	5.4-7.2	6.7	1.5-9.5	6.8	7.4	7.3	6.5-8.5
Potassium, mg/l			2-1,920	270	2.8	2.9	
Sodium, mg/l			15-8,000	796	21.9	9.3	
*Specific Conductance	880-13,400	6,163	240-990,000	20,540	640	575	

(1) Minnesota/U.S. Environmental Protection Agency

Table 6-1 (continued)

Parameter	Minnesota Leachates Range	Minnesota Leachates Mean	Illinois Leachates Range	Illinois Leachates Mean	Ambient Ground Water All Aquifer Mean	Ambient Ground Water Surficial Sand Mean	Drinking Water Standards
*Sulfate, mg/l	17-350	108	0-84,000	1,204	77.3	115.5	250
Suspended Solids			21-3,670	915			
Zinc, ug/l	40-34,000	7181	0-250,000	12,100	120	109	5,000

Those parameters preceded by asterisks are recommended for routine monitoring.

The ambient ground water data is from the publication, "Ground Water Quality Monitoring Program, A Compilation of Analytical Data, Volume 4, 1981." Data is given on mean values obtained from all the samples taken (the all aquifer mean) and the mean values for samples from the surficial sand aquifers only. The surficial sand aquifer data was included to give more specific information on the quality of Minnesota's shallow ground water. Drinking water standards are either the USEPA primary drinking water limits or the Minnesota 1A standards for domestic consumption.

Table 6-2 shows the susceptibility of leachate constituents to various attenuation mechanisms. Most of the information presented in that table comes from the USEPA document "Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities." Some modifications were made following conversations with MPCA staff soil scientists. The table as it now stands represents estimates as to the possible fate of various parameters in the zones encountered. Conditions within each of the zones will vary significantly based upon geologic and soil conditions, type of wastes disposed, cover material used, age of the waste deposit, etc. Attenuation, therefore, will vary according to the initial attenuative capacity of the underlying soils and changing pH and redox (reduction-oxidation) conditions throughout the site's operational history.

Table 6-3 gives a compilation of costs charged to landfills for the various analyses as well as a brief synopsis of services provided. Costs shown are for a single sample; quantity discounts of 20 to 40 percent are normally given. Each of the parameters chosen for use as indicators is discussed in detail below, including justification for analysis of same.

Table 6-2

Parameter	Solid Waste Zone	Unsaturated Zone	Aquifer
Alkalinity	0,C	0,C	0
*Ammonia	0,B	0,A,B	0,A
Arsenic	0,B	0,B	0
Cadmium	0,A,C	0,A,C	0,A,C
Calcium	0	0,A	0,A
*COD	0	0,B	0
*Chloride	0	0	0
Chromium	0,B	0,B	0,B
Copper	0,A,C	0,A,C	0,A,C
Dissolved Solids	0,A,B,C	0,A,B,C	0,A,B,C
*Iron	0,A,C	0,A,C	0,A,C
Lead	0,A,C	0,A,C	0,A,C
Magnesium	0	0,A	0,A
Manganese	0,A,C	0,A,C	0,A,C
Mercury	0,A,C	0,A,C	0,A,C
*Nitrate + Nitrite	0,B	0,B	0
*pH	0,B	0,B	0,B
Potassium	0	0,A	0,A
Sodium	0,B	0	0
*Specific Conductance	0,A,B,C	0,A,B.C	0,A,B,C
*Sulfate	0,B	0,B	0
*Suspended Solids	0,F	0,F	0,F
Zinc	0,A,C	0,A,C	0,A,C

Those parameters preceded by asterisks are recommended for routine monitoring.

0=no attenuation; A=adsorption; B=biochemical or chemical degradation or conversion; C=chemical precipitation; F=filtration by transport medium.

Table 6-3

Parameter	Cost Range	Mean Cost	No. of Labs Performing Test In-House
Alkalinity	$ 3.00 - 12.00	$ 7.36	14
Ammonia	4.00 - 16.00	10.78	14
Arsenic (2 ug/l d.l.)*	10.00 - 36.00	20.44	11
Cadmium (.15 ug/l d.l.)	7.75 - 20.00	15.42	11
Calcium	3.00 - 18.00	8.93	12
COD	9.00 - 25.00	17.67	14
Chloride	3.50 - 12.05	7.31	14
Chromium (2 ug/l d.l.)	7.75 - 20.00	14.69	11
Copper (20 ug/l d.l.)	7.75 - 18.00	13.12	11
Dissolved Solids	3.00 - 13.00	7.25	14
Iron	3.50 - 17.50	10.65	13
Lead (10 ug/l d.l.)	7.75 - 26.00	16.02	11
Magnesium	4.00 - 18.00	10.30	12
Manganese	5.00 - 18.00	10.19	13
Mercury (.2 ug/l d.l.)	10.00 - 36.00	23.64	11
Nitrate + Nitrite	4.00 - 14.10	9.47	14
pH	free - 6.00	3.23	14
Potassium	4.00 - 18.00	9.52	12
Sodium	4.00 - 18.00	9.80	12
Specific Conductance	2.00 - 15.00	6.53	14
Sulfate	3.00 - 12.05	6.52	14
Suspended Solids	2.00 - 9.00	8.71	14
Zinc (50 ug/l d.l.)	7.75 - 18.00	11.38	11
Organics: Halogenated Volatiles	65.00 - 190.00	105.00	6
Aromatic Volatiles	65.00 - 200.00	107.00	6

d.l.=detection limit recommended in ground water manual

Number of labs which provide sampling is 13.
Number of labs which provide bottles when clients do sampling is 12 (One lab does all sampling.)
Number of labs which can provide or use field filtration apparatus is 13.

A total of 14 labs were contacted. Twelve were private labs currently doing landfill work, two were consultants affiliated with northern Minnesota Universities, also doing landfill analyses. Not all labs provided all services, but most subcontracted to other labs which did.

Prices shown here are for a single sample. Most laboratories give quantity discounts of 20 to 40 percent, as well as discounts for established accounts.

Chemical Oxygen Demand: In the COD test, organic and oxidizable inorganic substances are oxidized by potassium dichromate. The amount of potassium dichromate which remains unchanged is measured by titration, and a value calculated to describe the oxygen demand exerted by a sample. This test differs from the biochemical oxygen demand (BOD) determination in that the oxidation is done by potassium dichromate rather than by seeded organisms. Therefore the presence of toxic compounds will not inhibit oxidation in the COD test as it may in the BOD test.

Anaerobic decomposition of putrescible landfill materials leads to formation of organic acids such as acetic acid and butyric acid, which contribute in large part to the COD. Other organic compounds may be dissolved in the leachate as well. In addition, COD measures not only the oxygen demand exerted by organic compounds but also by oxidizable inorganic substances such as chloride, sulfide, manganese, and ferrous iron. The anaerobic conditions typical of landfills leads to the presence of many reduced constituents such as those in the leachate. This increased sensitivity to leachate constituents makes the COD test valuable as a landfill indicator.

COD values for leachate are typically high. The Illinois data showed a range of 63 to 70,740 mg/l, with a mean of 7,996 mg/l. Only one data point was found for Minnesota leachates, with a value of 1,100 mg/l. Ambient ground water testing shows a statewide all aquifer mean COD value of 8.2 mg/l and a surficial sand aquifer mean COD value of 7.6 mg/l. Table 2 shows COD has little capacity for attenuation although some biological transformation may occur. The testing procedures for COD are well-established and readily performed by most laboratories statewide, usually at a cost of $9 to $25 per sample.

Thus, the COD test meets all the requirements for an indicator parameter, and its inclusion on the parameter list for routine monitoring is justified.

Chloride: Testing procedures for chloride measure the concentration of the Cl ion. Due to its solubility and abundance in municipal solid wastes, chloride is a significant component of leachate. Minnesota leachate values range from 99-1,000 mg/l, with a mean of 425 mg/l. Illinois data shows a wide range, 31-4,350 mg/l, and a higher mean value, 773 mg/l. The drinking water standard

Ambient ground water data shows a statewide all aquifer mean value for chloride of 19.5 mg/l and a mean for the surficial sand aquifers of 11.4 mg/l. As shown in Table 6-2, chloride is a very mobile ion in both saturated and unsaturated zones. The likelihood for attenuation is low. Testing procedures for chloride are also well-established and readily performed by most labs.

While chloride contributes in part to the COD values measured, it is not a one to one relationship. For instance, 1,000 mg/l of chloride in solution will exert a COD of around 250 mg/l. This, along with the fact that testing procedures for chloride are more sensitive than for COD, makes it advantageous to require chlorides along with COD.

The above information shows that chloride is a valuable indicator of leachate contamination. It is a relatively inexpensive test, run at a cost of $3.50 to $12.05.

Ammonia and Nitrate-Nitrite: Organically-bound nitrogen is a major component of decaying organic matter in landfills. Under anaerobic conditions, the organic nitrogen will be bacterially converted to ammonia. In the presence of oxygen, the ammonia will be further coverted to nitrite and subsequently to nitrate.

Depending on the amount of oxygen available in the landfill, unsaturated zone and aquifer, any of these compounds could be present in a leachate plume. Conversion of the various forms of nitrogen could occur in any of the zones.

Typically, measured levels of nitrate + nitrite are low in fresh, non-aerated leachates. Minnesota leachates showed a value of 0.04 mg/l; in the Illinois data the values ranged from 0 to 1.8 mg/l, with a mean value of 0.46 mg/l.

Values measured for ammonia are significantly higher. The Minnesota range is 0.15-410 mg/l, with a mean of 142 mg/l; the Illinois range is 1.8 to 1,250 mg/l, with a mean of 158 mg/l. It is important to remember, however that conversion of ammonia to nitrate or nitrite could occur once the leachate is generated.

The Minnesota ambient ground water data does not include any information on background levels of ammonia. Nitrate-nitrite values listed are 2.6 mg/l for the all aquifer mean and 3.7 mg/l for the surficial sand aquifer mean. The drinking water standard for nitrate is 10 mg/l. There is no standard for ammonia.

Table 6-2 shows that ammonia may be adsorbed in soils, converted to another form of nitrogen or pass through unchanged, depending on conditions at the site. Nitrate-nitrite may be susceptible to conversion or may pass through unchanged. Nitrate is generally more mobile in soil systems than most compounds, with little chance of attenuation. Analytical procedures for ammonia and nitrate-nitrite are long-established and commonly performed by many laboratories statewide. Costs for ammonia range from $4 to $16, and nitrate-nitrite from $4 to $14.10.

In conclusion, the use of both ammonia and nitrate-nitrite can provide useful information to aid in detecting leachate contamination. While ammonia is generally more abundant in leachates, it is less mobile than nitrate and not as likely to travel through all soils. Nitrate may be produced from the ammonia and is more mobile, so if present, it is a better indicator.

Iron: Iron is most soluble at lower pH under anaerobic conditions. It is not surprising, therefore, to learn that concentrations of iron in fresh, unaerated leachates are high. The range of values for Minnesota leachates are 5,100 to 1,300,000 ug/l, with a mean of 370,000 ug/l. The Illinois data shows levels of 90-42,000,000 ug/l, with a mean of 697,000.

The drinking water standard for iron is 300 ug/l. Untreated Minnesota ground water typically exceeds the drinking water standard. The statewide all aquifer mean is 1,230 ug/l and the mean for the surficial sands is 1,800 ug/l. These naturally elevated levels make it especially important that ground water be protected from increasing levels of iron due to disposal sites.

The movement of iron through soils is in large part dependent upon soil pH and oxidation conditions in the soil. Reduced (ferrous) iron is more soluble; ferric iron is more likely to be adsorbed or precipitated. The high levels of iron found in solution in fresh leachate suggest that ferrous iron is more prevalent. Therefore, significant amounts of iron may travel through the soil under a landfill and enter the ground water. Testing procedures for iron are well established and relatively inexpensive, ranging from $3.50 to $17.50.

Iron was added to the list of indicators as a representative of the metals in routine analysis. That, and the reasons listed above, show that iron can also be a valuable indicator of leachate contamination.

Sulfate: Sulfates may occur in leachate from aerobic decomposition of putrescibles or may leach from sulfate containing materials such as plaster, concrete, ash and sheet rock. Under anaerobic conditions, hydrogen sulfide gas will be produced in place of sulfate.

Concentrations of sulfate in fresh leachate are higher than would be expected under anaerobic conditions, indicating that other leaching processes are providing sulfates to the leachate. Sulfate values for Minnesota leachates range from 17 to 350 mg/l, with a mean value of 108 mg/l. The Illinois leachate data ranges from 0 to 84,000 mg/l, with a mean of 1,204 mg/l.

Minnesota ground water appears to be naturally high in sulfate. The ambient statewide all-aquifer mean is 77.3 mg/l and the mean for the surficial sand aquifer is 115.5 mg/l. Maximum values reported for Minnesota ground water are 800 mg/l for all aquifers and 430 mg/l for the surficial sand aquifers. The drinking water limit for sulfates is 250 mg/l. At higher sulfate levels, water consumption can have a cathartic effect on the bowel (Hem, 1971).

Sulfate is relatively mobile, and is not readily adsorbed in most soils. Testing procedures for sulfates are well-estabished, and relatively low in cost. For these reasons, sulfate was added to the list of indicator parameters.

Specific Conductance: Specific conductance is a numerical expression of the ability of a water sample to conduct an electrical current. This number depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. A significant change in specific conductance is indicative of changes in levels of one or more of the following parameters: pH, total dissolved solids, chloride, sulfate, phosphate, alkalinity, acidity, nitrogen series, sodium, potassium, calcium, magnesium, hardness, heavy metals, cyanide, fluoride, and COD.

For that reason, specific conductance is an important part of routine monitoring. For instance, if a significant change is noted in conductance and not accompanied by a large shift in one of the other indicators, more testing will be necessary to determine what other parameters are changing. Conversely, if a major change is shown in another parameter and no reaction noted in conductance, it may signify problems in one or more of the analytical procedures. In this way, conductance can serve as a quality control yardstick.

As expected, specific conductance values for fresh leachates are quite high. The range for Minnesota leachates is 880-13,400 umhos/cm, with a mean value of 6,163 umhos/cm. Illinois data shows a range of 240-990,000 umhos/cm, with 20,540 umhos/cm as a mean. Ambient ground water in Minnesota is well below these levels, with a statewide all aquifer mean of 640 umhos/cm and a surficial sand aquifer mean of 575 umhos/cm.

Some of the constituents which contribute to the conductance value measured are susceptible to attenuation in the subsurface environment. However, others are not susceptible, which means that conductance can still be used as a general indicator of increasing mineralization in water due to leachate enrichment.

Conductance values change readily in ground waters once they are exposed to the atmosphere, due to changes in dissolved gases and precipitation reactions. For that reason, conductance must be measured immediately in the field. Field testing procedures for conductance are quite reliable, and very inexpensive after initial purchase of the instrument. Field conductance meters can be purchased for as little as $220. Laboratory measurement of conductance costs from $2 to $15.

Conductance has been required as a monitoring parameter since the landfill monitoring program started in the early 1970's. Its continued use is supported by all the information presented above.

pH: The anaerobic decomposition of putrescible wastes in a landfill results in production of organic acids. Some of these acids are biologically converted to methane. Those not converted are dissolved in the leachate, lowering the pH. The range of pH values for Minnesota leachates is 5.4 to 7.2, with a mean value of 6.7. The range from the Illinois data is 1.5 to 9.5, with a mean of 6.8. Ambient Minnesota ground water has statewide all aquifer mean of 7.4, and a surficial sand aquifer mean of 7.3.

The pH of a solution can change as it percolates through various soils due to dissolution and precipitation. However, review of ground water data from contaminating landfills shows lower pH in affected downgradient wells. Thus, pH can be used as an effective indicator of landfill leachate pollution when viewed not as an absolute value but compared relative to upgradient wells at each site.

The measurement of pH is required both in the field and the laboratory. This is because pH changes rapidly in response to changes in dissolved constituents. The immediate field measurement is to provide accurate measurement of aquifer pH. The subsequent laboratory measurement gives an idea as to the amount of change experienced by the sample during transportation. Data from the Minnesota ambient ground water program shows an approximate increase of 0.2 pH unit for these relatively clean waters. Greater shifts would be expected in more contaminated waters, since more changes are likely to occur during transportation.

Laboratory analysis of pH is among the most basic of tests, usually run at a cost of $0 to $6. Field testing of pH with a meter is more complex than field testin for conductance. It is, however, inexpensive after the meter has been purchased, for as low as $250. An alternative to a pH meter is pH paper which is much less expensive (about $1.50 per 15 foot roll or $.02 per test) and can provide accuracy to 0.2 pH unit. The greater accuracy of the pH meter, of course, is more desirable.

Like conductance, pH has long been required as a landfill monitoring parameter. The test has proved to be an effective indicator of landfill leachate contamination.

Extended Parameter Lists: An extended list of parameters is required at the initial well sampling and once every two years thereafter. This is designed to provide more complete data on ground water quality, and to establish background levels and track water quality trends. The extended list can be divided into two major groups. The first group is those parameters which characterize the major constituents of water. The other group is those parameters for which drinking water standards have been set. The only parameters included in the second group are those for which leachate data shows that drinking water limits may be exceeded. Each of these groups is discussed in detail in the following sections.

Major Constituents: Parameters which comprise this group include:

alkalinity,
calcium,
magnesium,
manganese,
potassium,
sodium,
dissolved solids, and
suspended solids.

Several of the indicator parameters could also be included in this group, notably chloride, iron and sulfate.

Together, this group of parameters is used as a yardstick for characterization of the overall quality of water. It is not used to assess the appropriateness of the water as a water supply. It is used to develop individual "fingerprints" for the state's waters, as shown in the Piper diagrams of Appendix D of "Ground Water Quality Monitoring Program, a Compilation of Analytical Data for 1981." Similar data presentations are given in the USGS Hydrologic Investigations Atlas series.

Data presented in Johnson and Cartwright (1980) shows that "hardness halos" may form around landfills as cation exchange processes liberate calcium and magnesium from soil lattice structures. Therefore analyzing for these parameters may aid in detection of leachates in soils with high cation exchange capacities.

Data from this group also provides a valuable tool for quality control. Values for dissolved solids should be roughly equivalent to the sum of the dissolved species. Suspended solids has been included to provide information on monitoring well performance. The theory behind this is that a well which is improperly constructed or insufficiently developed will yield waters with high levels of suspended solids. Including this parameter periodically will provide valuable information on well performance, over time, as well as on sampling techniques (such as insufficient purging).

The analytical procedures for these parameters are routinely performed by laboratories state-wide. Costs for analyzing this group are generally $75 to $100 per sample.

Parameters Which Cause Health Concerns: This group of parameters can be further subdivided into the metals subgroup and the organics subgroup. The metals subgroup contains the following.

arsenic,

cadmium,

chromium,

copper,

lead,

mercury, and

zinc.

Each of these metals is toxic to man or aquatic life at relatively low levels, given in Table 6-1. Leachate data also given in Table 6-1 shows that the concentrations of these metals in leachate has at some time exceeded drinking water standards. Ambient ground water levels in Minnesota for these metals on the other hand, are well below the drinking water standards.

Methods for analyzing these metals are well-established. However, due to the low natural levels of these compounds, the manual requires low detection limits which are not within the capabilities of many smaller labs. This portion of the biennial sample may need to be sent to a different laboratory than is used for routine monitoring. Cost for analyzing this suite of metals generally is from $100 to $125.

The organics subgroup represents one of the most radical changes in monitoring requirements presented in the manual. Many of the compounds may be carcinogenic, tetratogenic or cause various illnesses at low levels. Data generated by MPCA staff in the past year indicates that volatile organics quite commonly appear in leachates at concentrations far above USEPA's recommended levels.

Volatile organics are classified as low molecular weight compounds which may evaporate rapidly when exposed to the atmosphere. Many are soluble in water, and will remain in solution unless open to air. Analytical methodology for these compounds is quite sensitive, with detection limits in the parts per billion range. Some private laboratories in Minnesota are now equipped to perform the analyses.

Typically, these compounds are solvents with household and industrial uses. They may be used in their pure forms as paint thinners or removers, cements (such as rubber cement), cleaners, degreasers, refrigerants, or drying agents. They also may be contained in other products such as inks, paints, dyes, varnishes, preservatives, pesticides, fire-retardants, shampoos, and detergents. It is likely that many individuals and businesses dispose of small quantities of these products regularly, and that many end up in landfills.

A variety of volatile organic compounds has been detected in landfill leachate and leachate-contaminated ground water. The list of compounds includes some of the priority pollutants, both halogenated and non-halogenated volatile compounds. The current leachate data base contains analytical results from Minnesota landfill leachates, five Wisconsin leachates and one leachate sample from New York. Data has also been compiled from monitoring wells at 13 Minnesota landfills which were showing signs of leachate contamination, based upon review of inorganic leachate indicators. Landfills chosen represent both rural and urban areas of Minnesota.

Results of the leachate analyses show some volatile compounds to be present in every leachate. The most commonly detected compounds (in $\geq$ 50 percent of leachates) were the priority pollutants toluene; methylene chloride; 1,1,2-trichloroethylene; 1,1-dichloroethane; ethylbenzene; benzene and trans-1,2-dichloroethylene. The non-priority pollutant parameters acetone, 2-propanol and xylenes were also detected in 50 percent or more of the leachates. Similar although less consistent data were obtained from the analysis of leachate-contaminated ground water from landfill monitoring wells. Table 6-4 gives the Minnesota data in tabular form along with USEPA's recommended levels for comparison.

Research is currently ongoing in other parts of the country to establish the mobility of various synthetic organics in different soil types. Some preliminary findings show high concentrations of xylenes, acetone and methanol can increase the permeabilities of saturated clay soils be several orders of magnitude (Anderson, 1982). Therefore the mobility of these compounds may be greater than other types of contaminants.

Several test procedures have been approved by USEPA for detection of volatile organics, each giving results on a different set of compounds. Efforts are currently under way among MPCA staff to decide which methods provide the most appropriate level of information at a relatively reasonable cost.

Testing procedures for volatile organics are neither standardized nor well-established. A number of labs statewide have the capability to perform at least some of the procedures. Staff should be prepared to be quite explicit in setting requirements for testing.

Monitoring for volatile organics is costly. A telephone survey of seven local

TABLE 6-4

Compound, ug/l	Leachate from Minnesota Landfills, Compiled 1/4/83	Number of Samples in Which Compound is Detected/Number of Samples Tested	Priority Pollutant[1] (x=yes)	Carcinogen (x=yes)	10^{-5} Risk Level[2] ug/l
Ethanol	23,000-110,000	2/6			
Acetone	140-13,000	6/6			
2-Propanol	94-41,000	6/6			
1-Propanol	76-37,000	3/6			
Tetrahydrofuran	18-430	5/6			
Methyl Ethyl Ketone	110-28,000	6/6			
Ethyl Acetate	18-290	4/6			
1-Butanol	120-25,000	5/6			
Benzene	17-960	6/6	X	X	6.6
Methyl Isobutyl Ketone	10-740	6/6			
Toluene	7.5-600	6/6	X		143,000
Ethyl Benzene	12-820	6/6	X		14,000
m-Xylene	21-120	6/6			
o-Xylene and p-Xylene	12-170	6/6			
1,4-Dichlorobenzene	7.7-14	2/6	X		4,000
Methylene Chloride	64-1,300	5/6	X	X	1.9
Trichlorofluoromethane	15	1/6	X	X	1.9
1,1-Dichloroethane	0.6-42	6/6	X		

(1) Priority pollutants are a list of 129 toxic pollutants specified by USEPA in 1978. The list of 29 represents the compounds of greatest concern from among the thousands of substances declared toxic in Section 307(a) of the Clean Water Act.

(2) Levels shown indicate the level at which one additional cancer death per 100,000 population occurs when two liters of water are consumed daily over the average lifetime.

TABLE 6-4 (continued)

Compound, ug/l	Range Found in Leachate from Minnesota Landfills, Compiled 1/4/83	Number of Samples in Which Compound is Detected/Number of Samples Tested	Priority Pollutant (x=yes)	Carcinogen (x=yes)	10-5 Risk Level ug/l
Trans-1,2-Dichloroethylene	3.8-88	3/6	X		
1,1,1-Trichloroethane	7.6	1/6	X		184
1,2-Dichloropropane	2.0-49	4/6	X		
1,1,2-Trichloroethylene	1.2-125	5/6	X	X	27
1,1,2,2-Tetrachloroethylene	250	1/6	X	X	8.0
Chlorobenzene	1.5-60	2/6	X		4,880
1,2-Dichlorobenzene	10-32	3/6	X		4,000
Cis-1,2-Dichloroethylene[3]	190-470 (NP to P)	4/6	X		
Chloromethane[3]	(NP to P)	3/6	X	X	1.9
Chloroethane[3]	(NP to P)	3/6	X		
Vinyl Chloride[3]	(NP to P)	1/6	X	X	20
Bromomethane[3]	(NP to P)	1/6	X	X	1.9
1,2-Dichloroethane[3]	(NP to P)	2/6	X	X	9.4
Dichlorodifluoromethane[3]	(NP to P)	2/6	X	X	1.9

(3)Parameters not quantified by Minnesota Health Department at all times.

NP to P = not present to present

labs showed a range of costs from $45 to $190 for a scan reporting both halogenated and aromatic compounds. It is anticipated that once the MPCA sets its requirements, the laboratory community will react by developing more competitive pricing policies.

Despite the problems in analysis and cost, the presence in leachate, mobility and sensitivity of the volatile organics test makes it a valuable assessment tool when dealing with the effects of leachate.

CHAPTER 6

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CHAPTER 7

DISPOSAL SYSTEM SITE ASSESSMENTS AND RECOMMENDATIONS

Introduction

As a means of adding to the data base required for development of a statewide ground water protection strategy, analysis of data from site-specific hydrogeologic investigations was determined to be a method likely to provide the most immediately needed and useable information (MPCA, 1982a). Preliminary results from limited ambient, regional and statewide ground water quality monitoring networks have shown that ground water contamination problems in Minnesota are generally site-specific and only limited instances have been documented where broader, regional problems exist (i.e., southeast Minnesota, Anoka sandplain). Examples of such monitoring results from networks which have been published recently include MPCA, 1982b; MPCA, 1982c; Myette, 1982; Singer, Osterholm and Straub, 1982.

Approximately $128,000 of Clean Water Act-Section 208 funds were dedicated to site-specific hydrogeologic studies as a part of the ground water protection strategy work plan. Staff compiled a list of categories of facilities to be considered for study with 208 funds designated for that purpose. The categories were developed with the input of the Ground Water Protection Strategy Work Group discussed previously. Categories of potential study sites were based on two major factors. First, it was felt that there was a need to study facilities having high loading rates to the ground water, and therefore, the greatest potential to impact ground water quality. Second, there was a need to study facilities for which the majority of MPCA permit decisions will need to be made in upcoming years. An overall factor in site selection was that facilities believed to employ good design and management practices should be considered as well as sites poorly located, designed and operated. Based on these criteria, among others, nine sites (Figure 7-1) in five categories were selected for study representing a variety of geographic and geologic settings (Table 7-1). Results of site-specific studies may be found in reports by Braun, 1982; Hickok, 1983a; Hickok, 1983b; and USGS, 1983.

The purpose of this chapter is to summarize results and recommendations from these site-specific studies and to discuss them in the context of the range of waste management systems (including several categories of sites which were not selected for study) which have the potential to impact ground water. The waste systems will be discussed by media, as shown in Table 7-2. Included in the discussion are two waste types - agricultural wastes and hazardous wastes - which cross media lines in that they may involve both solids and liquids. Although site-specific studies were not conducted on either of these types of facilities for the purposes of this report, their effects on ground water have been extensively documented in previous studies and these will be summarized in the following discussion under items C and D.

A. Liquid Wastes

Existing Regulatory Program:

Minnesota Statutes, § 115.07 states that it is "unlawful for any person to construct, install or operate a disposal system, or any part thereof, until plans therefore shall have been submitted" and "a written permit therefore shall have been granted" by MPCA. Minnesota Rule 6 MCAR § 4.8036 establishes a state permitting program that includes regulating the on-land disposal of liquid wastes. The regulation provides for the evaluation of the permit application;

TABLE 7-1

SITES SELECTED FOR HYDROGEOLOGIC STUDIES

Site Type	Site Location	Contractor
Sand landfill	Anoka County: Waste Disposal Engineering Sanitary Landfill/ Andover	E.A. Hickok and Associates
Clay landfill	Lyon County: Lyon's Sanitary Landfill/Marshall	E.A. Hickok and Associates
Community drainfield	Scott County: Bonnevista Terrace Mobile Home Park/ Shakopee	Braun Environmental Laboratories, Inc.
Spray irrigation system	Otter Tail County: Land O' Lakes Creamery/ Perham	Braun Environmental Laboratories, Inc.
Spray irrigation system	Olmsted County: Seneca Foods Cannery/Rochester	Braun Environmental Laboratories, Inc.
Municipal wastewater spray system	Becker County: Detroit Lakes POTW/Detroit Lakes	Braun Environmental Laboratories, Inc.
Industrial impoundment	Waseca County: E.F. Johnson Company/Waseca	Braun Environmental Laboratories, Inc.
Industrial impoundment	Goodhue County: S.B. Foot Company/Red Wing	Braun Environmental Laboratories, Inc.
Abandoned tailings basins	St. Louis County: Hanna Mining Company/Keewatin	U.S. Geological Survey

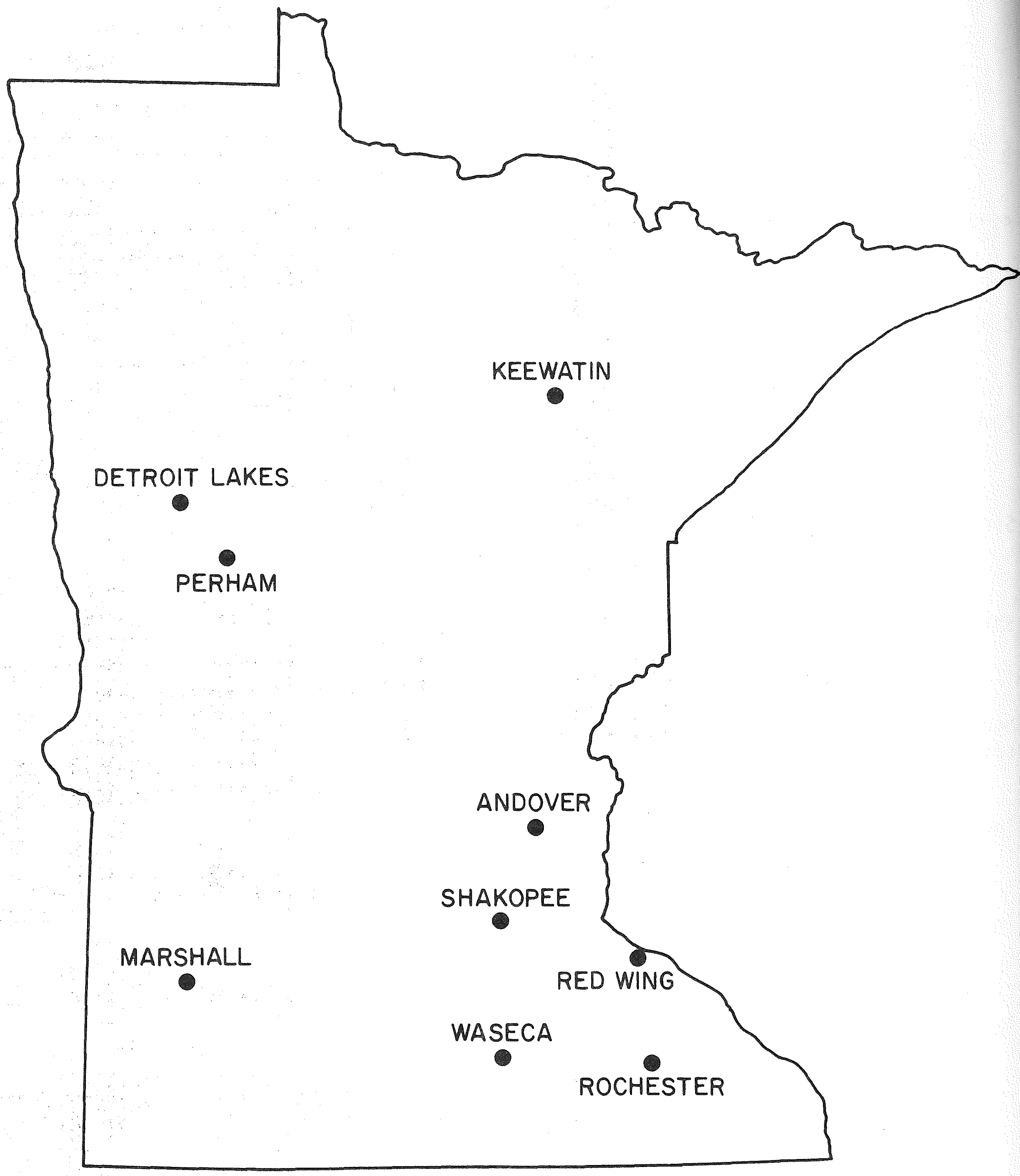


Figure 7-1: Site Location Map

TABLE 7-2

WASTE SYSTEM SUMMARY BY MEDIA

A. Liquid Wastes

1. Existing Regulatory Program
2. Method of Disposal

    a. Drainfields
    b. Spray Irrigation Systems
    c. Rapid Infiltration Systems
    d. Impoundments
    e. Sludge Handling Systems

B. Solid Wastes

1. Existing Regulatory Program
2. Method of Disposal

    a. Mixed Municipal Waste (Sanitary) Landfills
    b. Industrial Waste Landfills
    c. Demolition Landfills
    d. Open Dumps

C. Agricultural Wastes

D. Hazardous Wastes

establishment of terms and conditions; establishment of monitoring, recording, and reporting requirements; issuance and denial; modification, suspension, and revocation; and the reissuance of State Disposal System (SDS) permits. The primary objective in issuing a SDS permit for land disposal system is to preserve and protect underground waters of the state as prescribed in Minnesota Rule 6 MCAR § 4.8022. According to this regulation, this is facilitated through the submission of regular reports to the MPCA "on the operation of the disposal system, the waste flow, and the characteristics of the influent, effluent, and underground waters of the vicinity." These reports must provide "sufficient data on measurements, observations, sampling and analysis, and other pertinent information" as judged necessary and sufficient, by MPCA, to accurately reflect any impacts a disposal system may have on ground water.

The initial step in issuing a SDS permit is the review of the permit application. This review consists of a complete evaluation of the proposed or existing land disposal system and any possible effects it may have on ground water. Site-specific soils and hydrogeologic information is reviewed before a determination is made whether to issue or deny the SDS permit. If a permit is to be issued, monitoring requirements are incorporated into the permit based on the type of disposal system, hydrogeological setting at the disposal site, and the amount and characteristics of the waste. Ground water monitoring requirements include, at a minimum, the frequency of sampling and parameters to be analyzed. The type and location of ground water sampling devices may be specified in the permit or a monitoring plan required and submitted within a designated time.

Other conditions typically included in a SDS permit for a land disposal system are effluent limitations and management requirements. Ground water quality standards are not established in the permit. The permit essentially authorizes the construction and operation of a system with an approved monitoring program. Monitoring results reported to the MPCA are reviewed pursuant to standards established in Minnesota Rule 6 MCAR § 4.8022. The rule states that it is the policy of the MPCA "to provide maximum protection to all underground waters." It therefore becomes necessary to "employ a non-degradation policy to prevent pollution of the underground waters of the state." An alternate standard may be applied which is less stringent than the "non-degradation standard," in cases where the background level of a parameter due to natural origin is reasonably definable and is higher than the standard for potable water, based on the mandatory and recommended requirements of the U.S. Public Health Service Drinking Water Standards (USPHS, 1962) including any subsequent revisions, amendments, or supplements. In summary, any land disposal system may be required to be upgraded if it is determined ground water is adversely being impacted based on the review of monitoring results by MPCA staff.

Once a permit application has been reviewed and a draft permit completed, it is placed on notice, (usually 30 days,) for public comment. Within this comment period, any interested person may file a petition with the Director of MPCA requesting a public hearing concerning the application of the SDS permit. Following review of the permit application and consideration of comments received from interested persons, and, if applicable, of the public hearing record, the MPCA Board makes a final determination on the issuance of the permit.

Methods of Disposal

(a) Drainfields:

Design Considerations: In this disposal method raw wastewater is discharged to a sewage tank followed by a soil treatment system. The tank is a watertight, covered receptacle designed to decompose and/or separate solids in raw sewage so that a clarified liquid is discharged to the soil treatment system. The treatment system, in turn, treats wastewater below the ground surface by filtration and percolation through the soil. A variety of soil treatment systems exists including those commonly known as seepage beds, trenches, electro-osmosis systems, mounds, and seepage pits.

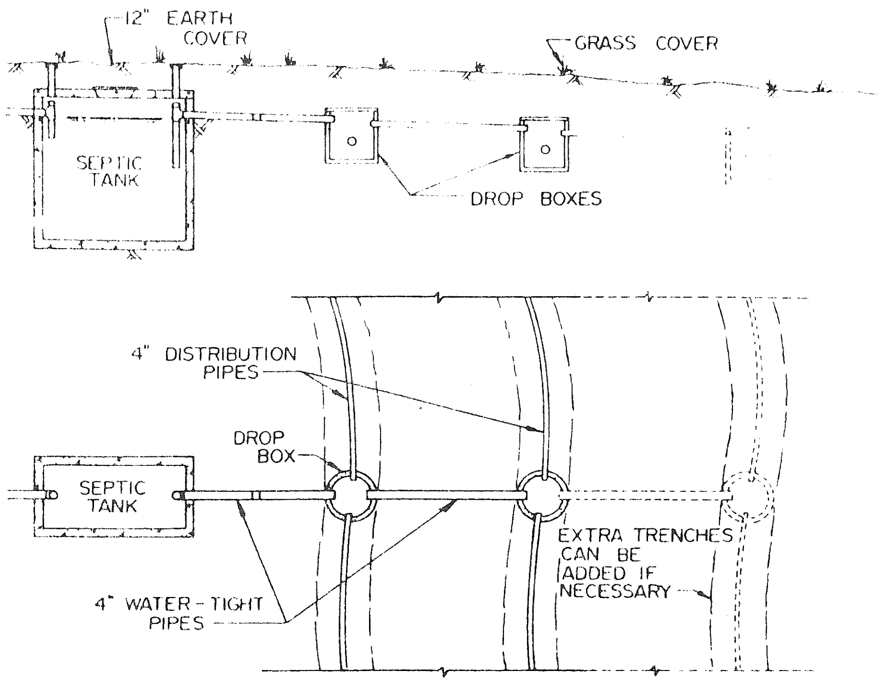
Minnesota Rule 6 MCAR § 4.8040 provides minimum standards for the proper design, location, installation, use, and maintenance of individual sewage treatment systems including drainfields. These standards apply to systems in shoreland and floodplain areas, and to larger systems regulated by the State of Minnesota. For other systems, these standards "provide recommended guidelines for the adoption of local ordinances." Systems commonly known as cesspools in which raw sewage is discharged directly to the soil treatment area are prohibited installations.

Design criteria in the rule specifically address construction of sewers, sewage tanks, distribution systems, and soil treatment areas. The final soil treatment area is designed according to information generated from a site evaluation. Site characteristics that must be considered include depth to ground water, soil conditions, topography, flooding probability, and setback distances from property lines, ordinary high water marks of surface waters, water supply wells and other soil treatment systems. Soil conditions are defined by conducting borings and percolation tests. The size of a treatment area is determined by the daily sewage flow and the percolation rate of the soil. The number of bedrooms per dwelling is used for estimating minimum daily sewage flows. The required soil treatment area in square feet for each gallon of daily sewage flow is derived from the measured percolation rate (see 6 MCAR § 4.8040). The total area needed is then calculated by multiplying this number by the total daily sewage flow. The location of a treatment area is subject to minimum setback requirements, and restrictions on slope and construction in flood-proned areas. Finally, the bottom of a system must be constructed a minimum of three feet above the water table or bedrock.

A typical drainfield design is illustrated in Figures 7-2 and 7-3. The system consists of septic tank discharging to a gravity distribution network of perforated pipes. The septic tank is a sewage tank that treats raw wastewater by separating solids from liquid and digesting organic matter during a period of detention. An alternate type of sewage tank is an aerobic tank that utilizes oxidation in decomposing sewage through the introduction of air. The distribution system contains 4" perforated distribution pipes overlying at least 12" of trench rock. Sewage tank effluent is transmitted by gravity to distribution pipes through a series of drop boxes. These boxes are progressively placed at lower elevations so that pipes from the first drop box are loaded before effluent reaches the second drop box. An alternative to this type of system is the use of pressure distribution.

It should be noted that there are a variety of design alternatives for drainfield systems ranging from the sewage tank to the distribution of effluent. Most existing and proposed systems in Minnesota consist of the standard septic tank - drainfield type with gravity distribution. Alternative sewage treatment systems are constructed or proposed in areas of limiting soil conditions, or where a standard system cannot be used or is not the most suitable. An important alternative system has been the mound system which is used where it is necessary to build the soil treatment area at or above the natural ground surface to overcome limits imposed by a high water table or

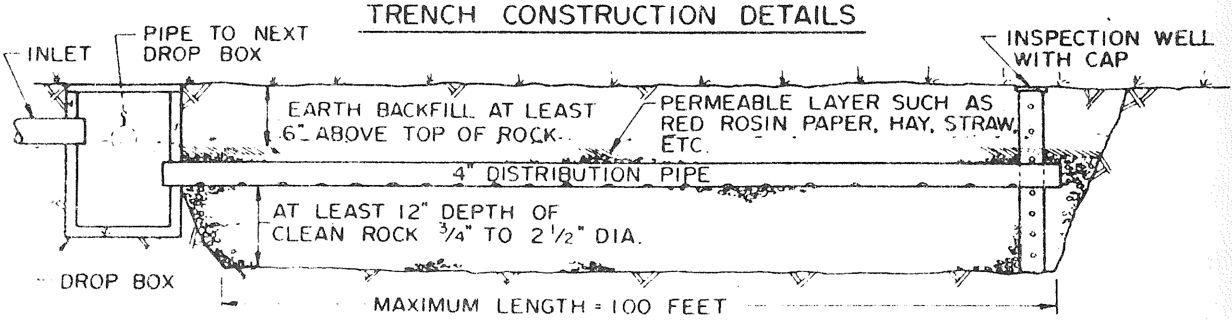
Figure 7-2



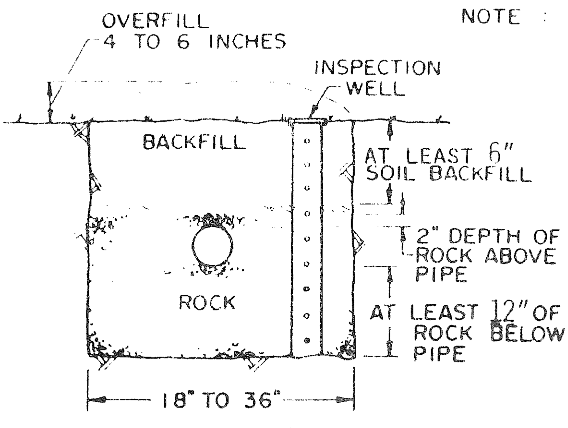
SEWAGE TREATMENT SYSTEM WITH DROP BOXES

Figure 7-3

TRENCH CONSTRUCTION DETAILS



NOTE : I. BOTTOM OF TRENCH MUST BE FLAT ALONG LENGTH



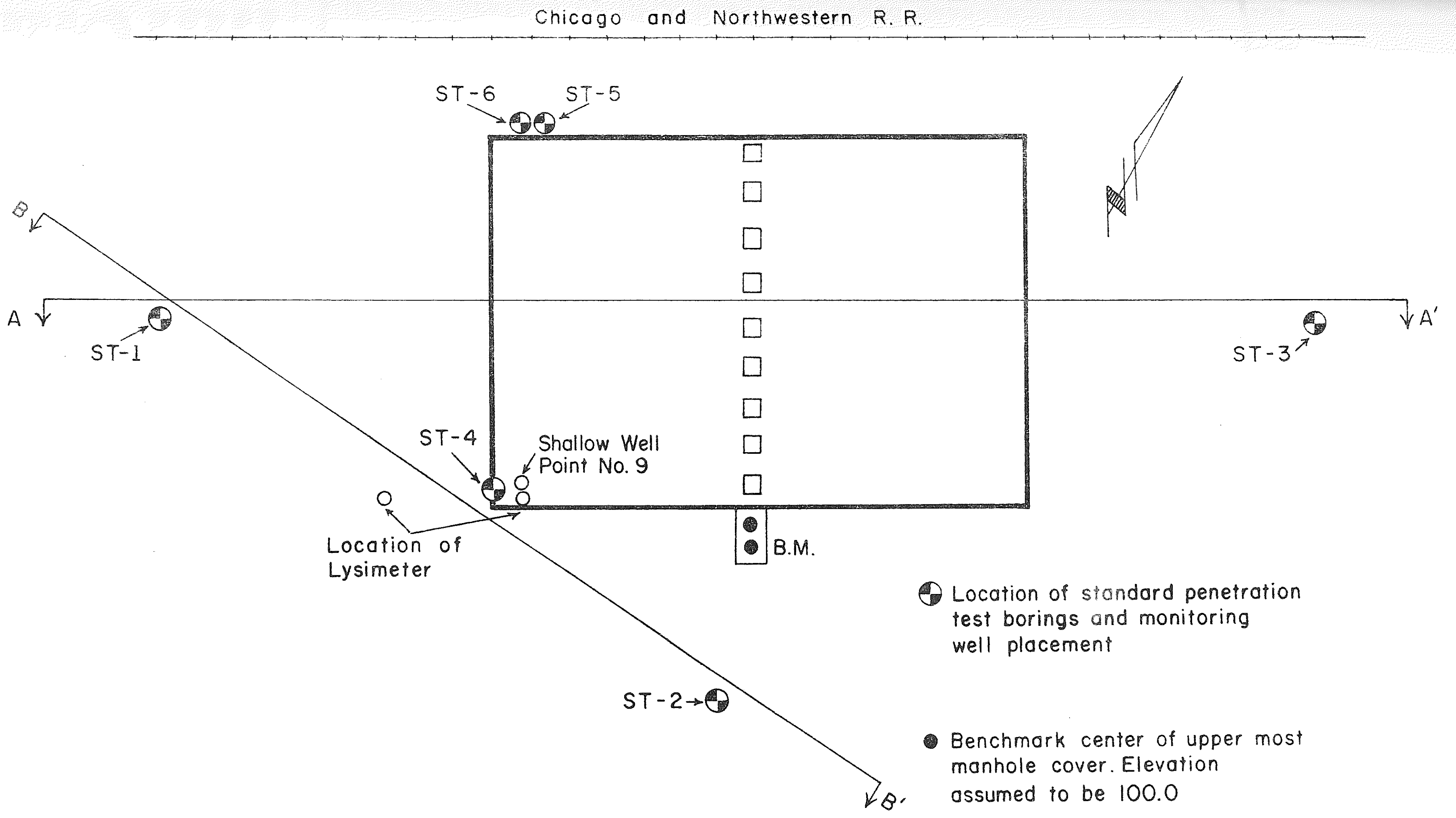
shallow bedrock, or by rapidly or slowly permeable soils. Other systems include seepage pits, electro-osmosis and reduced area systems.

Ground Water Monitoring: Only for those systems permitted by the state is consideration given to requiring ground water monitoring. According to MPCA regulations, any single facility generating more than 15,000 gallons per day; or collector system serving 15 dwellings or generating 5,000 gallons per day, whichever is less, that discharges to an individual sewage treatment system must make application for and obtain an SDS Permit. Systems below these limits may require a permit if the MPCA considers it necessary to ensure a system will not constitute a source of pollution to underground waters.

To date, approximately 40 of these larger systems have been permitted. Ground water monitoring requirements are included in permits for all systems that are designed to treat 15,000 gallons or more of sewage per day. Systems treating less than 15,000 gallons per day are reviewed on a case-by-case basis to determine the need for a monitoring program. Monitoring programs normally consist of quarterly sampling with samples analyzed for pH, specific conductance, chloride, nitrate-nitrogen, and ammonia-nitrogen. In lakeshore areas total phosphorus is also monitored. Of the systems permitted, many have either not yet been constructed or only recently been constructed. Therefore, monitoring data has been lacking for assessing the performance of these systems. This comes at a time when more and larger systems are being proposed.

Site Investigation: The septic tank-drainfield system at Bonnevista Mobile Home Park consists of two separate drainfields. The system is designed for all sewage to discharge to a recently installed 15,000 gallon septic tank and 31,000 square-foot drainfield with an older system consisting of a 13,000 gallon septic tank and 8,000 square feet of drainfield used as a back-up system. Only the newer system was used during the study. This system is designed similar to Figures 7-2 and 7-3 employing nine drop boxes with effluent discharged to a total of six distribution pipes at each box (three on either side). The site was instrumented with six monitoring wells, one shallow well, and two lysimeters as shown in Figure 7-4. Subsurface conditions are described in Figures 7-5 and 7-6 as derived from borings performed at each of the six monitoring well locations. Ground water sample collection was scheduled according to modifications made in loading different sections of the drainfield. Ground water elevations were measured on a weekly basis to study the effects of loading on ground water hydraulics and resulting water quality. Samples from the six monitoring wells were collected four times during the study.

Prior to the study, the new drainfield system had been operating for approximately one year serving, 150 mobile homes generating an estimated 22,500 gallons per day of effluent. Additional flow estimated at 7500 gallons per day (50 units) discharging to the old system was redirected to the new system at the time the site was instrumented. This resulted in loading changes to the system as reflected by the observed movement of effluent into an additional drop box after the first month of the study. At this time, modifications to system loading were made by blocking the flow from certain drop boxes to selected distribution pipes. All pipes leaving boxes 1 thru 4 and those that discharge to the east half of the field from boxes 5 thru 7 were blocked for six weeks. During this period approximately 30,000 gallons per day of effluent discharged to only one drop box for two weeks, two drop boxes for one week, and three boxes for the remaining three weeks. This amounts to loading rates varying from a maximum of 2.2 feet per day using one drop box to a minimum of .75 feet per day

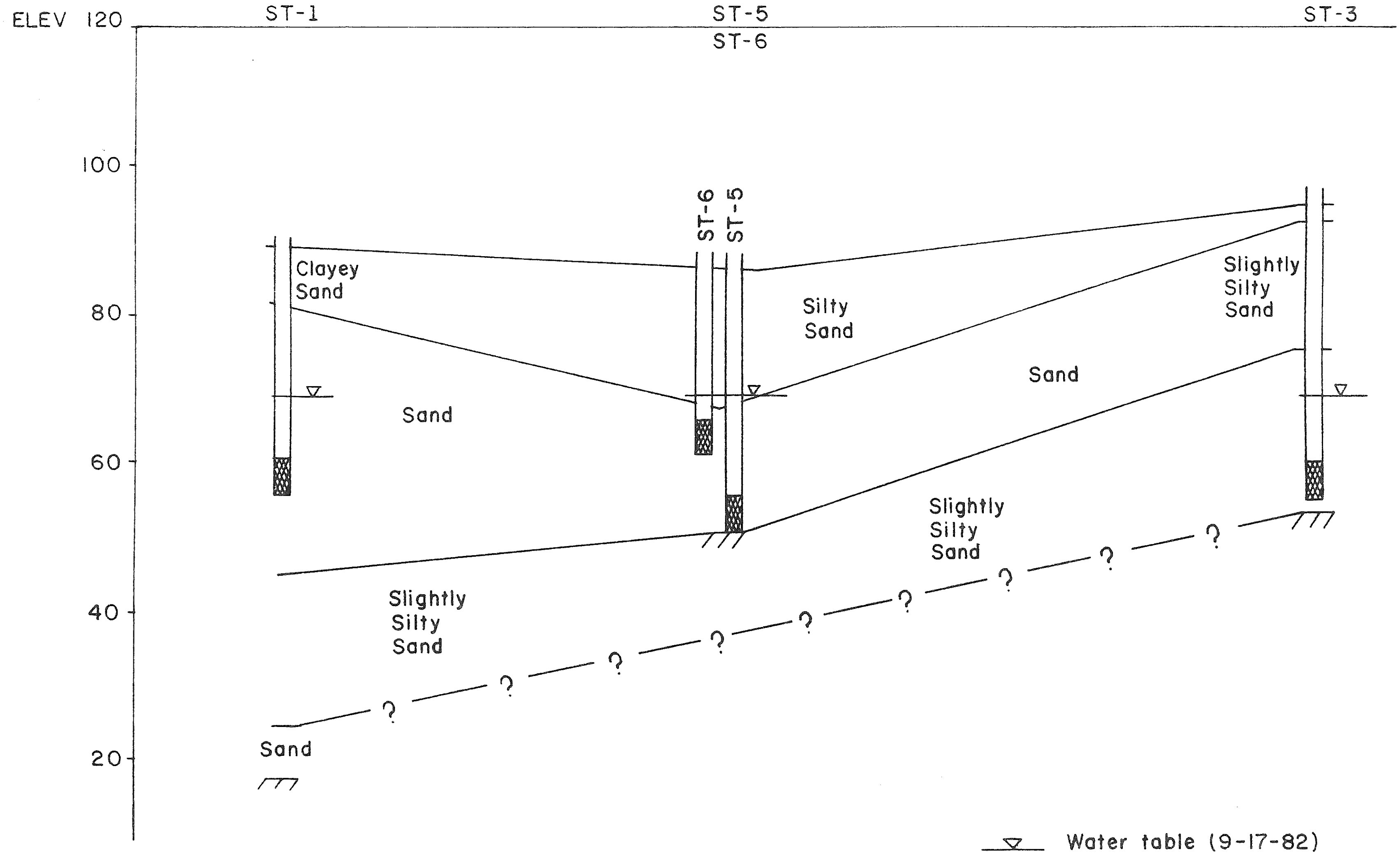


BRAUN

Figure 7-4: Site Instrumentation: Ground Water Study, Bonnevista Terrace Mobile Home Park, Shakopee

(Figure drafted by MPCA based on information provided by Braun Engineering Company.)

Date:
Revised:
Drawn:
Scale: None



BRAUN

Figure 7-5: General Soil Cross Section A-A'
Bonnevista Terrace Mobile Home Park

(Figure drafted by MPCA based on field measurements made by Braun Engineering Company and MPCA staff.)

Date:
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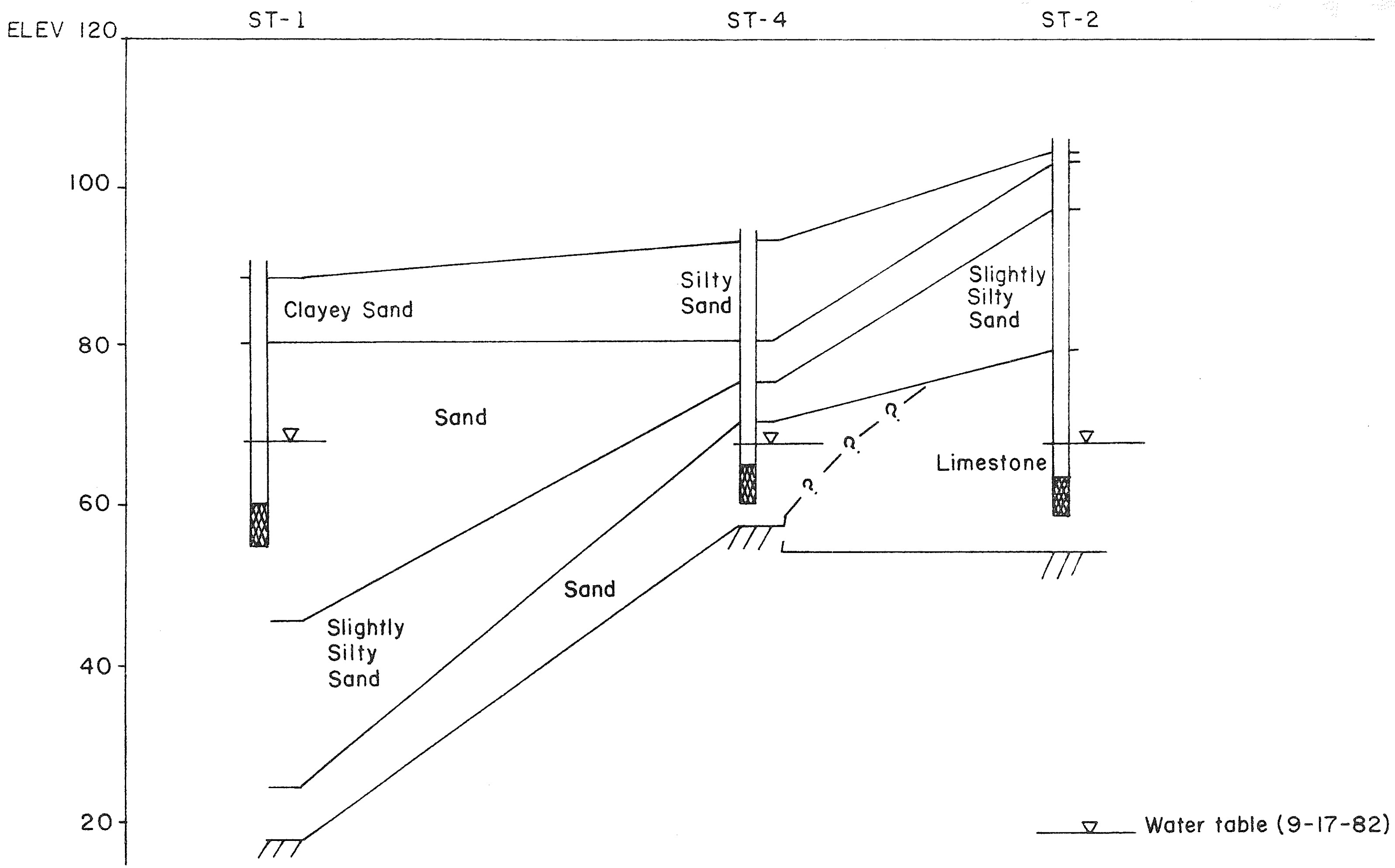
Scale: None



BRAUN

Figure 7-6: General Soil Cross Section B-B'
Bonnevista Terrace Mobile Home Park

(Figure drafted by MPCA based on field measurements made by Braun Engineering Company and MPCA staff.)

Date:

Revised:

Drawn:

Scale: None

after six weeks using three drop boxes. This decrease in loading rate represents a decrease in permeability caused by the build-up of a bio-mat at the trench-soil interface. Changes in loading were also observed after all the blocking elbows were removed returning the system to its original operation.

After one week effluent was being discharged to the field from drop boxes 1 and 2 only. Effluent moved as far as drop box 4 two months later and into drop box 5 after four months. This represents a decrease in the loading rate from 1.1 feet per day to .22 feet per day. The latter rate is more indicative of what would be considered stabilized conditions relative to the development of the bio-mat and the effects of climate on loading. Climatic conditions tended to stabilize since the study period extended into the winter season where the effects from evapotranspiration and precipitation were minimized.

Ground water elevation measurements taken during the study period indicate the flow direction is toward the north. Since the study was initiated after the system had been operated for a year, there could be no determination of natural flow conditions below the site. Defining any ground water mound, therefore, becomes difficult as there is no basis for comparison. Modifications made in loading the system did not prove helpful since no significant changes in ground water elevations occurred during the study. This can be interpreted to mean that a mound either extends beyond the boundary formed by the monitoring wells or has not developed. The former interpretation suggests a mound shape that is very flat vertically compared to horizontal extent. Either interpretation suggests effluent moves from the trenches laterally as well as vertically through the uppermost soil layer consisting of silty sand. When effluent reaches an underlying sand layer having a higher permeability, it moves downward more rapidly than it does horizontally. The horizontal component again becomes more prevalent when silty sand is encountered below this sand. This results in effluent being dispersed over a larger area than the area being loaded (and possibly beyond monitoring well locations). Whether this causes any mounding still remains uncertain.

Water quality results from a lysimeter located outside the loading area appears to verify a dispersive type of movement. A sample indicated quality only slightly better than the effluent discharging to the drainfield. This migration of effluent beyond the area of loading presents a potential problem in interpreting ground water quality data, as background conditions may not occur at existing monitoring well locations. A review of monitoring results shows that the well at ST-6 most consistently had the highest quality water in the surficial aquifer at the site, suggesting this as the best indicator of background conditions. This is based on analyzing samples for conductivity, pH, chlorides, biological oxygen demand, total dissolved solids (TDS), nitrate-nitrogen, ammonia-nitrogen, total phosphorus, and fecal coliform. Most notable changes from background conditions occurred in conductivity, chlorides, and TDS.

At ST-4, the well was placed immediately adjacent to the drainfield. This sampling point was impacted less than any of the remaining locations, probably reflecting the movement of effluent through two layers of silty sand. Here, effluent is dispersed more than at other locations where there is a single layer. Higher values were reported at both ST-2 and ST-3.

The sampling point ST-2 is placed into shallow limestone which provides easy access and rapid movement of effluent through fractures from overlying soils to the well screen. The surficial silty sand layer that extends to a depth of 18 feet on the west side of the drainfield narrows to 2 feet on the east side, resulting in less dispersion of effluent and higher values at ST-3. This surficial layer, as reflected by lower permeabilities, promotes greater dispersion than the silty sand soils in which the well screen is placed. While both deposits contribute to dispersion the uppermost layer is the most significant. Furthermore, ST-3 is likely impacted more because it is the only well located downgradient from the site.

Ground water quality at ST-5 indicates levels above background conditions (ST-6). This represents a vertical change in quality as both wells are located in the same vicinity. The decrease in quality with depth may be explained by evaluating ground water flow at the site. Elevations measured at these wells define a small downward component to flow. Although effluent will reach ST-6, more effluent is directed to a greater depth where ST-5 is screened. Finally, the impact at ST-1 was similar to ST-2 and ST-5. The operation of the old system may have contributed to values received at ST-1, as it is located between both systems.

Modifying system loading resulted in significant changes in ground water quality at wells ST-3 and ST-5 only. Higher values for conductivity, chlorides and TDS were reported when loading occurred closer to ST-5. The reason values at ST-3 increased is unclear. Chlorides and TDS did not exceed drinking water standards during the study. Standards were exceeded, however, for nitrate-nitrogen (10 mg/l) a number of times. The first sampling in August produced values above these standards in wells ST-3, ST-4, and ST-5. Subsequent samples collected in October and December revealed a significant change dropping below the standard in these wells while exceeding it at ST-2.

Since most nitrogen in the effluent is in the form of ammonia, the impact of nitrates on ground water will depend on the amount of ammonia transformed to nitrate (nitrification). This transformation is primarily controlled by the availability of oxygen. A lack of oxygen will favor the formation of the ammonium ion while an ample supply will favor formation of nitrate ions. The transformation to nitrate also means a change in mobility. Whereas ammonium is readily tied up by the bio-mat and underlying soils, nitrate is easily leached to ground water. Changes in ground water quality relative to nitrate would therefore be expected to be similar to changes already discussed for other parameters. As can be seen, this was not the case.

An explanation for the difference may be that a parameter such as chloride is very mobile and is not transformed. The total amount of chloride reaching ground water, therefore, is limited only by the amount being discharged to the drainfield. The resulting ground water quality changes are better defined and simpler to interpret. Water quality changes in nitrate, on the other hand, are due to more complex considerations including not only the amount of ammonia discharged but the level of development of the bio-mat, soil types at the site, subsurface conditons relative to temperature and oxygen availability, and depth to ground water. Some of these considerations in turn may change according to the season or any modifications in loading.

The only conclusion that may be drawn is that there is evidence the drainfield does impact ground water with nitrates, sometimes exceeding drinking water standards. However, defining the movement of nitrate to ground water goes beyond the scope of the study. The other parameters analyzed in the study, i.e. ammonia, total phosphorus, pH, and fecal coliform generally did not significantly impact ground water. An exception was a significant increase of ammonia in samples from ST-1. The reason for this change is unclear.

Recommendations

1. The study was conducted at a site for which very little was known about subsurface conditions. As data was generated it became more apparent that conditions at the site were complex, making interpretation difficult. It would have been helpful to instrument the site with more lysimeters and monitoring wells to better define effluent movement and ground water impacts. However, an important achievement of the study was the identification of various site conditions that effect the soil treatment of effluent in a drainfield system. Each condition requires further study to better understand ultimate impacts on ground water. Therefore, it is recommended that proposed drainfields be constructed at sites that allow the effects of a specific subsurface condition to be determined. This would require a site with limited variability. For example, the effects of the condition described in the report whereby soils increase in permeability with increasing depth should be studied at a site where soil types have uniform thickness and the depth to bedrock is uniform.

2. Study results indicate that large drainfields do impact ground water, particularly for mobile constituents such as chloride and nitrate. Nitrate had the greatest impact as drinking water standards were exceeded on occasion. Routinely drainfields are sized according to hydraulic properties of subsurface soils encountered at a site. Water quality results from the study show that sizing a system based on percolation rates alone may impact ground water where highly permeable soils occur. Unfortunately, criteria are lacking on alternate methods of sizing drainfields, in these type of soils. There is a need to generate additional information on the ground water impacts from larger systems constructed at sites having these conditions. Therefore, drainfields should be designed carefully with consideration given to restricting loading rates, the

volume of sewage discharged to a system, and construction of systems within a specified distance from ground water and in highly permeable soils. The study specifically showed that ground water quality was impacted when an estimated 30,000 gallons per day of effluent was loaded at an estimated average rate of .75 feet per day in an area consisting of granular soils with a permeability (derived from lab tests and particle size analysis) of 1.3 inches per hour and a depth to ground water of 27 feet.

3. The loading study conducted at the site illustrated how rates change over time. Loading rates changed from a maximum of 2.2 feet per day when no bio-mat existed to .22 feet per day when bio-mat development was greatest. During part of the study, development was observed for six weeks without stabilizing. This can have consequences on ground water quality since the bio-mat becomes less permeable, resulting in effluent being discharged over a larger area in a greater number of distribution pipes. Water quality would in most cases improve as this occurs. A problem with declining permeability is that limitations are placed on the life of the drainfield system. These limitations have been overcome to a degree by certain modifications to design and operation. They consist of a system with an enlarged treatment area and a capacity to block flow to distribution pipes so that a scheduled operation of loading and resting a treatment area can be employed. Resting an area allows the bio-mat to break down causing an increase in permeability and extending the life of the system. In coarse-grained soils, this increase in permeability may have a significant impact on ground water quality, particularly at system start-up when no bio-mat is present. Therefore, for large drainfields it is suggested that pressure distribution be considered at a site where this may be a problem. Pressure distribution has greater capacity to control effluent loading so that ground water impacts may be minimized while extending the life of a system.

4. Monitoring results emphasize the importance of all elements of a ground water monitoring program. First, the study showed the importance of placing background monitoring wells far enough away from a loading area beyond the influence of any effluent migration in both the unsaturated and saturated zones. A necessary part of any monitoring program is to define ground water flow before any loading occurs. This may include the determination of any vertical components to flow which can impact the movement of constituents and the location and depth of downgradient monitoring wells. Routine monitoring at a site should include ground water elevations to establish the effects of loading on the depth to ground water and assist in the interpretation of water quality data. It is suggested that well nests be considered at sites where there is a vertical component to flow that significantly effects the location of constituents in an aquifer. Downgradient wells should be placed at a depth and location in the aquifer most impacted by the disposal system. The study verified a need to analyze samples at least for conductivity (or TDS), chlorides, ammonia-nitrogen, and nitrate-nitrogen. Conductivity and chlorides provide good indicators of the impact of effluent on ground water. Nitrate-nitrogen and ammonia-nitrogen should be analyzed in samples since high values for both may be found in ground water. At the study site, a lysimeter installed two feet below one of the trenches indicated only a small amount of ammonium had been retained by the bio-mat. Apparently, ammonium was primarily taken out or transformed to nitrate in underlying soils. If ground water had occurred at a shallower depth, ammonia-nitrate values could potentially be high. Of the four parameters, chlorides and nitrates are the most important as they are very mobile and have drinking water standards. Phosphorus, which would be a concern in lakeshore areas, was not a problem as reflected by very low values of total phosphorus in the lysimeter below the site and monitoring wells.

Frequency of sampling for these systems should correspond to any changes in loading or climate. If the volume of sewage to a system or the number of distribution pipes being loaded remains unchanged, sampling would normally correspond to seasonal changes only, or four times a year in Minnesota. Finally, monitoring of the facility should continue to define the areal extent of impact, for example, to determine what a necessary separation distance from a well is in regard to nitrate standards.

(b) Spray Irrigation Systems:

Design Considerations: Both industrial and domestic wastewater in Minnesota is discharged to land by spray irrigation. In these systems wastewater is sprayed into the air and allowed to fall on the land surface in a uniform pattern at a designed rate of application. Application rates can be classified according to the purpose for irrigating, i.e., wastewater may be applied for either agronomic or disposal purposes. Agronomic rates (consumptive use) are restricted to the amount of water needed during crop growth for transpiration and building plant tissue and what is evaporated from adjacent soil or intercepted precipitation on plant foilage. The application of wastewater at a rate for consumptive use allows for the recycling of nutrients and the utilization of rates normally well within a soil's hydraulic and treatment capacities. Application rates at a site will depend on soil conditions, type of crop planted, irrigation system efficiency, and climatological data. If wastewater disposal is the main objective, a critical loading rate must be determined, usually based on hydraulics or nutrients. A primary concern in using these generally higher application rates is the potential for impacting ground water quality. Therefore, effluent quality and ground water conditions at and near a site must be considered in addition to the data used in determining agronomic rates. Unlike agronomic rates, for disposal purposes the production of a cash crop is secondary to sewage treatment.

Climatological data is an important design tool in determining any type of application rate. First, climate will restict the length of the irrigation season, generally six months in Minnesota. At agronomic rates, this corresponds to the growing season while a longer season may be acceptable when using critical loading rates. The difference between evapotranspiration and precipitation will effect application rates when considering either consumptive use or hydraulic loading. A deficit in precipitation, for example, would allow a higher loading rate than would a surplus. This balance can further be affected by the type of crop planted. Crops such as reed canary grass have a higher rate of water uptake than corn, thus permitting higher loading rates. In a spray irrigation system, equipment used has an impact on evaporation losses. An efficient system will minimize evaporation losses so that less water is applied to meet crop requirements. The object, however, in applying wastewater may be to maximize evaporation losses to maintain an acceptable loading rate while minimizing land requirements. This can be achieved by using high pressure spray nozzles that produce small diameter droplets more susceptible to evaporation. The small droplet size used in spraying wastewater does have limitations. Smaller droplets have the capacity to drift greater distances with wind. Since effluent should be uniformly applied and confined to the boundaries of the spray field, droplet size must balance the effects of evaporation and wind movement. Finally, all application rates are affected by soil conditions at the site.

The hydraulic adaptability of a soil for irrigation is dependent on properties such as available water capacity, permeability rates, slope, and wetness. The available water capacity is a measure of water retained by soil particles making it available for plant growth. Permeability is a measure of soils capacity to absorb water at the surface and move through the soil profile. This is important in replenishing a soil's available water capacity as well as avoiding saturated conditions that affect plant growth at a site. Plant growth is also impacted by runoff as reflected in the slope and the depth to ground water as indicated by wetness. When spraying wastewater, runoff should not be allowed to leave the application area making it necessary to construct dikes around many areas.

The objective in using agronomic rates is to replenish only the available water capacity for the soil throughout the crop rooting zone. As a result, little or no effluent reaches ground water. If the loading rate is limited by soil permeability only, effluent can be applied at a higher rate as long as saturated conditions are avoided. The potential for impacting ground water may be increased significantly as these rates result in the downward movement of effluent rather than the effluent being retained by soil particles.

If wastewater disposal is the primary concern, a critical loading rate is determined by calculating both a hydraulic and nutrient loading rate. The most limiting rate plus annual wastewater flow is used in calculating the required field area. Hydraulic loading rates are derived from climatic conditions and soil properties already discussed. This rate is limiting at sites where slowly permeable soils are encountered or nutrient limits are not critical. Additional information is needed when deriving nutrient loading rates. An evaluation of ground water conditions at a site and a complete wastewater characterization are required to determine which nutrient is most limiting as well as an acceptable nutrient loading rate.

For example, municipal systems that spray primarily domestic wastes may have nitrogen as the most limiting constituent. A nitrogen loading rate would be based on the ground water quality limitations on nitrogen and degree of treatment obtained at a site. Water quality limitations may be applied at a number of locations, such as the property line or where effluent enters ground water below a site. Treatment for nitrogen would be evaluated according to the nitrogen uptake of a selected crop and losses from denitrification. Denitrification results in nitrogen being removed from effluent through conversion of nitrate to nitrogen gas. Factors that affect these processes are organic matter content, soil texture, depth to ground water, wetness, temperature, vegetative cover, and soil pH. The nitrogen loading rate, therefore, is derived primarily from the treatment capacity of a site and the level of treatment required. This type of evaluation can also be done using other constituents that may be limiting, such as chloride or any of the metals.

In Minnesota, where climate limits the length of the application season, storage ponds are required where wastewater is generated year round. Many industrial generators that spray irrigate do not have storage ponds as they are operated only during the irrigation season, while some industrial and all municipal dischargers do provide storage. Storage requirements are directly related to the length of the spray season which depends on the cover crop, climatic region, and type of application rate. Ponds should be designed and constructed according to MPCA criteria used for wastewater stabilization ponds. Adequate treatment must be provided to prevent nuisance conditions in ponds such as odors and insure applied wastewater does not exceed the standard for fecal coliform of 200 MPN per 100 milliters.

Ground Water Monitoring: Any spray irrigation system may require an SDS permit if the MPCA determines it is needed to insure proper management practices and the protection of surface and ground waters. There are approximately 23 industrial and 37 domestic permitted spray irrigations systems in the state. All permits impose a limitation on application rates, usually specifying a minimum field area and the maximum volume of wastewater to be applied. This rate is normally designated on a yearly basis to allow for the flexibility of spraying more effluent over hot and dry period when evapotranspiration is optimum (or less during cool and wet periods) during the irrigation season. For industries with no storage, annual application rates are necessary since wastewater generation will vary on a daily to monthly basis. The only other limitation in SDS permits is that effluent must meet the standard of 200 MPN per 100 milliliters for fecal coliform.

Permit requirements usually include management practices and monitoring of the site. Management requirements may specify the type of crop to be planted, how to maintain a crop, methods of preventing runoff, or a schedule for loading and resting separate spray areas. To properly monitor the performance of a spray irrigation system it is necessary to sample effluent being discharged to the field and obtain water samples from below the field. Ground water monitoring programs for spray sites have consisted of sampling ground water using monitoring wells, sampling soil moisture below a crop's rooting zone using lysimeters, or both. Most sites are sampled for soil moisture only using suction cup lysimeters. The frequency of sampling is generally monthly during periods of irrigation and once prior to and following the irrigation season. Effluent sampling may be less frequent, ranging from one to three times a year for industries to once a month during the application season for domestic wastewater facilites. Flow and the acreages irrigated must be monitored daily for most industrial and municipal systems. At a minumum, soil moisture and ground water samples are analyzed for specific conductance, chloride, nitrate-nitrogen, and ammonia-nitrogen in domestic wastewater applications. Fecal coliform, total nitrogen, biological oxygen demand, and total suspended solids are analyzed in effluent samples. Parameters analyzed in samples from industrial systems will depend on wastewater characteristics. The monitoring program as described may be less stringent for pemitted systems that utilize agronomic rates. These systems may only require sampling of nearby drinking wells prior to system start-up for establishing background ground water quality, with no on-site monitoring required except for sampling effluent.

Spray irrigation systems in the state have provided more monitoring data than other land applications systems as they have been operating longer and are more numerous. Problems in collecting data, however, have been encountered at many spray sites particularly where suction cup lysimeters are used. In many cases, lysimeters have failed to produce sufficient samples either because a site is unsuitable for lysimeters or due to improper installation, maintenance, and/or operational procedures. Another problem has been the interpretation of monitoring results where background conditions have not been adequately defined. This makes it difficult to detect any impacts on ground water from land disposal. Available results suggest that these systems do effect ground water when effluent is sprayed for disposal purposes. Elevated values above background have been reported for chloride, conductivity, and ammonia-nitorgen in domestic systems. Industrial wastes in Minnesota, primarily from canneries and dairies, have produced very high levels of biological oxygen demand, chloride, and conductivity. Generally, chloride is the only drinking water standard to be exceeded (250 mg/l) in these systems, usually showing greater concentrations at industrial sites.

Site Investigations:

Perham Site: This site consists of two irrigation fields with a total area of 180 acres planted in corn adjacent to the Otter Tail River. A maximum of 108 million gallons of wastewater per year from Land-O-Lakes creamery may be discharged to two synthetically lined aerated lagoons followed by two center-pivot irrigation systems. Each system has a single lateral mounted on wheels and supported by towers. The self-propelled system operates by moving around an anchored pivot point located at the center of the field. Treated wastewater is sprayed through downward facing nozzles to minimize drift. Ground water at the site has routinely been sampled from four existing monitoring wells. As part of the study, four additional wells, two vacuum lysimeters, and one pan lysimeter were installed (see Figure 7-7). Monitoring wells were placed at two locations between the spray fields and river. All lysimeters were installed within one spray field near an existing monitoring well. Figures 7-8 and 7-9 illustrate subsurface conditions at the site as derived from borings conducted at the location of lysimeters, and all new and existing monitoring well sites. Sample collection was scheduled twice during the irrigation season and twice after the season at all lysimeters, new wells, and at two of the existing wells. Ground water elevations were generally measured in all wells during these scheduled samplings. Samples were analyzed for chloride, conductivity, total dissolved solids (TDS), ammonia-nitrogen, nitrate-nitrogen, pH, total phosphorus, biological oxygen demand, and fecal coliform. Some of these parameters were also analyzed in samples collected from the storage pond and a drinking well just north of the site.

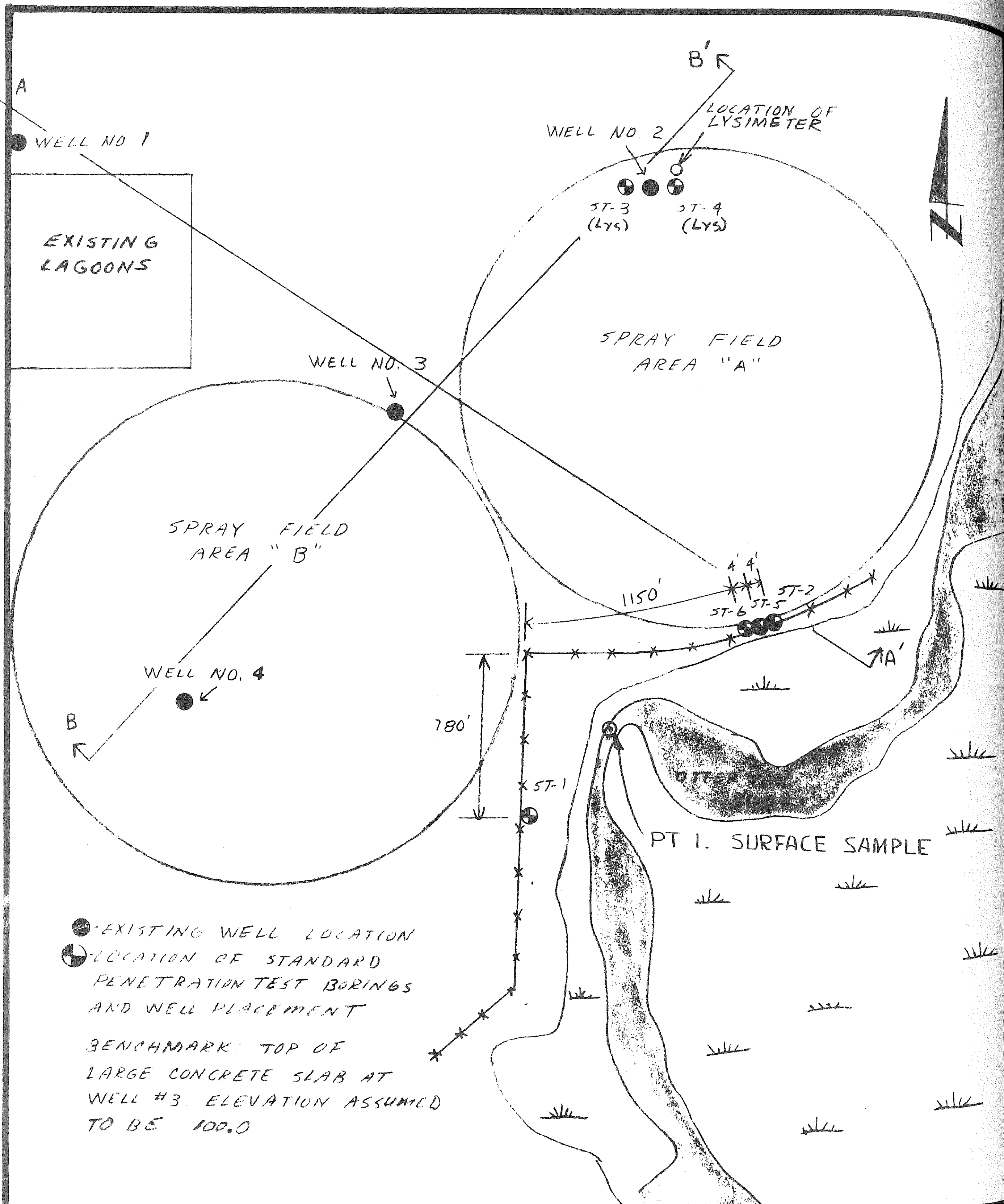


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FIGURE 7-7 SITE INSTRUMENTATION

GROUNDWATER STUDY LAND O'LAKES SPRAY FIELDS. (PERHAM, MINNESOTA)

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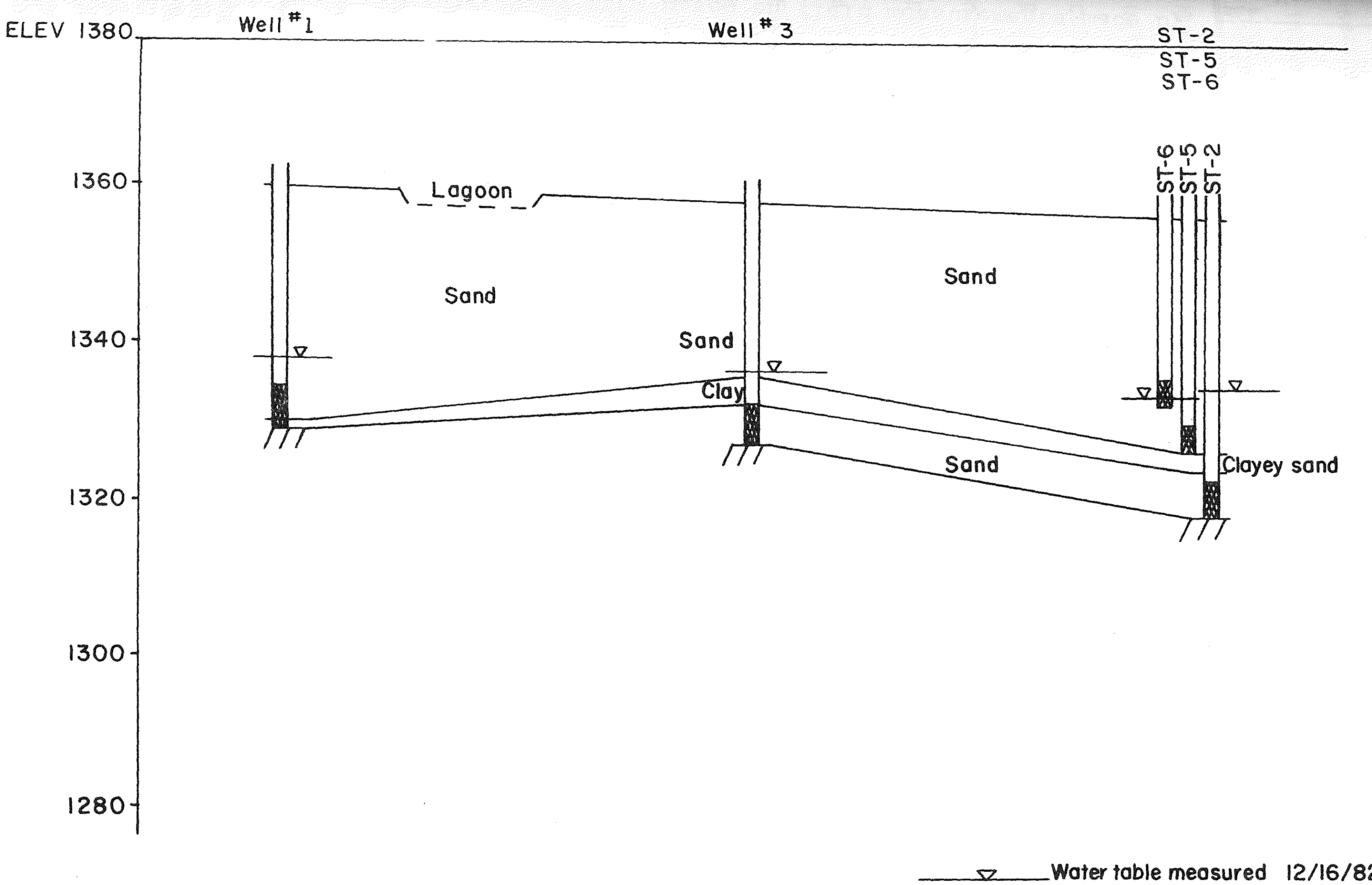

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Figure 7-8: General Soil Cross Section A-A'
Land O' Lakes Spray Fields

(Figure drafted by MPCA based on field measurements made by Braun Engineering Company and MPCA staff.)

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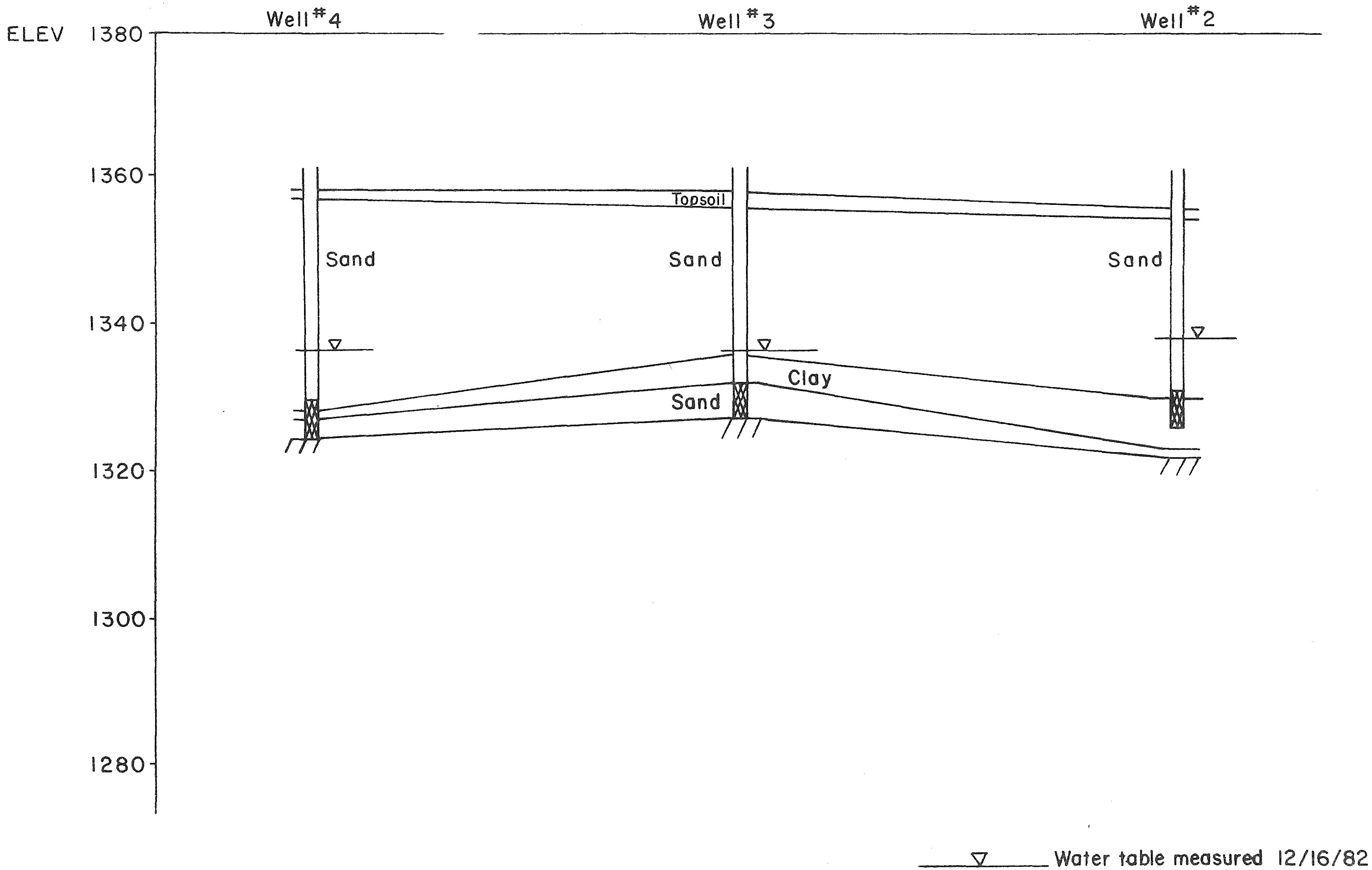

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Figure 7-9: General Soil Cross Section B-B'
Land O' Lakes Spray Fields

(Figure drafted by MPCA based on field measurements made by Braun Engineering Company and MPCA staff.)

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Scale: None

Approximately 96 million gallons of effluent was sprayed during the irrigation season in which the study was conducted. This amounts to a loading rate of 20 inches for the year with ten inches applied up to the first sampling in August and an additional seven inches to the second sampling in September. This is much lower than previous years when loading rates reached 40 inches per year using less land. Ground water elevation measurements conducted during the study consistently showed ground water below the site moving toward the Otter Tail River. Since the river bends adjacent to the site, flow comes from the north, northwest, and west following a gradient in the surficial aquifer that bends parallel with the river.

All monitoring wells but one (ST-2) were constructed so that measurements reflect the flow gradient of this aquifer. A clay layer was encountered in the borings which varied in thickness from one to seven feet. This clay apparently acts as a restricting layer separating the surficial aquifer either from an underlying buried aquifer or into two zones of the same aquifer. Three wells had screens that were placed below the clay layer. Wells 3 and 4 are existing wells where gravel was used to fill the annular space between the borehole and well. This gravel pack could provide a conduit for ground water to move easily through an otherwise flow restricting layer. The monitoring well at ST-2 was constructed with bentonite grout placed above the screen which restricts such movement. Measurements from this well indicate an aquifer or part of an aquifer under confined conditions below a restrictive clay layer that behaves independently of the unconfined surficial aquifer while wells 3 and 4 are affected by conditions above the clay layer. This will be an important consideration when interpreting ground water quality data from the site.

Ground water measurements also showed a general rise in elevation beginning with those first taken in mid-June and continuing until mid-September. From this point elevations gradually declined until the following March. These changes correspond quite closely to when spraying was scheduled during the irrigation season. Most spraying occurred during July and August, the months with the greatest available water deficit (precipitation minus potential evapotranspiration), resulting in an elevation peak in September. It appears this mounding largely comes from effluent recharging ground water although major precipitation events during this period likely contributed also. The decline in elevations represents less recharge with the termination in spraying and from a gradual decline in precipitation with the arrival of the winter season. Changes in elevation during the study were rather small (.2 feet) at the upgradiet well while slightly greater (.5 feet) at wells on the spray field. This small mounding effect below the field reflects the highly permeable soils at the site and suggests operation of the irrigation systems was effective in keeping the amount of effluent entering ground water relatively low by spraying during periods of maximum evaporation and crop uptake. Once effluent reaches ground water, movement is toward the river at a rate estimated at less than 50 feet per year. Elevations measured in downgradient wells ST-1, ST-5, and ST-6, may reflect, therefore, ground water mounding by effluent sprayed months or years earlier. This interpretation is supported by a smaller decline in elevation at these wells than what was observed in background or onsite wells over the winter. More frequent measurements scheduled around specific precipitation and loading events are needed to better define the effects of each on ground water recharge.

An understanding of ground water flow at a site is important in interpreting any water quality data. Samples were collected from all newly installed wells and existing wells 1 and 2. Vacuum lysimeters were placed at different depths at ST-3 and ST-4 but did not produce any samples. A pan lysimeter which did provide samples was installed one foot below ground surface near well 2. Impacts on ground water quality from the operation of the irrigation system can be defined best using monitoring results for chloride, conductivity, and TDS. Background quality (well 1) at the site was notably better than other locations while well 2 had the highest levels for these parameters. Ground water at well 2 exceeded drinking water standards for chloride (250 mg/l) and TDS (500 ug/l). As could be expected, samples from the pan lysimeter had even higher values approaching those of the applied wastewater. Samples from ST-5 and ST-6 come from the same location but at different depths within the surficial aquifer. These wells generally had results that were considerably better than well 2 but still above background levels. A trend of slightly increasing values was observed over the study at the bottom of the aquifer where ST-5 is screened. At this same location ST-2 is screened at a greater depth below the clay layer. Here water quality is further improved, approaching background conditions.

The clay layer encountered throughout the site apparently affords good protection to ground water below it. The other downgradient well at ST-1 was screened from approximately one foot above to one foot below this layer. As would be expected, sampling both above and below the layer provided levels between those measured at ST-2 and ST-5. Conductivity measurements were taken in the field at new and existing wells in December and March. These readings correspond closely with analytical results but did provide some additional information. All existing wells on the spray field were high in conductivity with wells 2 and 3 about the same but slightly lower than well 4 in December. Readings at well 2 stayed relatively constant while wells 3 and 4 increased noticeably from December to March. This probably has to do with the location of these wells in the spray fields. Wells 3 and 4 are more centralized in the fields so that when ground water moves across the site during the irrigation season, ground water impacts become cumulative. That is, impacts are greater because more effluent is added to a volume of ground water as it moves downgradient below the spray field. Well 2 is situated on the edge of the upgradient side of the field where less effluent would ultimately enter ground water. Since the flow rate is low relative to the time between irrigation seasons, ground water below this site will be degraded year round with some fluctuation. As discussed earlier, wells 3 and 4 extend below a clay layer. The high conductivity at these wells indicates the surficial aquifer is being greatly impacted. It also means these wells are providing a passageway for contaminants to migrate into ground water below the clay. There is no evidence to indicate ground water impacts are mounding beyond the site. This is based on the sampling of the background well and a nearby residential well north of the site, both completed in the surficial aquifer. No determination could be made on the impacts of ground water discharging to the river, as conductivity readings were not taken upstream from the site.

It is more difficult to interpret results concerning nitrate-nitrogen. Again, the highest values that consistently exceeded drinking water standards (10 ug/l) were obtained from well 2. All downgradient wells had very low values while the background well and residential well had higher values. Although the system likely contributes nitrates to ground water, there are other sources that probably contribute greater amounts such as the application of fertilizers.

converting the cover crop at the site from grasses to corn within the last two years has resulted in such applications. The levels obtained upgradient from the site could be due to discharges from a nearby individual sewage treatment system. Wastewater had low levels of ammonia-nitrogen and total phosphorus which resulted in no impact to ground water. Ammonia was either transformed to nitrate or tied up in soils as with phosphorus. No problems were encoutered with pH, or fecal coliform.

Rochester Site: Wastewater discharged to this site is generated from the processing and canning a variety of vegetables by Seneca Foods (formerly Libby's). Spray irrigation occurs when processing peas from mid-June to August, corn in August and September, lima beans in late September, and carrots from early October to mid-November. The system is permitted for a maximum annual flow of 58 million gallons which is distributed over a 180 acre field maintained with a cover crop of perennial grass and/or alfalfa. Treatment prior to spraying consists of wastewater passing through a series of screens and holding tanks to remove solids. There are no storage ponds in the system so that wastewater is sprayed only at times of vegetable processing which may occur continuously over a period including nights and during precipitation events. Effluent is pumped to hand-moved solid set and wheel roll irrigation systems. The solid set system has lateral line pipes and sprinklers that are set at one location and allowed to remain until the desired irrigation is achieved. In a wheel roll the lateral line is the axle with the wheels spaced apart and the sprinklers midway between. The lateral line is moved between sets by rolling the wheels using a lever or gasoline engine. Existing monitoring wells were constructed of either 2-inch PVC or 4-inch steel casing. Plastic wells were installed to a depth of 20 feet with 1.5 feet of screen and identified as wells

1, 3, and 5 in Figure 7-10. An additional seven monitoring wells, and four lysimeters were installed for the study. The background well at ST-1 was replaced by ST-5 when it became dry. Nested wells were placed in the area of ST-4 to a depth of 5, 10, and 15 feet. A set of suction cup lysimeters was installed at 2 and 4 feet each, within (lysimeters 3 and 4) and outside (lysimeters 1 and 2) a spray area. Figure 7-11 illustrates subsurface conditions at the site as determined from borings conducted at all new monitoring well locations. Ground water measurements and sample collection were scheduled according to vegetable processing changes. Samples were generally analyzed for the same parameters as the Perham site. Additional data was generated from conductivity readings taken in Willow Creek adjoining the site as well as sampling a few nearby drinking wells.

Ground water elevations were measured at the beginning and end of June prior to initiating any irrigation. The highest elevations were measured at existing wells 1 and 5 which are located on the edge of spray areas. Another ground water high was measured at ST-3. This suggests that the drainage ditches through the site help control ground water flow as elevations decrease closer to the ditches. Therefore, ground water below spray areas 3, 4, 5 and a small part of 1 moves south and southeast toward a ditch while below most of area 1 and all of 2, movement is to the north and east (see Figures 7-10 and 7-11). Measurements made at ST-1 and ST-5 indicate flow may also be in other directions. These wells had the lowest elevations of all wells, which defines a downward gradient to the west from spray area 3. Apparently, a mound has developed in this area through the 30 years of irrigation (20 years were at twice the loading rate) causing ground water to move away in all directions. Also, another mound below spray areas 1 and 2 has developed over the last 10 years of irrigation.

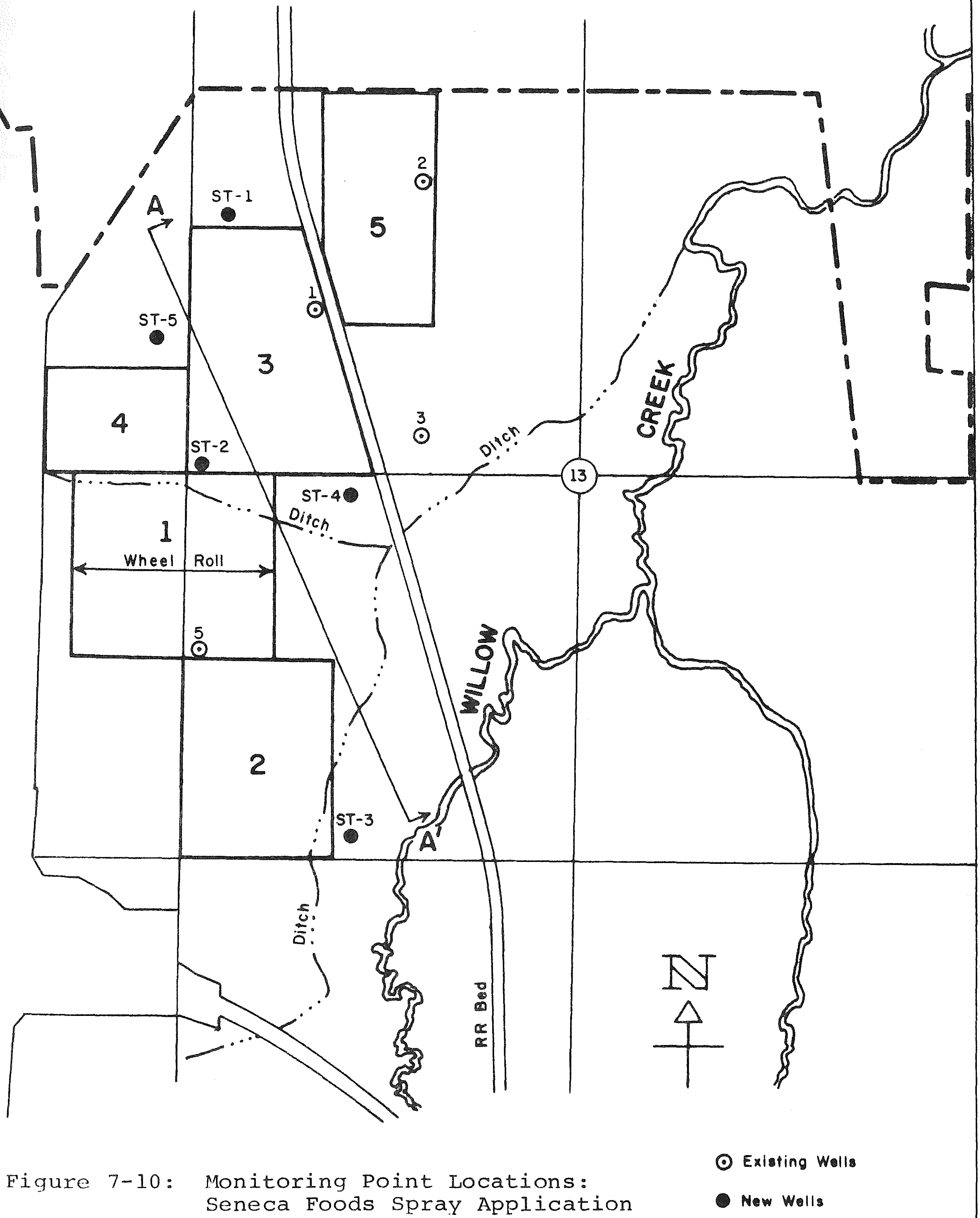

Figure 7-10: Monitoring Point Locations: Seneca Foods Spray Application Site, Rochester

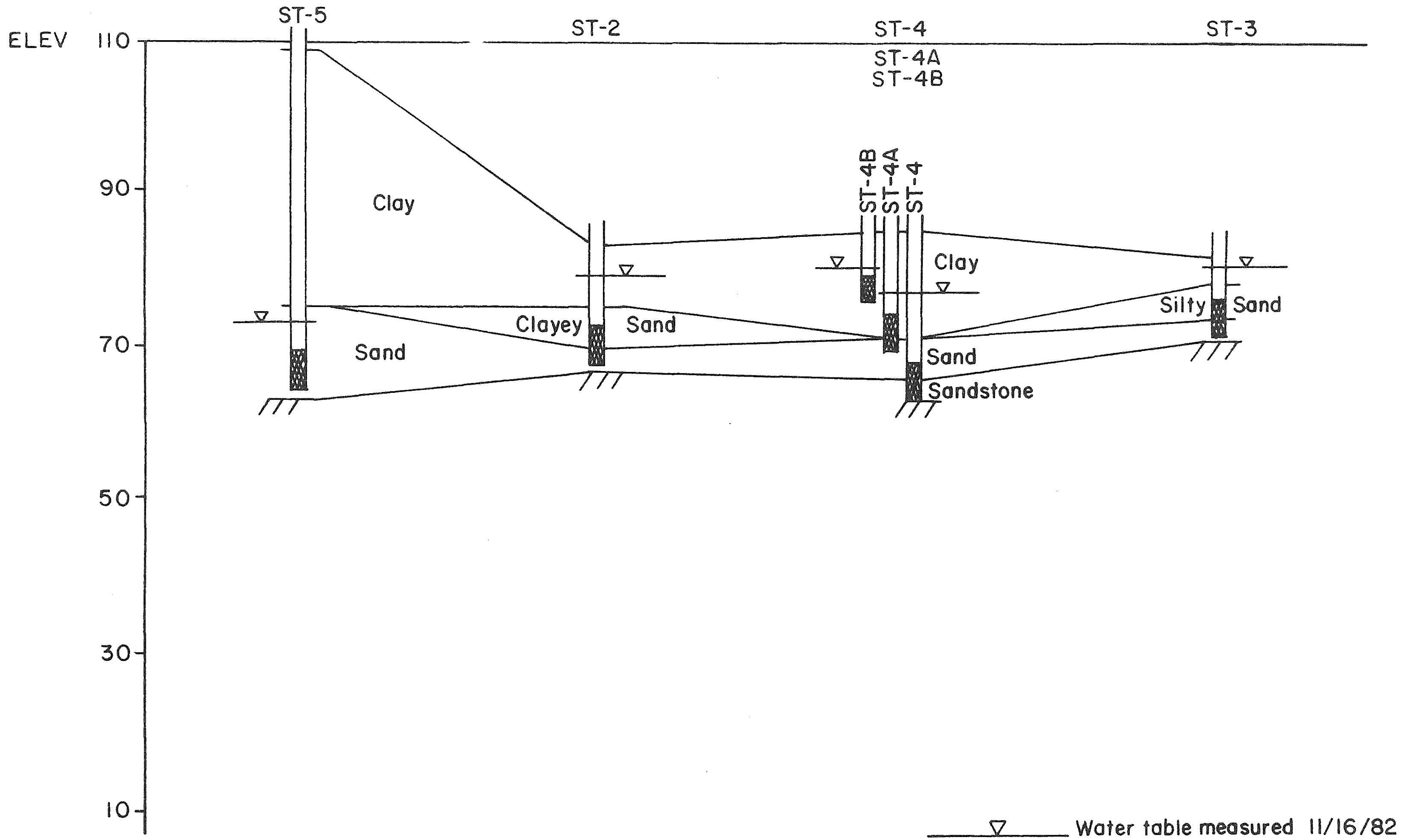

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Figure 7-11: General Soil Cross Section A-A'
Seneca Foods Spray Application Site

(Figure drafted by MPCA based on field measurements made by Braun Engineering Company and MPCA staff.)

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Scale: None

This mounding effect is promoted by the occurrence of sandy clay soils at the site that have low permeability (10^{-4} cm/sec) resulting effluent moving slowly (approximated at 4.8 feet per year) away from the site. At the beginning of June this mound was within two feet of the surface near the spray areas. A decline in elevations was observed until spraying was initiated. This drop was probably due to evapotranspiration losses as there was a high available water deficit in June. Over the course of the irrigation seasons, approximately 50 million gallons of effluent was sprayed on 150 acres, amounting to a loading rate of 12 inches for the year. Only small increases in elevation were noted following the pea pack, which sprayed 3.5 inches for six weeks, mostly in July. Spraying during the corn pack resulted in much greater increases particularly at ST-2 where the rise was 4 feet. Here the combination of an additional application of six inches and a very low available water deficit during August could have caused ground water to rise over August and September. The final three inches sprayed during the carrot pack did not show elevation changes through mid-November. When measurements were taken the following March, some elevations rose slightly while others dropped. Slight increases occurred at wells 1 and 5 where the effects of spring recharge would first be reflected as ground water is very close to the surface while downgradient wells had small declines. Therefore, the largest drop observed during the previous June at wells 1 and 5 has resulted in small drops at perimeter wells in March as ground water moves from the site. This suggests that while ground water movement during periods of minimal recharge may lower elevations in slowly permeable soils, evapotranspiration may have a much greater effect.

Wastewater generated from the processing of vegetables is generally characterized by very high levels of biological oxygen demand, chloride, conductivity, nitrogen, and phosphorus. Since ground water is mounding, it is difficult to determine background conditions from wells at the site. Off-site wells are likely needed to define the extent of mounding and background conditions. The well at ST-3 consistently had the best quality, making this the best indicator of background conditions. This is not unexpected when considering ST-3 is located east of one drainage ditch in a separate flow system where effluent is not applied. All other wells are located in flow systems where irrigation occurs. Samples collected prior to the spray season showed elevated values for chloride, conductivity, and TDS, with the greatest degradation encountered at existing wells 1, 2, 3, and particularly at well 5. The well at ST-2 had better quality while ST-4 approached background conditions. Lysimeters provided sufficient soil moisture samples most of the time but were inconsistent. Soil moisture results generally show quality improved with depth but decreased within the spray field.

Subsequent sampling was conducted after each of the vegetable packs, usually at newly-installed wells only. Monitoring results from these wells generally show a gradual increase in levels over the irrigation season. Changes were most dramatic at ST-2, where values increased to three times the drinking water standard for chloride (250 mg/l) and TDS (500 mg/l). All of these new wells except a shallow well at ST-4 provided samples from sand deposits underlying clay in the surficial aquifer. In some cases, effluent must move through 13 feet of clay before reaching these sampling points. Therefore, any changes in water quality or ground water depths may result from effluent being applied months or years earlier. Accordingly, it becomes difficult to determine the cause for changes in ground water quality so that impacts of disposal practices on future ground water quality or the effectiveness of any proposed corrective actions may be evaluated. While no consistent pattern has emerged the limited amount of data available does suggest a general decline in quality over an irrigation season and from year to year. A review of 1981 monitoring data from existing wells shows an increase in chloride and conductivity during the season. No significant changes in these parameters were observed from the end of the 1981 season and the beginning of the 1982 season. Although only one sampling from existing wells was performed during the study, there is evidence that ground water continued to degrade at the site as illustrated by sampling results from the new wells. Also, conductivity readings taken in all monitoring wells at the end of the irrigation season and the following March indicated no significant changes. This may mean further degradation will occur over the coming season.

An important question that still remains to be answered is how far and in what concentrations do constituents migrate from the site. As already discussed, constituents have migrated in high concentrations through the slowly permeable clay soils into underlying sand with a higher permeability (10^{-2} cm/sec). While migration of constituents in the underlying sand and sandstone would be more rapid, the amount of a constituent present is controlled primarily by effluent quality, the diffusion of constituents, and permeability of the clay. In clay soils diffusion can be a particularly important method of contaminant migration. There is evidence that some vertical migration beyond the monitoring wells has occurred, but the extent is uncertain. This is based on water quality samples collected from a company supply well on-site and a residential well adjacent to the site. The company well was an open hole from 300 to 475 feet in the Prairie du Chien-Jordan aquifer. The residential well was reported to be 75 feet deep with no construction details available. An inspection of other well logs in the area indicates this well is likely drawing water from underlying sand, sandstone (St. Peter), or both. The company well had elevated levels and the residential well had considerbly higher levels compared with samples from other wells in the area that are constructed in the same aquifer. Finally, conductivity readings were taken in nearby Willow Creek upstream and downstream of the site once prior to and twice during the irrigation season to determine the effects of ground water quality on the stream. There was a slight increase during the season but this increase could not necessarily be attributed to the site.

Wastewater was also characterized by high values of biological oxygen demand, nitrogen, and phosphorus. Ground water samples showed very low levels of ammonia-nitrogen and total phosphorus. Ammonia is either transformed to nitrate or retained by clay soils. Phosphorus is also being effectively retained and used by plants. Nitrate-nitrogen was low, indicating good removal from the cover crop of perennial grass and denitrification. Denitrification is likely significant as effluent is very high in organic content. Clay soils showed a good buffering capacity as effluent had low pH for pea and corn packs while ground water approached background conditions. Biological oxygen demand and fecal coliform levels ranged from low to undetectable in ground water samples.

<u>Conclusions and Recommendations</u>

1. Both spray irrigation studies were conducted on industrial discharges having similar characteristics. The primary problem at both sites from irrigating effluent was the high levels of chloride, and TDS, although the degree of the problem was significantly greater at the Rochester site. This appears to be the case at most spray irrigation sites throughout Minnesota, whether industrial or municipal. Nitrogen in the form of nitrates and ammonia generally has not shown

to be a problem as these sytems have high dentrification rates and/or low enough application rates to either allow crops to take up or soils to retain nitrogen. Treatment for phosphorus is achieved by the same soil-plant system essentially eliminating any impact to ground water. The study also showed adequate treatment was provided for biological oxygen demand and pH. Unfortunately, there is little these systems can do to reduce the impacts of chloride, and TDS except for decreasing the loading rate. Results further indicate that significant impacts occur year round with some fluctuations in quality. Based on limited information there appears to be a tendency for ground water to gradually decline in quality over time as it moves horizontally below a site. This may be balanced to an extent by the dispersion of contaminants through the surficial aquifer, which can be significant in sandy soils. Diffusion can be an important factor in the vertical migration of constituents where low permeable clay soils occur such as the Rochester site. This points out the importance of proper site selction for these types of systems.

Perham offers an excellent example of a site acceptable for any of the wastes that are presently being discharged to irrigation systems. Subsurface features at the site control ground water movement so that contaminants are directed toward a discharge point (Otter Tail River) and away from existing and potential drinking water sources. It is suggested that loading rates at sites with these features may be limited by either hydraulic loading rates of the soil or crop tolerance to the effluent provided proper management practices are pursued. Subsurface conditions combined with waste characteristics and proximity to drinking wells as found at the Rochester site, require more restrictions. Here it would be more appropriate to use loading rates based on the consumptive use of the cover crop. Other sites could be sized according to nutrient or any constituent loading if subsurface conditions are uniform so predicted effects on ground water quality can be made with a high degree of confidence. Since chloride appears to be the most limiting in these systems, it is suggested consideration be given to basing a loading rate on chloride where acceptable levels are determined for a particular location in ground water. Attention should be given to changes in ground water quality expected over time both vertically and horizontally.

2. Studies at the two sites emphasize the importance of buffer zones around an irrigation system to protect existing and potential drinking water sources. This is necessary because of mound development below spray areas that may induce flow in all directions away from the site until flow is returned to natural conditions. At the Perham site changes in mounding were detected by comparing elevation measurements from existing wells 2, 3, and 4 with those at well 1. Measurements at these wells during the study were also compared with those made prior to irrigating at the site. After 8 years of operating the system, mounding has increased approximately 5 feet below the spray area over background conditions. As yet, this apparently has not resulted in contaminants migrating beyond the property line. At the Rochester site no background data exists to determine the changes in mounding since irrigation began at the site. However, data indicates mounding has come very close to the surface and extends beyond the property line. The latter interpretation is supported by the high levels of chloride and TDS obtained from ST-5 at the property line and a nearby residential well. The high loading rates in previous years and low permeable soils at the site have likely contributed the most to this migration. Therefore, consideration should be given to evaluating mounding effects in determining site suitability for an irrigation system.

3. Management practices performed at a site may have significant effects on ground water. The most prominent example in the studies was the application of fertilizers at the Perham site. High values for nitrate substantially above drinking water standards were observed at existing wells within the spray field. It has been reported that fertilizers have been applied the last two years when the cover crop was converted to corn from reed canary grass. As a result, there has not been enough time for any impacts to reach downgradient wells. Since both industrial and domestic wastewater generally have some quantity of nitrogen, it is recommended that fertilizer applications only supplement what the effluent provides to a point equalling crop uptake.

Other management practices should be employed to prevent runoff within the spray area as well as off the site. Loading rates for a system are based on the premise that effluent will be applied uniformly over the site. Runoff from one part of the site to another will result in areas of lower and higher loading rates than designed. In areas of higher rates, lower ground water quality and greater mounding can be expected. Numerous practices are available for preventing runoff including methods for maximizing infiltration (e.g. contour plowing), selection of a cover crop, sprinkler rates that do not exceed soil intake rates, and irrigation schedules that limit spraying to periods of dryness and/or maximum evapotranspiration. Irrigation schedules incorporating loading and resting cycles have been used successfully for some solid set systems. If this is done, good records must be kept to insure effluent is sprayed uniformly over the site.

4. For canneries such as Seneca Foods that operate on a seasonal basis, there frequently is no storge provided. Some canneries in the past have furnished storage but it has ultimately been abandoned because of odor problems. Study

results indicate that storage is not needed at these facilities from a treatment standpoint as chloride and TDS, which were shown to be the primary ground water quality problems, are not treated in pond systems. However, spraying continuously while operating at night and during precipitation events can result in saturated soil conditions and runoff from the site. As a result, some short-term storage should be provided to prevent runoff and maximize evapotranspiration losses.

5. Studies at both sites illustrate the importance of properly designed ground water monitoring systems. Three wells at the Perham site were constructed so that contaminated ground water could migrate into an otherwise protected aquifer. Monitoring wells should only be screened into one aquifer or, if subdivided by restrictive layers, a single section of an aquifer. This is important not only in containing the movement of contaminants but also to provide samples that accurately reflect ground water movement under natural conditions. To further facilitate these objectives, the borehole around a well should be backfilled with low permeable material (e.g. bentonite) up to at least the bottom of the deposit closest to the surface. If high loading rates are approved based on a site's capacity to protect existing and potential drinking water sources, a monitoring system should be designed to verify a system is operating as intended. At the Perham site, this would require a nest of two wells in the spray field, one each above and below the clay layer. Also, a well nest downgradient of the site would be useful in defining any movement of contaminants if discontinuities in the clay layer exist. Wells may be used to indicate whether mounding is causing contaminants to leave a site. If a nutrient loading rate is used, monitoring wells will need to be located where designated levels in ground water are considered acceptable. This may mean a

monitoring system design that addresses vertical as well as horizontal distances from the site. The Rochester site illustrates the importance of defining impacts in a vertical direction.

The study also demonstrated limitations in using lysimeters for sampling soil moisture. Both sites were instrumented with vacuum lysimeters that were designed differently but installed in the same manner at two depths in a single location. A set of two lysimeters was placed within the spray area at Perham, within and outside the spray area at Rochester. No samples were obtained at the former site probably because sandy soils at the site have relatively high permeability and large pore spaces so that the movement of percolating water is preferentially downward with little or no water subject to capilliary forces around the lysimeter. Although the reliability of producing soil moisture samples at Rochester was much greater, the collection of ground water samples from monitoring wells still proved to be the most successful because of the occurrence of high permeable sandy soils.

In addition to problems of reliability, analytical results raise questions concerning usefulness of the lysimeter as a sampling device. First, there was no apparent correlation between monitoring results from lysimeters and ground water quality. Generally, quality of samples was much higher for lysimeters, apparently making this a poor indicator of ground water quality. Lysimeters outside the spray area had only slightly better sample quality than inside with quality improving with depth. The problem could be related to when a vacuum is generated. A vacuum was placed on each lysimeter at the beginning and a sample collected at the end of each vegetable pack. Once a vacuum is placed, the lysimeter will begin collecting water until it has filled. The device, for example, could fill rapidly before any irrigation occurs when only precipitation contributes to a sample. Also, if the vacuum is weak compared to tension in the surrounding soil, a volume of sample could be reduced by water moving out of the lysimeter. If conditions change again, water having a different quality could move back into the device. Given these potential effects on samples and the small size of the sampling area, it is not surprising these results do not reflect the impacts to ground water below a site. It is therefore recommended that lysimeters not be substituted for monitoring wells in assessing ground water impacts. Only at sites where lysimeters will most likely work and where monitoring wells will not produce sufficient samples should lysimeters be considered. If lysimeters are used, they should be placed at different depths with sample collection carefully timed so impacts to ground water will be accurately reflected. Since lysimeters sample a very small area, these devices should be used in greater numbers than monitoring wells. These devices may also be used in conjuction with wells. Pan lysimeters are acceptable in granular soils where installation will not significantly disturb natural soil conditions. These lysimeters have not generally been used, as they are difficult to install. Finally, it is suggested ground water monitoring programs for spray irrigation systems continue to follow current requirements, as discussed before, concerning parameters to be analyzed and frequency of sampling.

(c) Rapid Infiltration Systems:

Design Considerations: Rapid infiltration systems are considered high rate as hydraulic loading rates used at various facilities around the country have reached as much as 100 feet per year or more. These facilities generally discharge domestic wastewater with some degree of pretreatment. Since storage may be needed where climatic conditions limit the use of rapid infiltration, 90 to 120 days of storage is currently recommended in Minnesota to allow for severe winter climate. This storage in turn can provide a minimum of primary treatment prior to final disposal. Ponds used for storage must meet MPCA criteria for stabilization pond construction.

Final disposal in these systems consists of discharging wastewater to spreading basins constructed in rapidly permeable soils such as sands and loamy sands. Wastewater is treated primarily in underlying soils and to a lesser extent by vegetation, if present. More of the applied wastewater percolates to the ground water than with spray irrigation systems as there is little or no consumptive use by plants and less evaporation over a reduced surface area. In some cases, underdrains or wells may be used to recover treated wastewater from ground water below a site for reuse or discharge to surface waters. Interrelated factors used in designing rapid infiltration systems include hydraulic loading rate per application cycle, soil infiltration capacity, application and resting cycle, solids applied in the wastewater and subsoil permeability. For instance, when designing an acceptable hydraulic loading rate it must be taken into account that the operating infiltration rate will change from an initial rate to a lower rate as wastewater is applied and surface accumulation of organics and other suspended solids develops. This change in rate will depend not only on infiltration rates of soils at a site but also on the extent of pretreatment.

An evaluation of subsoil permeability to establish the most limiting layer in the soil profile is also important in determining conditions that may control hydraulic loading rates. Since rates decrease over time, it becomes necessary to restore infiltration capacity of basins to initial rates by providing a resting period. For a specific site, a balance between suspended solids application, land area requirements, and resting requirements is incorporated into a final design. This requires the total infiltration area be divided into a series of basins to accommodate both loading and resting periods. Since basins may have bare surfaces or be covered with vegetation, management practices should be utilized to promote infiltration such as periodic harrowing on bare surfaces or minimizing surface compaction in basins with vegetation.

Application rates for domestic wastewater in these systems may not only be limited by hydraulics but by nitrogen loading. Since crop uptake is relatively minor, nitrogen treatment is primarily achieved through nitrification, denitrification, and ammonium sorption. Wastewater contains nitrogen in ammonia, nitrate, and organic forms with the amount of each dependent on the level of pretreatment. Raw wastewater entering a treatment system will largely consist of ammonia and organic nitrogen. Primary and secondary treatment will decrease organic nitrogen and increase nitrates and possibly ammonia in wastewater discharged to infiltration basins. Organic and ammonia nitrogen will be retained by soils until loading exceeds the adsorption capacity of a site. If this capacity is exceeded, these forms of nitrogen will reach ground water along with any nitrate not lost to denitrification. Therefore, to achieve long term nitrogen removal in effluent discharged to ground water, it is necessary to provide conditions that promote nitrogen loss by nitrification-denitrification. This requires soil oxygen be replenished so that ammonium is converted to nitrate (nitrification) followed by anaerobic conditions which favor the transformation of nitrate to nitrogen gas (denitrification). The latter transformation is dependent on a source of organic matter which may be provided by soils at the site, effluent being discharged, or both.

Studies have shown that lower application rates increase nitrogen removal in some cases to over 80 percent. Infiltration rates in the field can be changed by modifying the depth of flooding, by compacting the soil surface, or by applying wastewater containing higher biological oxygen demand and suspended solids. Denitrification is further promoted by longer application cycles where soil reaeration is restricted, while short application cycles followed by relatively long resting cycles favor nitrification. If nitrogen removal is important, final design and system operation must balance this objective with acceptable infiltration rates.

Other water quality parameters of concern in domestic wastewater include biological oxygen demand, phosphorus, heavy metals, and microorganisms. Treatment is provided for these by the retention capacity of the soil and aerobic conditions during resting periods. Biological oxygen demand and microorganism removal require aerobic conditions while phosphorus and heavy metals are removed by adsorption, ion exchange, and precipitation in soils. However, because of high loading rates and the coarser textured soils used for rapid infiltration, the potential for these systems to impact ground water quality does exist.

Ground Water Monitoring: To date, four rapid infiltration systems have been permitted in Minnesota, with construction completed on two. Three other systems have been proposed but are still under review by the MPCA. All of these except for one proposed system will treat domestic wastewater. As discussed previously for spray irrigation systems, permits for rapid infiltration systems have limitations on the minimum infiltration area and maximum annual volume of wastewater that can be applied. This insures a uniform application rate from year to year while allowing variability in rates on a weekly or monthly basis. Variable rates are introduced when completed cycles for loading and resting periods in all basins do not correspond to a weekly or monthly schedule or when any change in the loading to resting ratio is employed to attain better treatment. Other limitations imposed on effluent discharged to infiltration basins are for biological oxygen demand and total suspended solids. This is done to insure pretreatment provides the effluent quality designed for an infiltration system. Limitations may require primary or secondary treatment, or may be absent, with only routine monitoring of effluent required. Most permits issued to date set a limitation of 50 mg/l for both biological oxygen demand and total suspended solids. If underdrains are used at a site, limitations may be imposed at the point of discharge.

Other permit requirements include a routine ground water monitoring program and specific management practices. Management practices may consist of the designation a cover crop (usually perennial grass), maintenance of vegetation or bare basin surfaces, or the scheduling of loading and resting periods. In most cases, a schedule will not be specified to allow for flexibility. The ground water monitoring requirements for rapid infiltration are more complex than those for other land application systems. The high loading rates for these systems make it necessary to define mounding effects of a particular loading/resting schedule. This requires piezometers be installed at selected locations throughout the basin system so that ground water elevations may be measured at different times during a complete cycle of loading all basins. The permit will generally specify when these measurements must be taken during the cycle. This is to insure that basins are operated to maintain an unsaturated zone above a mound to maximize treatment.

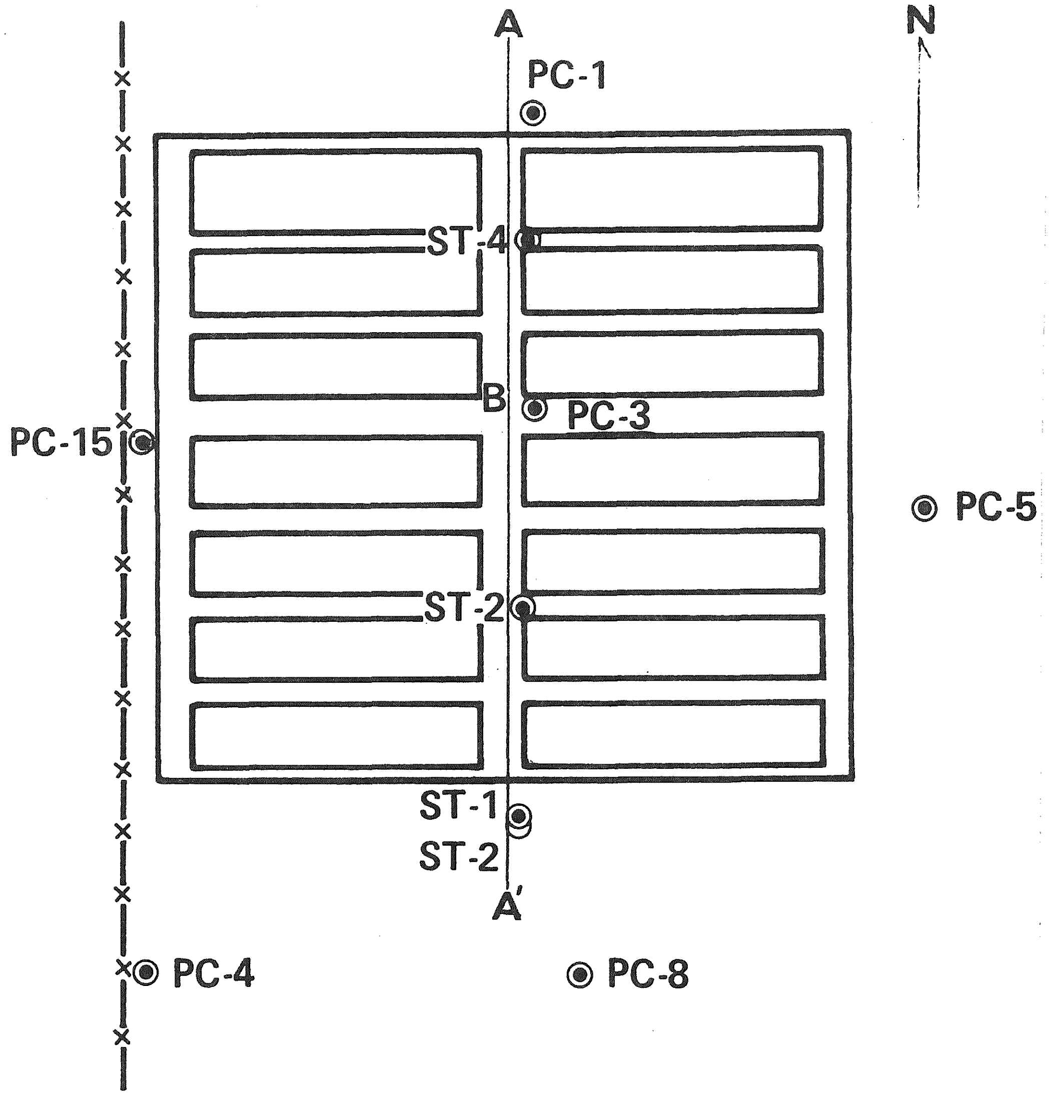
Monitoring wells must also be installed for obtaining ground water samples, although some wells may be used for both sampling and water level measurements. Parameters normally analyzed in samples are chloride, conductivity, ammonia-nitrogen, nitrate-nitrogen, and in some cases total phosphorus.

Frequency of sampling ranges from once every two months to quarterly. Ground water elevations are required on a monthly to sometimes quarterly basis during the application season. On occasion, a permit may require further monitoring for effluent or discharges from underdrain systems for parameters such as total nitrogen and/or total phosphorus.

No ground water monitoring data has been generated from these systems to date as only two systems have been constructed. One system has only recently begun operation while the other system has been in operation for less than eight years on a limited basis usually during the spring and fall. Since this system treats a small portion of the total wastewater, most attention has been given to monitoring only the greater volumes that are discharged to surface waters and spray irrigated.

Site Investigation: The rapid infiltration system at the municipal wastewater treatment plant for the city of Detroit Lakes is one of three methods used by the city for final disposal of its effluent. The facility is designed to treat a maximum of 1.4 million gallons per day with wastewater discharged through screens, trickling filters, an aerated pond, settling tanks and into an 18-day detention stabilization pond. From this pond wastewater is treated chemically and discharged to a dispersion ditch in a peat absorption area at one end of a lake from mid-October to mid-April, spray irrigated from mid-May to mid-September, and applied to infiltration basins from mid-April to mid-May and mid-September to mid-October. This infiltration area consists of 14 basins covered with perennial grass, each approximately a half acre in size underdrained with six tile lines.

Six monitoring wells designated in Figure 7-12 with the prefix PC had been



BRAUN
ENGINEERING TESTING

Figure 7-12: Rapid Infiltration System: Detroit Lakes Wastewater Treatment Facility

Date:
Revised:
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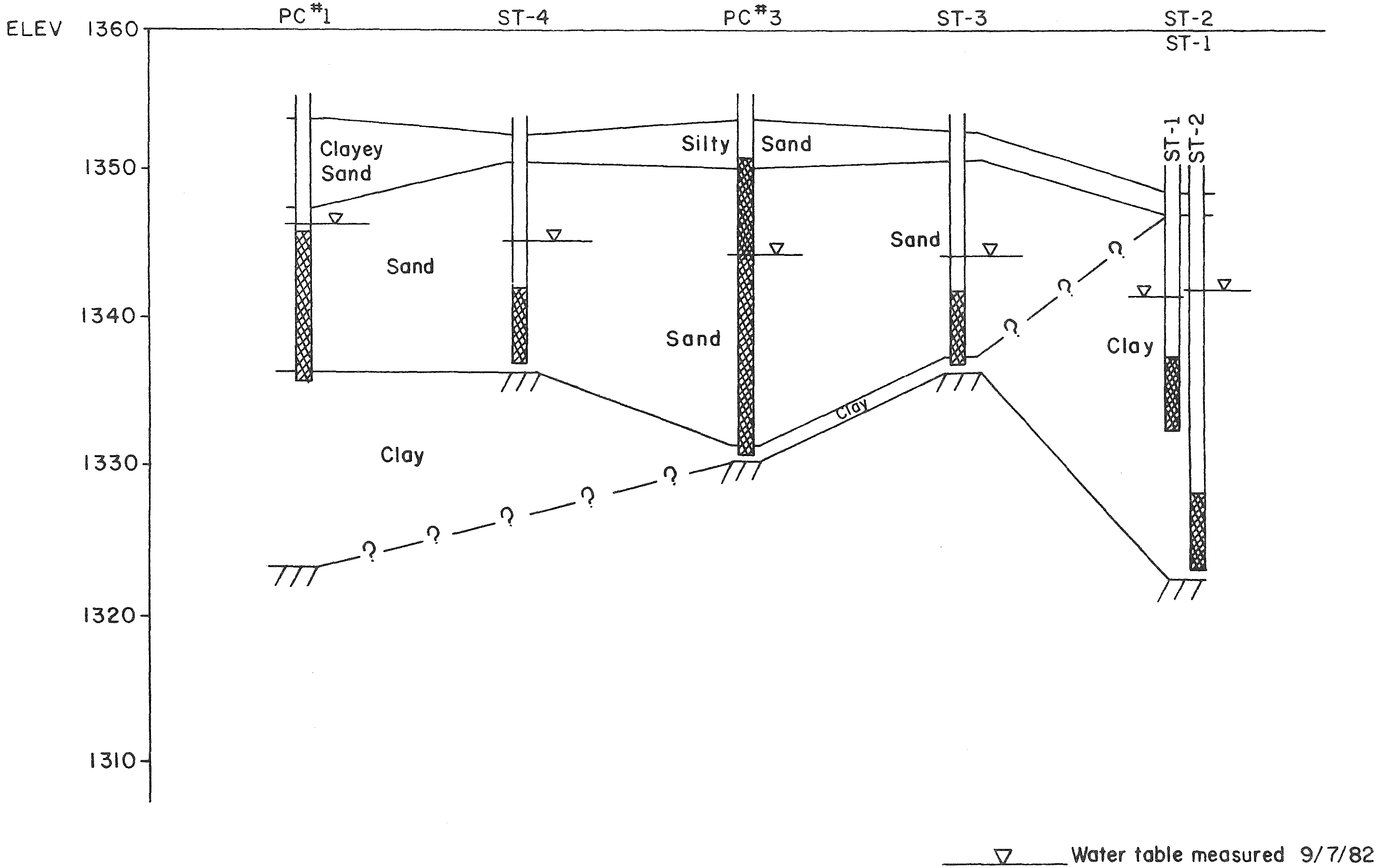
Scale: None

constructed in and around the infiltration area prior to the study. The investigation included instrumenting the site with four additional wells (prefixed ST). Two wells were installed in the same location but extended to different depths. Subsurface conditions as described in Figure 7-13 were derived from logs of both new and existing wells. Underdrains were blocked off during the study so that any mounding effects from loading would occur under natural conditions. Sample collection was scheduled at four different times before and after loading periods. Samples were analyzed for chloride, conductivity, total dissolved solids (TDS), ammonia-nitrogen, pH, total phosphorus, biological oxygen demand (BOD), and fecal coliform. Sampling was generally restricted to new wells with existing wells used on occasion. Effluent samples were collected and analyzed twice during the study. Ground water elevations were measured more frequently ranging from three times a day, to daily, to quarterly.

A loading-resting schedule for all basins was initiated in the second week of September, 1982. During the summer prior to this loading, infiltration basins were only used for six days in June. The schedule consisted of loading four basins at a time for a 24-hour period running from noon to noon with flow measurements recorded on a daily basis. Each day, flow was directed to a different set of basis so that one day of loading was followed by two days of resting. The two southernmost basins were not used during this part of the study. Ground water elevation measurements were taken three times on the first day of loading and daily for the next six days. Loading rates averaged 10 inches per day ranging from 8 to 12 inches per day over the one week period using 2.1 acres of infiltration area per day.

After collecting ground water samples and resting all basins for one week, the same schedule was employed for the next month except for a one week rest



BRAUN

Figure 7-13: General Soil Cross Section A-A'
Detroit Lakes Wastewater Treatment Facility

(Figure drafted by MPCA based on field measurements made by Braun Engineering Company and MPCA staff.)

Date:

Revised:

Drawn:

Scale: None

midpoint of this period followed by another round of sampling. The loading rate during this period averaged 12 inches per day with a range of 10 to 13 inches. The final loading period began with the same schedule for one week followed by three weeks of continous loading of all basins before ground water samples were again collected. Continuous loading means no resting cycles were provided for the 12 basins. After sampling, the two southernmost basins were started on a schedule of loading one day and resting two while the other basins were continously loaded. This schedule was continued until the basins froze up which occurred for all basins at the same time at the end of December.

While the total volume of wastewater discharged to the system was nearly doubled when loading continuously, the daily loading rate was reduced from previous loading periods by using more basins. The average loading rate during this period was 7.1 inches per day ranging from 12 inches per day using four basins down to 5.7 inches per day when all 14 basins were used. However, when basins were not rested during the loading period, rates increased for a basin when determined on a weekly or monthly basis. For example, the weekly rate for a basin during the first loading period averaged 23 inches while approximately 40 inches was applied when all basins were used every day. Regardless of the daily or weekly loading rate during the study, there was no problem with wastewater disposal being limited by subsoil permeability (approximately 10^{-2} cm/sec) or any changes in infiltration capacity of the basins. The only limitations observed resulted from basins freezing up in late December and lasting until the middle of the following April.

Ground water elevations measured prior to the first loading period indicate flow direction is from the northwest to the southeast. This corresponds to a depth to ground water below infiltration basin surfaces of four feet at the northwest corner to ten feet in the southeast corner. After one week of loading, the depth to ground water decreased to two feet in the northwest corner while the southeast corner remained the same. This means a mounding effect has developed as illustrated by the addition of two feet to the water table elevation below the infltration area. Mounding has apparently been confined to this area since there was no change in elevation on the downgradient side (southeast corner). However, elevations taken from wells further downgradient from the area indicate that although no visible mounding has occurred, ground water has been affected beyond the site. The ground water gradient here has been decreased by advancing contours further downgradient. Therefore, loading has resulted in a gradient increase below the site in the form of a mound. Wells within and directly adjacent to the infiltration area showed a gradual increase in elevation throughout the week of loading. Smallest increases were observed at ST-1 and ST-2 which were completed in clayey till. The wells with the greatest response to loading and resting cycles were the centrally-located wells completed in sandy soils, i.e. PC-1, PC-3, and ST-4. These wells had the greatest increases in elevation with relatively small elevation drops (.1 to .7 feet) when basins were rested. Flow direction throughout this and subsequent loading periods remained the same, from the northwest to the southeast.

Elevations were measured once at the beginning and end of the second loading period. After resting all basins for one week, elevations dropped between .5 to 1.0 foot from the end of the first to the beginning of the second loading period. This three week period decreased the depth to ground water from infiltration surfaces 2 feet to 1 foot in the northwest corner and 10 to 9 feet in the southeast corner of the infiltration area. The relative configuration of the flow field is the same as the first loading period, with the only difference being ground water had mounded a foot higher.

The final loading period was initiated after all basins had been rested for one week. Most of this period consisted of loading 12 basins continuously for three weeks with measurements taken once at the end of the period. This resulted in the depth to ground water being reduced to below one foot in the northwest and declining to eight feet in the southeast. The flow field configuration begins to change in this loading period with the flow gradient becoming smaller below the infiltration area while increasing downgradient from the site. This suggests that the mound is growing laterally in the downgradient direction. Two months after the basins were made inoperable by freezing, a final round of ground water measurements was taken. These measurements indicate a return to pre-loading conditions, i.e., the same gradient with ground water depth ranging from four feet in the northwest to ten feet in the southeast.

Ground water sampling from existing wells at the site had been conducted before and after the infiltration basins were constructed and prior to this study. Two wells near the infiltration area showed low levels of chloride, nitrate-nitrogen, and phosphorus with TDS values around 500 mg/l two years prior to construction. From this point until construction, samples were taken from existing wells and analyzed for total nitrogen and total phosphorus. Mean concentrations during this period generally were less than 5 mg/l for nitrogen and 0.4 mg/l for phosphorus. Following construction, four years of sampling data were generated as part of a study commissioned by the Pelican River Watershed District. These results show that discharges to the rapid infiltration system increased chloride levels in ground water to the point of reaching effluent quality and exceeding drinking water standards (250 mg/l) during the first year.

When loadings were terminated, levels began to decrease to below drinking water standards by the time the next application season began. Subsequent years of loading produced levels well above pre-operation conditions but within standards and below effluent concentrations. Conductivity during this period generally approached or exceeded effluent levels during the application season and dropped considerably over the winter months. Values for total nitrogen and total phosphorus in effluent and ground water fluctuated throughout the study. It was reported that the phosphorus applied with effluent was largely responsible for changes in ground water quality during growing seasons, while other fluctuations could not be explained. For nitrogen, a relationship was identified between concentration changes of the effluent and the season of the year. Lower nitrogen levels in effluent during the growing season were attributed to growth and proliferation of plants in the stabilization pond. Variations in ground water quality below the infiltration area, however, were considered to be unrelated to these changes in effluent quality. Both phosphorus and nitrogen were further evaluated according to the percent reduction of these nutrients between concentrations in effluent and ground water. Reductions in nitrogen varied from 12 to 97 percent, generally increasing from year to year with the last year of record averaging approximately 53 percent. Phosphorus had higher and more uniform reductions, ranging from 50 to 93 percent, with the last year having the highest average of 84 percent. The highest concentration of total nitrogen reported in ground water was 8 mg/l with all other results below 5 mg/l. The highest phosphorus level was 2.5 mg/l with most results below 1.0 mg/l. Infiltration basins throughout the period were loaded continuously with no scheduled resting cycles.

No further ground water data were collected at the site until the new wells were installed two years later. The first sampling was conducted prior to the first loading period to define background conditions. Values for chloride, nitrate-nitrogen, phosphorus, and TDS at all new wells were above pre-construction conditions. Ground water at wells completed in sandy soils at ST-3 and ST-4 was impacted by chloride more than at ST-1 and ST-2, likely because of spray irrigation occurring north of the area. Conductivity and TDS were generally higher at ST-1 and ST-2 where clayey soils were encountered, with higher values noted at the greater depth. Levels for ammonia-nitrogen and total phosphorus were low at all wells while nitrate-nitrogen was higher than effluent levels at ST-3 and ST-4 suggesting a source of contamination other than spray irrigation.

A second round of sampling was conducted at the end of the first loading period at a time when only those basins surrounding ST-3 were being used. This generally resulted in an increase in levels for chloride, conductivity, and TDS at ST-3 and ST-4. The most dramatic changes occurred in conductivity at new and existing wells within the infiltration area. Slightly higher values were observed at wells in the northern part of the area. Chlorides increased more at wells ST-3 and ST-4 than in the south where ST-1 and ST-2 essentially stayed the same. All new wells had increases in TDS with the largest occurring at ST-3. Small rises in ammonia-nitrogen were observed at all wells while total phosphorus was largely eliminated. Nitrate-nitrogen values declined substantially from pre-loading conditions at all new wells. The highest levels in nitrate were encountered at ST-3 adjacent to where effluent was being discharged. All values obtained from ground water samples for all parameters were lower than basin effluent except for nitrate-nitrogen. Only slight reductions were found for chloride, conductivity, and TDS while ammonia-nitrogen was reduced by as much as 95 percent with phosphorus not detected. For nitrate-nitrogen, however, levels in ground water exceeded the effluent level by 400 percent at ST-3 and by 150 percent at ST-4.

Sampling at the end of the second loading period was performed when basins surrounding ST-4 were being loaded. At this time, an additional sample was taken from an existing well upgradient from the infiltration area. There were no apparent changes in ground water quality from the first loading period for chloride, conductivity, and TDS. Values generally represented a reduction from effluent levels but showed large increases over upgradient conditions. There was a significant decline in nitrate-nitrogen from the previous sampling. At ST-4 values were reduced from effluent levels by as much as 75 percent. Ammonia-nitrogen and total phosphorus remained the same, except at ST-4. Here, phosphorus increased to levels above effluent quality.

The final round of sampling occurred when all but two basins were being loaded. Results showed a rise in chloride, conductivity, and TDS at ST-3 and ST-4. Drinking water standards were reached or approached at these wells for chloride (250 mg/l). Ammonia-nitrogen at all wells remained the same while nitrate-nitrogen increased at ST-3 and ST-4 to levels observed at ST-3 after the first loading period. Monitoring results from ST-1 and ST-2 throughout the study showed much lower levels for all parameters reflecting very slow changes caused by slowly permeable clay (10^{-9} cm/sec) encountered in the southern part of the site. Conductivity readings were also taken from existing wells in and adjacent to the infiltration area during this sampling round, as well as the following March. Readings indicate a small improvement in quality below and directly adjacent to the infiltration area with increased ground water impacts downgradient from the site. Finally, during the course of the study pH and fecal coliform did not show significant changes or provide results of any concern. Values for biological oxygen demand were consistent but very low in both effluent and ground water.

Conclusions/Recommendations: 1) Loading rates to the infiltration area varied from one foot per day when four basins were used to one-half foot per day for twelve basins. This resulted in weekly loading rates of approximately two feet and over three feet, respectively. Since all infiltration surfaces were constructed to the same elevation, mounding can easily be defined according to the depth to ground water from this point. The first two loading periods developed a mound primarily below the infiltration area with the mound building up more vertically during the first loading period and moving more laterally during the second loading. Daily ground water measurements during the first loading generally showed a gradual increase in mounding with only small drops in elevation during resting cycles. More significant drops were observed between loading periods. The final loading period showed a slight increase in elevation below the area with more increases occurring downgradient. This suggests mound growth is more lateral than vertical.

At the end of the final loading period ground water had mounded to a maximum of within one foot of basin surfaces in the northwest corner of the area. This can be compared to a depth of six feet that was measured at the site three years prior to construction. The study illustrates that rapid infiltration systems can create significant mounding effects that reduce the treatment area below basins and may reduce hydraulic capacity if a mound extends to basin surfaces. To avoid this situation, it may be appropriate for a proposed infiltration system to be divided into separate infiltration areas so that an entire area may be rested to allow time for mounds to dissipate to a minimum level before reuse. Areas should be far enough apart so mounding from one area will not effect the operation of another area. An alternative to this would be the use of an underdrain system.

2) Ground water quality results at a site will, to a great extent, be affected by effluent quality. Effluent discharged in the study had better than secondary treatment as indicated by very low levels of biological oxygen demand. The investigation conducted prior to this study provided data suggesting that nitrogen and phosphorus is removed by plants growing in the stabilization pond from which effluent is discharged to the basins, helping to produce low levels of ammonia-nitrogen, nitrate-nitrogen ($\leq$4.0 mg/l), and total phosphorus in effluent. High levels, however, were encountered for chloride, conductivity, and TDS in both effluent and ground water. Study results for chloride and conductivity correlate closely with the previous investigation where small reductions were observed between effluent and ground water below the basins. Reductions were higher during the first two loading periods of the study than the last period or previous years.

Nitrate-nitrogen was very high before loading and decreased dramatically afterwards. The high values were probably caused by fertilizer applications that have been reported on land west of the site. Each of the two subsequent loading periods showed improved levels of nitrate followed by a substantial increase in the last loading. The low levels of ammonia-nitrogen and total phosphorus throughout the study indicate a good retention capacity by basin surfaces and subsurface soils. These results illustrate loading/resting cycles are effective in reducing nitrates and to a small degree chloride, conductivity, and TDS. A schedule of loading one day followed by two days of rest resulted in improved reductions for nitrate by promoting denitrification. Greater reductions could likely be achieved if effluent with higher organic content (less pretreatment) were applied. This schedule was also helpful in reducing chloride, conductivity, and TDS. The primary reason for this was that resting cycles ultimately resulted in lower loading rates on an annual basis when effluent is applied uniformly over an infiltration area than under conditions of continuous loading. It is therefore recommended that consideration be given to designing loading rates and loading/resting cycles according to not only those factors previously discussed for rapid infiltration but also to an acceptable level of chloride in ground water downgradient from a site. Chloride would be a good constituent to use for a criteria as conductivity and TDS values depend to a great extent on chloride levels and a drinking water standard for chloride exists.

Furthermore, since rapid infiltration systems have relatively good design flexibility, it is suggested that designs be used that minimize ground water impacts. For example, the configuration of basins and/or infiltration areas consisting of many basins can be designed so that they are narrow with the longer sides normal to ground water flow. This would decrease impacts by spreading out effluent where there would be better dispersion with native ground water.

3) The primary restriction to infiltration in the basins was provided by cold weather. There were no observed problems in disposing of effluent until basins froze up at the end of December. Since the treatment facility was constructed, the most the basins have been loaded continually is for two months which resulted in no infiltration problems. This is likely because effluent was

pretreated to better than secondary standards eliminating most organic waste. Another factor is that management practices included disking basin surfaces twice a year to maintain infiltration capacity. During the study, 12 basins were loaded continuously through November and December. Ambient temperatures in November averaged 23°F (4°F below normal) while December averaged 19°F (7°F above normal). This resulted in a drop in the effluent temperature discharged from the stabilization pond to the basins from 38°F to 35°F in November and to 32°F one week before freeze-up at the end of December. The two southernmost basins froze at the same time while being loaded one day and rested two days during this period. Since all basins did not thaw until the third week in April, which is the first month of the year with an average temperature above freezing (41°F), it is suggested a minimum of four months of storage be required for these systems. This may be reduced where warmer effluent, climate, and/or bare basin surfaces are present. The loading period at this facility probably could be extended by removing all vegetation so that the ice cover could float on effluent discharged to basins and not become anchored by freezing to vegetation. It is uncertain whether this would require continuous loading or could be done using loading and resting cycles. Further study is needed to determine appropriate storage requirements for other designs and climates in addition to assessing the effects of cold weather on a system's treatment capability. The study illustrates very well the value of good pretreatment in maintaining infiltration capacity. If there is less pretreatment, it would be necessary for a design to provide reduced loading rates and/or more intensive management practices.

4. The study demonstrated a need for specific ground water monitoring requirements concerning well placement, frequency of sampling, and parameters.

Monitoring is not only important in assessing impacts on ground water but also to determine a loading/resting schedule that will provide the best treatment. This requires that monitoring wells be placed adjacent to infiltration basins so the highest point of a mound can be measured to determine when loading should be terminated. This is to maintain a minimum unsaturated zone below the basins to promote treatment. Wells at these locations and effluent samples are important in determining the amount of treatment which is achieved in this zone for parameters such as nitrogen, phosphorus, biological oxygen demand, bacteria, and possibly heavy metals.

In domestic wastewater, nitrate-nitrogen and ammonia-nitrogen are usually the major concerns. Phosphorus may be important to monitor in lakeshore areas. Other constituents that should be analyzed in ground water are chloride and conductivity (or TDS) as they are normally high in domestic wastewater. Monitoring should be scheduled so that wells are sampled when basins adjacent to them are being loaded. Background and downgradient wells should be installed for each infiltration area to better assess impacts and determine compliance with acceptable ground water quality criteria. Criteria may be applied to locations in ground water laterally or vertically from the site. Depending on the loading rate and volume of wastewater, sample collection and ground water measurements may be performed on a monthly to quarterly basis during periods of scheduled loading so that the same basin is not being loaded on successive samplings.

(d) Surface Impoundments:

Surface impoundments variously described as lagoons, ponds, basins, pits or excavations, are used to store, treat or dispose of liquid or semi-liquid wastes. Final disposal of wastes directed to surface impoundments may be to sewer systems, to surface waters, to the soils by land application such as spray irrigation, or directly to the ground by seepage through the sides and bottom of the impoundment. According to the USEPA (1976), the major cause of ground water pollution in the United States other than the use of septic systems, is leakage of wastes from holding ponds or lagoons. The potential for ground water contamination depends on many factors including the type, amount, and concentration of wastes seeping from the impoundment, and the geologic and hydrologic characteristics of the unsaturated and saturated zones. The most serious problems have developed where the impoundments are unlined (or improperly lined), located over highly permeable strata and the wastes being directed to the impoundment are hazardous or if not strictly hazardous, of sufficient concentration and quantity to render the aquifer unsuitable for use.

Surface impoundments have generally been categorized as industrial, municipal, agricultural or mining impoundments. The latter three categories have been previously studied in Minnesota (Hickok, 1978; Barr, 1982; USGS, 1983) to determine their effects on ground water. The subject of this discussion is industrial impoundments. While the types of waste directed to municipal, agricultural and mining (in Minnesota) impoundments do not vary significantly in type within each category, industrial impoundments are difficult to generalize because the types of wastes directed to them vary considerably. In Minnesota surface impoundments have been used by industries in all of the major standard industrial classifications.

<u>Design Considerations</u>: Design considerations or criteria for impoundments have been established for several purposes. These are: 1) to ensure adequate treatment of the wastes to meet discharge requirements whether to sewers,

surface waters or land; 2) to prevent or limit ground water contamination due to excess seepage of untreated or inadequately treated waste; and, 3) to prevent structural failure which could cause surface or ground water contamination. The primary focus of this discussion is protection of the ground water and will therefore be limited to those criteria and regulations which may affect ground water protection.

There are two factors which have a significant bearing on the design criteria for surface impoundments in Minnesota. The first is whether the wastes being discharged to the impoundment are hazardous or nonhazardous. The second is the geographic location of the impoundment. If the waste is hazardous, the facility is required to comply with all applicable state and federal hazardous waste regulations for treatment, storage or disposal (TSD) facilities. If the waste is nonhazardous, less stringent design criteria are applied. Certain locations in southeastern Minnesota are subject to development of karst features and more intensive hydrologic evaluations and design criteria may be required for impoundments proposed in these areas than in the rest of the state.

Location Restrictions and Design Criteria: Much of southeastern Minnesota is underlain by very soluble limestone and dolomite and is subject to development of karst features. Ellison-Pihlstrom (1976) describes failure of a wastewater holding pond at Altura, Minnesota and the loss of 20 million gallons of treated wastewater due to the opening of sinkholes directly beneath the pond site. Proposed state hazardous waste rules will specifically exclude establishment of hazardous waste facilities from areas characterized by surficial karst features. MPCA pond design review considerations for nonhazardous waste surface impoundments also prohibit the location of ponds on specific sites which may be subject to karstification.

Any pond systems proposed in an area generally defined as south of the Twin Cities Metropolitan Area and east of Interstate Highway 35 will be subject to intensive hydrogeologic site evaluation and even if the specific site does not show evidence of karst features, either outwardly or on the subsurface, a 20 mil synthetic liner may be required as a precaution.

Hazardous Wastes Federal Regulations: Hazardous wastes cannot be discharged to surface impoundments without obtaining the necessary state and federal permits for TSD facilities. Federal hazardous waste regulations are contained in Chapter 40 Code of Federal Regulations (CFR) Parts 260 to 266 and 122 to 124. Regulations and permitting requirements differ for facilities in operation or with construction commitments on November 19, 1980 the effective date of Part 265. Facilities in operation on that date are subject to Interim Status Standards which are less stringent than those for new facilities.

Interim status standards do not address significant design criteria for existing impoundments. Because they do not address the potential for seepage, the ground water monitoring requirements for impoundments with interim status are very important so that any ground water contamination resulting from use of the impoundment is detected. Subpart F of Part 265 sets forth the ground water monitoring requirements.

The minimum monitoring system required is one well upgradient and three at the downgradient edge of the waste management area. It is required that the number, location and depth of the wells ensure that they immediately detect any significant amounts of hazardous waste or hazardous waste constituents that migrate from the waste management area to the uppermost aquifer. For the first year, USEPA requires quarterly monitoring for each of three parameter groups: 1) parameters with primary drinking water standards, 2) parameters to establish ground water quality, and 3) generalized parameters used as indicators of ground water contamination.

At least four replicate samples are required from the upgradient well for group three parameters so background levels of these parameters can be established. In subsequent years, group two parameters are required annually from all wells, and group three parameters are required semiannually. Waste specific monitoring parameters are not required. Subpart F also provides the required statistical tests to be applied to make a determination as to whether a facility is exerting an effect on ground water. If a facility is negatively impacting ground water, increased monitoring is required. Guidance as to when or how to undertake corrective actions to limit ground water impacts is not given. A clause is provided which states that the requirements for monitoring may be waived if the operator can demonstrate to the USEPA that ground water will not be affected by the facility.

Closure requirements given in Subpart G, Section 265.117 require that post-closure care continue for thirty years after the closure date, including ground water monitoring in accordance with Subpart F and maintenance of monitoring and waste containment systems for that period.

Technical standards for new impoundments are set forth in 40 CFR, Part 264. The basic requirement of Subpart K is a liner to prevent migration of wastes out of the impoundment into the soil, ground water and surface water throughout the active life of the impoundment. Ground water monitoring requirements are set forth in Subpart F. An exemption from ground water monitoring requirements is provided for impoundments that have double liners and leak detection systems. A variance may also be obtained from the liner requirement if it can be shown that the hazardous constituents will never migrate from the impoundment into the ground water or surface water.

The ground water protection standard requires that hazardous constituents in the ground water at the waste boundary not exceed concentration limits set in the permit. Hazardous constituents are defined as those waste constituents specified in Appendix VIII of Part 261 of the rules, which are reasonably expected to be in or derived from wastes contained at the facility. The concentration limits which cannot be exceeded are the background (pre-operational) or upgradient level for constituents for which primary drinking water standards are not set, or the primary drinking water standard for those parameters with standards. USEPA has retained the authority to set alternate limits and to exempt certain hazardous constituents if the situation warrants.

General ground water monitoring requirements call for an unspecified but sufficient number of wells to yield samples representative of background water quality and the quality of the water passing under the downgradient waste boundary. A two-phase approach is taken, requiring detection monitoring to initially detect ground water impacts, to be followed by a more intensive compliance monitoring if the ground water protection standard is violated. The statistical method to be used to determine background levels specified is similar to that outlined for interim status facilities, but the necessary monitoring parameters chosen are much more waste-specific and are individually set in each permit.

In detection monitoring, semi-annual sampling is to be conducted during the active life of the facility and thirty years thereafter, as long as no effects are noted. Samples are to be analyzed for the permit-specified parameters only, and calculations made as to whether background levels are exceeded. If the ground water protection standard is violated, and contamination detected, the compliance monitoring requirements apply. Under compliance monitoring, samples are gathered quarterly and analyzed for the parameters specified in the permit. In addition, samples from all wells at the waste boundary must be analyzed at least annually for all the hazardous constituents in Appendix VIII of Part 261, a list which contains more than 350 parameters.

At the time that compliance monitoring is required, the facility operator must also initiate a corrective action program for removing or treating in-place water contaminants. Some general guidance is given as to requirements of the corrective action programs.

Closure requirements of this part are similar to those for interim status facilities. Subpart G, Section 264.117 requires that post-closure care continue for thirty years after the closure date, including ground water monitoring in accordance with Subpart F and maintenance of monitoring and waste containment systems for that period.

Hazardous Wastes State Regulations: Current state hazardous waste rules 6 MCAR §§ 4.9001-4.9010 state that the facility operator shall prevent the discharge of hazardous waste from the facility to the surface waters or ground waters of the state. Ground water monitoring requirements state only that the facility operator shall construct and begin operating a site monitoring system that is approved by MPCA and adequate to determine the effects of the facility on the soil, ground water, and air before accepting or storing any hazardous waste at the facility. No specific requirements are given. Facilities are restricted from locations where the topography, geology, hydrology or soil is unsuitable for the protection of ground water and surface water.

The existing state hazardous waste rules are currently being revised. Proposed rules were published (MPCA, 1982) in June 1982 and are expected to go to hearing in late 1983. Proposed state rules regulating facilities with interim status are similar to federal regulations, however, the state will require more waste-specific ground water monitoring parameters and quarterly monitoring rather than semiannual. Proposed standards for new hazardous waste surface impoundments differ significantly from federal regulations with respect to ground water protection and monitoring.

Double liners and leak detection systems will be required for all surface impoundments. Ground water monitoring will be required of all such facilities and there are no provisions for exemptions. Monitoring may be required of all potentially affected aquifers along with uppermost aquifer. Quarterly monitoring may be required for a greater number of parameters during compliance monitoring and hazardous constituents to be tested may include not only the list cited for federal rules but also unlisted wastes that may be determined as hazardous in Minnesota by meeting criteria for toxicity established in 6 MCAR § 4.9132 F.

Nonhazardous Waste: MPCA design criteria for surface impoundments receiving nonhazardous wastes do not specify a required permeability for pond seals but rather set limits on the seepage rate allowed. In general, loss by seepage from the pond may not exceed 500 gallons per acre per day although seepage rates up to 3,500 gallons per acre per day may be permitted for secondary or storage ponds if it can be demonstrated that: 1) The water levels in the pond will provide adequate treatment; 2) the increased seepage rate will not endanger ground or surface water resources; and 3) that compliance with the 500 gallon per acre per day requirement would excessively increase project cost.

Specific quality control tests to ensure that seepage requirements can be met are outlined in the pond design review considerations and include a requirement to fill the pond with water prior to receiving waste to provide a final quality control test through calculation of a water balance. Daniel (1983) presents four case histories of pond liners where the actual average hydraulic conductivities of the clay liners were found to be 10 to 1,000 times higher than values obtained from laboratory tests on either undisturbed or recompacted samples of the clay liners.

An approved system for ground water monitoring may be required around the perimeter of the pond site to facilitate ground water monitoring. The use of wells and/or lysimeters is determined on a case-by-case basis depending on the proximity of private wells, ground water elevations, rates of seepage and other extenuating circumstances. If monitoring is required, a routine sampling program must be initiated prior to pond operation and continued thereafter.

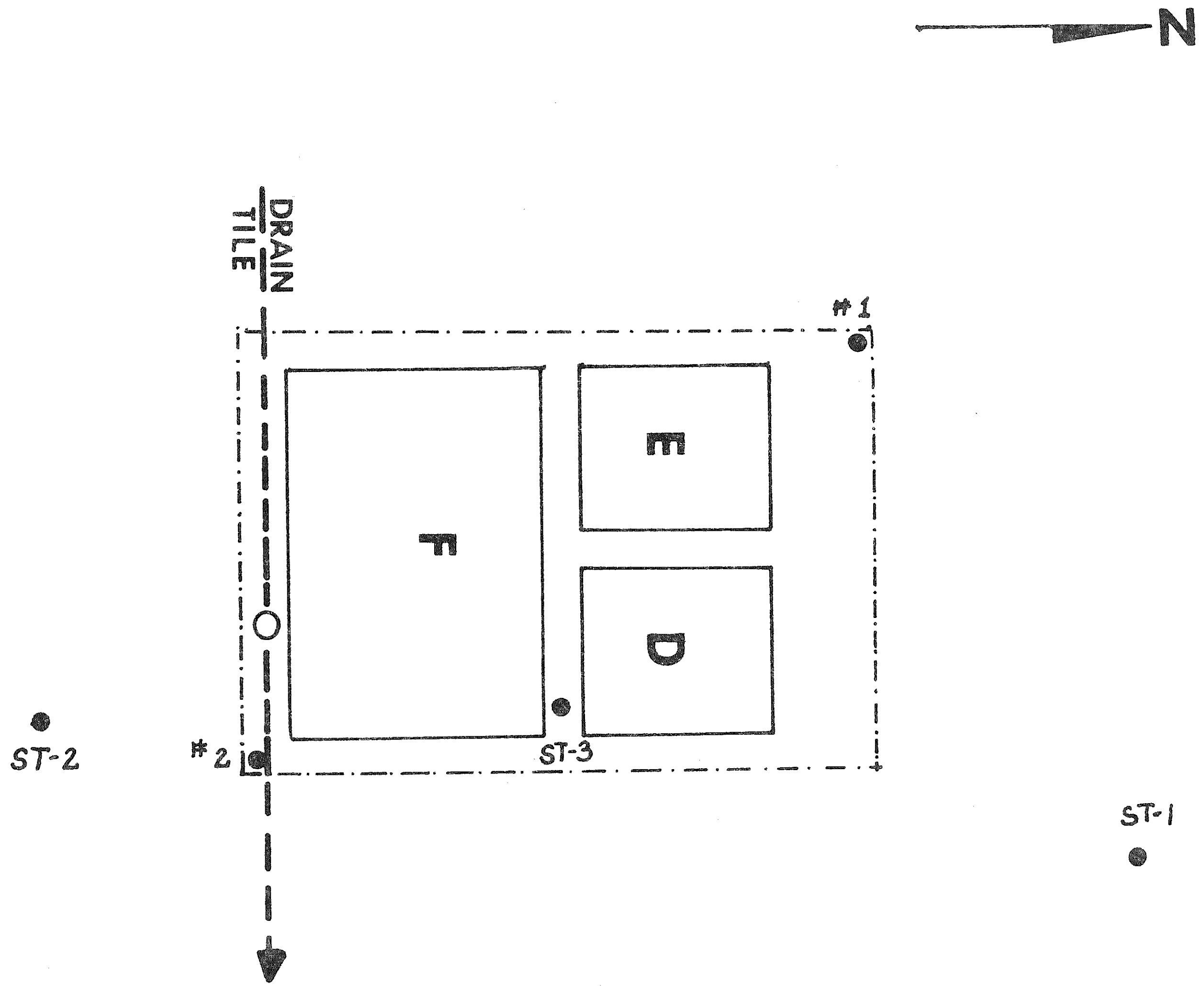
Site Investigations:

(1) Waseca Site: The waste disposal and treatment impoundments of the E.F. Johnson Company, Waseca, Minnesota were chosen for part of the study (Braun, 1982) because the soils were considered to be ideal for a waste treatment/disposal facility and we were interested in determining whether or not

the soils would compensate for a pond design that would not meet current MPCA design criteria. The site is located on a till plain with approximately 200 feet of clay and sandy clay over bedrock. Soil permeabilities range from 5.4 x 10^{-8} cm/sec to 1 x 10^{-9} cm/sec. The E.F. Johnson Company manufactures two-way radio equipment primarily for the land mobile and mobil telephone radio services. The impoundments are part of the waste treatment system for the metal finishing operation.

Metal bearing rinse waters are collected and treated daily to precipitate, neutralize, coagulate, and stabilize the metals and destroy the cyanide present. The supernatant is siphoned into the outgoing water and directed to the impoundments and the sludge is collected and further concentrated to about 10 to 15 percent solids. The sludge is periodically hauled to a drying bed located near the impoundments. Free moisture and leachate from the sludge bed is directed to one of the impoundments.

The impoundment site consists of three equalization ponds and a sludge drying bed. The ponds have a total capacity of 236,000 gallons with a daily flow-through of approximately 18,000 gallons. The ponds are normally operated in series. Most of the precipitation of solids remaining in the supernatant occurs in the first pond in the series, pond D (Figure 7-14). Periodically, this pond is isolated and the water drawn off. Sludge in the pond is then collected and directed to the sludge drying bed. Water draining from the sludge again returns to pond D and the solids are filtered out. After flow through the three ponds the water discharges to Waseca County Ditch 15-2 via a county drain tile under provisions of NPDES Permit MN 0001031. Average hydraulic detention time is approximately 13 days based on the previously described pond capacity and flow rates.



BRAUN
ENGINEERING TESTING

Figure 7-14:

WELL LOCATIONS

Waseca Site

Date:
Revised:
Drawn:
Scale: 1" = 50'

Ground water around the ponds was monitored in five wells. Two of the wells had been previously installed and three were added as a part of this study. Samples were analyzed for pH, conductivity, chlorides, total dissolved solids, cadmium, nickel, copper, zinc, and chromium, both hexavalent and total. A sample was also drawn and analyzed for 52 volatile hydrocarbon compounds.

Hydrogeology: The geology of the site consists of approximately 200 feet of glacial till overlying the Ordovician Galena Limestone. Soil borings on site returned 2.5 to 3.5 feet of silty sandy clay topsoil overlying a sandy clay (CL) to the boring termination depth of 16 feet. Other less specific soils information from the site indicated clay to at least 50 feet. A thin layer of saturated sand was observed in one boring but did not appear to be continuous throughout the site as it was not observed in the other boreholes. Permeabilities of the soils were measured both from recompacted bag samples and thin wall tube samples taken from borings. The range of permeabilities was from 5.4×10^{-8} cm/sec to 1×10^{-9} cm/sec.

The site straddles the watershed divide between the Blue Earth River to the southwest and Cannon River to the northeast. The natural drainage systems are not well developed in the area and agricultural tiling is used to provide drainage. The regional ground water flow direction in the drift is probably to the north (Anderson, 1974). Local flows, however, are controlled by the agricultural tiling. Water elevations measured in the five wells indicate flow near the impoundments is toward a drain tile immediately south of the site with a gradient of approximately 0.016 foot per foot. Two wells were located south of the drain tile and water level measurements in the wells indicate that flow past the impoundment is intercepted by the drain tile. Concentrations of ground water contaminants in the wells support this data.

Monitoring Wells: Ground water data was collected from five wells at the site. Two were existing wells from which data had been collected and submitted to the MPCA. Three additional wells were installed in July 1982. One (ST-1) was installed upgradient from the impoundments because the existing "upgradient" well number 1 was thought to be located too close to the sludge bed and impoundments. A monitoring well (ST-3) was installed downgradient from the first pond in the series because the highest contaminant levels and most of the sedimentation were expected in that basin.

Monitoring wells were not installed downgradient from the final pond in the series because there was concern that the heavy equipment might damage the drain tile and outfall from the final pond in the series to the drain tile. The third well (ST-2) was installed south of the drain tile. It was determined that ground water flow was toward the drain tile from both north and south and that the previously existing "downgradient" well was not functioning in that capacity because the flow was intercepted by the drain tile and never reached that well.

Monitoring Results: Ground water samples and pond samples were collected and analyzed by Braun Environmental Laboratories. Analyses of soils collected from beneath the sludge drying bed were provided by E.F. Johnson. Data from previous ground water monitoring, waste stream analyses, sludge analyses and sludge leach tests were also provided by E.F. Johnson as part of their NPDES permit application and a state hazardous waste permit application, which was not processed because cadmium was eliminated from the process and the facility was to proceed directly toward closure. The cadmium-bearing sludge is being excavated from the sludge bed and shipped to a hazardous waste facility out of state.

Sludge: Analyses indicate that high concentrations of metals are present in the sludge when it comes from the plant. Table 7-3 shows the results of the sludge and sludge leach tests for selected constituents.

TABLE 7-3

SLUDGE AND SLUDGE LEACH TEST RESULTS

	Total Analysis Dry Weight (mg/kg)		Water Leach Test (ug/l)	
Constituent	Wet Sludge	Dry Sludge	Wet Sludge	Dry Sludge
Cadmium	15,600	704	20	20
Chromium	24,300	1,080	100	<50
Copper	42,600	3,970	150	150
Nickel	1,300	1,610	<50	<50
Zinc	24,800	2,440	30	10
Percent Solids	8.0	91.1		

The large difference in values between the total analyses for wet and dry sludge indicates that most of the metals are still in solution when the sludge is deposited in the sludge drying beds and during the dewatering process flows back into ponds where dilution and further sedimentation occur. Because the flow from the sludge bed to the pond is relatively small compared to the total flow to the pond, a significant amount of dilution of the metals concentration occurs. Based on soil analysis from cores taken beneath the sludge drying bed (Table 7-4) some of the metals are entering the soils beneath the sludge drying bed.

TABLE 7-4

METALS CONCENTRATION IN THE SOILS BENEATH THE SLUDGE DRYING BED

Constituent	Concentration (mg/kg)
Cadmium	9.5
Chromium	36.
Copper	200.
Zinc	120.

The water leach tests of the sludge indicate that there would be little additional input from leaching of the dry sludge.

Ponds: Concentrations of metals (except zinc) in the pond water show a definite decrease in concentration from the first to third pond in the series (D to F) (Table 7-5). The amount of sediment in the ponds is pH dependent. So long as an elevated pH is maintained, some sedimentation will occur. The pH in the discharge is maintained between 7.6 and 8.4

TABLE 7-5: CONCENTRATION OF METALS IN PONDS AND OUTFALL

Constituent	Pond			Outfall	
	D	E	F	Daily Maximum	Long Term Average
Chlorides mg/l	45	35	25		
Total Dissolved Solids mg/l	736	812	806		
Nitrates mg/l	10	18	4.2		
Cadmium ug/l	<40	<30	<30		
Nickel ug/l	1700	750	350	450	200
Copper ug/l	725	375	325	250	155
Zinc ug/l	140	50	160	520	260
Chromium (Total) ug/l	600	180	100	50	47
(Hexavalent)	280	50	30		

Although the values for ponds D-F are one time grab samples, the value for pond F is reasonably consistent with the long term average concentrations reported for the outfall which is from pond F.

Ground Water: Ground water elevations were measured in the five wells at the site and ground water samples were collected and analyzed for cadmium, chromium (both total and hexavalent), copper, nickel, zinc, pH, conductivity, chlorides, nitrates, and both halogenated and nonhalogenated volatile hydrocarbons. Ground water elevations indicated that there is approximately a two foot separation between the bottom of the sludge drying bed and the water table but that the bottoms of the impoundments are below the water table. There was no measurable mounding of the water table and in fact, there appears to be ground water flow through the ponds. Based on the average hydraulic head differences between the pond and the ground water from one end of the pond to the other, the average seepage rate is estimated at less than 5 gallons per acre per day. Despite the fact that the ponds are in contact with the ground water, the concentrations of metals in the ground water (Braun 1982) are one to two orders of magnitude lower in the downgradient monitoring well than in pond D. For some metals such as cadmium, nickel and zinc, the concentration cannot be distinguished from background levels. None of the levels exceed primary or secondary drinking water standards. Ground water samples collected and analyzed for volatile organics contained three non-halogenated and three halogenated compounds in the monitoring well downgradient from pond D. Only one of the compounds is presently used in the plating operation. Trichlorethylene is employed as a cleaner in a totally enclosed, vapor phase system. Cleanout sludges and spent solutions are barreled and shipped to a recycling facility. Table 7-6 lists the organic compounds present in well ST-3 and their concentrations.

TABLE 7-6

VOLATILE ORGANIC COMPOUNDS IN WELL ST-3

Compound	Concentration ug/l
Acetone	12.
Tetrahydrofuran	16.
Methyl Ethyl Ketone	11.
1,1-Dichloroethane	0.8
Cis-1,2-Dichloroethylene	0.7
1,1,2 Trichloroethylene	3.5

Tetrahydrofuran and methyl ethyl ketone are sometimes found in ground water samples taken from wells constructed of PVC although usually with solvent welded joints. Wells ST-1 and ST-3 were constructed with coupled joints. Since well

ST-1 did not contain either of the compounds and was constructed the same as ST-3, another source is probable. The source of the other organic compounds is unknown. Trichloroethylene is indicated as "believed absent" in the discharge from the plant in the NPDES permit application. Trichloroethylene and 1,1,1,-trichloroethane are listed on the E.F. Johnson hazardous waste disclosure filed in accordance with MPCA and federal hazardous waste rules. None of the other compounds are listed. The compound 1,1,1-trichloroethane was not detected in the ground water.

Conclusions:

1. Although there is a large concentration of metals still in solution when the sludge is deposited in the sludge drying bed, the concentration is significantly reduced by dilution and sedimentation in the pond system prior to discharge.

2. Very low levels of some contaminants were observed in the ground water downgradient from the first pond in the series. Despite the fact that the ponds are below the water table, the very low seepage rates and natural attenuation mechanisms have effectively protected the ground water from metals contamination. However, low levels of several organic compounds were observed.

3. Ground water flow in the vicinity of the impoundments is controlled by the drain tile south of the pond system.

Recommendations:

Site Specific: Additional ground water samples should be collected from the monitoring wells and analyzed for sulfates and cyanide which were inadvertantly omitted from the original sampling parameters. If these parameters do not appear to be a problem, no further recommendations for study are necessary. Semi-annual monitoring should be continued by E.F. Johnson during the active life of the facility. After all of the sludge is removed from the facility, soils and water samples should be collected and analyzed and a determination made on requirements, if any, for post-closure monitoring. If no problems are observed, no post-closure monitoring is believed necessary. The last monitoring event should include a volatile hydrocarbon scan and all monitoring data should be reviewed before well abandonment occurs.

Generic: A systematic review of the need for ground water monitoring at industrial impoundments as a followup to the Surface Impoundment Assessment should be conducted. Strong consideration should be given to sampling for volatile hydrocarbon compounds at many of the facilities. The E.F. Johnson NPDES permit application indicated that none of the measured organics were believed to be present in the waste stream. The hazardous waste disclosure however indicated that several compounds were used at the plant and their presence in the waste stream, though unlikely, was possible. As evidenced by this study, this was the case with trichloroethylene. In addition, several other compounds were observed in the ground water but there was no indication of their possible presence in the waste stream. In this case, the levels are low and do not appear to represent a threat, however this may not be the case elsewhere. Many of these volatile hydrocarbon compounds have wide application in industrial settings even if not directly used in the process.

The use of artificial drainage systems to lower water table elevations should be reviewed carefully. Where they are necessary and approvable, care should be taken in locating monitoring wells to be sure that they are located between the drainage system and the impoundments. If this is not possible, provisions should be made for obtaining samples from the drainage system to ensure that it is not acting as a leachate collection system and transferring the problem to another location. The pre-existing monitoring system at this facility would not have detected any contamination of the ground water because neither the location nor the significance of the drainage system was known when the wells were installed. Consideration should also be given to the presence of drainage systems not specifically related to the facility such as agricultural drain tile in adjacent fields or sewer lines that may be below the water table and subject to infiltration.

(2) Red Wing Site: The S.B. Foot Company processes cattle hides into a final leather product used in making shoe uppers. The current waste treatment facilities on site are owned and operated by the city of Red Wing. They consist of an aerobic biological reactor preceded by screening and primary clarification and followed by final clarifying and chlorine contact. Discharge is to Hay Creek, a tributary to the Mississippi River, under provisions of NPDES Permit MN0038962. Sludge from the primary clarifier is directed to a filter press and the cake is landfilled on site. This process has been in operation since 1973. Prior to construction of the treatment plant through a USEPA demonstration grant, treatment consisted of sedimentation in six settling basins constructed in 1956. These basins were reported to be lined with clay, however few other details about them are known. Subsequently, four of the basins were lined with concrete for use in the aerobic biological reactor system and two were abandoned. In 1969, the effluent flow was approximately 1.2 million gallons per day (MGD). Current effluent discharge is approximately 0.4 MGD.

Tanning is accomplished using either a chrome or vegetable solution with chrome tanning being the most prevalent. This is the process used by S.B. Foot.

There are typically four operations in a cattle hide tannery which contribute to waste flow. These are beam house, tan house, color and fat liquor retanning and finishing. All four processes were conducted at this facility, however, the beam house and tan house operations were discontinued in 1980 and relocated out-of-state. The current operation consists of retanning and finishing approximately 97,200 pounds of (split and shaved blue sides) cattle hides per day.

Investigations have shown that holding ponds and lagoons may continue to pollute the ground water long after their abandonment, even though the structures have been filled with earth materials (USEPA 1976). It was the MPCA's original intent to study the effects of the abandoned impoundments, however monitoring results indicate that ground water contamination problems are probably due to on-site sludge disposal and that the basins either have had little effect on the ground water or the residual effects are not significant enough to detect.

Discussions of the leather tanning and finishing industry were prepared by the USEPA (1974) and SCS Engineers, Inc. (1976). The latter report indicates that the waste in the form of treatment plant sludge from virtually every chrome tannery was potentially hazardous due to the high concentrations of metals, primarily trivalent chromium, lead, copper and zinc. The treatment plant sludge generated at the S.B. Foot facility is considered hazardous under existing state regulations due to the high lead content. Analysis of the sludge currently being generated before and after dewatering is contained in Table 7-7. One soil boring (ST-9) was taken through the sludge disposal area and four solids samples were retrieved and analyzed for metals. The soil boring profile is shown in Figure 7-15 and the results of the analyses in Table 7-8.

TABLE 7-7

ANALYSIS OF SLUDGE CURRENTLY BEING GENERATED

	Wet Sludge Dry Weight	Dry Sludge Dry Weight
Total solids (percent)	7.19	90.4
pH	6.5	8.3
Specific Conductance (umhos/cm)	70100	4590
Ammonia-N (mg/kg)	5050	361
Total Chromium (mg/kg)	52000	41000
Copper (mg/kg)	80	150
Lead (mg/kg)	670	2300
Zinc (mg/kg)	680	640

TABLE 7-8

METALS CONCENTRATION IN LANDFILLED SLUDGE AND UNDERLYING SOILS

Depth (Feet)	Type of Sample	Moisture Content %	Concentration (mg/kg dry weight) Chromium	Zinc	Copper	Lead
2-3	Sludge	54.9	6430	92	22	155
4-5	Sludge	36.1	7824	47	16	47
12-13	Soil	21.5	178	38	13	13
19-20	Soil	12.8	<11	<11	<11	<11

Analysis of the waste paint sludge from the finishing process had previously tested as a hazardous waste and that sludge is not being landfilled, but rather is being transported to a hazardous waste facility out-of-state. Under the current state hazardous waste rules 6 MCAR §§ 4.9001-4.9009, the dry sludge from the filter press being landfilled is a listed hazardous waste under 6 MCAR § 4.9002 B.1. due to its lead content. The waste analysis was not specific enough to determine if it is hazardous under the provision of 6 MCAR § 4.9002 B.2. Under proposed state hazardous waste rules, the sludge would not be hazardous because concentration limits in the total analysis would be dropped and the concentration limit for lead in the EP toxicity leach test would be raised to 5.0 mg/l which the sludge now meets.

Figure 7-15: **LOG OF BORING**

BRAUN ENGINEERING TESTING

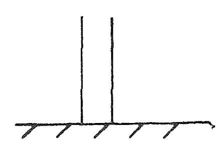
PROJECT: E82-036F GROUNDWATER STUDY
S.B. Foot Wastewater Treatment Facility
Red Wing, MN

BORING: ST-9 (Well #9)

LOCATION: See Attached Sketch

DATE: 7-19-82 **SCALE:** 1"=4'

Elev. 704.9	Depth 0	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
702.9	2	SC	SILTY CLAYEY SAND, fine to medium -grained, with a trace of fine Gravel, brown. (Fill)			Top of Well Elevation: 706.9
695.4	9.5	☒ ☒	SLUDGE, black, wet.	8, 3, 2		
688.9	16	ML ☒	CLAYEY SILT, organic, dark grayish brown, wet, very loose to loose. (Alluvial Deposit)	2, 5, 5		
685.9	19	ML	CLAYEY SILT, slightly organic, gray, wet, loose. (Alluvial Deposit)	7		
679.4	25.5	SP ☒	SAND, fine-grained, light gray, wet to waterbearing, loose. (Alluvial Deposit)	4, 5		Well point set at the 25 foot depth. 5' well point used.
			Jetting water used to clear the auger between the 20 and 25' depths. Water level down 16' with 25' of hollow-stem auger in the ground. Water level down 16' immediately after withdrawal of auger. Monitoring well installed.			☒ = Sample collected for metals analysis



(See Report and Standard Plates for evaluation and descriptive terminology.)

The total amount of sludge which has been deposited and its composition are unknown. The NPDES permit application indicated that 2,350 gallons per day of filter cake was being landfilled.

Hydrogeology: The site is located in a valley drained by Hay Creek, a tributary to the Mississippi River. The alluvial deposits in the river valley are probably over 100 feet thick in the axes of the valley and thin towards the flanks where Cambrian bedrock formations are exposed. Borings indicate alluvial deposits up to 70 feet thick directly beneath the site. The alluvial deposits consist of interlayered sands and clayey silts to silty clays. Thin layers of highly organic swamp deposits were encountered in several of the borings. Soil borings conducted during monitoring well installation encountered three to eight feet of clayey silt to silty clay overlying five to ten feet of fine to medium sand. The sand in turn, is underlain by at least 7.5 feet of an organic clayey silt to silty clay. As indicated, this sequence is repetitive at depth although the thickness of the units varies. The boring through the fill area encountered 7.5 feet of sludge with a two-foot thick cover of silty clayey sand.

Hydraulic conductivities of the three upper soil layers were estimated or measured in the laboratory from thin wall tube samples taken in the field. Where samples were unable to be obtained intact, permeabilities were estimated based on grain size analysis. Attempted hydraulic conductivity testing of the upper clayey silt stratum caused significant compaction of the soil and it was felt that the test would not be representative of actual field conditions. Based on grain size analysis, the conductivity was estimated at approximately 9×10^{6} cm/sec. Conductivity of the sand layer below it was estimated at approximately 3×10^{-2} cm/sec. The conductivity of the lower clayey silt/silty clay layers was measured at 2.5 X 10^{-7} cm/sec. The significant differences in conductivity among layers suggests a differential horizontal flow in the intermediate sand layer which is reflected in the ground water quality monitoring results.

Ground water flow beneath the site is north towards an unnamed stream rather than east towards Hay Creek. Due to the high concentration of chlorides in the ground water and corresponding high conductivity, these measurements were good tracers of ground water flow. The specific conductivities of creeks in the area were surveyed. The conductivity measurements of surface water bodies were consistent with flow directions derived from monitoring wells. The specific conductance of the water in the unnamed stream immediately north of the site was measured at 1,233 umhos/cm and decreased to 986 umhos/cm just upstream from its confluence with Hay Creek. The conductivity of Hay Creek increased slightly at the outfall from the treatment plant and again below the confluence with the unnamed creek.

The ground water gradient in the intermediate sand is approximately 0.5 percent. Based on an assumed porosity of 30 percent, the horizontal seepage velocity is estimated at 1.4 feet per day. A well nest was installed at ST-8 (Figure 7-16) to measure vertical gradients. One well was screened in the second silty clay layer (ST-8), one at the bottom of the sand (ST-8A) and one in the center of the sand layer (ST-8B). On two of the sampling events the hydraulic head in the silty clay was higher than the sand, indicating a vertically upward component of flow. However, on one occasion, the reverse was observed. Because of the short time interval over which measurements were obtained it is not possible to establish a trend. Water quality results indicate a downward vertical component

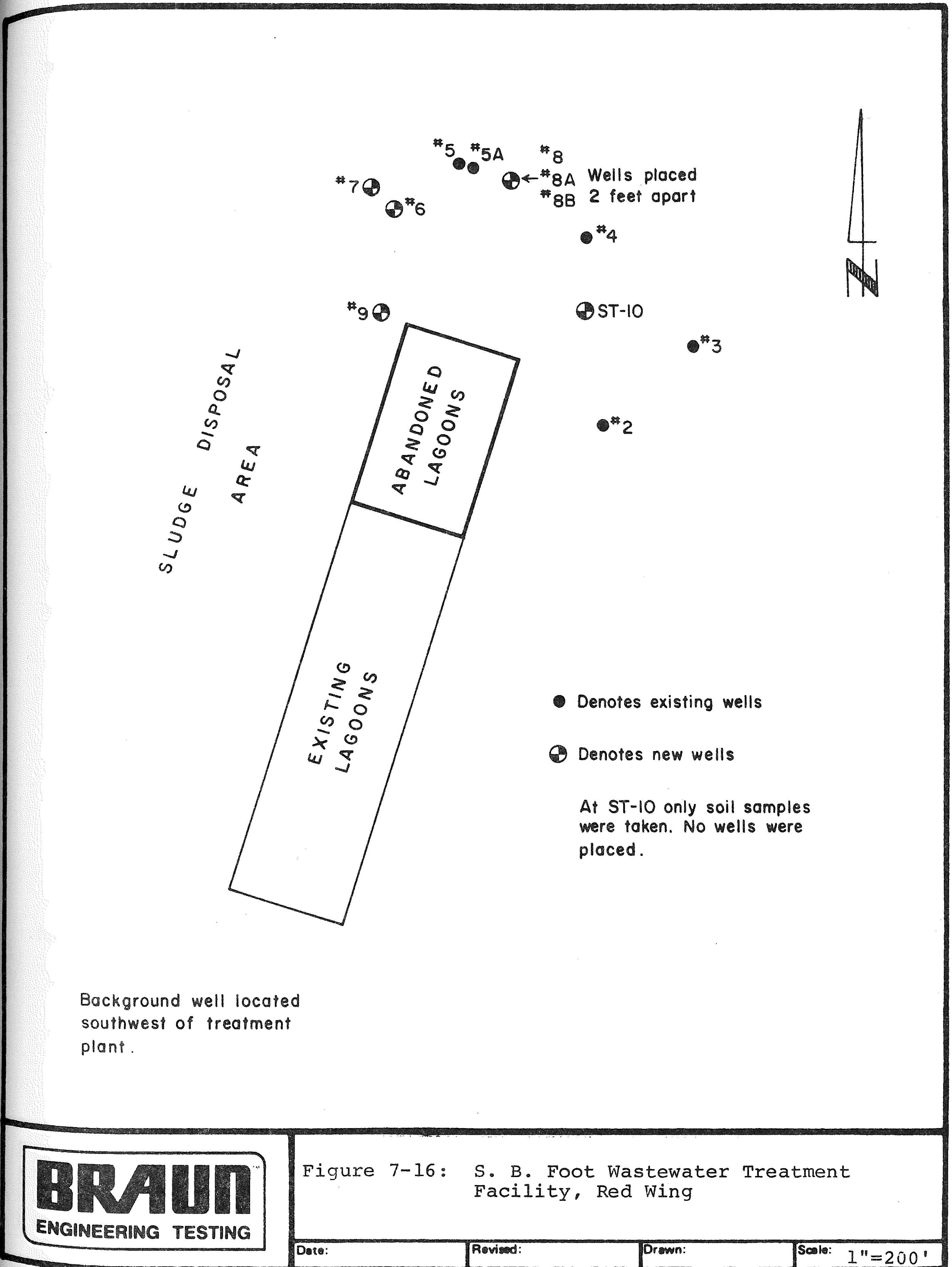


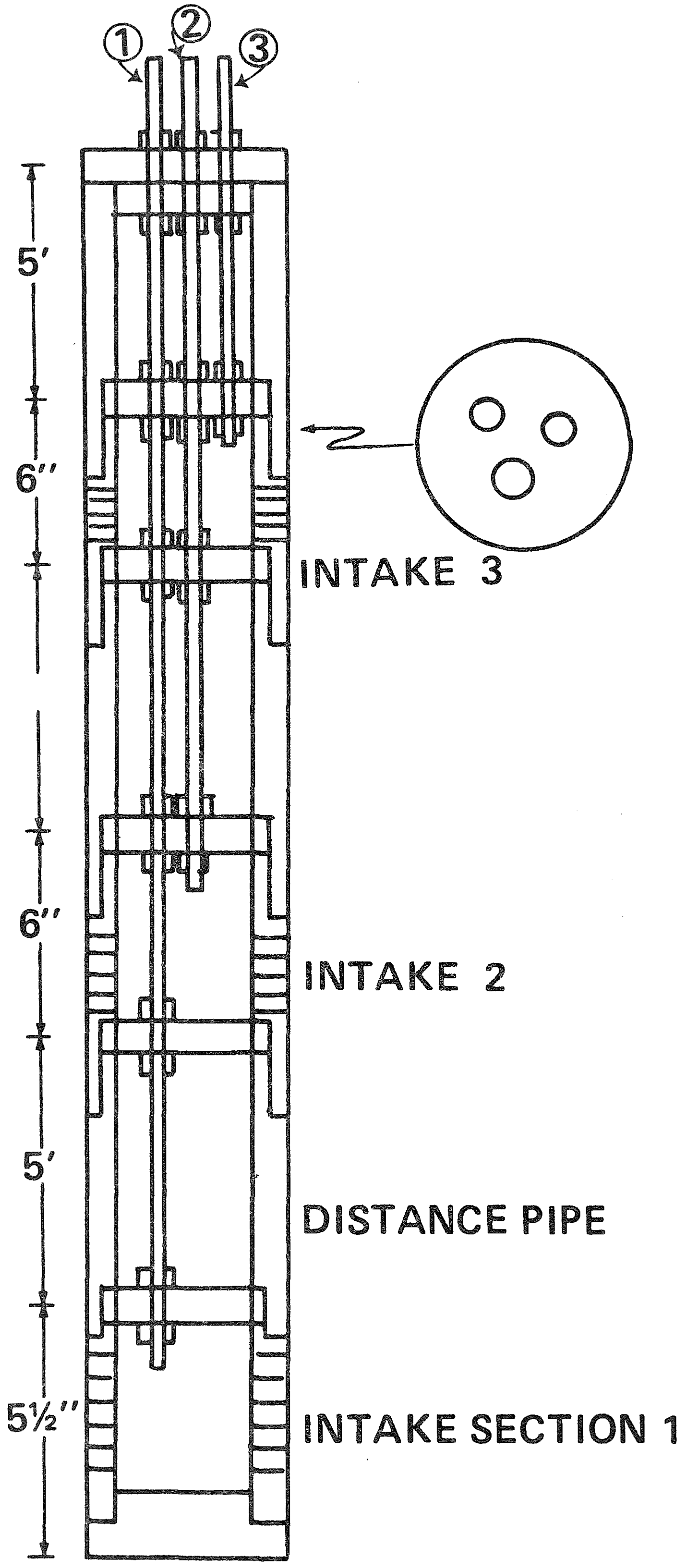
Figure 7-16: S. B. Foot Wastewater Treatment Facility, Red Wing

of flow as results from well ST-8, the deepest of the three-well nest, indicate contaminant levels above background.

Ground water monitoring at the site began in July 1980 after five sand points were hand driven into the intermediate sand layer. Monitoring through July 1981 indicated that the ground water north of the impoundments and sludge disposal area was highly contaminated by chlorides and nitrates. Chromium levels were significantly elevated over background levels. Additional monitoring wells were installed in July 1982 as part of this study. One (ST-9) was installed through the landfilled sludge. Wells were also installed laterally away from the contaminated wells in an effort to define the width of the plume. One location, to the east, consisted of the previously mentioned conventional well nest (ST-8, 8a, 8b). The others, to the west, consisted of a single well and a multi-level well consisting of three six-inch long screens on a single casing string separated by five feet and isolated from each other by means of bentonite grout (Figure 7-17).

Ground water samples were collected three times in the summer and fall of 1982 and analyzed for specific conductance, pH, chlorides, COD, total dissolved solids, nitrates, chromium, copper, lead, and zinc. The first analysis also included hexavalent chromium. Since the concentration of hexavalent chromium was below detection limits in all wells, subsequent analyses were not performed. In addition, one round of samples was collected from wells 1, 5, and ST-8A and analyzed for 57 halogenated and nonhalogenated volatile hydrocarbon compounds and 11 phenolic compounds.

Primary drinking water standards were exceeded in several downgradient wells on one or more sampling rounds for chlorides and lead. Although elevated above



BRAUN ENGINEERING TESTING

Figure 7-17: **MULTI LEVEL WELL**

Date:	Revised:	Drawn:	Scale:

background levels, zinc and copper concentrations were one to three orders of magnitude below primary drinking water standards. The primary drinking water standard for chromium was exceeded in one well on one sampling event however it remains above background levels in several downgradient wells.

Concentrations varied considerably from well to well as would be expected and often from sampling event to sampling event within each well. The change in the concentrations of the different constituents within each individual well was generally very consistent. That is, the concentrations of constituents were nearly always increasing or decreasing over the same time intervals within individual wells. This was not always the case comparing the same constituent from well to well. In some wells, the concentrations were increasing over the same time interval in which they were decreasing in other wells. These spatial and temporal variations in constituent concentrations appear due to variations in leaching of contaminants caused by temporal variation in precipitation and infiltration. The surprising aspect of this was the relatively short time period over which the variations occurred. This may be due in part to the shallow depths at which the contamination occurs and the relatively rapid flow rates in the intermediate sand layer. It does point out that widely-spaced or single monitoring events may yield misleading (not necessarily incorrect) monitoring results and lead one to believe that contamination has not occurred or the concentrations are not significant when, in fact, they may be considerably higher at other times. Table 7-9 (following page) shows the water balance for the 1982 water year and the 30 year average. It indicates that, on average, 4.21 inches of precipitation would be available for infiltration. As opposed to leaking surface impoundments where a steady state condition frequently exists, with landfills or filled abandoned impoundments, the

Table 7-9: Climatological Data
Site F, Red Wing

Month	O (1981)	N (1981)	D (1981)	J (1982)	F (1982)	M (1982)	A (1982)	M (1982)	J (1982)	J (1982)	A (1982)	S (1982)	Total
Temperature °C	7.78	2.67	0.86	-10.20	-3.83	2.67	12.22	27.56	24.50	30.28	26.67	18.33	
PETM (in.)	0.82	0.14	-	-	-	0.18	1.92	5.36	6.10	8.47	6.44	3.21	32.69
PM (in.)	2.99	.62	.81	1.71	.18	1.36	2.00	5.43	2.05	4.98	4.35	5.04	31.52
AW (in.)	2.17	.48	.81	1.71	.18	1.18	0.08	0.07	-4.05	-3.49	-2.14	1.83	-1.17

	O	N	D	J	F	M	A	M	J	J	A	S	Total
30-Year Average Temperature °C	9.61	.33	-7.67	-12.22	-8.67	-2.17	7.22	14.28	19.50	21.94	20.67	15.56	
PETM (in.)	1.58	.03	-	-	-	-	1.37	3.37	4.84	5.63	4.86	3.02	24.69
PM (in.)	2.04	1.31	.90	.78	.68	1.59	2.61	3.51	4.35	4.30	3.69	3.14	28.90
AW (in.)	.46	1.28	.90	.78	.68	1.59	1.24	.14	-.49	-1.33	-1.17	0.12	4.21

contaminant loading to the ground water may be more periodic. In a karst situation, with only perimeter monitoring, contaminants could periodically pass detection systems unnoticed. Results of the organic analyses are presented in Table 7-10.

TABLE 7-10

ORGANIC COMPOUNDS IN GROUND WATER

Compound (ug/l)	1	5	8A	Field Blank	10^{-5} Criteria
Tetrahydrofuran	<5.0	<5.0	480	<5.0	
Benzene	<1.0	18.	<1.0	<1.0	6.6
Toluene	<1.0	<1.0	4.2	<1.0	14,300
m-xylene	<1.0	1.1	<1.0	<1.0	
p-xylene + o-xylene	<1.0	2.1	<1.0	<1.0	
1,4-Dichlorobenzene	32.	<2.0	<2.0	<2.0	400.
Methylene Chloride	2.3	<2.0	6.5	2.4	1.9
Chlorobenzene	14.	400.	0.6	<0.5	488.
1,1,2-Trichloroethylene	<0.2	<0.2	97.	<0.2	27.
Pentachlorophenol	47	<6.0	6.1	6.3	

The 10^{-5} health risk criteria is exceeded by the concentrations of benzene, methylene chloride, and trichloroethylene. However, the field blank for methylene chloride also contained a measurable amount so the result does not appear to be reliable. Of the above listed compounds, only toluene, xylene and unspecified alyphatics were reported in the hazardous waste disclosure, management and past management forms filed in accordance with existing state and federal hazardous waste rules. During the period 1968 to 1976 these three compounds, components of paint thinner, were being sewered. The paint thinner is now being reclaimed. Tetrahydrofuran has been observed frequently in water from PVC cased wells although usually those which have been solvent welded rather than those with threaded joints as well 8A has. The source of the other compounds is currently unknown. None are listed as likely components of plant effluent on the NPDES permit application.

Conclusions: Sludge analysis indicates that the sludge from the wastewater treatment plant is hazardous under existing state rules. If the proposed state hazardous waste rules are adopted, the sludge will no longer be considered hazardous. Even if the sludge is nonhazardous the facility would still require a solid waste facility operating permit.

Ground water and surface water contamination have resulted from waste disposal at the facility. The extent of the contamination is currently unknown. Ground water contaminants include chromium, copper, lead, zinc, chlorides and volatile halogenated and nonhalogenated hydrocarbons. Primary drinking water standards for chromium, lead and chlorides have been exceeded on one or more occasions. Specific conductivity measurements in the streams and creeks around the site indicate that they have been impacted by the waste disposal although analysis for specific parameters has not been conducted. The 10^{-5} health risk criteria for two hydrocarbon compounds were also exceeded.

Rapid fluctuations of concentrations of contaminants in the ground water appear due to periodic leaching of the sludge caused by infiltration of precipitation due to poor covering and grading, shallow ground water levels and relatively rapid ground water flow rates. Although the concentrations of metals in the sludge is extremely high the concentration in the ground water is comparatively low (but not insignificant). Analysis of samples of sludge and soil from a boring through the fill indicate that the metals concentration decreases significantly with depth.

The utility of the multi-level well (ST-6) was limited. The drillers experienced problems with caving and installation of bentonite seals and sand packing of the screens. They indicated however, that with more experience in installing this type of device many of these problems would be eliminated. This type of device has limited usefulness for sampling however and also requires a manometer to measure heads in the field. Little or no samples could be obtained from sections finished in the silty material and no sampling could be done for volatiles analysis because only suction lift can be used. Pickens et.al. (1978) describe a device of similar concept but different design that has been used successfully. Although the device used at this facility appears to have application depending on field conditions and monitoring programs, the conventional well nest at ST-8 (although more expensive) was considerably more useful in this situation.

Recommendations: The extent of ground water and surface water contamination at the facility and the amount and the chemical characteristics of the landfilled sludge must be determined as should the origin of the organics in the ground water. The facility should be brought into compliance with all applicable state and federal solid and/or hazardous waste regulations.

The MPCA should assess the contamination potential for all industrial disposal sites and impoundments. In addition to the standard inorganic parameters and waste specific parameters, monitoring should be conducted for a wide variety of organic compounds. Both industrial sites had organics present in the ground water at the facility which were not listed on hazardous waste disclosures or NPDES permit applications.

(3) Iron Mining Impoundment Site: The iron mining industry is unique in that large tracts of land are needed to dispose of wastes generated during the taconite milling process. The industry is also unique in that it is a principal employer in the Mesabi Iron Range of northeastern Minnesota. MPCA regulations

specifically require the assessment of both economic and social considerations in addition to maintaining the natural quality of our ground waters. Therefore, the implementation of specific recommendations on future monitoring programs for taconite tailings basins could have potentially major economic impacts for the industry and economic and social impacts for the people living in northeastern Minnesota.

Artificial taconite tailings basins have been designed and built to cover extensive areas. The tailings basins are usually constructed as water containment basins. This poses two basic ground water questions. First, although the basins are designed as water containment basins, does the hydrologic head within the basins force tailings waters through the bottom liner and into the ground water? Second, if the tailings water is vertically migrating into the ground water, what is the net effect on the ground water?

Design Considerations: Unlike other liquid waste impoundments, the taconite tailings basins across the range have few common design features. The geographic and hydrogeologic situation usually dictates each basin design. A tailings basin is built as a water containment basin, with a bottom liner to retard vertical flows added only where a natural barrier does not already exist. Most basins install a concrete weir to handle overflow during extreme rain events so that the dikes will not be washed out. The size of a basin will vary from a few hundred acres to several square miles. The larger basins are usually subdivided into smaller cells to promote stability and provide a buffer should the dikes of a sub-basin fail for some reason.

Monitoring System: A ground water quality monitoring program was developed by the USGS at National Steel Pellet Company's Butler taconite tailings basin near Keewatin, Minnesota (USGS, 1983). This site was selected because it has been dormant for several years. The assumption was that if the tailings were leaching into the ground water, this site should best reflect years of impact.

A USGS water quantity study was run concurrently with the water quality monitoring. The quantitative investigation strongly indicates vertical movement of the tailings waters through the thin peat liner and into the ground water. The tailings waters are highly mineralized and elevated levels of sulfate as SO_4, arsenic as As, fluoride as F, and molybdenum as Mo were measured in the ground water below the tailings basin liner.

The USGS installed and monitored four wells on site for quality (Figure 7-18). They installed numerous other smaller diameter wells inside and outside the basin to measure water levels (Figure 7-19). Two water quality monitoring wells were drilled inside the basin, one shallow well in the tailings (KTB-32) and the other in the aquifer below the peat liner (KTB-31). An "upgradient" or background well (KTB-30) was installed outside the basin in the same glacial outwash aquifer as the deeper in-basin well (KTB-30). The "downgradient" well was placed outside the basin but finished in residual tailings deposited before the construction of the dikes (KTB-26). Table 7-11 gives geologic log information for the study wells.

Water quality samples were collected at each of the four wells every other week from mid-October to the end of November, 1982. The original plan called for every other month sampling, but delays in well installation necessitated the sampling schedule modification. The first samples were analyzed for the physical, bacteriological and inorganic parameters listed in the MPCA Drinking

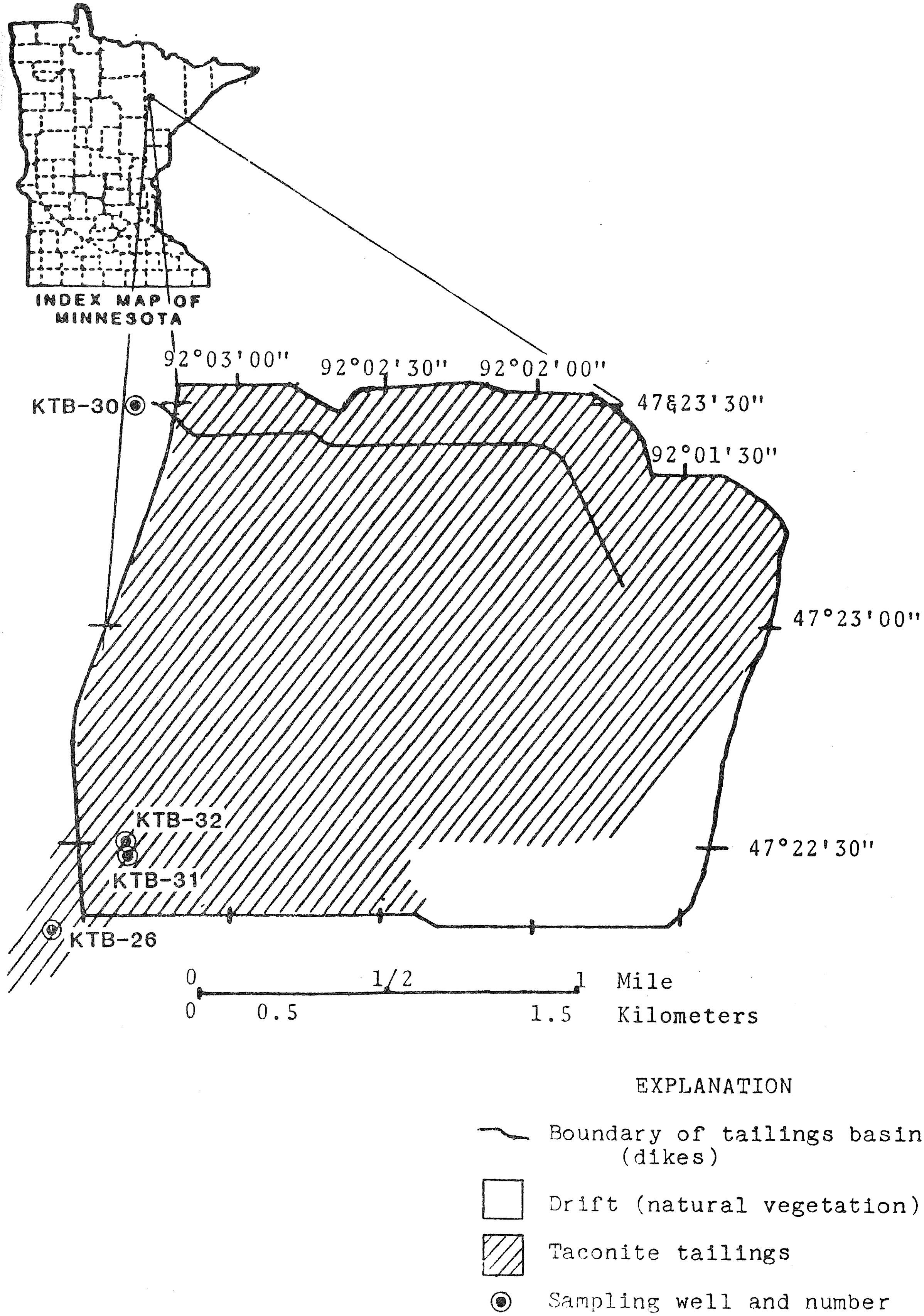
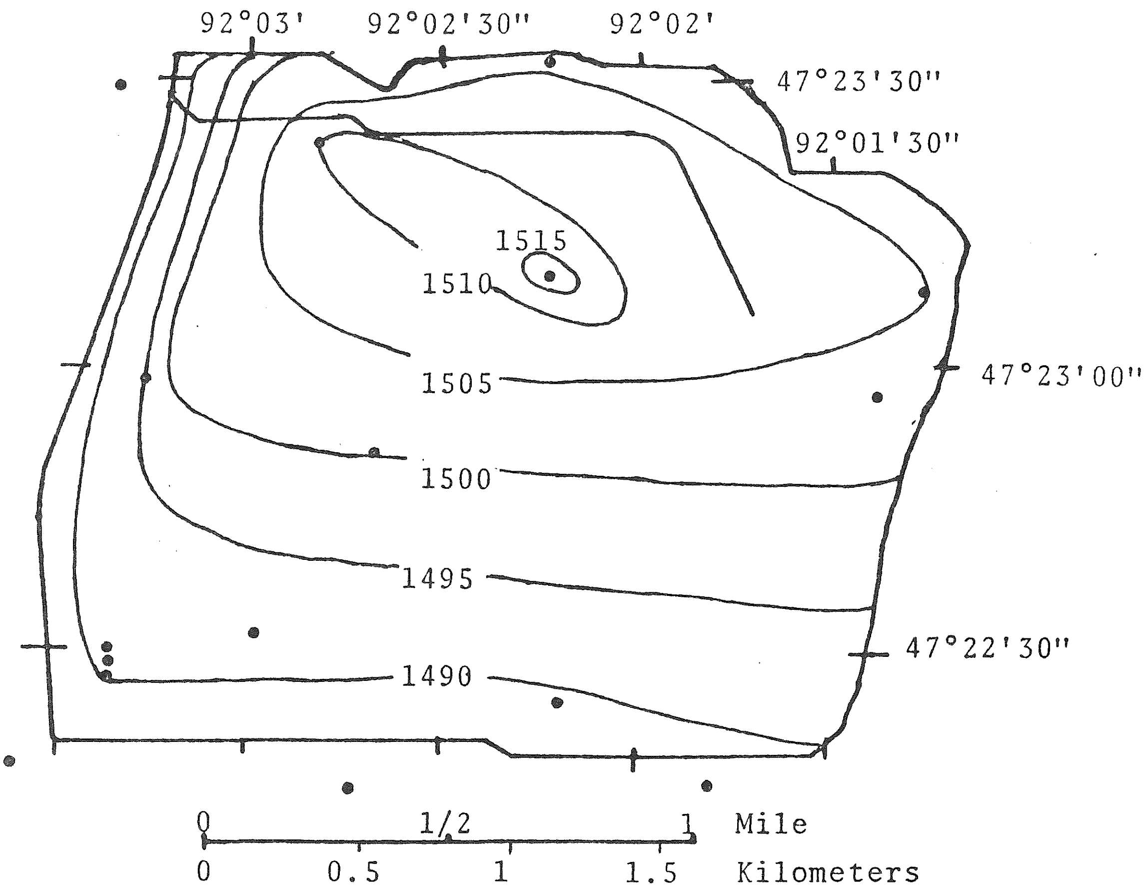


Figure 7-18: Location of study, areal extent of tailings, and location of sampling wells



EXPLANATION

Boundary of tailings basin (dikes)

~1500~ WATER-TABLE CONTOUR
Show altitude of water table, November 1, 1982. Contour interval 5 feet. Datum is National Geodetic Vertical Datum of 1929

• Observation well, water table

Figure 7-19: Water-table configuration in the taconite-tailings basin near Keewatin, Minnesota, November 1, 1982

Table 7-11: Construction and lithologic data for sampling wells at a taconite-tailings basin near Keewatin, Minnesota

Station No.	Local identifier	Site number	Date of construction	Altitude of land surface	Altitude of water level	Date of water level	Diameter of well (inches)
472217093033502	056N21W06BBA02	KTB26	8-19-82	1481.7	1462.1	11-1-82	2
472330093032103	057N21W30DBB03	KTB30	9-20-82	1495.0	1478.6	11-1-82	5
472228093032203	057N21W31DCB03	KTB31	9-21-82	1495.4	1484.1	11-1-82	5
472228093032204	057N21W31DCB04	KTB32	9-22-82	1495.4	1490.9	11.1-82	5

Station Site No.	Lithology	Thickness (feet)	Depth interval (feet)	Length of casing (PVC) (feet)	*Screened interval (feet)	**Measuring point (feet)
472217093033502/KTB26	Tailings, coarse sandy, gray.......	24	0 - 24	24	21 - 24 (tailings)	3.3
	Till, sandy, gray..............	2	24 - 26			
	Sand, medium.......	3	26 - 29			
	Till, gravelly, red...............	8	29 - 37			
472330093032103/KTB30	Sand, fine, silty with trace of clay..........	17	0 - 17	19	16 - 26 (outwash outside of basin)	3.4
	Sand, fine with some medium to coarse, silty...	9	17 - 26			
	Till, sandy with scattered rocks, red.............	3	26 - 29			
472228093032203/KTB31	Tailings, very fine sand, silty, gray............	38	0 - 38	48	45 - 60	3.0
	Peat, organic, black...........	3	38 - 41		(outwash below tailings)	
	Sand, fine to coarse, with fine gravel..........	27	41 - 68			
	Till, sandy, red.	7	68 - 75			
472228093032204/KTB32	Tailings, very fine, sand, silty, gray............	17	0 - 17	10	7 - 17 (tailings)	3.1

* Feet below land surface. **Feet of casing above land surface.

Water Standards and for other inorganic parameters tested as part of the Ambient Ground Water Quality Monitoring Program (see Table 7-12). On subsequent sampling runs the list of parameters analyzed was reduced considerably. Only the major cations and anions, a few physical parameters and any inorganic parameter which exceeded Drinking Water Standards were measured (see Table 7-13).

Summary: The study found a statistically significant change in the ground water quality as it moves vertically through the tailings into the lower aquifer (see Figure 7-20). The general water quality composition of the upgradient (or background) well and the in-basin lower aquifer well are quite different from the shallow wells finished in tailings both inside and outside of the basin.

There is some question about the independence of the background (or non-impacted) well (KTB-30). A mounding of water was measured in the northern portion of the basin. No piezometers were installed between the basin dike and KTB-30, and therefore it cannot be determined whether the hydrologic head within the basin is great enough to influence the KTB-30 site.

If the background well is being influenced by basin water radiating out under hydrologic head to KTB-30, it is possible that the similarities between KTB-30 and KTB-31 reflect a common source after attenuation into a lower aquifer. If KTB-30 (the background well) is not being influenced by the basin leachate, then the study shows little adverse impact on the lower aquifer by the vertically moving basin waters.

Sulfates (SO_4), fluoride (F), arsenic (As), and molybdenium (Mo) were routinely higher in the shallow tailings wells than in the deeper background and lower aquifer well. The tailings waters were highly mineralized but these parameters were substantially higher than measured in the background well.

TABLE 7-12

WATER QUALITY CONSTITUENTS ANALYZED IN GROUND WATER
AT A TACONITE TAILINGS BASIN NEAR KEEWATIN, MINNESOTA
ON MPCA LIMITS FOR DOMESTIC CONSUMPTION

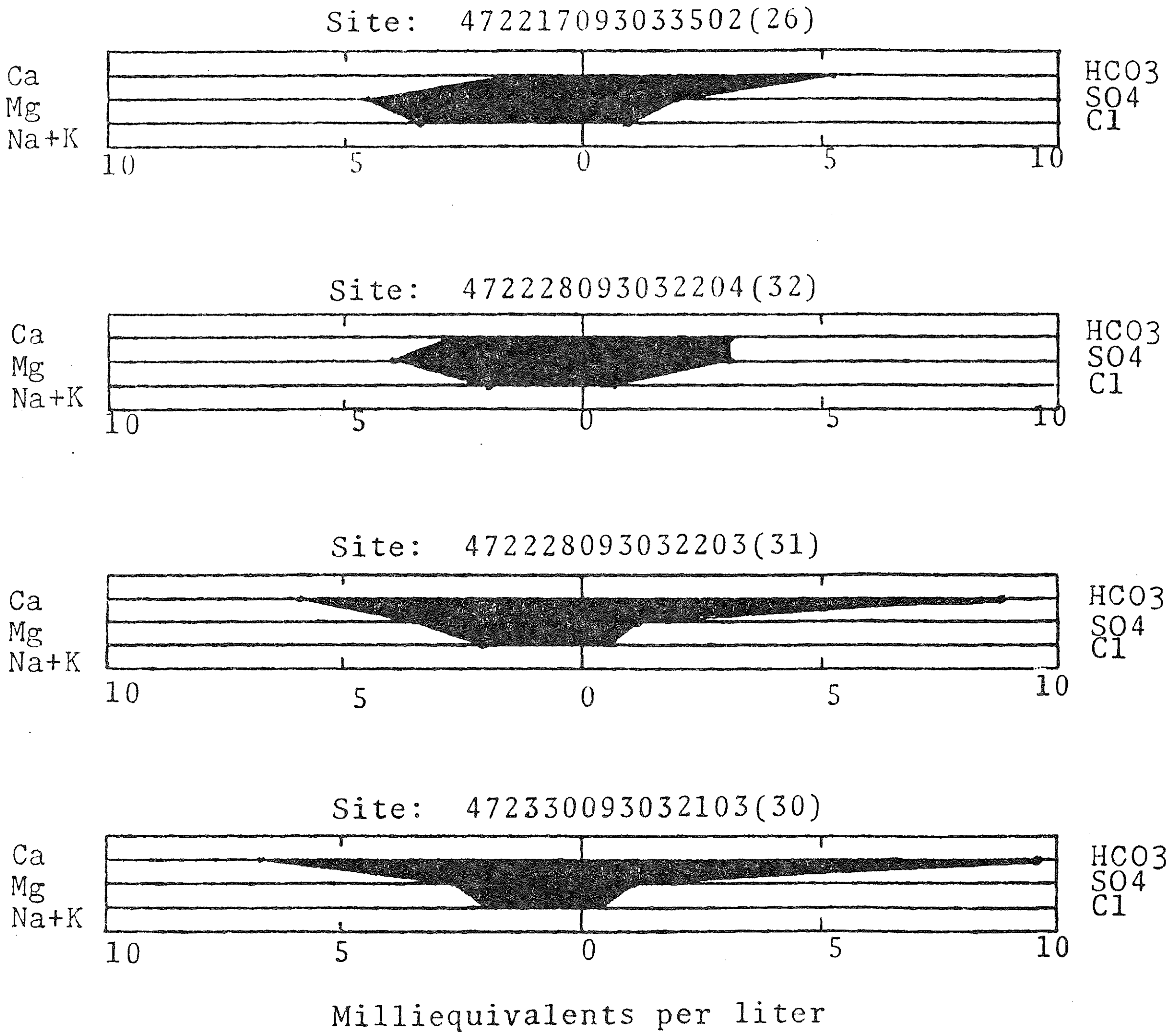
Temperature	Solids, dissolved (500 mg/l)
pH, field	Carbonate
pH, lab	Bicarbonate
Conductance, field	COD
Conductance, lab	Arsenic (0.1 mg/l)
Alkalinity, field	Barium (1.0 mg/l)
Alkalinity, lab	Boron
Chloride (250 mg/l)	Calcium
Sulfate (250 mg/l)	Cadmium (0.01 mg/l)
NO_2 + NO_3, as nitrogen (10 mg/l)	Chromium (0.05 mg/l)
Kjeldahl nitrogen	Copper (1.0 mg/l)
Ammonia nitrogen	Fluoride (1.5 mg/l)
Total coliform (1 colony per 100 milliliters)	Iron (0.3 mg/l)
Fecal coliform	Lead (0.05 mg/l)
Fecal streptococci	Magnesium
Hardness	Manganese (0.05 mg/l)
Sodium	Mercury
Potassium	Nickel
TOC	Selenium (0.05 mg/l)
Phosphorus	Silica
Solids, total	Zinc (5.0 mg/l)
Solids, total volatile	Phenol (0.001 mg/l)

* USEPA recommended limit for NO_3. For these analyses, concentrations of NO_2 is assumed to be negligible.

TABLE 7-13

SELECTED WATER-QUALITY CONSTITUENTS ANALYZED IN GROUND WATER AT A TACONITE-TAILINGS BASIN NEAR KEEWATIN, MINNESOTA

Temperature	Ammonia nitrogen
pH, field	Total coliform
pH, lab	Hardness
Conductance, field	Sodium
Conductance, lab	Potassium
Alkalinity, field	TOC
Alkalinity, lab	Solids, total volatile
Chloride	Solids, dissolved
Sulfate	Bicarbonate
NO_2 + NO_3, as nitrogen	Calcium
Kjeldahl nitrogen	Magnesium



EXPLANATION

WATER ANALYSIS PATTERN - Pattern is based on water analyses from indicated observation wells. Concentrations, in milliequivalents per liter, are plotted for calcium (Ca), magnesium (Mg), sodium plus potassium (Na+K), bicarbonate (HCO3), sulfate (SO4), and chloride (Cl). The larger the area of the pattern, the greater the chemical constituent concentration

Figure 7-20: Stiff diagrams of ground-water quality at the taconite-tailings basin near Keewatin, Minnesota, October 1982

The USGS analyzed some substances not required under the contract. However, the detection limits used on cadmium and lead were so high that it would have been surprising to find any. USGS used a minimum detection limit of 1 ug/l for cadmium and 10 ug/l for lead. The ambient ground water quality monitoring program calculated a state-wide mean value of 0.13 ug/l for cadmium and 8.39 ug/l for lead, based on over 300 samples collected throughout Minnesota. The detection limits used for chromium, mercury, and selenium were lower than the statewide average, but only slightly.

The high detection limits make comparisons with other ground water situations difficult or impossible for a few parameters. While State Drinking Water Standards are not apparently in any danger of being exceeded due to infiltration of tailings waters, the USGS study cannot be used to determine the relative or absolute change in most heavy metals in ground water due to infiltration.

Conclusions: The quality of ground water influenced by tailings appears to be degraded slightly, but the amount of change and the parameters most affected do not indicate that this type of a waste disposal facility is of immediate concern, with the possible exception of arsenic. The USGS was not in a position to extrapolate the findings from this individual abandoned tailings basin to any other tailings basin.

However, a review of monitoring data supplied to the MPCA by individual permittees shows a strong similarity in all taconite tailings basins for the basic inorganic and physical parameters. This suggests that the same effects on ground water could be expected in geologically similar situations. In situations where till or peat provide a thin veneer over bedrock, a different concern may arise. Underground seepage rapidly becomes surface runoff and the basin waters may be required to meet 2A or 2B standards if the seepage adversely impacts a class 2 stream segment. Even under the more restrictive standard (class 2A) where maximum allowable limits for copper (Cu) are ten times lower than class 1A and chromium (Cr) is 2.5 times lower and measured as total chromium, not just hexavalent, the water quality in tailings basins appears to meet either of these standards without treatment.

Recommendations:

1. Given the results of this study and the MPCA staff's previous experience in looking at other monitoring data on other active and non-active tailings basins, it is recommended that the MPCA make taconite tailings basins a low priority for long term ground water monitoring.
2. The MPCA should continue to actively support a continuation of the water quality portion of the Hanna Mining Study being done by the USGS. Our support should be in the form of verbal encouragement, not funding. The water quantity portion of the study is scheduled to continue for at least two more years. Minor water quality work could be done for a minimal amount of effort and a slight rearranging of the budget. IRRRB and/or Hanna may be willing to continue the water quality work to confirm if the preliminary results of the USGS study hold up over the next two years. At this time if it can be shown that the preliminary results are valid, the MPCA might develop very minimal monitoring plans for existing and future tailings basins.

<u>(e) Sludge Handling Systems</u>:

<u>Design Considerations</u>: Sludge is defined as the solids and associated liquids that are encountered and concentrated during wastewater treatment not including

incinerator residues and grit, scum or screenings. Sludge can be generated in treatment systems for both industrial and municipal discharges. Rules have been established to provide for the design, location, and operation of landspreading sites and facilities for municipal sewage sludge, while no rules or criteria presently exist for industrial sludge.

The purpose of Minnesota Rules 6 MCAR §§ 4.6101-4.6136 is to provide for the protection of the public health and the environment in the utilization or disposal of sewage sludge. The most commonly used methods of sludge disposal are landspreading, incineration, and landfilling. Of these, landspreading is the most widely used in Minnesota, with more than 90 percent of the publicly owned mechanical sewage treatment facilities disposing of sludge in this manner. Sludge landspreading has economic advantages as large capital and operational expenditures are usually not necessary. Additional benefits are derived through the improvement of soil physical and chemical properties and crop production at the landspreading site.

Before landspreading, sludge can be treated to increase handling efficiency and decrease public health concerns and nuisance conditions. For example, thickening and dewatering the sludge will increase the solids content resulting in a reduction in handling costs. Lime treatment can be used to reduce odor and pathogen levels in sludge. By rule, sewage sludge is required to be treated, at a minimum, by a process that significantly reduces pathogens prior to landspreading. Significant reduction of pathogens is specifically defined in the rule for the treatment processes of aerobic digestion, air drying, anaerobic digestion, composting, as well as lime stabilization.

In landspreading, sludge can be placed on or incorporated into the soil surface. The rule differentiates between a landspreading "site" and "facility." A landspreading facility is land "owned, leased, or rented by a political subdivision generating the sewage sludge" whereas a site is not. For landspreading sites, limitations on sludge application are established for soil soluble salt content, soil pH, additions of heavy metals and nitrogen, soil phosphorus content and organic priority pollutants (PCBs). Where food-chain crops are grown, the pH of the soil and sewage sludge mixture must be 6.5 or greater. Limits to cumulative heavy metal additions at a site are specified for cadmium, copper, lead, nickel, and zinc based on soil cation exchange capacity. The annual cadmium application can not exceed two pounds per acre. Sludge application rates, together with other nitrogen sources, can not supply more nitrogen than the amount required by the vegetation grown at the site. If sludge is applied to fallow land, rates are restricted according to soil texture and annual precipitation. In addition, a crop must be grown the following year. Concentrations for priority pollutants in sludge are considered on a case-by-case basis except for specific limits on PCBs of 50 milligrams per kilogram.

Other limitations at landspreading sites concern soil conditions and separation distances. A soil profile at a site must provide a minimum of six inches of available water-holding capacity between ground surface and bedrock or the seasonal high water table and have at least one horizon with a permeability of six inches per hour or less. These conditions will protect ground water and facilitate crop uptake of nutrients. To prevent runoff, liquid sewage sludge must not be applied on soils with surface permeabilities of less than 0.2 inch per hour or on slopes greater than six percent unless sludge is immediately incorporated. Separation distances are required from the site to places of habitation, surface waters, and private and public water supplies. Additional requirements are specified for the short-term and long-term storage of dewatered sewage sludge.

The requirements and limitations for landspreading facilities may vary from those prescribed at sites. Basically, the same minimum design requirements apply to both sites and facilities. The primary difference between the two is that in facilities landspreading can be regulated by these minimum design requirements <u>or</u> by designated performance standards. Landspreading under the latter limitations is allowed provided standards for ground water, surface waters, food-chain crops, and public health and safety are observed.

<u>Ground Water Monitoring</u>: The rule requires that existing landspreading facilities obtain a state disposal system permit within a given time period while proposed facilities must be permitted prior to development and use. The same procedure is used for sites except a letter of approval is needed rather than a permit. In this case, a permit for the wastewater treatment facility has already been issued with one of the provisions requiring a plan for disposing of sludge if requested by the Director. A written approval of the sludge plan must be obtained prior to any landspreading. Ground water monitoring is not required at landspreading sites. For facilities, a minimum of six monitoring wells is required by rule unless the permittee can demonstrate compliance with 6 MCAR § 4.8022. Two wells must be placed in the area of landspreading with two upgradient and two downgradient within the ground water flow system. All wells must sample the uppermost part of the first aquifer encountered below a facility. Frequency of sampling must be at least semi-annually but may be increased by the Director. Parameters to be analyzed in samples will be determined by the Director based on "soil permeabilities, depth to ground water, direction of ground water flow in relation to the location of potable water

supply wells, distance to potable water supply wells, sewage sludge application rates, sewage sludge quality, and suitability of the ground water as a source of potable drinking water." To date, two facilities have been permitted and two have applications pending. Based on limited data, there have not been significant impacts to ground water from the operation of these facilities.

B. Solid Wastes

Existing Regulatory Program:

Minnesota Rule SW-1 (30) defines solid waste as "garbage, refuse and other discarded solid materials, except animal waste used as fertilizer, including solid waste materials resulting from industrial, commercial and agricultural operations, and from community activities." Minnesota Rule SW-6 requires that permitted mixed municipal waste (sanitary) landfills be used for the final disposal of all such solid waste. That rule contains some sections which deal specifically with ground water protection. These are:

1. SW-6 (2)(g) which states that landfills cannot be located in areas "unsuitable because of reasons of topography, geology, hydrology or soils." While this section does not define "unsuitable," it has been used as a basis for not allowing landfills to be constructed in areas which are not conducive to ground water protection.
2. SW-6 (2)(b) states "Solid waste shall not be deposited in such a manner that material or leachings therefrom may cause pollution of underground or surface water." It further requires at least a five-foot separation between the lowest portion of the landfill and the high water table elevation, but does not specify the type of materials which are to constitute that separation. However, it does include a clause, which states "...additional ground water protection shall be provided if

needed." Historically, this has been used by MPCA as justification for requiring liners under certain landfills located in areas which are not naturally protective of the ground water.

3. SW-6 (2)(s) requires that a water monitoring system be constructed and operated to determine whether solid waste or leachings therefrom are causing pollution of underground or surface water, and gives the MPCA Director authority to set and change monitoring requirements.

4. SW-6 (2)(t) gives the MPCA authority to require leachate collection and treatment where needed to protect underground or surface waters.

5. SW-6 (3)(b)(ii) establishes the technical information which is to be submitted to MPCA in the permit application. Those requirements which pertain to ground water are: a hydrogeologic study, soil boring data (at least one boring is to be a minimum depth of 50 feet below the lowest proposed waste elevation), water table profile, direction of ground water flow, and initial quality and use of water resources in the potential zone of influence of the landfill.

6. Several sections of the rule deal with soil cover requirements. Minnesota Rule SW-6 (2)(d)(i) requires daily compaction of wastes followed by covering with a compacted six-inch layer of suitable cover materials. Suitable cover material is defined but permeability requirements are not given. Minnesota Rule SW-6(2)(d)(ii) requires at least twelve inches of suitable cover material on all fill areas which will be inactive 120 days or more. Minnesota Rule SW-6 (2)(d)(iv) provides for grading of the fill and cover materials to promote surface water runoff without excessive erosion. Minnesota Rule SW-6 (2)(aa)(i) requires 24 inches of final cover graded to at least 2 percent slope on completed fill areas, and Minnesota Rule SW-6 (2)(aa)(ii) requires that topsoil be applied and suitable

vegetation established. All of these requirements are intended to limit infiltration of water, thus retarding leachate production.

Due to the possible negative environmental impacts which landfills may cause, obtaining a permit for a landfill is a long and complex process. To foster communication during the project, the MPCA has initiated a procedure which involves much staff interaction with the potential permittee in the first stages of site study.

Upon initial contact with the MPCA, the potential permittee is instructed to prepare a work plan, detailing the specific field work, planned locations for soil borings and the methods of predictive analysis and interpretation to be undertaken. MPCA staff discuss the work plan with the potential permittee, providing guidance as to needed changes. The potential permittee then contracts a consultant to perform a hydrogeologic study, aimed at obtaining the following information:

- definition of the underlying strata,
- determination of the potentiometric surface,
- determination of ground water flow velocities,
- definition of vertical flow components,
- definition of ambient water quality,
- determination of recharge/discharge areas, and
- providing accurate and complete geologic information.

Once the study is complete, the potential permittee submits a permit application to the MPCA. The permit application and supplementary information are reviewed by Solid and Hazardous Waste Division staff, according to current facility review guidelines. These guidelines provide for close scrutiny of geologic and hydrologic information to ensure the maximum degree of protection to ground and surface water supplies, as well as assuring that permit review are as complete and consistent as possible. Some direction is also provided on design and operational topics, such as cover permeabilities liner placements and thickness, sequence of filling and so on.

After a review of site-specific soils and hydrogeologic data, and facility design and operational information, a determination is made whether to issue or deny the solid waste permit. If a permit is to be issued, monitoring requirements are incorporated into the permit based on type of solid waste facility, hydrogeologic setting, and amount and characteristics of the waste. Ground water monitoring requirements include, at a minimum, the frequency of sampling and parameters to be analyzed. The type and location of ground water sampling devices are also specified in the permit. Most landfills accepting mixed municipal wastes are required to monitor ground water. Other landfills, such as demolition and industrial waste landfills, may be required to monitor depending on waste characteristics and, in the case of existing sites, past operational history. For a more complete discussion on ground water monitoring, see Chapter 6.

As with SDS permits, ground water quality standards are not established in solid waste facility permits. Following certification of the monitoring system and collection of background samples, monitoring results reported to MPCA are reviewed pursuant to standards established in Minnesota Rule 6 MCAR § 4.8022. Any facility may be required to amend its monitoring system or upgrade its design or operational practices if it is determined ground water is adversely being impacted based on the review of monitoring results by MPCA staff. Comments applying to public noticing of SDS permits also apply to solid waste facility permits.

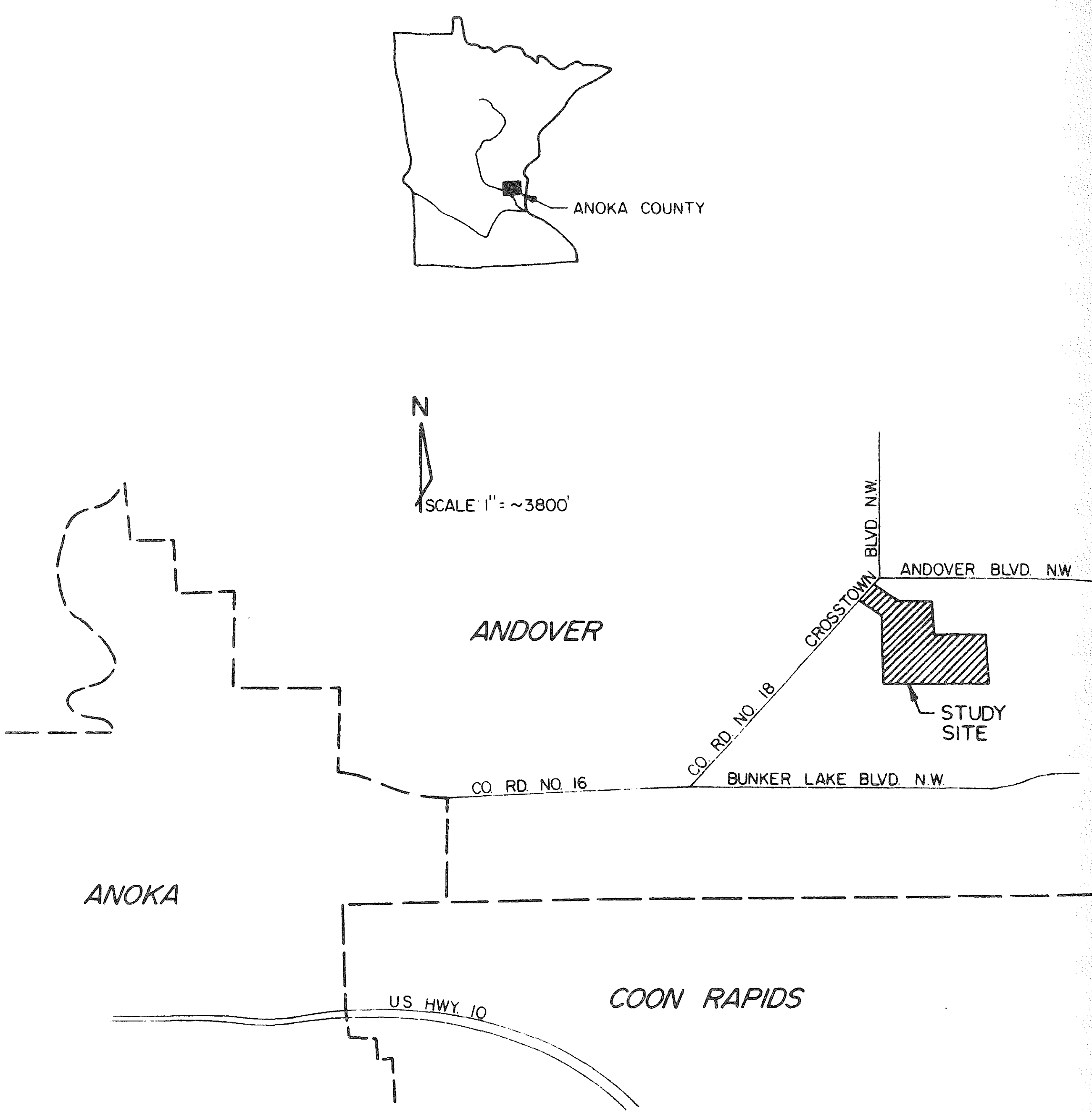
Methods of Disposal

(a) Mixed municipal waste (sanitary) landfills: Two site-specific hydrogeologic studies were performed at sanitary landfills, to assess the effectiveness of the current solid waste management program at controlling ground water pollution (Table 7-1). The contract for the studies was awarded to E.A. Hickok and Associates (Hickok, 1983a; Hickok, 1983b). Sites were chosen to represent two very different geologic settings. The first site is located on the Anoka Sandplain where coarse-grained sands underlie the landfill and are used as cover materials. The other site is located in the Des Moines Lobe Till of southwestern Minnesota, where silty clays underlie the waste and constitute the cover materials.

Site Investigations:

Sandplain Site: The sandplain site chosen was the Waste Disposal Engineering Landfill in Andover, Minnesota, (MPCA Permit SW-28) (Figure 7-21). The permit for that site was issued on March 30, 1971. At the time the study was completed, the site had been in continuous operation since 1971 and operated since 1961 as an uncontrolled dump. There is no liner under the site. The fill covers 81 acres, with a maximum depth of refuse of approximately 34 feet. Some areas of the fill have received a less-permeable cap of lime sludge, but it has not been consistently applied. From 1971 to 1974 the site operated a toxic waste pit. The pit covers an area of approximately 10,000 square feet on the northwest part of the site and is lined with packed clay overlain by six inches of blacktop. When closed in 1974, the pit was covered with 12 inches of clay soils. Wastes were disposed in barrels and included: inks, solvents, caustics, strong acids, paint sludges and metal sludges.

Ground water flow under the site is from south to north. Both the shallowest

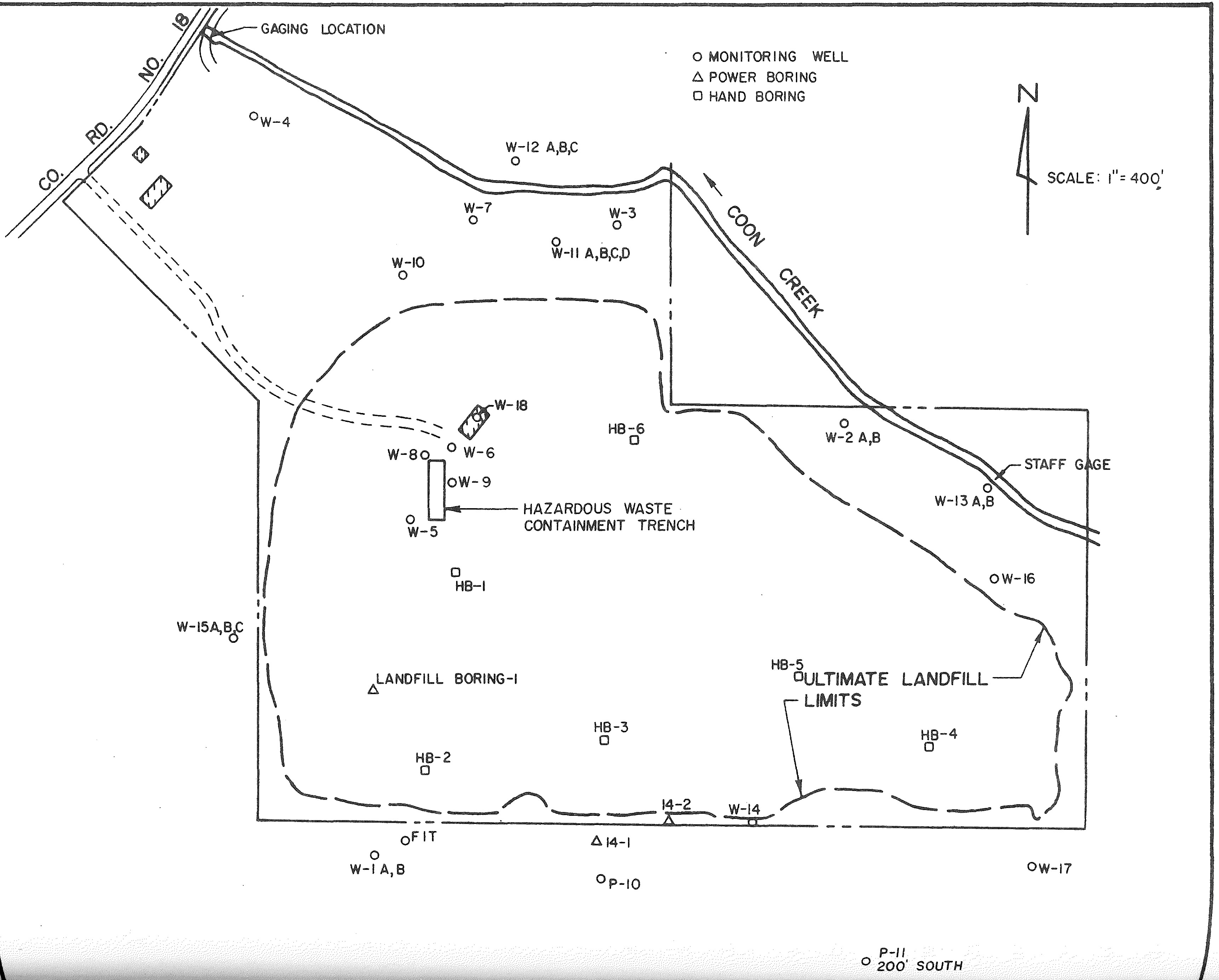


MPCA SANDPLAIN LANDFILL STUDY	E.A. HICKOK & ASSOCIATES HYDROLOGISTS - ENGINEERS MINNEAPOLIS - MINNESOTA	SEPT. 1982
REGIONAL LOCATION MAP		Fig. 7-21

ground water and the deeper ground water discharge into Coon Creek, which lies approximately 300 feet north of the fill. Apparently, Coon Creek serves as a leachate interceptor for the site. The contractor installed 12 ground water monitoring wells, six hand borings in the cover, one exploratory boring through the landfill and two exploratory borings near the landfill (Figure 7-22). Other monitoring wells were already installed prior to initiation of this study. The contractor collected water samples from the new wells three times during the course of the study. Other monitoring results from existing wells were tabluated also.

The following observations were made concerning water quality surrounding the landfill:

1. The ground water beneath and downgradient of the site is showing signs of leachate contamination. This is shown graphically in Figures 7-23, 7-24; and 7-25. Figure 7-23 shows chloride values encountered in ground water; Figures 7-24 and 7-25 show concentrations of specific conductance and toluene, respectively. Other parameters indicative of leachate contamination also show increases downgradient of the landfill.
2. Effects of the discharge of this contaminated ground water can be seen in the monitoring data from upstream and downstream points on Coon Creek. The levels of organic contaminants found in the creek were in excess of the human health recommendations from EPA, but did not exceed recommended levels for aquatic life.
3. Based upon the classification requirements of the RCRA criteria for solid waste disposal facilities (Federal Register, September 13, 1979), this site would be classified as an open dump. This judgement was made because the leachate contamination at the waste management area boundary caused primary drinking water standards to be exceeded in the ground water.



MONITORING WELL LOCATION MAP

MPCA SANDPLAIN LANDFILL STUDY

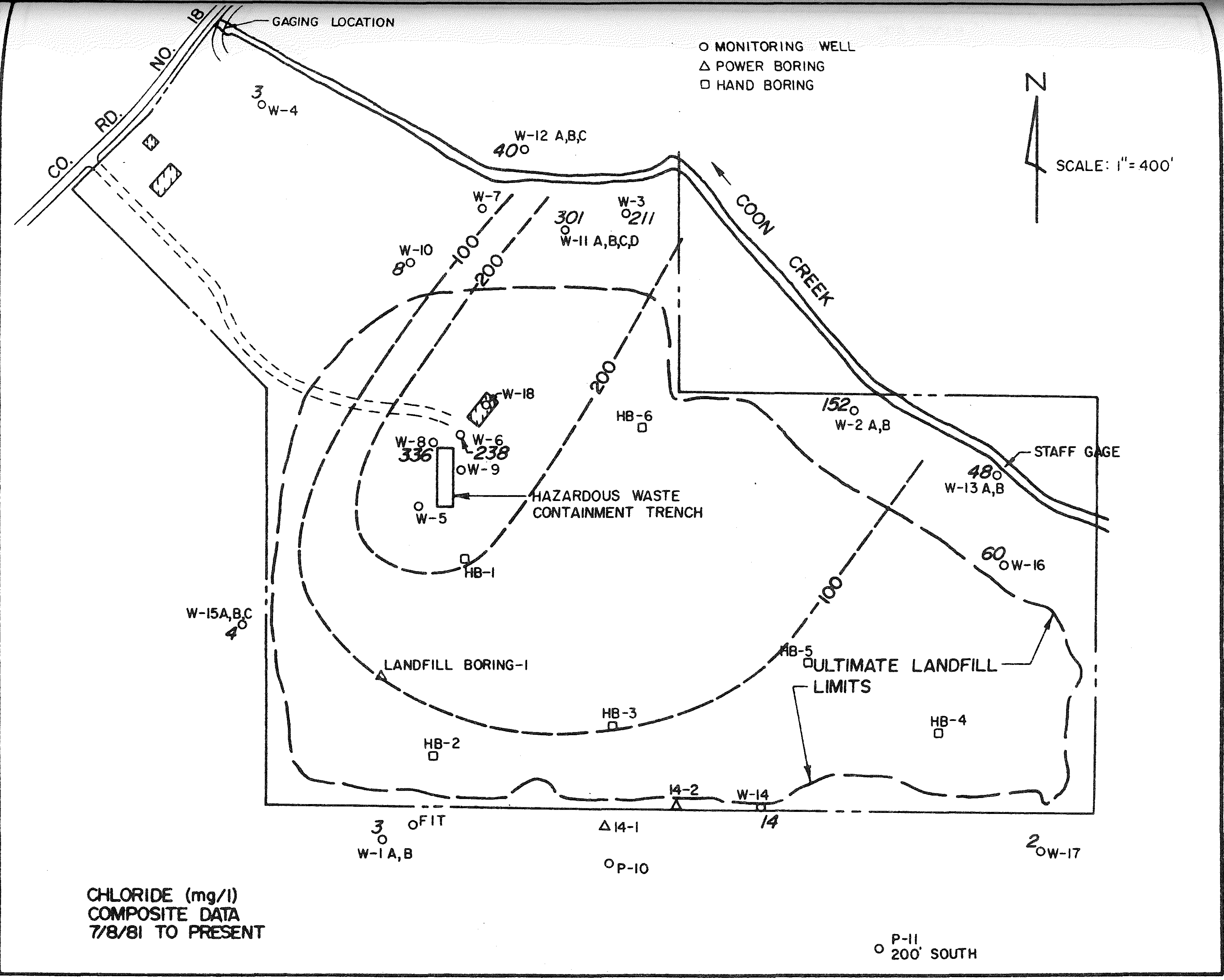
E.A. HICKOK & ASSOCIATES
HYDROLOGISTS-ENGINEERS
MINNEAPOLIS-MINNESOTA

SEPT. 1982

Fig. 7-22

MPCA SANDPLAIN LANDFILL STUDY

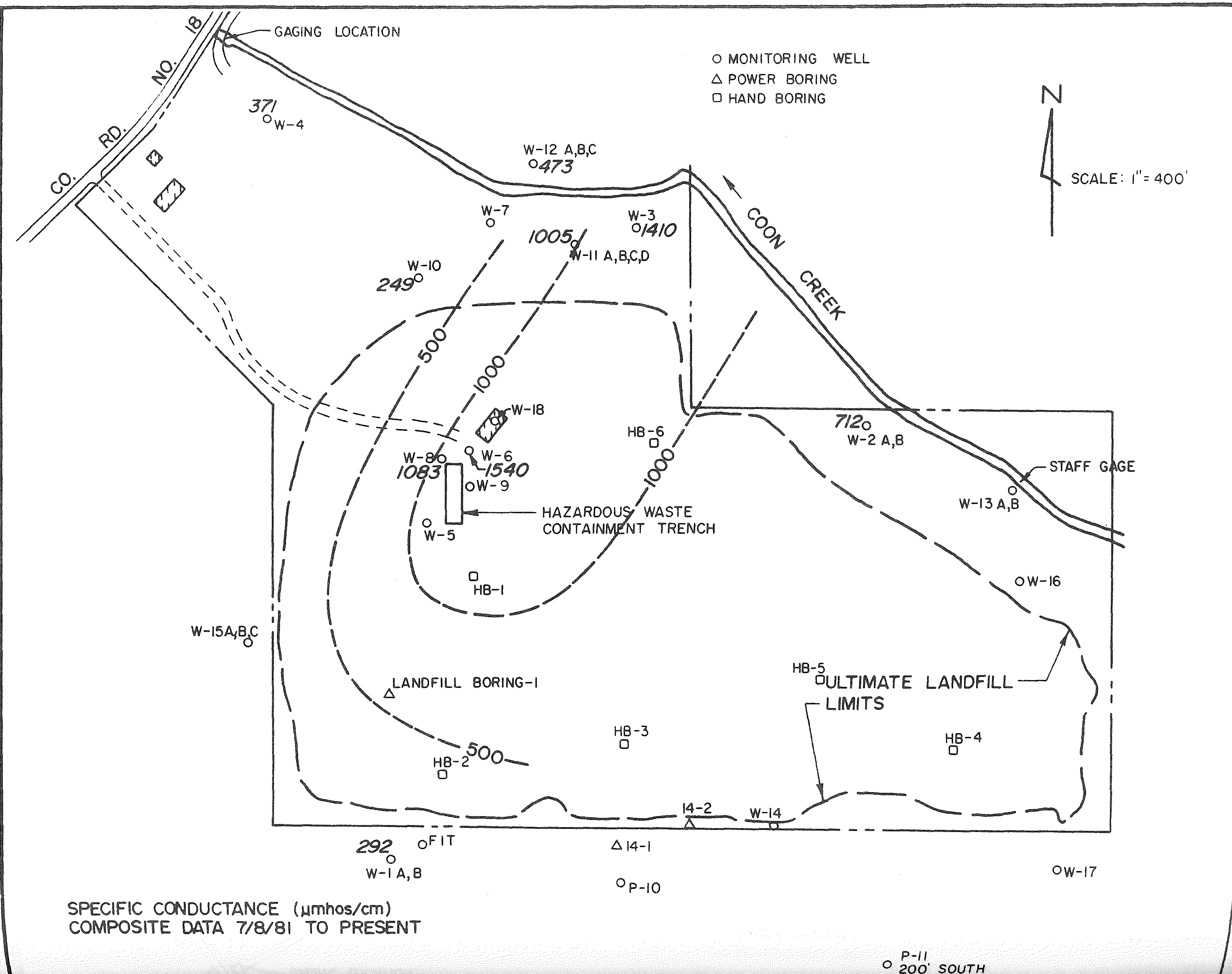
CHLORIDE CONTOUR MAP



E.A. HICKOK & ASSOCIATES
HYDROLOGISTS-ENGINEERS
MINNEAPOLIS-MINNESOTA

SEPT. 1982

Fig. 7-23



SPECIFIC CONDUCTANCE CONTOUR MAP

MPCA SANDPLAIN LANDFILL STUDY

E.A. HICKOK & ASSOCIATES
HYDROLOGISTS-ENGINEERS
MINNEAPOLIS-MINNESOTA

SEPT. 1982

Fig. 7-24

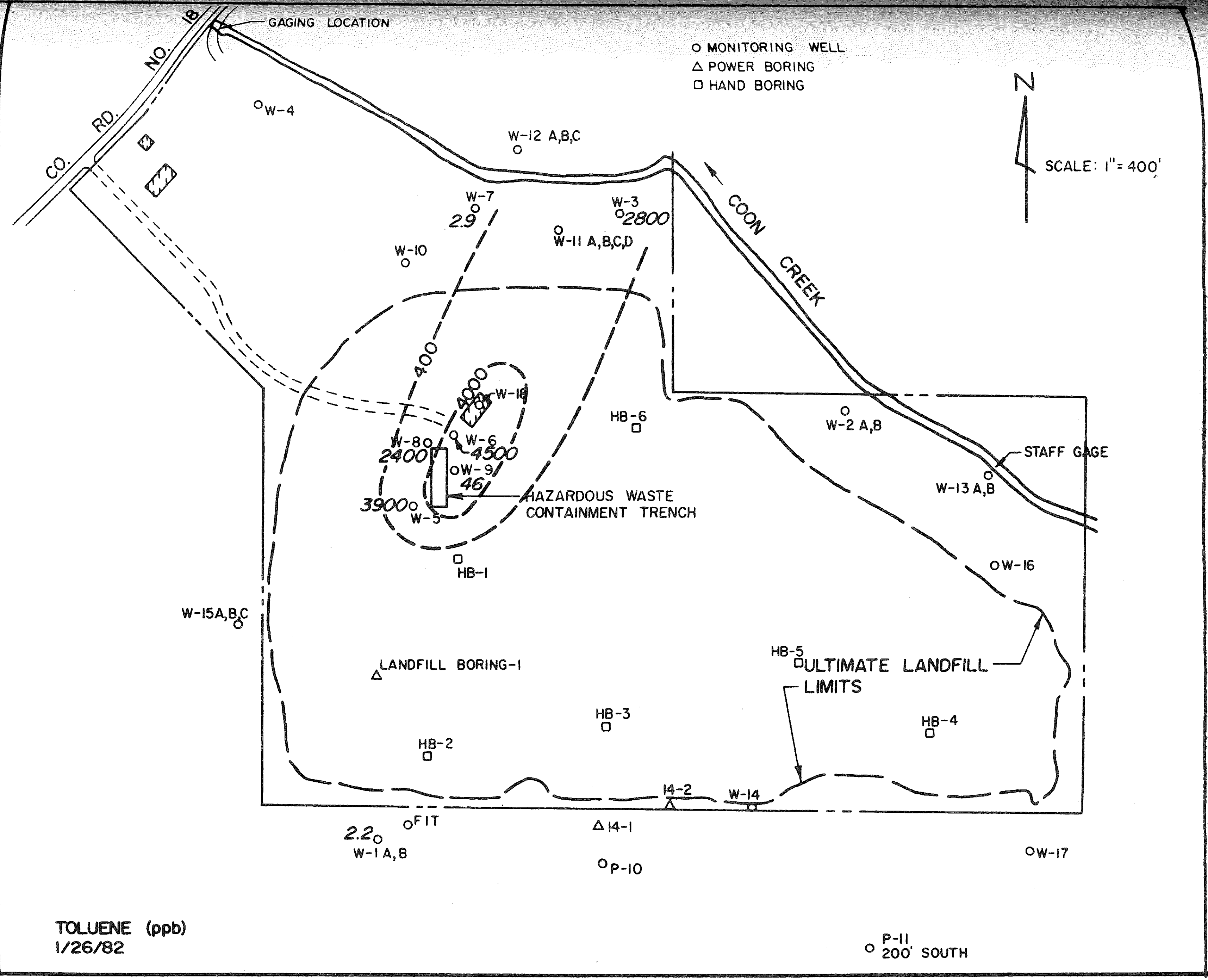
MPCA SANDPLAIN LANDFILL STUDY

TOLUENE CONTOUR MAP

E.A. HICKOK & ASSOCIATES
HYDROLOGISTS-ENGINEERS
MINNEAPOLIS-MINNESOTA

SEPT. 1982

Fig. 7-25



When the Open Dump Inventory (ODI) was conducted in Minnesota in 1980, the site was given a failing rating based upon suspected ground water contamination. This study confirmed the ODI rating.

4. A water balance study calculated for the site shows that a sloped cap of the less-permeable lime sludge could serve to limit infiltration substantially, and subsequently reduce the annual volume of leachate produced. The time of leachate production will be lengthened substantially (from an estimated 7.3 years to 19.8 years), however at lower loading rates, the effects on Coon Creek should be lessened.

Samples of the soils beneath the landfill were collected when the boring through the fill was completed. Cation exchange capacity tests in these soils indicate that little attenuation of leachate is likely to occur under the site.

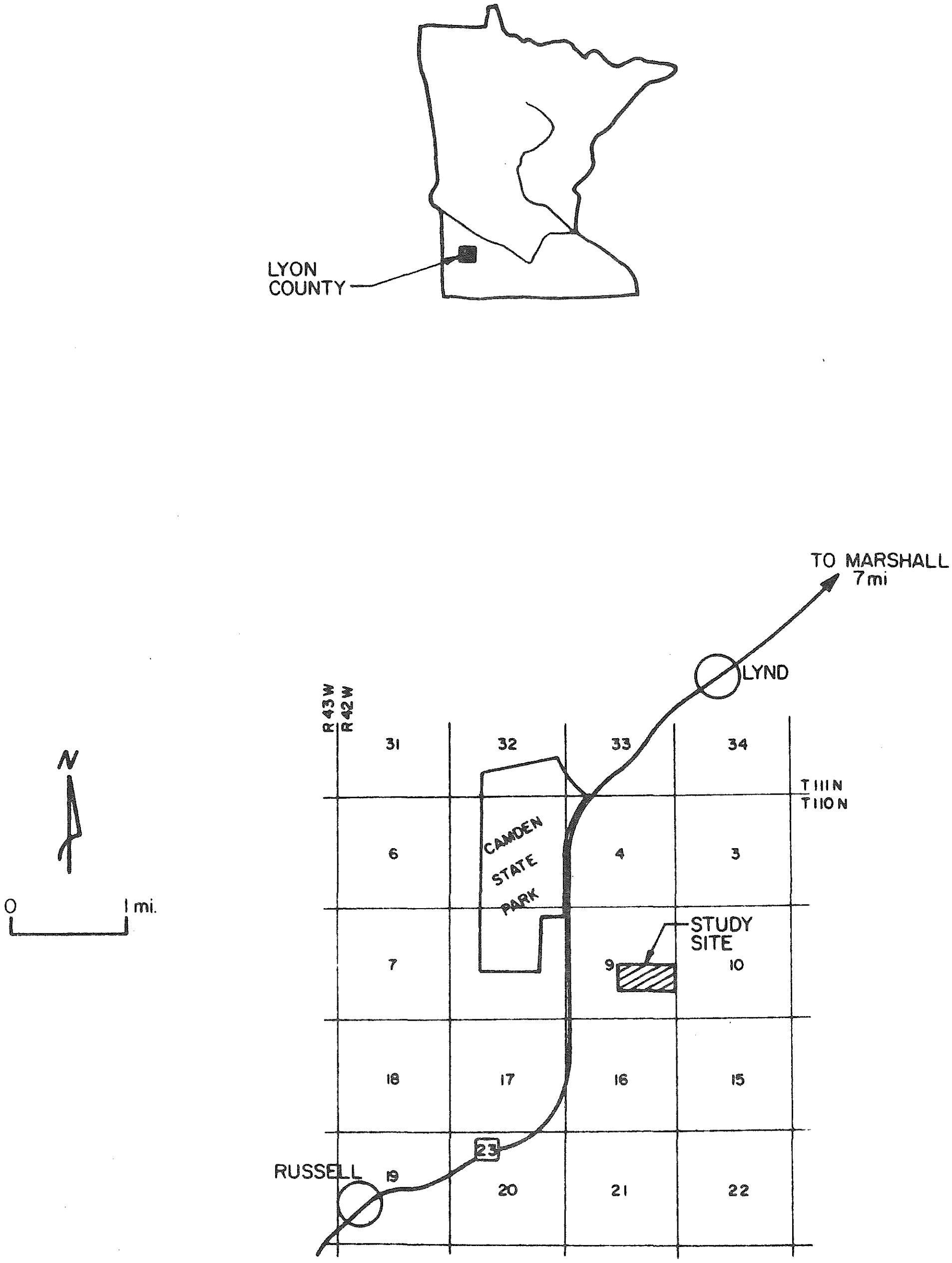
Another facet of this study was a literature search conducted to review available landfill literature pertinent to sites in sand environments. The review presented data on 16 sites in six states and provinces. Six of the sites were located in Minnesota. All of the sites are unlined. Five out of the six are known or suspected to have caused ground water contamination. The sixth site differs from the others in that it has had a consistent program of lime sludge application to construct its sloped cap. No ground water contamination has been detected at this site.

The other ten sites were in the states of Wisconsin, Illinois, New York, North Dakota and the province of Ontario. Eight of the ten sites are unlined and have shown evidence of ground water contamination. The two sites with clay liners have not shown evidence of ground water impairment after approximately 10 years of operation. It is important to emphasize that due to uncertainties in monitoring, it is possible to state with certainty only that contamination has been detected. Failure to detect contamination may be due to many factors besides the absence of contaminants such as inadequate placement of wells, improper well construction, poor sampling techniques, and low-quality analytical work, all of which can obscure a correct interpretation of the reported monitoring data.

The major conclusions of this report are that the ground water effects of sandplain landfills can be minimized by the use of sloped, impermeable cover materials and clay liners. Leachate collection is another alternative which can be beneficial. The natural environment offers little protection from products of waste decomposition. Much ground water can be affected when adequate safeguards are not employed at these sites. Therefore, care must be exercised when siting and permitting these facilities.

Clay Site: The site chosen for the clay landfill study was the Lyons Sanitary Landfill, located ten miles southwest of Marshall, Minnesota (Figure 7-26). The site was issued MPCA Permit SW-23 in December, 1970 and has been in operation since spring of 1971. Waste types accepted include industrial, municipal and demolition wastes. There is no record that the site ever accepted toxic or hazardous wastes. Most of the soils encountered at the site are relatively impermeable silty clays. Some thin, apparently discontinuous seams of sand and gravel were observed. It is interesting to note that gravel pits are located on adjoining properties to the south and northwest of the site. Ground water surface elevations at the site range from three feet to nine feet below the original ground surface. The direction of ground water flow is from north to south.

The study consisted of constructing ten ground water monitoring wells, eight hand borings in the cover and one exploratory boring through the landfill. Two



MPCA CLAY LANDFILL STUDY	**E.A. HICKOK & ASSOCIATES**	MAR. 1983
REGIONAL LOCATION MAP	**HYDROLOGISTS - ENGINEERS** **MINNEAPOLIS - MINNESOTA**	Fig. 7-26

additional monitoring wells and an in-use domestic well were on the site when the study began. Ground water samples were collected in three consecutive months during the course of the study. A tabulation of permittee-generated monitoring data was also presented. Ground water sampling data from the study showed the following:

1. The landfill does not appear to be causing degradation in the ground water from either metals or other inorganic parameters. The water sample collected from the boring through the fill indicates that leachate has seeped from the landfill at this one location but no evidence of leachate migration is seen in the monitoring wells. Data presented in Van Voast, Jerabek and Novitzki (1970) shows ground water contained in glacial drift aquifers in southwestern Minnesota is generally low in chloride and high in sulfates. If landfill leachate contamination were a problem, chlorides would be elevated substantially and sulfates may be lower. Data from the study site shows that the monitoring well and domestic well chloride and sulfate trends are similar to those reported in Van Voast, with minor indication of leachate effects in one close-in shallow monitoring well. By contrast, the water from the fill boring shows very high chlorides, but sulfates were not detected. This analysis supports the contractor's conclusions.
2. Fairly high concentrations of both halogenated and non-halogenated volatile organic compounds were found in the water sample from the fill boring. Low concentrations of a few compounds were found in the monitoring wells. Unfortunately, the data from the fill boring was not available at the time the wells were installed. The results of water analyses from the newly constructed monitoring wells were obscured by the fact that the wells were

constructed of PVC pipe and some were solvent-welded. Had organics been known to be a problem, different construction practices would have been followed. No organics were detected in the previously-installed wells or the domestic well on site. The contractor believes that eventually the well-construction effects will become minimal. A resampling for organics should be done at some time in the future to verify the migration of these compounds through the on-site clay soils.

3. Based upon the classification requirements of the RCRA criteria for solid waste disposal facilities (Federal Register, September 13, 1979), this site would not be classified as an open dump. This rating confirms the ODI rating for the site made during the 1980 survey.

4. A water balance study calculated for the site shows that the proposed final cover (24 inches of silty clay with at least a 2% slope with topsoil and vegetation) could theoretically eliminate leachate production at this site. This would not be true of clay landfills in the more humid areas of Minnesota, although leachate production could be significantly reduced.

Samples of the soils beneath the landfill were collected when the fill boring was completed. As expected, cation exchange capacity was found to be higher in the clay soils than in the sandy soils of the sandplain study. Analysis of the soil samples reveals elevated chemical parameters, which indicates that some attenuation of leachate may be occurring.

The literature search performed for this study found only limited information and concluded that clay landfills have been historically perceived as not having problems and therefore, little has been published concerning ground water impacts from clay landfills.

Volatile Organics in Landfill Leachates:

Volatile organics are classified as low molecular weight compounds which may evaporate rapidly when exposed to the atmosphere. Many are soluble in water, and will remain in solution unless exposed to air. Analytical methodology for these compounds is quite sensitive, with detection limits in the parts per billion range. Many private laboratories in Minnesota are now equipped to perform the analyses.

Typically, these compounds are solvents with household and industrial uses. They may be used in their pure forms as paint thinners or removers, cements (such as rubber cement), cleaners, degreasers, refrigerants, or drying agents. They also may be contained in other products such as inks, paints, dyes, varnishes, preservatives, pesticides, fire-retardants, shampoos, and detergents. It is likely that many individuals and businesses dispose of small quantities of these products regularly, and that many end up in landfills.

A variety of volatile organic compounds has been detected in landfill leachates and leachate-contaminated ground water. The list of compounds include some of the priority pollutants, both halogenated and non-halogenated volatile compounds. The current leachate data base contains analytical results for seven Minnesota landfill leachates, five Wisconsin leachates and one leachate sample from New York. Data has also been compiled from monitoring wells at 13 Minnesota landfills which were showing signs of leachate contamination, based upon review of inorganic leachate indicators. Landfills chosen represent both rural and urban areas of Minnesota.

Results of the leachate analyses show some volatile compounds to be present in every leachate. The most commonly detected componds (in $\geq$50% of leachates) were the priority pollutants toluene; methylene chloride; 1,1,2-trichloroethylene; 1,1,dichloroethane; ethylbenzene; benzene and trans-1,2-dichloroethylene. The non-priority pollutant parameters acetone, 2-propanol and xylenes were also detected in 50 percent or more of the leachates. Similar although less consistent data were obtained from the analysis of leachate-contaminated ground water from landfill monitoring wells.

Research is currently on-going in other parts of the country to establish the mobility of various synthetic organics in different soil types. Some preliminary findings show that high concentrations of xylenes, acetone and methanol can increase the permeabilities of saturated clay soils by several orders of magnitude (Anderson, 1982). Therefore, the mobility of these compounds may be greater than other types of contaminants.

All of these reasons illustrate the need to give greater attention to the question of landfill leachate collection and treatment. Volatile organics testing is currently being required at landfills in Minnesota once every two years. More research is needed on treatment methods for removal of these compounds.

Recommendations:

These studies confirm what past experience has shown namely, that regardless of their hydrogeology, landfills may pose a threat to ground water quality. For that reason, great care must be exercised when permitting new facilities and existing facilities must receive close attention when corrective action becomes necessary.

In most areas of Minnesota, the amount of water which falls as precipitation exceeds the amount which reenters the atmosphere through evaporation and plant transpiration. This is the reason that Minnesota's ground and surface water resources are so abundant. It is also the reason that the elimination of leachate production is virtually impossible.

The use of low permeability materials such as lime sludge or clay as cap and liner materials cannot eliminate infiltration and percolation, but can limit either substantially. Synthetic materials used as caps and liners further limit infiltration and percolation, but may be subject to physical failures and chemical reactions with the wastes in contact with them. These facts, coupled with the net gain of water due to percolation, reinforce the observation that a leak-proof landfill cannot be built in Minnesota.

When siting new landfills, initial hydrologic work must be coupled with projections of leachate quantity and movement. This information can then be used to predict potential areas of impact, and to judge the appropriateness of the proposed design features and location. Similar work should be done on existing sites, and reviewed in light of evidence from ground water monitoring systems to determine the effects.

Following are recommendations made to limit the effect that landfills may exert on ground water. The first recommendation applies to new sites only, while the others can apply equally well to existing sites, expansions and new sites.

1. Mixed municipal waste landfills should not be located in local ground water recharge areas. Ground water impacts will be minimized if landfills can be located in ground water discharge areas having no downgradient water users. Surface water systems have greater capacity to negate the influence of pollution sources than do ground water systems. However, careful calculations must be performed to determine the potential impacts of any

waste disposal sites on nearby surface waters. Discharge of contaminated ground water into surface water systems with low flow rates, such as lakes or wetlands, can seriously impact water quality and aquatic life.

2. Landfills should be contructed in such a way that infiltration is limited to the greatest extent possible. The use of low permeability cover materials is now required in most situations; under current facility review guidelines, the permeability of cover materials should not exceed 2 x 10^{-6} centimeters per second. Increased emphasis is needed in the area of daily operations. The water balance studies discussed in the site-specific reports show the effect of improperly graded refuse cells during the operational period. For example, in the clay landfill water balance study the amount of water projected to be entering the waste deposits was cut more than 50 percent by applying 2 percent slope to the daily cover and eliminating ponded water on the fill areas.

3. The control of leachate migration is another important aspect of landfill design and operation. Clay soils used as liners or leachate barriers can slow the movement of leachate significantly and provide opportunity for the attenuation of contaminants. This would aid in reducing the loading rates to receiving waters in ground water discharge areas. In more sensitive areas, such as ground water recharge areas or areas of heavy reliance on ground water, leachate collection systems are strongly recommended. The collected leachate should receive treatment (in a wastewater treatment plant, or through other alternatives) prior to discharge.

4. Hydrogeologic concerns of sanitary landfill design and operation are receiving much closer attention currently than even two or three years ago.

Now, ground water hydrologists and engineers work together in matters of facility review and permit issuance or modification. Sites which have received recent attention, therefore, are much more likely to have adequate ground water safeguards than are other sites. These other sites may have facility reviews conducted when leachate contamination is detected in the monitoring wells or surface discharges are noted. However, even lacking this evidence of problems, the older permits should be periodically reviewed, and the necessary changes made (such as ground water diversion, leachate collection, monitoring network upgrade, etc.) to minimize the impacts these sites may have on ground water.

(b) Industrial waste landfills: Industrial waste landfills (nonhazardous) encompass a wide variety of waste materials and disposal methods. Examples of typical MPCA-permitted industrial waste facilities include combustion residuals disposal sites, lime waste storage/disposal areas, and paper mill waste disposal sites. Currently, 25 solid waste (SW) permits have been issued for construction and operation of industrial waste facilities.

Minnesota Rules SW-1 through SW-12 for design, operation and monitoring of mixed municipal waste (sanitary) landfills also apply to industrial waste facilities. Most industrial waste sites also have ground water monitoring systems, pursuant to Minnesota Rule SW-6 (2)(s). Monitoring requirements for these sites are determined on a case-by-case basis at the time of permit review, based upon such factors as site characteristics, composition and reactivity of the waste, and present and potential downgradient water uses. Waste composition is the most important factor in distinguishing between a mixed municipal waste monitoring program and one for industrial waste. An industrial waste with a waste well-known and tightly controlled composition may be required to monitor for a relatively limited number of parameters, as long as the waste stream remains relatively constant.

Because of the limited number of permits issued to these facilities so far, data from operational ground water monitoring systems are scarce. More study of industrial waste facilities, including a range of waste types in a variety of hydrogeologic environments is recommended.

(c) Demolition landfills: Demolition landfills receive wastes normally associated with construction and demolition operations, and include wood, concrete, asphalt, plaster and glass. Minnesota Rule SW-1 (30) explicitly excludes "materials normally handled in construction operation" from the definition of solid waste. There is no definition given for construction or demolition materials, however. Historically, solid waste (SW) permits have been issued to larger demolition landfills following the criteria contained in Minnesota Rule SW-6. About 20 such permits have been issued since 1970. Demolition landfills of limited duration and low volume are generally issued letters of approval rather than permits.

The major differences between permits for mixed municipal waste and demolition landfills are frequency of covering and ground water monitoring requirements. Most demolition landfills are exempted from the daily soil cover requirement associated with sanitary landfills. Also, most demolition landfills are not required to monitor ground water, the thought being that demolition wastes are largely inert and should not generate appreciable amounts of leachate. This is a notion which has gained wide acceptance, but one which should be tempered with caution.

Several factors suggest that hydrogeologic investigation of selected demolition landfills is warranted to document their perceived non-problem status. First, there is always the danger that material other than the normally expected concrete, wood and plaster may be present in the waste. For example, if an old industrial or commercial site is being demolished, care is often not taken to exclude any contaminated debris which may be present. This is true both at the demolition site and at the landfill. Demolition landfill operators are frequently contractors themselves and are rarely concerned about segregation of wastes at the fill site. Second, demolition landfills are not normally subject to the same security and other safeguards afforded sanitary landfills. Their hours are often irregular, a caretaker is not always present, and site access is often not restricted. These factors combine to invite after-hours, unauthorized dumping of waste other than demolition materials at these sites, some of which obviously may have the potential to produce leachate.

A third factor concerns location and operation of demolition sites. Frequently, these sites do not benefit from the same site selection process as sanitary landfills. They may be located in marginal areas, as they are often designed to reclaim marginal land. As mentioned previously, they are covered less frequently than sanitary landfills, and so usually receive more infiltration which may contact the waste and ultimately move toward ground or surface water. Finally, there are a number of demolition landfills which originated as mixed municipal waste landfills or dumps, which may already be generating leachate. In summary, further investigation of the effects of demolition landfills on ground water is warranted.

(d) Open dumps: Open dumps were discussed in some detail in Chapter 5. There are at least 1,274 dumps in the state, of which less than 200 are still operating. The effects of these operating, closed or partially terminated sites on ground water is largely unknown. This information is important to enable MPCA to make decisions regarding the urgency to close open dumps, the need for continued monitoring by responsible parties and the potential need to initiate remedial measures at dumps which may have contaminated ground water. In early 1982, MPCA made a request to the Legislative Commission on Minnesota Resources (LCMR) to approve funding for the 1983-1985 biennium to enable MPCA to study approximately a dozen dumps in various hydrogeologic settings. The Water Planning Board, in its 1983-1985 priority recommendations to the legislature (WPB, 1983) was strongly supportive of this proposed project. Since funds have now been appropriated, this project should receive a high priority for implementation by MPCA.

C. Agricultural Wastes

Minnesota is the fifth largest agricultural producing state in the nation generating 40 percent of the state's revenue. Farming and agricultural-related industries represent a sizable potential hazard to ground water because of the large number of facilities statewide (see Chapter 5). The Agricultural Waste Team in the Permits Section, Water Quality Division serves clientele across the state by interacting with the public, local officials as well as state and federal agencies on agricultural issues. The team has primary responsibility for animal feedlots, non-point source pollution, and storage of wastes or by-products from the agricultural industry.

The major emphasis is on processing of feedlot permit applications and resolving citizen complaints about agricultural pollution. Minnesota Rules 6 MCAR § 4.8051 and 4.8052 govern pollution from animal feedlots. There are an estimated 90,000 feedlots in the state. Since the program originated in 1971 over 13,000 permits have been issued. The number of permit applications received varies annually with economic conditions and cycles within the industry itself.

Feedlot owners are required to apply for a permit under the following conditions: 1) where a new feedlot operation is proposed; 2) when a change or modification of housing or manure storage is proposed; 3) when a change of ownership is proposed; 4) if a National Pollutant Discharge Elimination System (NPDES) permit is required; or, 5) if an inspection by MPCA staff or county feedlot pollution control officer determines that the animal feedlot creates or maintains a potential pollution hazard. Feedlots are evaluated on their potential to pollute surface and ground waters. They are required to control discharge of surface runoff and other pollutants for storms of less magnitude than the 25 year-24 hour event (ranging from 3.5-5.0 inches depending on location). Feedlot operations are required to prevent ground water contamination by preventing seepage from manure storage areas and animal housing areas. The rules require that manure be spread on cropland at rates not exceeding crop nutrient requirements.

Recent trends in the livestock industry have been toward total confinement barns and manure storage systems. Manure storage for 6 to 12 months has become more common due to a desire for convenience systems which eliminate the need for daily hauling. Manure storage is most easily justified for large operations which generate large volumes of manure requiring special equipment for pumping and land application. Manure storage in general helps prevent contamination of surface waters, assuming proper management of pumping and land application. Waste storage structures have potential to impact ground water. Variable soil conditions require careful review of manure storage plans prior to approval. Soil borings and plans are required for all manure storage structures to be constructed below ground. Structures storing over 500,000 gallons of manure must have plans completed by a registered professional engineer or a soil conservation service employee.

Careful review and ground water monitoring for selected situations is the present procedure used by staff to minimize the impact of manure storage areas on ground water quality. In order to improve on the present situation, MPCA plans for additional research in the area of earthen pond sealing and the results of various construction specifications and techniques. MPCA staff provide training for county officials on the feedlot rules and stressing the importance of proper planning, review, and inspection of feedlot facilities. This past year the training was expanded to include contractors with emphasis on proper design and construction of earthen and concrete structures for pollution control.

Because of the recent emphasis on manure storage systems as a part of agricultural waste management facilities, MPCA recently completed a consultant contract to study the rate of seepage that typically occurs from manure storage ponds and the potential impact of pond seepage on ground water quality (Barr, 1982). The report presents information from an investigation of two existing earthen manure storage ponds in southeastern Minnesota. The objectives of the investigation were to estimate the rates of seepage that are occurring from the two ponds, to assess the impact of the seepage on adjacent ground water quality, to evaluate the design criteria typically used for earthen manure storage ponds in Minnesota, and to provide MPCA with recommendations regarding any changes to the design criteria that seem to be warranted by data collected in the investigation.

The two manure storage ponds that were investigated were the Neil Brown site located in Rock Dell Township in southwestern Olmsted County and the Marshman Brothers site located in Planview Township in southeastern Wabasha County. Water quality monitoring devices were installed and ground water, soil, sludge, and pond water samples were collected at each site. Ground water and pond water samples were analyzed for chemical constituents indicative of animal waste. Soil samples were classified as to soil type and the permeability coefficient and grain size distribution of pond bottom samples were measured.

A summary of recommendations from these studies is as follows:

1. A series of soil borings should be installed to at least ten feet below all proposed manure storage ponds. A small diameter well should be placed into at least one boring to measure the regional water table elevation.
2. Drain tile should be used to intercept seepage around ponds proposed to be located less than ten feet above the regional ground water level. Drain tile effluent should be monitored quarterly for indicators.
3 Where ponds are located above bedrock aquifers, a minimum of ten feet of clay soils should be present between the pond bottom and the bedrock.
4. Further investigations are needed of facilities where geologic settings have less than ten feet of unsaturated non-clay soils between the ponds bottom and bedrock aquifers.

D. Hazardous Wastes

Introduction:

The regulation of hazardous wastes is a complex and often emotion-filled area. For that reason, the history of rules regulating hazardous wastes follows a long and tortuous path. Nationally, sites such as New York's Love Canal have aroused public fears and made the siting of hazardous waste facilities difficult if not impossible. The following discussion outlines current and proposed rules for regulating hazardous wastes and siting hazardous waste facilities.

The MPCA began a hazardous waste program in 1970 as a result of state legislation calling for the control of "toxic and hazardous wastes." The program prohibited disposal of such wastes in sanitary landfills, but gave no guidance as to what made a waste hazardous or how it should be managed. A 1973 study identified these and other shortcomings of the legislation, and ultimately resulted in the Hazardous Waste Act of 1974. This law defines "hazardous waste"; directs the MPCA to develop rules governing labeling, classification, storage, collection, transportation and disposal of hazardous wastes; and gives the seven metropolitan counties the authority to develop their own hazardous waste ordinances, provided they are at least as restrictive as the state rules.

Draft state rules were prepared, and a review committee of 120 representatives of industrial, governmental, academic and environmental groups was formed in 1975. Public meetings were held in 1976, and a second draft of the rules was prepared. In 1977, public hearings were held on these proposed rules. After much debate, the hearings ended in March of 1978.

In July of 1978 the MPCA Board adopted the rules, and submitted them to the Chief Hearing Examiner for review. His August 1978, report reversed earlier decisions and declared that the MPCA had made major revisions in the rules without sufficient public notice. However, the final decision on those issues is made by the state Attorney General. The Board submitted the rules to the Attorney General, who ruled in favor of the MPCA. In October of 1978, the Board again adopted the rules, which were then approved by the Attorney General.

Publication of the rules was delayed after several state legislators contacted the MPCA objecting to the MPCA's handling of the rules. Ultimately, a legislative committee asked an outside consultant to make recommendations on implementation of the rules. The recommendation was made that the rules be implemented as soon as possible, and finally the current set of state hazardous waste rules became effective in June of 1979.

On the federal level, the Resource Conservation and Recovery Act (RCRA) became law in 1976. Under that act, the USEPA was directed to develop regulations for the control of hazardous wastes. USEPA published its initial set of rules regulating hazardous wastes on May 19, 1980. These rules cover identification of hazardous waste as well as standards for generators and transporters of waste and for treatment facilities and existing storage and disposal facilities. The rules for newly permitted on-land storage or disposal facilities were published in July of 1982.

When RCRA was developed, it was recognized that many states were already regulating hazardous wastes. Therefore, Congress intended that the states run the program with guidance and assistance from USEPA. The transfer of the program to the states is accomplished through authorization wherein the state program operates in lieu of the federal program. To receive authorization, a state must have rules and a program equivalent to and consistent with USEPA's. For that reason, Minnesota has proposed draft rules which conform more closely to the federal rules in form and content than the current state rules. These proposed rules were published in June of 1982, and are expected to go to public hearing in the second half of 1983. Other amendments to Minnesota's rules on land disposal and a permit rule will be published this summer.

Even though Minnesota's hazardous waste program is not yet authorized, USEPA prefers that the state run as much of the program as possible. In order to accomplish this, a Cooperative Arrangement between the USEPA and the state of Minnesota was written. This type of agreement is used by USEPA only when the state is actively working toward authorization.

The MPCA performs all the functions of the federal program under the Cooperative Arrangement with the exception of enforcement litigation and final permit issuance. This arrangement assures efficient allocation of public funds, minimizes duplication of effort, avoids confusion in the regulated community and helps set in motion as soon as possible the federal hazardous waste management system under RCRA. In addition, certain areas are covered by the more stringent state rules but not the federal, such as facilities which recycle the wastes of others and small quantity waste generators (under 1000 kg/month). These programs are administered by state and local authorities.

Receipt of final authorization will have the state administering all of the hazardous waste program with the USEPA retaining only some general overview activities. The Cooperative Arrangement will terminate when the state receives final authorization.

Present State Regulatory Program:

The present state rules (6 MCAR §§ 4.9001-4.9010) governing hazardous waste management and disposal became effective in 1979. A number of provisions dealing with ground water protection are contained within those rules. For the purpose of this discussion, the word "facility" refers to hazardous waste containerized or non-containerized storage facilities, hazardous waste transfer stations, hazardous waste processing facilities, and hazardous waste land treatment or land disposal facilities.

1. 6 MCAR § 4.9004 B.2. restricts anyone from establishing, constructing or operating a facility in a location where the topography, geology, hydrology

or soil is unsuitable for the protection of the ground water and the surface water. "Unsuitable" is not defined.

2. 6 MCAR § 4.9004 C.1.d. requires initial monitoring of soil, ground water and air before facility operations begin. No further guidance is given as to how to conduct the monitoring.

3. 6 MCAR § 4.9004 C.1.i. requires the facility operator to prevent the discharge of hazardous waste to the surface or ground waters of the state.

4. 6 MCAR § 4.9004 C.3.d. allows the outdoor storage of containerized hazardous wastes only within a liner and dike system, and sets some standards for liner permeabilities and enclosed volume. These standards do not apply to non-containerized wastes or to disposal sites.

5. 6 MCAR § 4.9004 C.5.a. prohibits discharge of hazardous waste directly into the saturated zone via injection wells or other means. This provision reiterates the condition of 6 MCAR § 4.8022 d.1., which prohibits the discharge of any waste to the saturated zone, and is supported by the MDH Rule 7 MCAR § 1.218 A.3. which states that wells shall not be used for the disposal of liquid, gas or chemicals.

6. 6 MCAR § 4.9004 C.5.d. states that operation of a facility cannot contaminate soil unless authorized to do so in a Hazardous Waste Facility permit. This clause would be applied when permitting land treatment or disposal facilities.

7. 6 MCAR § 4.9004 E. sets out the requirements for land disposal facility closure.

6 MCAR § 4.9004 E.2.b. requires the facility operator to provide, construct and maintain measures to protect ground water and surface water and to control air emissions from the facility.

6 MCAR § 4.9004 E.2.c. requires an adequate amount of cover material to minimize leachate production. "Adequate" is not defined, the type or permeability of cover material is not specified and no guidance is given as to what is meant by "minimize."

6 MCAR § 4.9004 E.2.f. requires the construction of air, ground water and surface water monitoring systems if not already installed.

8. 6 MCAR § 4.9004 G. gives requirements for long term maintenance of land disposal facilities. The exact length of time for which these requirements apply is not specified, however, the rule states that the requirements continue as long as the hazardous waste poses a threat to the environment unless the state or federal governments assume responsibility.

9. All the preceding citations apply to permitted or unpermitted, and new, existing or abandoned facilities. 6 MCAR § 4.9007 sets forth the geologic informational requirements which must be met to receive a facility permit.

   6 MCAR § 4.9007 B. gives the required information for a preliminary permit application. Some geologic information listed includes:

   - A plot plan delineating the ground water surface, directions of ground water flow, perched water tables, and locations of soil borings, monitoring wells and piezometers.
   - Drilling logs and construction details for soil borings, monitoring wells and piezometers.

- An estimated water balance for the site.
- A detailed description of on-site soils, including a discussion of the ability of the soil to attenuate the anticipated contaminants.
- A description of ground water level fluctuations.
- Preoperational ground water quality data.

Preliminary specifications for liners and leachate collection systems are also to be submitted.

10. 6 MCAR § 4.9007 C. gives the informational requirements for final permit application. These requirements include:
    - Final specifications for liners and leachate collection systems. However, liners are not specifically required, and no standards are set as far as permeability requirements, liner thickness or materials, minimum performance, etc.
    - A report discussing the fate of contaminants which may be released due to a failure of engineering design or construction.
    - An operations manual specifying how the air and ground water monitoring programs will be conducted.
    - A financial plan that indicates how funds will be provided for maintenance, monitoring and surveillance at least thirty years post-closure.

Federal Regulatory Program:

On May 19, 1980 USEPA published an initial set of rules regulating hazardous wastes. Part 265 of those rules contains interim status standards for owners and operators of hazardous waste treatment, storage and disposal facilities. Interim status standards apply to those facilities which were either in operation or had construction commitments on November 19, 1980, the effective date of the rules. The requirements of the interim status standards are overall less stringent than those of Part 264, the permitting, operational and closure requirements for new land storage and disposal facilities published July 26, 1982 and effective January 26, 1983. A discussion of non-hazardous waste facilities is provided later in this section. The ground water protection requirements of the interim status standards include the following.

1. Subpart F of Part 265 gives requirements for ground water monitoring at surface impoundments, landfills and land treatment facilities. The minimum monitoring system required is one well upgradient and at least three at the downgradient edge of the waste management area. It is required that the number, location and depth of the wells ensure that they immediately detect any significant amounts of hazardous waste or hazardous waste constituents that migrate from the waste management area to the uppermost aquifer. For the first year, USEPA requires quarterly monitoring for each of three parameter groups: 1) parameters with primary drinking water standards, 2) parameters to establish ground water quality, and 3) generalized parameters used as indicators of ground water contamination.

   At least four replicate samples are required from the upgradient well for group three parameters so background levels of these parameters can be established. In subsequent years, group two parameters are required annually from all wells, and group three parameters are required semi-annually. Waste-specific monitoring parameters are not required. Subpart F also provides the required statistical tests to be applied to make a determination as to whether a facility is exerting an effect on ground water. If a facility is negatively impacting ground water, increased monitoring is required. Guidance as to when or how to undertake corrective actions to limit ground water impacts is not given. A clause is provided which says that the requirements for monitoring may be waived if the operator can demonstrate to the USEPA that ground water will not be affected by the facility.

2. Closure requirements are given in Subpart G. Section 265.117 requires that post-closure care continue for thirty years after the closure date, including ground water monitoring in accordance with Subpart F and maintenance of monitoring and waste containment systems for that period.

3. Subpart M sets requirements for land treatment facilities. At these facilities, soil cores and soil pore-moisture samples are required from the unsaturated zone to detect vertical migration of contamination. Ground water monitoring requirements of Subpart F must also be met.

4. Subpart N gives the requirements for landfills. Liners and leachate collection systems are not required under the interim status standards unless the landfill is receiving liquid waste or waste containing free liquids.

The requirements of Part 264 apply to facilities newer than those which qualify for interim status, and for expansions to existing facilities beyond the boundaries of their interim status area. All new facilities must comply with these requirements, published July 26, 1982 and effective January 26, 1983.

1. Subpart F of Part 264 sets the standards for ground water protection at hazardous waste facilities, as well as giving ground water monitoring requirements. The provisions of this subpart apply to owners and operators of facilities that treat, store or dispose of hazardous waste in surface impoundments, waste piles, land treatment units and landfills. A clause is

included which says that all requirements for monitoring ground water may be waived if the operator can demonstrate to the USEPA that ground water will not be affected by the facility during the time that monitoring is required. The rule recognizes that in some instances contamination will move so slowly that it will not be detected during the period monitoring is required.

The ground water protection standard requires that hazardous constituents in the ground water at the waste boundary not exceed concentration limits set in the permit. Hazardous constituents are defined as those waste constituents specified in Appendix VIII of Part 261 of these rules, which are reasonably expected to be in or derived from wastes contained at the facility. The concentration limits which cannot be exceeded are the background (pre-operational) or upgradient level for constituents for which primary drinking water standards are not set, or the primary drinking water standard for those parameters with standards. USEPA has retained the authority to set alternate limits and to exempt certain hazardous constituents if the situation warrants.

General ground water monitoring requirements call for an unspecified but sufficient number of wells to yield samples representative of background water quality and the quality of the water passing under the downgradient waste boundary. A two-phase approach is taken, requiring detection monitoring to initially detect ground water impacts, to be followed by a more intensive compliance monitoring if the ground water protection standard is violated. The statistical method to be used to determine background levels specified is similar to that outlined for interim status facilities, but the necessary monitoring parameters chosen are much more waste-specific and are individually set in each permit.

In detection monitoring, semi-annual sampling is to be conducted during the active life of the facility and thirty years thereafter, as long as no effects are noted. Samples are to be analyzed for the permit-specified parameters only, and calculations made as to whether background levels are exceeded. If the ground water protection standard is violated, and contamination detected, the compliance monitoring requirements apply. Under compliance monitoring, samples are gathered quarterly and analyzed for the parameters specified in the permit. In addition, samples from all wells at the waste boundary must be analyzed at least annually for all the hazardous constituents in Appendix VIII of Part 261, a list which contains more than 350 parameters.

At the time that compliance monitoring is required, the facility operator must also initiate a corrective action program for removing or treating in-place water contaminants. Some general guidance is given as to requirements of the corrective action programs.

2. Closure requirements of this part are similar to those for interim status facilities. Subpart G, Section 264.117 requires that post-closure care continue for thirty years after the closure date, including ground water monitoring in accordance with Subpart F and maintenance of monitoring and waste containment systems for that period.

3. The Part 264 design and operational requirements for surface impoundments, waste piles, land treatment facilities and landfills are given in Subparts K, L, M, and N, respectively. While similar in tone and intent, the requirements vary for each facility type and so will be discussed separately.

a. Surface impoundments are required to have at least a single liner which will not allow migration during the active life of the facilities, and may be exempted from the ground water protection requirements of Subpart F if double liners and leak detection systems are installed. This exemption will be rescinded if leaks are detected, and the requirements of Subpart F will apply.

b. Waste piles also must have at least a single liner, which will not allow migration during the active life of the facilities and are required to have leachate collection systems above the liner. The double liner-leak detection system exemption outlined for surface impoundments also applies to waste piles. Also, waste piles which will not generate leachate or which are placed on liners which can be periodically inspected are exempt.

c. Land treatment facilities must demonstrate the feasibility of their treatment methods prior to initiating operation. Liners and leachate collection systems are not required, but surface water run-off must be collected and treated if necessary. The unsaturated zone monitoring requirements are similar to those outlined for the interim status standards. Land treatment facilities may be exempted from the post-closure ground water monitoring requirements if the owner can demonstrate that levels of hazardous constituents in the soil do not exceed background levels upon closure of the facility, and if no hazardous constituents have ever been detected below the treatement zone.

d. Landfills are required to have at least a single impermeable liner and leachate collection systems. The double liner-leak detection system exemption outlined for surface water also applies to landfills.

Liquid wastes are allowed to be disposed in landfills with conforming leachate collection systems.

Proposed Amendments to State Rules:

As mentioned above, the MPCA has proposed amendments to the existing state hazardous waste rules. The goal of these amendments is to make the rules conform more closely to the federal rules in form and content. Most of the proposed rules were published in June of 1982, and are expected to go to public hearing in the second half of 1983. The land disposal facility standards are currently in draft form and will likely go to hearing as a part of the amended rules package. The March 10, 1983 draft of the land disposal facility standards rules was used as a basis for this discussion.

The federal standards for interim status facilities were perceived as being generally sufficient for sites in Minnesota, so their requirements were for the most part incorporated into the rule amendments of 6 MCAR § 4.9380-4.9432. The only changes made from federal to state affecting ground water were in the area of ground water monitoring, 6 MCAR § 4.9397. Under the proposed rules, the state will require analyzing waste-specific parameters as well as indicators when that will give more accurate information as to ground water contamination than would general indicator parameters. Quarterly monitoring will also be required, rather than semi-annual.

The land disposal facility standards proposed in June, 1982, and those currently in draft form, represent a combination of current state rules and federal rules. The portions of these rules which affect ground water are more stringent than the federal requirements. Differences between the proposed and draft state land disposal standards rules and the federal land disposal standards rules are outlined below.

1. The locational standards for hazardous waste facilities were expanded from the federal floodplain restrictions to include the locational standards outlined earlier for the existing state rules. The federal seismic restriction was deleted, since none of the restricted areas are within Minnesota.

2. The general ground water monitoring requirements which correspond to Subpart F in the federal rules have been changed in the following ways:

   a. Monitoring of all potentially affected aquifers may be required along with monitoring of the uppermost aquifers.

   b. The hazardous constituents to be tested may include not only the list cited for the federal rules, but also unlisted wastes that may be determined as hazardous in Minnesota by meeting criteria for toxicity established in 6 MCAR § 4.9132 F.

   c. Double-lined facilities are required to perform semi-annual monitoring during the active life of the site and thirty years thereafter.

   d. Facilities with single liners, or double-lined facilities which leak, or land treatment facilities where increased levels of hazardous constituents have been detected below the treatment zone are required to perform quarterly monitoring for the same length of time frame as double-lined facilities.

   e. Quarterly testing may be required for a greater number of parameters during compliance monitoring than was originally specified in the facility's permit.

   f. The facility is required to cease accepting wastes once any monitoring well at the property line (not waste boundary) is shown to contain levels of any hazardous constituent in excess of the background levels.

3. Additional locational standards are set for surface impoundments, waste piles and landfills. These prohibit establishment of a facility in an area characterized by surficial karst features; require that facilities, including their liners, be located entirely above the seasonal high water table; and set standards for required hydrogeologic information to accompany the permit application.
4. Surface impoundments and landfills are required to have double-liners and leak detection systems.
5. No provision is included which would allow the facility operator to demonstrate that ground water could not be affected and thereby avoid the monitoring requirements, and no exemption is provided for alternate design, location and operation of facilities.
6. Land treatment facilities are required to continue monitoring soil pore-moisture after closure, even if the soils in the treatment area are not shown to contain levels of any hazardous constituent in excess of background levels.
7. Liquid wastes or wastes containing free liquids are not allowed in landfills, even in facilities with leachate collection.

Hazardous Waste Facilities Projected in Minnesota:

At the present time, approximately 2,500 hazardous waste generators are participating in Minnesota's hazardous waste management program. Most of these generators are large waste producers such as large manufacturing concerns. Enforcement efforts are currently increasing the number of known generators; projections estimate that 3,500 generators will be in the system by mid-1984, and 4,500-5,000 generators by mid-1985. The increase will be due to the number of small-quantity waste generators brought into the system, such as automobile repair and body shops, printers, etc.

The number of treatment, storage or disposal facilities which qualify for interim status under the federal rules is estimated to be 160. About two-thirds of these are storage facilities. Most of the rest are treatment facilities, usually incinerators, chemical processors or land treatment facilities. The maximum number of land disposal facilities is projected to be five.

At this point, it should be noted that the current staffing levels of the MPCA are inadequate for meeting the regulatory burden imposed by the hazardous waste rules. With current enforcement staff, each generator will be inspected on the average of once every 37 years. It would take around 27 years to issue the number of hazardous waste permits projected. Efforts are underway to obtain funding from the state legislature to significantly increase the staff in the hazardous waste area.

Due to the high degree of public opposition to hazardous waste facilities (particularly landfills), the Minnesota Waste Management Board (MWMB) was created in 1980, with the responsibility for opening oportunities for hazardous waste facility siting. One of the MWMB's tasks is to establish a site for development as a hazardous waste land disposal facility. Goals to be considered in site selection include saving prime agricultural land from development, siting near most of the waste generators in the Twin Cities, siting on public land and choosing an area where the geology and hydrology are conducive to environmental protection. The search has been narrowed to four sites state-wide.

Another ongoing task of the MWMB in the hazardous waste field is designating sites for incinerators and storage facilities. While facilities are not limited to these designated areas, in these areas the MWMB has the authority to override local disapprovals and approve the development of the facility if other state agencies, particularly the MPCA, find the facility permittable.

Conclusions/Recommendations:

The present state rules for hazardous waste management as well as the present federal regulations require modification in order to provide an adequate degree of protection to Minnesota's ground water. For that reason, it is important that the rulemaking procedure be kept moving and the proposed amendments to the state rules be adopted as quickly as possible. Equally as important, MPCA staffing should be increased to the levels necessary to adequately implement and enforce the program.

CHAPTER 7

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CHAPTER 8

UNDERGROUND INJECTION IN MINNESOTA

Underground Injection of Wastes

Another method of disposing of wastes on land is by discharging to a bored, drilled, driven, or dug well. This is differentiated from other land disposal methods by either discharging directly to the subsurface or to the land where the discharge area is deeper than its largest surface dimension. Other wastes that can be injected include "material which flows or moves whether semisolid, liquid, sludge, or any other form or state" (Federal Register; Volume 44, Number 78; Friday, April 20, 1979).

Injection wells may consist of anything from a cased well to an open hole to a borehole drilled through low permeability material (e.g. clay) filled with higher permeability material (e.g. gravel). Injection can be achieved either through gravity flow or pressure. Material may be directly injected into anywhere from a deep aquifer to a shallow unsaturated zone.

The purpose of this discussion is to summarize underground injection activities in Minnesota. This includes a description of existing injection practices and regulatory controls that impact these practices. Since there are both state and federal authorities that control injection in Minnesota, the following summary will approach the subject from both of these perspectives.

State Authorities

State regulatory authority concerning underground injection is addressed in state statutes and regulations. Regulatory control of injection is divided among three separate state agencies. The Minnesota Department of Natural Resources (MDNR) has statutory authority for the underground storage of gas or liquid, except water, in natural formations or through the displacement of ground water under pressure either in consolidated or unconsolidated formations. Both the Minnesota Department of Health (MDH) and the Minnesota Pollution Control Agency (MPCA) have regulations that prohibit any underground injection to ground water unless a variance is obtained. A description of state regulatory authorities follows.

MDNR: The state of Minnesota requires the issuance of a permit by the MDNR prior to any underground storage pursuant to Minnesota Statutes §§ 84.57-84.621. The permitting process includes the submission of an application accompanied by maps, plans and specifications, and any other data requested by the department, and the noticing and execution of a public hearing. Issuance of a permit is based on findings that the proposed storage:

1. "be confined to geological stratum or strata lying more than 500 feet below the surface of the soil,"
2. "not substantially impair or pollute any water resources," and,
3. serve "the public convenience and necessity of a substantial portion of the gas consuming public in the state" with reasonable protection of:
    a. "private property or any interest not appropriated,"
    b. "the rights of the owners of lands, or of owners of any interest in said lands," and,
    c. "any public resources of the state."

The permit contains specific requirements such as monitoring by the state and the responsible party, acquisition of needed property rights, adequate insurance coverage, limits on storage reservoir pressures and volumes, and other requirements designed to assure the safe operation of a permitted project. To date (January 1983) one permit has been issued for the injection and storage of natural gas through the displacement of ground water. It provides (as long as certain criteria are met) for the storage of up to 10 billion cubic feet of natural gas in a naturally occurring dome-shaped sandstone reservoir over 800 feet below ground surface. Only one other underground gas storage project is presently in operation in the state but does not involve the displacement of ground water. This project is not permitted, as it was initiated prior to the state statute regulating underground storage reservoirs not displacing ground water. The project consists of a cavern excavated into crystalline metamorphic bedrock 500 feet below the ground surface with a capacity for storing up to 14 million gallons of liquid petroleum gas.

MDH: Among the provisions of the Minnesota Water Well Construction Code as administered by the MDH, Minnesota Rule 7 MCAR § 1.218 (A) regulates the "reuse of water, disposal or recharge" wells for the "general protection of ground water quality and resources." The rule prohibits the use of a well for the "disposal of surface water, near surface water, or ground water or any other liquid, gas, or chemical" while citing MDNR authority over storage of gas or liquid under pressure. A "well" is the same as a water well, which is defined in Minnesota Statute § 156 A.02 as "any excavation that is drilled, cored, washed, driven, dug, jetted, or otherwise constructed when the intended use of the same is for the location, diversion, artificial recharge, or acquisition of ground water." According to this definition, this can include any excavation that intersects ground water or a "zone of saturation." Exclusions to this definition are excavations "for temporary dewatering of ground water for non-potable use during construction, where the depth thereof is 25 feet or less" and for certain mining and quarrying operations. The Commissioner of Health has the authority to modify the application of this provision when the rule "presents practical difficulties and unusual hardships."

A notable exemption from this regulation is recent legislation concerning the use of ground water heat pumps. Minnesota Statute § 156 A as amended by Minnesota Laws 1981, Chapter 179, authorizes the Commissioner of Health to issue permits for the injection of water into a properly constructed well from a ground water thermal exchange device. A total of 200 permits can be issued for small systems having capacities of up to 20 gallons per minute and 10 permits for larger systems having capacities from 20 to 50 gallons per minute. Proposed systems outside these limitations require a variance to the Well Construction Code from the Commissioner of Health. Permits are issued under the conditions that:

1. wells withdraw from and reinject into the same aquifer,
2. systems are constructed to be completely closed and sealed against the introduction of foreign substances,
3. provisions are made to allow sampling for water quality and temperature, and
4. owners agree to periodic inspections by representatives of the Commissioner.

From October 1981 to January 15, 1983, three systems have been permitted with one application pending. No sampling has yet been conducted at the permitted systems.

MPCA: Standards for underground waters as they relate to waste disposal are established in Minnesota Rule 6 MCAR § 4.8022. Part of these standards concerns the discharge of wastes to the subsurface. The regulation states "no sewage, industrial waste, or other wastes shall be discharged directly into the zone of saturation by such means as injection wells or other devices used for the purpose of injecting materials into the zone of saturation." This effectively prohibits any direct injection to ground water as "other wastes" is broadly defined by Minnesota Statute § 115.01, 1973 to be any substance "which may pollute or tend to pollute the waters of the state." "Water pollution" is defined as any "man-made or man-induced alteration of the chemical, physical, biological, or radiological integrity of waters of the state." The only exclusion to this standard is for "the discharge of cooling water under existing permits of the MPCA" which may be continued, subject to review of the permit by the MPCA. Provisions of the regulation concerning subsurface discharges to the unsaturated zone are less restrictive than for direct injection. In this case, discharges are allowed in "the zone between the land surface and the water table" as long as underground waters are not degraded. Any discharger can be directed by the MPCA through the issuance of a State Disposal System (SDS) permit to monitor such a system at his own expense. To date there has been only one SDS permit issued for this type of discharge. It consists of a drainage well discharging to the unsaturated zone from a wetland area.

These standards for underground injection to both the saturated and unsaturated zones can be modified through an established variance procedure. Variances can be granted when it is determined that strict enforcement would cause undue hardship, waste disposal is necessary for the public welfare, and "strict conformity with the standards would be unreasonable, impractical, or not feasible under the circumstances." The MPCA has discretion in allowing issuance of a temporary variance and prescribing conditions that insure "the general purpose of these standards and the intent of the applicable state and federal laws" are fulfilled. A variance must be approved by the MPCA Citizen's Board (Board) upon submission of a properly completed application. The Executive Director of the MPCA issues a SDS permit in conjunction with this approval, specifying all conditions, and monitoring and reporting requirements of the variance. A Board prerogative is to require a public hearing for the purpose of gathering information which may be useful in making a final decision on an application. Statutes concerning underground storage and ground water heat pumps as administered by DNR and MDH, respectively, are not affected by this regulation.

Presently, there is one temporary variance that has been approved by both the Board and the MDH. A SDS permit was issued for a period of 18 months to the University of Minnesota for conducting a research and demonstration project for Aquifer Thermal Energy Storage (ATES). The project consists of a two-well, closed system in which one well supplies cool ground water from an aquifer 700 feet below ground surface which is then reinjected into a second well placed in the same aquifer after being heated at an existing steam heating facility. After a storage period, the heated water is to be pumped out, the heat removed, and reinjected into the aquifer. Bacteriological, chemical, and physical ground water characteristics within, above, and below the aquifer are monitored. The project was approved by the MPCA Board after a public hearing was held and upon the recommendation of the hearing examiner. The Board has approved one extension of the project's expiration date after construction delays occurred. This occurred after MPCA staff solicited public comments on the extension for a 30-day period and no comments were received.

Regulatory review of the project has been coordinated with both the MDH and MDNR. The MPCA and MDH also cooperated in a review of the application itself. Resulting conditions and requirements are included in a variance to both agency's rules which prohibit direct injection to ground water. An appropriation permit from the MDNR is also necessary since the system is designed to withdraw ground water at more than 10,000 gallons per day and 1,000,000 gallons per year. Due to problems with clogging of the injection well, the University has recently sought additional extensions of the expiration date to all permits and variances. The MPCA Board authorized a one-year extension for the project at its May, 1983 meeting.

Federal Authorities

The Safe Drinking Water Act of 1974 (Public Law 93-523), as amended, recognized the need to protect underground sources of drinking water from contamination by well injection practices. The law requires the U.S Environmental Protection Agency (USEPA) to establish minimum requirements for state programs to protect underground drinking water sources from the subsurface emplacement of fluids through well injection. Other provisions of the Act require USEPA to list in the Federal Register each state for which an underground injection control (UIC) program may be necessary and once minimum requirements are promulgated by USEPA, it affords each state the opportunity to develop an enforceable UIC program. The USEPA will determine whether the UIC program developed by a particular state meets minimum requirements before a state can assume "primary enforcement responsibility" (primacy). If a state does not adopt and submit a UIC program or if a state's UIC program is deficient, USEPA must propose and promulgate UIC regulations to be effective in that state. In this case the state will not have primacy, resulting in direct federal enforcement of the UIC program.

In accordance with the Safe Drinking Water Act, UIC regulations were originally proposed by USEPA in August 1976. The proposal included the program regulations, the technical criteria and standards, and the related grant regulations. To assist states in assuming primary enforcement responsibility, final regulations were first issued by the USEPA in October 1978, concerning grants available to states for developing and administering a UIC program. The Administrator of the USEPA can make grant awards to eligible states listed as requiring a UIC program. Since the Act did not detail a method for the listing of these states, the USEPA evaluated a number of options in an attempt to develop an objective and quantifiable methodology. It selected seven criteria that would be important in assessing state's needs for a UIC program. The USEPA then calculated a rating scale for each of the seven criteria which was based on converting the number of each state's practices to a percentage of the national total number of practices. The USEPA then weighted five of the seven criteria to reflect relative potential for endangerment to ground water. After adding the calculated numbers for all criteria, Minnesota was ranked 27 among the states in June 1979. This resulted in Minnesota being designated as needing a UIC program. Grant funds allotted to eligible states which do not apply for grants or which choose not to assume primacy may be used in part, or in whole, by the Administrator to develop a program in those states. Funds which have been tentatively allotted to states but not used by the Administrator may be reallotted to other eligible states.

After numerous revisions, USEPA issued final technical criteria and standards in February 1982. These are organized into six subparts, designated A through F. Subpart A deals with general provisions and consists primarily of definitions used in the UIC program and a classification system for injection wells. Injection wells are classified as follows:

1. Class I: Wells used by generators of hazardous waste or owners and operators of hazardous waste management facilities and other industrial and municipal disposal wells which inject beneath the lowermost formation containing, within one-fourth mile of the well, an underground drinking water source.
2. Class II: Wells associated with oil and gas production and hydrocarbon storage where the hydrocarbons are liquid at standard temperature and pressure.
3. Class III: Wells used in the extraction of minerals including mining of sulfur, solution mining of salt or potash, and insitu production of uranium or other metals.
4. Class IV: Wells used by generators of hazardous waste or of radioactive waste, or by owners or operators of hazardous waste management or radioactive disposal sites that inject hazardous and radioactive wastes into or above a formation used as a drinking water source, within one-fourth mile of the well; wells used by generators of hazardous waste or

owners or operators of hazardous waste management facilities to inject in an area not specifically classified.

5. Class V: Wells not included in Class I, II, III, or IV. Wells in this classification applicable to Minnesota include return wells used in conjunction with ground water heat pumps, return wells used to inject water previously used for cooling, drainage wells used to drain surface fluid, cesspools with open bottoms or perforated sides, or septic system wells used to inject wastes from business establishments or community systems (except for those that have solely sanitary wastes and serve less than 20 people per day), dry wells used to inject wastes, and radioactive waste disposal wells other than Class IV.

Subparts B through F detail the construction, abandonment, operation, monitoring and reporting requirements of each of the five classes of wells. Subpart F has an additional requirement that an inventory of Class V wells be conducted along with an assessment of each well for potential contamination and available corrective alternatives.

UIC program regulations have had a number of proposed revisions but none has been issued to date in final form. Basically, the program will consist of a definition of the regulatory framework of the USEPA-administered permit program, elements of an approvable state program and procedures for USEPA approval of state participation in the permit program, and a description of procedures the USEPA will use for issuing permits.

<u>UIC Program in Minnesota</u>

The state of Minnesota has been designated by the USEPA as needing a UIC program. The USEPA has notified the state of this need and requested the designation of a state lead agency for the program. Funds allocated to Minnesota in fiscal year 1980 for the UIC program totaled $82,100. In a response dated October 23, 1979, the state specified the MPCA as the designated contact but declined to assume primacy for the UIC program. This multi-agency decision was made in view of existing state statutes and regulations that already provide strict controls over injection activities in Minnesota. It was believed at the time that requirements for the state to administer the UIC program were extensive, resulting in an increase in administrative work without achieving an increase in ground water protection. Specifically, Class II wells are regulated by the DNR through a permitting program that requires a public hearing. A limited number of Class V wells consisting of return wells for ground water heat pumps may be permitted through a program administered by the MDH. All other wells that discharge directly to ground water are prohibited by the MPCA and MDH unless a variance is obtained. Discharges into the unsaturated zone are regulated by the MPCA through the SDS permit program. Thus, all elements of the federal program are already addressed by existing state programs and rules.

Since Minnesota has not assumed primacy, the USEPA is required to propose and promulgate UIC regulations to be effective in the state. To date, the USEPA has contracted with the U.S. Geological Survey (USGS) and MDH to complete selected program elements for developing a UIC program. They include the designation of underground sources of drinking water in the state, and an inventory and assessment of Class IV and V injection wells. Further program development is contingent upon final program regulations not yet issued. A description and the status of these program elements are summarized as follows:

1. USGS contract: The Safe Drinking Water Act requires that regulations protect "underground water which supplies or can reasonably be expected to supply any public water system." It therefore becomes important to define and to describe the general hydrogeology and geochemistry of principal aquifers in the state. The USGS is under contract to USEPA to provide this information in a series of 9 reports covering Minnesota's 14 principal aquifers. Reports are to contain "a series of maps of the aquifers with discussions of the areal extent, dominant water quality types, and the distribution of mean dissolved-solids concentrations" (Adolphson, Ruhl and Wolf, 1981). While this information primarily comes from existing sources, additional water quality data is being generated in some areas where information is lacking. All reports are scheduled to be completed in 1983. A further discussion of the principal aquifers in Minnesota may be found in Chapter 5, Ambient Ground Water Quality in Minnesota.

2. MDH contract: Of the five well classes, the USEPA has regarded Classes IV and V to be the most difficult to regulate, as they typically include shallow injection practices. Class I, II, and III wells were not considered to be as great a concern since many states have current operating programs that either prohibit, or regulate the construction and operation of these types of wells. In Minnesota, Class II wells are regulated by the DNR while Class I and III wells are not known to exist in the state. As a result, the USEPA contract with the MDH includes provisions for an inventory and assessment of Class IV and V wells so that a clearer perspective of ground water contamination in the state can be determined. Other work elements of the contract consist of evaluations of ground water

heat pumps and the ATES project. These evaluations would assist the state in developing a strategy to address injection from these types of systems, which are now permitted on a very limited basis. As discussed previously, ATES evaluation has not been completed as this project is still in progress. The findings of the other two work elements are as follows:

a. "Identification of Class IV and Class V Wells." Bruce A. Liesch Associates, Incorporated, 1981.

   The report verifies the existence of eight injection well systems in Minnesota. All were Class V wells consisting of seven wells used for cooling or air-conditioning purposes, and one recharge testing system. No Class IV or other Class V wells were identified as being used for the disposal of wastes. This does not, however, rule out the possibility that these wells exist. The report also identified the possible or definite existence of 48 non-residential septic systems but did not define "septic system" or indicate their size. Finally, an evaluation of operational and environmental problems including physical, chemical, biological effects was provided.

b. "Evaluation of Ground Water Source Heat Pumps." Ernest K. Lehmann and Associates, Incorporated, November 1981.

   The typical design and optional components for heat pumps are described in the report. Purchase and installation costs were reviewed and operational costs compared with other space heating alternatives. Ground water source heat pumps compared favorably with other alternatives by supplying three times more energy than is used. Heat pumps have the lowest cost per 1,000,000 BTU's except for natural gas (January 1982 costs). An additional benefit is that heat pumps can also be used for cooling. The primary effect of injecting to ground water is the thermal effect during the cooling season when temperature differences are greatest between injected and receiving waters. Higher temperatures created during the cooling mode can cause bacterial or chemical reactions such as the precipitation of carbonates. This may result in the injection well becoming clogged in the recharge zone. Clogging can also occur from air entrainment, injecting clay and silt-sized particles, and the formation of hydrous iron oxides. The report indicates more background data is needed on which to base regulations and to alleviate some of the above problems. It states that this would require more flexibility in existing statutes and regulations to accommodate data gathering. Examples include allowing treatment of injected water, and allowing heat pumps to use the same water supply as other domestic uses.

Future State UIC Activity

A basic understanding of existing state activities provides an important foundation for making decisions on any future actions. The following recommendations are made in view of the above summary and a perceived need for improving regulatory efficiency, consistency and, if appropriate, flexibility:

1. UIC is one of the major federal ground water programs at the present time. The USEPA has not, to date, completed development of a program in Minnesota as final administrative rules have not yet been completed. Existing state rules and statutes provide maximum protection to ground water which would be as restrictive, if not more so, than any federal program. From the

standpoint of an efficient and consistent program, it would be desirable to have only one agency responsible for regulating underground injection in the state. It would appear reasonable that the state, having the most restrictive authority, should have that responsibility. However, the extensive administrative program requirements proposed have served as a disincentive to date. The possibility may exist that final rules issued in the future may be modified from earlier proposals to provide more incentives for states to assume primacy. It is therefore recommended that the state reevaluate its decision of not seeking primacy when final program rules are issued by the USEPA to determine the feasibility of assuming the UIC program.

2. Both the MDH and MPCA have provisions in their respective regulations prohibiting direct injection to ground water unless a variance is obtained. Again, to facilitate regulatory efficiency and consistency, it would be desirable to have one agency responsible for the enforcement of a single regulation concerning, in whole or part, underground injection. It is recommended that the MPCA have sole regulatory responsibility on the utilization of injection. The MDH would continue to regulate injection relative to the proper construction of wells.

3. The state has made a limited commitment to the reinjection of water from ground water source heat pumps. Because of rising energy costs in Minnesota for space heating, there has been an increase in interest for alternative energy sources. Data indicates ground water source heat pumps are an efficient alternative in supplying energy. This could prove valuable to the state as there is an abundance of ground water in Minnesota. The existing problem is the disposal of the water.

Injection provides a possible disposal method as ground water is returned to the aquifer after use and there are fewer disposal site restrictions relative to the size and location of the owner's property. Suggestions offered in the report to MDH on heat pumps included the need to generate more information on these systems by providing greater flexibility in existing statutes and regulations. Along these lines, it is recommended that the state of Minnesota support the study and utilization of ground water source heat pumps and reinjection as a disposal method.

CHAPTER 8

REFERENCES

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CHAPTER 9

MINNESOTA'S FRAMEWORK FOR GROUND WATER PROTECTION: A PROGRAM DEVELOPMENT STRATEGY

Introduction

Minnesota's ground water is a valuable yet vulnerable resource which has largely been taken for granted over the years. Yet, two of every three Minnesotans depend on it as a high quality source of drinking water. Notwithstanding the more visible surface water problems, we are beginning to see in our historically clean and abundant ground water supplies the evidence of past neglect.

Ground water supplies in Minnesota are threatened from both point and non-point sources of contamination including waste impoundments, underground fuel storage tanks, inadequate on-site sewage treatment systems, landfills, unregulated hazardous waste storage or dump sites, animal feedlots, salt storage piles, and a variety of other land use practices. Current indications are that while a relatively small percentage of available ground water has been degraded, incidents of contamination are widespread and there may be pollutants already in ground water that may not appear for years or decades in drinking water supplies.

The purpose of this chapter is to present and describe the framework for development of a comprehensive ground water protection strategy for Minnesota. In order to put the framework into perspective, previous chapters have provided background and detailed discussions on Minnesota's ground water resource, its use and its abuse. Based on the existing situation in the state, the Minnesota Pollution Control Agency (MPCA), in cooperation with other federal, state and local agencies involved with ground water management, has developed a set of program goals that provide the basis for the framework. This is discussed as a lead-in to a presentation of a plan of action which has as its basis the current organizational structure of MPCA's Solid and Hazardous Waste Division (SHWD). When implemented, this plan will provide a means of protecting our ground water resource from further abuse and maintaining its viability to support current and future uses. The plan of action is built around a three-part program of (1) rapid, effective site-specific response on critical ground water contamination incidents; (2) thorough, consistent regulatory compliance activities in ongoing programs of facility review and enforcement; and, (3) problem anticipation and early prevention through program development efforts.

Limits to Framework Development

If there is one underlying thread which is common to most discussions of ground water, it is that it is a misunderstood natural resource. Therefore, it is important to make explicit any limits within which the ground water protection strategy framework is structured so as to minimize any misunderstandings. These limits will extend into the implementation part of the strategy framework, as well.

1. Ground water threats will not be controlled quickly. The effort to develop a comprehensive protection program will be a long-term process.

2. No strategy will be able to identify all long-term priorities and policies. It must, however, start with a framework and a plan for initiating programs now and provide the tools necessary for making other decisions at the appropriate time in the future. There will never be a time when all the answers are available. The ultimate ground water program will never be complete. The planning and implementation process will be ongoing.

3. Coordination at all levels of government (federal, state, regional, and local) is essential to the success of any ground water protection strategy. The problem is complex and institutions dealing with activities affecting ground water are numerous.

4. The quantity and quality of ground water are so inextricably linked that any efforts to protect or enhance quality will have to be coordinated with the activities of governmental units responsible for managing the quantity of ground water use. Ground water management efforts must also be coordinated with surface water quality management programs.

5. Setting up a framework of institutional relationships and programs for further ground water protection will take time and information. To support the process, a priority must be assigned to gathering the needed scientific knowledge of ground water contamination, assessment and protection.

6. State and federal resources available for ground water issues are limited. It is important to phase a strategy over time and to encourage the use of resources on the highest priority ground water supplies identified with respect to vulnerable and needed ground waters, toxicity of contaminants, severity of risk from polluting activities, and susceptibility to management action.

7. The strategy should encourage new and innovative approaches to ground water protection through, for example, engineering and social modifications to reduce pollutant volumes, product substitution, increased recycling, and treatment techniques prior to disposal. It should also encourage innovative legal and institutional approaches to ground water quality management.

8. Existing authorities appear adequate to initiate the strategy and to begin to provide increased protection of ground water. Legislative changes may ultimately be necessary, but sound and specific proposals can best be determined after more data has been gathered and analyzed and experience has been gained.

9. The strategy should recognize that certain activities do and will degrade ground water quality and that a strict non-degradation policy is not possible everywhere. A process must be established to enable the public to participate in and eventually accept appropriate decisions regarding the siting of polluting activities and remediation of existing ground water contamination problems.

10. Implementing the program elements of the strategy on a specific-case basis may be controversial, even if the goals of the strategy are broadly accepted.

Framework Goals

In the broadest sense, the goal of the program leading to a ground water protection strategy for Minnesota has been to establish a framework for the development of comprehensive ground water protection policies and procedures which are consistent with existing state and federal requirements, yet specific to the needs of Minnesota and formulated with a firm technical basis. (MPCA, 1982a). This has been done through the review and analysis of both newly and previously collected site-specific ground water data, ambient ground water quality information and summary of existing ground water programs, regulations and data.

Ambient ground water quality in Minnesota generally meets primary and secondary drinking water standards established by the U.S. Environmental Protection Agency (MPCA, 1982b; USEPA, 1977). For many parameters, the existing quality is better than the standards by several orders of magnitude, emphasizing the high quality of the ground water resource in Minnesota. Because the cost of restoring contaminated water supplies to drinkable quality is high and is even higher to restore them to ambient or background levels, a primary goal of any ground water protection program should be prevention rather than restoration. Where restoration is necessary, remedial measures should be implemented with a full appreciation for the potential long-term commitment required by such actions.

Since potential threats to ground water are increasing as land use decisions are made, implementation of water protection programs must be given a high priority. The protection of ground water must be accomplished initially through the coordination and administration of existing regulatory programs intended to control activities which threaten ground water and through education to promote alternative practices. Examples include those federal programs for which administration has, in part, been delegated to the state, such as the safe drinking water program, pollutant discharge elimination system, solid waste management program, and the emerging program of hazardous waste regulation. Implementation of an initial ground water protection effort should start by using tools designed to achieve that objective. Existing tools include: best management practices, siting criteria, design criteria, construction criteria, maintenance criteria, performance standards and monitoring.

Since much ground water pollution is directly related to land use activities, understanding, controlling, monitoring and educating the public about these activities is prerequisite to preventing or controlling contamination. The ability to control use of land is limited by political, legal, and logistical constraints. Some polluting activities can be controlled by existing state regulatory programs, while others cannot. Local governments have traditionally exercised land use controls, but are limited by a lack of technical expertise in ground water protection. This suggests that the most practical approach is one where the state provides technical and limited financial support, regulatory guidance, and a policy framework, while local and regional units of government assume a shared role with the state in terms of implementation.

In view of the preceding discussion, MPCA is recommending that five major program goals form the framework for ground water protection in Minnesota. These goals are formulated to encourage management and regulation of the state's ground water resources in order to protect the health, safety and welfare of all Minnesotans and to ensure the overall economic and social well-being of the state. The five goals are:

1. To maintain the quality of ground water to as high a degree as possible, consistent with intended best use and to prevent degradation consistent with public health, economic, and social goals.
2. To assure that land use activities which have or may have the potential to impact ground water do not endanger the value of aquifers and associated surface water resources.
3. To monitor ground water to determine ambient conditions, trends, and compliance with regulatory requirements.
4. To manage all discharges, withdrawals and recharges of ground water to ensure that the above goals are realized.

5. To ensure the availability, and transfer of pertinent information data, strategies, and studies to involved institutions and the public, and to ensure their appropriate use.

A Program Development Framework for Ground Water Protection

Cooperation of Minnesota's principal ground water agencies regarding ground water management goals is but the first step in achieving an effective and efficient statewide program to protect and utilize ground water resources within the broader context of overall water resources management. The goals will serve as guideposts and evaluation criteria in the further evolution and implementation of programs.

To provide a plan of action for moving ahead that is consistent with the above framework goals, MPCA will implement a three-part program to address ground water protection needs for the state. The three elements of the approach are:

1. Site specific response on critical ground water contamination incidents. It is imperative that this response be rapid, yet well-reasoned and effective. This response should not have to be carried out to the exclusion of necessary ongoing programs, however. Therefore a dedicated set of resources to address these critical incidents is necessary.

2. Regulatory compliance activities through ongoing programs of enforcement and facility review. Implementation of these ongoing programs must be both thorough and consistent. Regulatory compliance activities should serve as a bridge between rapid site-specific response and the slower, more evolutionary approach required in program development.

3. Program development to anticipate and prevent problems. Problem anticipation should involve thorough analysis of the interrelationship between sources and receptors of ground water contamination. It must team this with prevention of problems through review and adjustment of ongoing programs to strengthen their approach to ground water protection.

It is important to understand that site-specific responses and ongoing regulatory programs, including enforcement and facility review, must be provided by MPCA as a part of its statutory mandates whether or not MPCA chooses to devote resources to program development. It is believed that through a balanced approach to each of these areas, a continuing audit of ongoing programs, and use of this information to effect changes in those programs when necessary, MPCA will be able to maximize its limited resources and, in so doing, protect Minnesota's ground water for present and future uses. The following discussion details the elements of the three-part approach to ground water protection. This approach is reflected in the current organizational structure of MPCA's SHWD. It is recommended that this organizational structure serve as the basis for implementing MPCA's future programs directed at ground water protection.

Site-specific response: As has been previously well-documented in this report (Chapter 5), there has been an increasing pattern of ground water contamination in Minnesota over the past few years. When such an incident occurs, it is critical that responsible public agencies respond quickly to identify and correct the source of the contamination, limit the spread of contamination where possible, and identify options available to the affected parties to ensure continued adequate sources of drinking water. All agencies having responsibility for ground water management activities, but especially, MPCA, MDH, and MDNR should strengthen the state's capability in this regard.

MPCA has developed and will maintain a section within the SHWD with the expertise and capability to respond to critical ground water contamination incidents through field studies and problem analysis. Current functions of this section include preliminary reconnaissance of problem sites, evaluation of available geologic and pollutant source information, review of trackdown monitoring networks and sampling schemes, supervision of well installation, sample collection, evaluation of results, review of ground water remediation proposals, overview of remedial actions, and technical support for litigation as needed.

In connection with this activity are source identification and specification of corrective measures as appropriate. If parties responsible for ground water contamination are unable or unwilling to implement corrective measures, the state must be prepared to do so. Limited financial resources are available nationally through the federal "superfund" to address the highest priority problems identified by the states. Emergency response legislation is now emerging at the state level which will enable Minnesota to take independent action to protect ground water at serious problem sites which may not be viewed as critical when prioritized nationally. Other state agencies, especially MDH and MDNR, should within the constraints of limited program resources provide expertise to specify and evaluate management options available to impacted water users, with an emphasis on ground water treatment where feasible rather than on new water supply acquisition.

Regulatory compliance activities: At the heart of any comprehensive ground water protection program are the ongoing regulatory functions which ensure that activities having the potential to impact ground water are properly controlled. This is done through review of design and operational procedures for waste management facilities, issuance of permits with specific requirements for, among other things, minimizing ground water impacts, and consistent enforcement to bring unpermitted facilities into compliance and to ensure that permitted facilities operate within conditions of their permits. Recent permits contain ground water monitoring requirements which are specific to a facility's operational history, hydrogeology, and waste characteristics. Analysis of results of samples collected from these systems is critical to confirm design decisions which may have been made at a facility as well as to determine if its operation is impacting ground water.

As with site-specific response, ongoing regulatory compliance demands a high degree of coordination with other agencies having ground water management responsibilities, especially MDH, MDNR, and MGS. For example, MDH can provide information on public water supply sources near planned waste management facilities and can provide health risk assessments in ground water contamination incidents. MDH also licenses water well contractors who may install monitoring wells and administers the well construction code for these installations. MDNR can provide information on ground water use in the area of a facility and address possible interactions between surface waters and wetlands and the ground water flow system under a proposed site. MGS maintains files of water well logs which may provide useful geologic information for a given area. As the degree of sophistication of the design and monitoring of waste management facilities increases, it is important that a coordinated effort toward review of these systems continues by all agencies having ground water management responsibilities.

Program development: Program development aimed at protecting ground water involves a two-part approach: problem anticipation and problem prevention. Among the essential elements of any ground water protection program are the technical capabilities to understand the nature of the ground water resource and to acquire and use pertinent information to anticipate threats to the resource. These must be teamed with ongoing monitoring and evaluation of existing programs which are eventually incorporated into management objectives which affect ground water resources to avoid, to the degree possible, problems of contamination and overuse.

To move toward the anticipation of problems, agencies with ground water responsibilities should strengthen efforts to organize and analyze the available data base concerning:

1. The nature of the state's aquifers and their relationship with surface bodies of water;
2. The users of the ground water;
3. The impacts of various land use activities on ground water quality;
4. Existing ambient and site-specific ground water quality.

The goal of work leading to problem anticipation should be to present information in ways which will strengthen the ability of the ground water agencies to prioritize and target most effectively the use of limited program resources toward areas most in need of regulatory and management attention.

Ultimately this must include a system of priorities to guide the distribution of regulatory and management efforts, area-specific management strategies to guide programs according to the physical pattern of resource availability, a summary of existing and potential water uses, assessment of quantity and quality problems, and a catalog of potential contamination threats for the state. Some of these elements have been addressed previously in this report.

The purpose of the second part of program development is to achieve routine operation of water programs in such a manner that serious contamination of ground water is prevented and the resource is maintained for vital water supply uses. The prevention function must be a long-term program. Historically, the state's environmental and public health programs have been geared to control of major municipal and industrial point discharges to surface waters. Many of the basic regulatory powers and functions inherent to these programs are similar to those needed for effective ground water protection. The current need is for greater emphasis; for developing the necessary technical capabilities; for adjusting the policies, procedures, and guidelines under which day-to-day regulatory operations are conducted; and for continued identification and elimination of any major "gaps."

Implementation of this component should involve use of this report as a guidance document. It should include continued evaluation of the array of known and potential problems, the sources of these problems and assessment of the applicable existing programs to deal with these problems. It should continue to document the existing program and recommend adjustments as needed to more effectively protect critical ground water resources. It should identify major program gaps and issues, and evaluate alternatives for addressing these.

The recommended three-part plan of action will help assure that Minnesota continues to respond to immediate ground water problems, begins to anticipate problems, and fosters a transition to a broader preventative strategy. It is MPCA's responsibility to articulate and lead a state program within this program development strategy. Yet, this cannot be accomplished without the concerted help of federal agencies (particularly USEPA and the USGS) and other state and local governments. MPCA must continue to seek active assistance and cooperation from all agencies with interests in protecting our ground water resource.

Recommendations for Framework Implementation

Future program directions in ground water management should be undertaken within the above framework. In addition, there are four underlying recommendations which should be implemented if the plan of action is to be realized. These are:

1. Build on the existing institutional system for ground water management: As discussed earlier in this report, there are at least 14 institutions currently administering a wide variety of programs pertaining to ground water management in Minnesota. Historically, the fact that there are so many involved parties has had the advantage of forcing institutions to coordinate their efforts in order to provide for effective ground water management. Although ground water has not been the major emphasis of each program, their objectives are generally compatible with ground water goals. Although some totally new ground water initiatives ultimately might be necessary, the existing structure of the operating programs already

contains much of the essential management framework. Thus, the focus should be to evaluate existing programs carefully and to adjust them to ensure that ground water will receive equal emphasis with surface water in all water management areas.

2. <u>Acknowledge regional differences</u>: Another strategy emphasis is the need to encourage regional ground water management sensitive to local differences in physical resources, uses, and problems. Since available ground water is not distributed equally, since uses vary from one locality to another, and since ground water is more naturally-protected in some areas than others, problems and appropriate responses will differ throughout the state. Local government also has an important role in ground water management through its land use control responsibilities. Long-term management options and examples of where they might apply include:

    a. Treatment at the wellhead to remove toxic contaminants (St. Louis Park; New Brighton).

    b. Adoption of more stringent procedures and criteria for permits (State Disposal System permits, Solid Waste permits) in critical aquifer areas, such as the Anoka sandplain and southeast Minnesota's karst areas.

    c. Stronger land use controls for critical aquifer recharge areas (Twin Cities basin).

    d. Stronger regulation of well locations in relation to sources of contamination (southeast Minnesota).

    e. Stronger regulation of permissible well yields in areas of competing water uses (Twin Cities; Red River Valley; west-central sandplains).

f. Prohibition on use of certain consumer products in sensitive aquifer areas (southeast Minnesota; irrigated sandplain areas).

g. Development of public education programs in areas of sensitive hydrology and land use (northern Minnesota; southeast Minnesota; Twin Cities basin).

3. <u>Encourage federal participation</u>: Successful implementation of a ground water strategy will also require continuing participation by the federal government. Financial assistance for program development efforts, cooperation in developing information and knowledge about the state's ground water resources, dissemination of information on means of solving ground water problems, and the setting of standards for drinking water are all activities which federal agencies should continue.

4. <u>Target a long-term preventative strategy</u>: Responding to immediate ground water problems and learning from the success and failures of these efforts to begin to anticipate future problems are but the beginning of development of a long-term strategy to protect ground water resources. Several specific, long-term program development efforts must be undertaken if the eventual goal of ground water protection in Minnesota is to be realized. These may be categorized as follows:

   a. Develop a ground water classification system which recognizes the high ambient quality of Minnesota's ground water, the sensitivity of certain aquifers in the state to degradation, and the necessity of protecting critical recharge areas.

   b. Develop an automated ground water data management system to provide information necessary for evaluating immediate impacts and making decisions, to assemble and use pertinent ambient and site-specific data, and to prevent potential problems from occurring by guiding regulatory program operations.

c. Refine current programs dealing with assessment and cleanup of unregulated or illegal land uses which may impact ground water.

d. Conduct a review of rules for permitting, operating, and monitoring those facilities having the greatest potential to impact ground water resources.

e. Continue to inventory and prioritize activities for which the potential to degrade ground water is either known or suspected.

f. Develop a strategy to address emerging issues in ground water protection in Minnesota such as ground water source heat pumps, underground injection control, aquifer thermal energy storage, natural resource development, and irrigation systems.

In summary, the five framework goals, the three-part plan of action to support those goals, and the recommendations to implement the ground water protection strategy framework should provide the basis from which future MPCA programs to protect ground water will evolve. Ground water threats will not be controlled quickly because ground water, by its nature, is generally not amenable to "quick-fix" solutions. However, through a consistent, reasoned approach involving site-specific response to critical ground water contamination situations, a strong ongoing program of regulatory compliance, and audit of existing ground water protection efforts to both anticipate and prevent future problems, MPCA will help determine that the quality of Minnesota's ground water will be ensured for many years to come.

CHAPTER 9

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APPENDIX A

Catalog of Ground Water Data Sources

The Minnesota Natural Resources Information and Data Exchange (INDEX), which contains the SWIM reference file discussed above, is currently composed of six kinds of environmental resources information in each file. These are bibliography, data source, environmental impact statement, map, research project and technical person. All the references (also called entries) in each file have similar characteristics. Each reference may contain up to 25 different units of information called paragraphs. These paragraphs describe the characteristics and location of the information. A brief description of the paragraphs and a listing of the files they are used in is listed below. These serve as a guide to the ground water data source information which follows.

Paragraph Label	Content of Paragraph	Files Involved*
AN	Bibliographic Retrieval Service number (For Internal Use)	All
ID	Identification code for file (For Internal Use)	All
NU	INDEX number (For Internal Use)	All
AU	AUthor: Author, Investigator, or Technical Person (name)	B,D,M,P,R
IN	INstitution: Institution or agency name and address (author's affiliation)	B,D,M,P,R
TI	TItle	All
ED	EDucation: Education and work experience	P
RS	ReSponsibilities: Purpose or goals	D,P,R
AC	ACcomplishments, AppliCations: Resulting publications or research	D,E,P,R
TY	TYpe: Data or publication type	B,D,M
SO	SOurce: Source information such as volume, edition, etc.	B,M
NT	NoTes: Additional information	All
PB	PuBlisher: Publisher's name and address	B,M
SN	SpoNsor: Sponsoring or funding agency or group	B,D,E,M,R
YR	YeaR, date	B,D,E,M,R
MT	MeThodology: Methods used in data collection or research	D,R
MS	MeaSurement: Data measurement units or scale	D,M
FT	FormaT: Data format (manual or computerized) or map format (color or black and white)	D,M
PR	PRice	B,M
DE	DEscriptors: Keywords	All
LO	LOcation: Name and address of institution or agency for additional information	B,D,E,M,R
AV	AVailability: Statement of availability and any restrictions on use	B,D,E,M,R
GC	Geographic Code: Geographic area of coverage	All
AB	ABstract: Summary	B,E
XX	Private file information (see INDEX staff)	B,D,E

* B=Bibliography, D=Data Source, E=Environmental Impact Statement, M=Map, P=Technical Person, R=Research Project

AN 0000Z001865*
ID DATA*
NU SWIM-D-002001*
NU MDAG-D-3*
NU DCAT-D-49*
AU MINNESOTA DEPARTMENT OF AGRICULTURE*
IN MINNESOTA DEPARTMENT OF AGRICULTURE,
DAIRY INDUSTRIES DIVISION,
530 STATE OFFICE BUILDING,
ST PAUL MN 55155*
TI DAIRY INDUSTRIES DIVISION: INDUSTRIAL PRIVATE WATER SUPPLY*
RS THE DAIRY INDUSTRIES DIVISION HAS THREE MAJOR FUNCTIONS: GRADE A MILK INSPECTION, MANUFACTURED MILK INSPECTION, AND INTERSTATE MILK SHIPPER CERTIFICATION. THESE THREE PROGRAM AREAS ADMINISTER AND ENFORCED DAIRY LAWS AND REGULATIONS DESIGNED TO PROTECT PUBLIC HEALTH AND BE OF SERVICE TO THE DAIRY INDUSTRY. PROGRAM OBJECTIVES ARE ACCOMPLISHED THROUGH INSPECTIONS, SAMPLING, CERTIFICATION AND EDUCATIONAL ACTIVITIES WHICH ASSIST THE DAIRY INDUSTRY AND INSURE ADEQUATE SUPPLY OF WHOLESOME, SAFE MILK AND MILK PRODUCTS FOR CONSUMERS.*
TY PRIMARY*
NT REQUIRED BY MINNESOTA STATE STATUTE 31-32 CHAPTER 41 AGR 975-993, PART B DAIRY INDUSTRIES GENERAL RULES; US FOOD AND DRUG ADMINISTRATION STANDARDS*
SN MINNESOTA DEPARTMENT OF AGRICULTURE*
YR 1979 - 1981 (RECORDS ARE KEPT FOR THREE YEARS AND THEN DESTROYED EXCEPT FOR DAIRY PLANTS WITH PROBLEM WATER SUPPLIES)*
MT (SOURCE)
PRIVATE WATER SUPPLIES FOR GRADE A DAIRIES AND DAIRY PLANTS;
(METHODS)
FIELD INSPECTORS USING METHODS AND PROCEDURES SET UP BY THE MINNESOTA DEPARTMENT OF HEALTH (MDH) LABORATORY COLLECT SAMPLES AT REGULAR INTERVALS, SAMPLES ARE PRESERVED (ICED) AND SHIPPED WITHIN SPECIFIED TIME TO MINNESOTA DEPARTMENT OF AGRICULTURE (MDA) LAB OR TO MDA CERTIFIED LAB;
(CLASSES)
COLIFORM*
MS (UNITS)
MPN/100ML;
(FREQUENCY)
GRADE A DAIRIES EVERY 2 YEARS, DAIRY PLANTS AND GRADE A DAIRY FARMS WITH PRIVATE WATER SUPPLIES EVERY 6 MONTHS;
(SIZE)
240 DAIRY PLANTS, 8000 GRADE A DAIRY FARMS*
FT MANUAL FILES*
DE GROUNDWATER, SURFACE WATER, BACTERIA, WATER SUPPLY, INDUSTRIAL WATER, MICROORGANISMS, COLIFORM, WATER ANALYSIS, LAWS*
LO MINNESOTA DEPARTMENT OF AGRICULTURE,
DAIRY INDUSTRIES DIVISION,
530 STATE OFFICE BUILDING,
ST PAUL MN 55155*

AV NO RESTRICTIONS, CONTACT ORLOWE OSTEN (612-296-3647)*
GC (REFERENCE)
NAME AND ADDRESS, COUNTY NAME;
(AREA)
MN*
/EOR

AN 0000Z001866*
ID DATA*
NU SWIM-D-003001*
NU MDAG-D-4*
NU DCAT-D-50*
AU MINNESOTA DEPARTMENT OF AGRICULTURE*
IN MINNESOTA DEPARTMENT OF AGRICULTURE,
FOOD, MEAT AND POULTRY INSPECTION DIVISION,
530 STATE OFFICE BUILDING,
ST PAUL MN 55155*
TI FOOD, MEAT AND POULTRY INSPECTION PROGRAM: PRIVATE INDUSTRIAL
WATER QUALITY*
RS TO INSPECT FOOD, MEAT AND POULTRY FACILITIES TO INSURE COMPLIANCE
WITH STATE LAWS AND REGULATIONS THAT ARE DESIGNED TO PROTECT PUBLIC
HEALTH AND BE OF SERVICE TO THESE INDUSTRIES.*
TY PRIMARY*
NT MUNICIPAL PUBLIC HEALTH AGENCIES AND MINNESOTA DEPARTMENT OF HEALTH
COLLECT SIMILAR DATA; LAWS: MINNESOTA STATE STATUTE 31, MS 20
AGR 434-448, MS 21 AGR 458-496, MS 76 AGR 1650-1679, MS 77-79 AND
96; DATA MEETS ENVIRONMENTAL PROTECTION AGENCY STANDARDS*
SN MINNESOTA DEPARTMENT OF AGRICULTURE*
YR 1980 - 1981 (CURRENT TWO YEARS ONLY THEN DESTROYED)*
MT (SOURCE)
PRIVATE INDUSTRIAL WATER SUPPLIES: RETAIL FOOD STORES,
BAKERIES, AND OTHER FOOD PROCESSING FACILITIES SUCH AS CANNERIES;
(METHODS)
FIELD INSPECTORS OBTAIN WATER SAMPLES FROM PETCOCK AT WELL OR
FROM METER OF THE WATER SUPPLY, SAMPLES ARE PRESERVED (ICED) AND
SENT TO MINNESOTA DEPARTMENT OF AGRICULTURE LABORATORIES FOR
ANALYSIS, INSPECTOR FOLLOWS METHODS AND PROCEDURES ESTABLISHED BY
MINNESOTA DEPARTMENT OF HEALTH;
(CLASSES)
COLIFORM, NITRATES*
MS (UNITS)
MPN/100ML, MG/L - N;
(FREQUENCY)
EVERY SIX MONTHS;
(SIZE)
1117 SAMPLES*
FT MANUAL FILES*
DE GROUNDWATER, SURFACE WATER, BACTERIA, MICROORGANISMS, WATER
QUALITY, WATER ANALYSIS, COLIFORM, LAWS*
LO MINNESOTA DEPARTMENT OF AGRICULTURE,
FOOD, MEAT AND POULTRY INSPECTION DIVISION,
530 STATE OFFICE BUILDING,
ST PAUL MN 55155*

AV NO RESTRICTIONS, CONTACT BERNARD STEFFEN (612-296-2627)*
GC (REFERENCE)
NAME AND ADDRESS OF ESTABLISHMENT;
(AREA)
MN*
/EOR

AN 0000Z001868*
ID DATA*
NU SWIM-D-004001*
NU MDAG-D-6*
NU DCAT-D-52*
AU MINNESOTA DEPARTMENT OF AGRICULTURE*
IN MINNESOTA DEPARTMENT OF AGRICULTURE,
PESTICIDE CONTROL DIVISION,
AGRONOMY SERVICES DIVISION,
90 WEST PLATO BOULEVARD,
ST PAUL MN 55107*
TI PESTICIDE CONTROL PROGRAM: DATA ON LICENSING AND REGISTRATION*
RS THE OVERALL OBJECTIVE IS THE PROPER USE OF PESTICIDE IN ORDER TO PROTECT THE IMMEDIATE AND FURTHER HEALTH, WELFARE, AND ECONOMIC STATUS OF THE PEOPLE OF MINNESOTA. WORKING IN COOPERATION WITH THE ENVIRONMENTAL PROTECTION AGENCY THE PROGRAM REQUIRES: REGISTRATION OF PESTICIDES SOLD IN THE STATE; LICENSING AND REGISTRATION OF COMMERCIAL, NON-COMMERICIAL, AND STRUCTURAL PEST CONTROL APPLICATORS, DEALERS, SELLERS AND CERTIFICATION OF USERS OF RESTRICTED USE PESTICIDES; AND CONFORMANCE WITH APPLICATION, HANDLING, STORAGE, AND DISPOSAL REQUIREMENTS.*
TY PRIMARY*
NT MINNESOTA POLLUTION CONTROL AGENCY, MINNESOTA DEPARTMENT OF NATURAL RESOURCES, AND MINNESOTA DEPARTMENT OF HEALTH (DIVISION OF EMERGENCY SERVICES) ALSO COLLECT SIMILAR DATA. REQUIRED BY MINNESOTA STATE STATUTE 18A.21 TO 18A.48, PUBLIC LAW 94-140 (FEDERAL INSECTICIDE FUNGICIDE AND RODENTICIDE ACT), 3MCAR SECTION 1:0338*
SN MINNESOTA DEPARTMENT OF AGRICULTURE*
YR 1960 - 1981 (TO PRESENT); 1969 - 1981 (TO PRESENT, FOR STRUCTURAL USE OF PESTICIDES)*
MT (SOURCE)
APPLICANTS FOR LICENSE OR REGISTRATION;
(METHODS)
STANDARD METHODS;
(CLASSES)
LIST OF PESTICIDES BY COMPANY NAME, COPY OF PESTICIDE CONTAINER LABEL, LICENSE APPLICATION FOR CUSTOM APPLICATOR (AERIAL APPLICATORS, BUILDING PEST EXTERMINATORS, ETC.), LICENSE APPLICATION FOR DEALERS WITH RESTRICTED USE CHEMICALS*
MS (FREQUENCY)
ANNUALLY;
(SIZE)
300 LICENSED DEALERS, 1500 COMMERCIAL APPLICATORS, 1000 NON-COMMERCIAL LICENSES, 150 BUILDING APPLICATORS LICENSES, 25000 PRIVATE APPLICATORS OF RESTRICTED USE CHEMICALS*

FT MANUAL FILES*
DE PESTICIDES, HAZARDOUS MATERIALS, CHEMICALS, SURFACE WATER, GROUNDWATER*
LC MINNESOTA DEPARTMENT OF AGRICULTURE,
PESTICIDE CONTROL DIVISION,
AGRONOMY SERVICES DIVISION,
90 WEST PLATO BOULEVARD,
ST PAUL MN 55107*
AV NO RESTRICTIONS, CONTACT MIKE FRESVIK (612-296-8547)*
GC (REFERENCE)
STREET ADDRESS, CITY/TOWNSHIP NAME (MCD);
(AREA)
MN*
/EOR

AN 0000Z001869*
ID DATA*
NU SWIM-D-004003*
NU MDAG-D-7*
NU DCAT-D-53*
AU MINNESOTA DEPARTMENT OF AGRICULTURE*
IN MINNESOTA DEPARTMENT OF AGRICULTURE,
PESTICIDE CONTROL DIVISION,
AGRONOMY SERVICES DIVISION,
90 WEST PLATO BOULEVARD,
ST PAUL MN 55107*
TI PESTICIDE CONTROL PROGRAM: DATA ON SPILLS AND EMERGENCIES AND REPORTED MISUSES*
RS THE OVERALL OBJECTIVE IS THE PROPER USE OF PESTICIDES IN ORDER TO PROTECT THE IMMEDIATE AND FUTURE HEALTH, WELFARE, AND ECONOMIC STATUS OF THE PEOPLE OF MINNESOTA.*
AC NO REGULAR PUBLICATIONS RESULT BUT DATA ON SPILLS AND REPORTED MISUSES ARE USED IN DAMAGE CLAIMS OR COURT CASES*
TY PRIMARY*
NT PROGRAM IS AUTHORIZED UNDER THE MINNESOTA PESTICIDE CONROL ACT OF 1976 AND PUBLIC LAW 94-140 (FEDERAL INSECTICDE, FUNGICIDE AND RODENTICIDE ACT); REQUIRED BY MINNESOTA STATE STATUTE 18A.21 - 18A.48; MINNESOTA POLLUTION CONTROL AGENCY, MINNESOTA DEPARTMENT OF NATURAL RESOURCES, AND MINNESOTA DEPARTMENT OF HEALTH (DIVISION OF EMERGENCY SERVICES) ALSO COLLECT DATA; DATA ON SPILLS AND REPORTED MISUSES ARE COLLECTED ACCORDING TO ENVIRONMENTAL PROTECTION AGENCY AND MINNESOTA POLLUTION CONTROL AGENCY GUIDELINES, MINNESOTA DEPARTMENT OF AGRICULTURE IS THE LEAD AGENCY, THEY MAY ALSO REFER THE CASE IF NECESSARY TO THE MINNESOTA DEPARTMENT OF NATURAL RESOURCES, MINNESOTA POLLUTION CONTROL AGENCY, OR MINNESOTA DEPARTMENT OF HEALTH FOR FURTHER WORK*
SN MINNESOTA DEPARTMENT OF AGRICULTURE*
YR 1960 - 1981 (TO PRESENT)*
MT (SOURCE)
FIELD INVESTIGATION BY MINNESOTA DEPARTMENT OF AGRICULTURE (MDAG) INSPECTORS FOR SAMPLES OF WATER, SOIL AND PLANT MATERIALS FROM DAMAGED AREAS;

(METHODS)
SAMPLES ARE ANALYZED FOR CHEMICAL RESIDUES BY MINNESOTA DEPARTMENT OF AGRICULTURE LAB;
(CLASSES)
NAME AND ADDRESS OF CLAIMANT OR REPORTER, COMPANY OR INDIVIDUAL SUSPECTED OF MISUSE, TYPE OF DAMAGE, PUBLIC LAND SURVEY (LEGAL) DESCRIPTION OF DAMAGED AREA, LABORATORY RESULTS OF CHEMICAL RESIDUES IN SOIL, WATER AND PLANT SAMPLES, DISTANCE TO WATER BODY*

MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
ONE TIME PER REPORT OF DAMAGE;
(SIZE)
APPROXIMATELY 100 REPORTS ARE INVESTIGATED PER YEAR*

FT MANUAL FILES, MAPS OF DAMAGED AREAS*

DE SURFACE WATER, GROUNDWATER, PESTICIDES, WATER QUALITY, WATER POLLUTION, HAZARDOUS MATERIALS, FARMS, PESTICIDE SPILLS, ENVIRONMENTAL DAMAGE*

LO MINNESOTA DEPARTMENT OF AGRICULTURE,
PESTICIDE CONTROL DIVISION,
AGRONOMY SERVICES DIVISION,
90 WEST PLATO BOULEVARD,
ST PAUL MN 55107*

AV NO RESTRICTIONS, CONTACT MIKE FRESVIK (612-296-8547)*

GC (REFERENCE)
CITY NAME, LEGAL DESCRIPTION, COUNTY NAME, SPECIFIED DIRECTIONS TO SITE ON EMERGENCY RESPONSE FORMS;
(AREA)
MN*

/EOR

AN 0000Z004250*

ID DATA*

NU SWIM-D-005001*

NU MNDH-D-7*

AU MINNESOTA DEPARTMENT OF HEALTH*

IN MINNESOTA DEPARTMENT OF HEALTH,
DIVISION OF ENVIRONMENTAL HEALTH, ANALYTICAL SERVICES SECTION,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*

TI ANALYTICAL SERVICES: SOIL AND WATER QUALITY*

RS THE FUNCTION OF THIS PROGRAM IS TO MAKE PHYSICAL, CHEMICAL, BACTERIOLOGICAL, AND RADIOLOGICAL EXAMINATIONS OF SAMPLES OF WATER, SLUDGE, SOILS, SEDIMENTS AND OTHER MATERIALS. THIS LAB SERVES 14 PROGRAMS IN THE MINNESOTA DEPARTMENT OF HEALTH (MDH) AND 32 PROGRAMS IN 4 OTHER AGENCIES. THE LAB IS A SUPPORT FACILITY AND DOES NOT GENERATE ITS OWN DATA OR RUN ITS OWN RESEARCH PROGRAMS. THE LAB MUST MEET FEDERAL TECHNICAL DATA STANDARDS UNDER THE CLEAN WATER ACT OF 1977 AND OTHER SUCH LEGISLATION.*

AC THE DATA IS MOST OFTEN USED IN RESEARCH PROGRAMS OF OTHER AGENCIES AND IN THEIR REGULATORY AND ENFORCEMENT FUNCTIONS. NO DATA IS PUBLISHED REGULARLY FROM THE MDH*

TY PRIMARY*
NT LAWS: MINNESOTA STATE STATUTES 144.05. IN ADDITION, THE LAB OPERATES UNDER FEDERAL GUIDELIES AND USES US ENVIROMENTAL PROTECTION AGENCY (EPA) APPROVED METHODS*
SN MINNESOTA DEPARTMENT OF HEALTH*
YR 1976 - 1981 (TO PRESENT), (FILES MUST BE KEPT FIVE YEARS AND THEN DESTROYED IN PRACTICE THE FILES ARE USUALLY KEPT 10 YEARS)*
MT (SOURCE)
SAMPLES OF VARIOUS TYPES SUCH AS SOIL, WATER, SEDIMENT, SLUDGE, ETC.;
(METHODS)
EPA APPROVED STANDARD METHODS;
(CLASSES)
PHYSICAL, CHEMICAL, BACTERIOLOGICAL, AND RADIOLOGICAL PARAMETERS. THE EXACT PARAMETERS DEPEND UPON THE NEEDS OF THE CLIENTS BEING SERVED*
MS (UNITS)
NOT INDICATED;
(FREQUENCY)
DEPENDS ON NEEDS OF CLIENT;
(SIZE)
ABOUT 150000 DETERMINATIONS ARE MADE ANNUALLY*
FT MANUAL FILES BEFORE 1975; COMPUTER FILES SINCE 1975*
DE SURFACE WATER, GROUNDWATER, SOILS, SLUDGE, SEDIMENTS, WATER QUALITY, WATER POLLUTION, CHEMICAL ANALYSIS, BACTERIA*
LO MINNESOTA DEPARTMENT OF HEALTH,
DIVISION OF ENVIRONMENTAL HEALTH, ANALYTICAL SERVICES SECTION,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
AV NO RESTRICTIONS, CONTACT ALLEN TUPIE (612-296-5300)*
GC (REFERENCE)
NOT INDICATED;
(AREA)
MN*
/EOR

AN 0000Z004252*
ID DATA*
NU SWIM-D-006002*
NU MNDH-D-9*
AU MINNESOTA DEPARTMENT OF HEALTH*
IN MINNESOTA DEPARTMENT OF HEALTH,
ENVIRONMENTAL HEALTH DIVISION,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
TI GROUNDWATER QUALITY INFORMATION SYSTEM: WATER WELL LOG DATA BASE*
RS THE FUNCTION OF THIS PROGRAM IS TO ACCUMULATE INFORMATION ON THE STATE'S GROUNDWATER SUPPLIES THROUGH THE DRILLER'S LOGS FURNISHED BY THE WATER WELL DRILLERS WHEN THEY CONSTRUCT A NEW WELL. COPIES OF THE DRILLER'S LOG (WHICH THEY ARE REQUIRED TO SUBMIT WITHIN ONE MONTH FOLLOWING THE DEPARTMENT OF NATURAL RESOURCES, AND THE SOIL AND WATER CONSERVATION DISTRICT OR OTHER UNITS OF LOCAL GOVERNMENT. THE MINNESOTA GEOLOGICAL SURVEY CHECKS THE LOG FOR ACCURATE LOCATIONAL REFERENCES AND THEN MAKES GEOLOGICAL INTEPRETATIONS BASED ON THE STRATA THAT THE DRILLER REPORTS GOING THROUGH.*

AC NO REPORTS ARE PUBLISHED FROM THE MINNESOTA DEPARTMENT OF HEALTH*
TY PRIMARY*
NT LAWS: MINNESOTA STATE STATUES 1561. ALSO 6MCAR SECTION 1.210-1.230.
SUBMISSION OF THE DRILLERS LOGS HAS BEEN REQUIRED SINCE 1975*
SN MINNESOTA DEPARTMENT OF HEALTH*
YR 1975 - 1981 (TO PRESENT)*
MT (SOURCE)
WATER WELL DRILLER PROVIDES A DRILLING LOG TO THE MINNESOTA DEPARTMENT OF HEALTH (MDH) AND MANY OF THE LOGS ARE OF DUBIOUS QUALITY;
(METHODS)
AS THE DRILLER DRILLS THE WELL, HE RECORDS ON A MDH FORM THE VARIOUS ROCK FORMATIONS AND THEIR DEPTHS THROUGH WHICH HE HAD TO DRILL TO REACH WATER;
(CLASSES)
WATER WELL CONTRACTOR'S CERTIFICATION, WELL USE, DRILLING METHOD, CASING, SCREEN, WELL HEAD COMPLETION, WELL GROUTING, PUMP TYPE, SOURCE OF POSSIBLE CONTAMINATION, SUBSURFACE FORMATION HARDNESS, FORMATION COLOR, FORMATION DEPTHS, WELL DEPTH, STATIC WATER LEVEL, PUMPING LEVEL, COLIFORM, NITRATES, PUBLIC LAND SURVEY DESCRIPTION, DISTANCE TO NEAREST ROAD INTERSECTION*
MS (UNITS)
ROCK FORMATIONS IN FEET;
(FREQUENCY)
ONE TIME;
(SIZE)
ABOUT 15000 LOGS IN AN AUTOMATED DATA BASE (ABOUT 35000 LOGS TOTAL), ABOUT 7000 LOGS ARE RECEIVED ANNUALLY*
FT MANUAL FILES; COMPUTER TAPES FOR 1977 - 1980 (UNIVERSITY COMPUTER CENTER)*
DE GROUNDWATER, WELLS, HYDROLOGY, HYDROGEOLOGY, AQUIFERS, POTABLE WATER*
LO MINNESOTA DEPARTMENT OF HEALTH,
ENVIRONMENTAL HEALTH DIVISION,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
AV NO RESTRICTIONS, CONTACT ED ROSS (612-296-5338)*
GC (REFERENCE)
MINNESOTA UNIQUE WELL NUMBER, COUNTY, PUBLIC LAND SURVEY DESCRIPTION, DISTANCE TO NEAREST ROAD INTERSECTION;
(AREA)
MN*
/EOR

AN 0000Z004251*
ID DATA*
NU SWIM-D-006003*
NU MNDH-D-8*
AU MINNESOTA DEPARTMENT OF HEALTH*
IN MINNESOTA DEPARTMENT OF HEALTH,
DIVISION OF ENVIRONMENTAL HEALTH,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*

TI GROUNDWATER QUALITY INFORMATION SYSTEM: GROUNDWATER QUALITY*
RS THE PURPOSE OF THIS DATA COLLECTION IS TO MONITOR CERTAIN TYPES OF GROUNDWATER QUALITY ESPECIALLY WITH REGARD TO WELL ABANDONMENTS AND SPECIFIC PROBLEMS OF GROUNDWATER CONTAMINATION. THE LATTER ARE OFTEN CONDUCTED IN COOPERATION WITH THE MINNESOTA POLLUTION CONTROL AGENCY.*
AC FOR WELL ABANDONMENTS THE DATA IS USED TO MAKE CERTAIN THAT ABANDONED WELLS WILL NOT BE A SOURCE OF CONTAMINATION OF GROUNDWATER AND INSPECTION BY THE MINNESOTA DEPARTMENT OF HEALTH (MDH) MUST OCCUR BEFORE THE WELL CAN BE SEALED. THIS PROGRAM IS PRIMARILY URBAN AND RELATED TO NEW BUILDING ON OLD SITES*
TY PRIMARY*
NT FOR GROUNDWATER CONTAMINATION THIS GROUP WORKS WITH THE HEALTH RISK ASSESSMENT SECTION WHEN POSSIBLE CONTAMINATION MIGHT AFFECT HUMAN HEALTH. THIS PROGRAM ALSO WORKS CLOSELY WITH THE MINNESOTA POLLUTION CONTROL AGENCY*
SN MINNESOTA DEPARTMENT OF HEALTH*
YR 1960 - 1981 (TO PRESENT)*
MT (SOURCE)
WATER WELL SAMPLES;
(METHODS)
MDH STAFF INSPECTS THE WELL, TAKES A SAMPLE WHICH IS ANALYZED IN THE MDH LAB, AND THEN THE CONTRACTOR MAY SEAL THE WELL, IN THE CASE OF ABANDONED WELLS;
(CLASSES)
TOTAL DISSOLVED SOLIDS, ALKALINITY, IRON, CHLORIDE, FLUORIDE, NITRATE NITRITE, SODIUM, SPECIFIC CONDUCTANCE AT 25 DEGREES CENTIGRADE, MAGNESIUM AS CACO3, BARIUM, CADMIUM, SELENIUM, ZINC, NICKEL, AMMONIA NITROGEN, ORGANIC NITROGEN, HARDNESS, PH, MANGANESE, SULFATE, TOTAL PHOSPHORUS, CALCIUM AS CACO3, POTASSIUM, ARSENIC, CHROMIUM, LEAD, SILVER, COPPER, TOC, PHENOL (USING MBTA METHOD), TOTAL CATIONS, TOTAL ANIONS, POLYNUCLEAR AROMATIC HYDROCARBONS (USING HIGH PERFORMANCE CHROMATOGRAPHY)*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
ONE TIME FOR ABANDONED WELLS, VARIES FOR CONTAMINATION STUDIES;
(SIZE)
100 TO 150 WELLS PER YEAR*
FT MANUAL FILES*
DE GROUNDWATER, WELLS, WATER QUALITY, WATER, WATER CHEMISTRY, BACTERIA, WELLS, GROUNDWATER MOVEMENT*
LO MINNESOTA DEPARTMENT OF HEALTH,
DIVISION OF ENVIRONMENTAL HEALTH,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
AV NO RESTRICTIONS, CONTACT ED ROSS (612-296-5338)*
GC (REFERENCE)
STREET ADDRESS;
(AREA)
MN, ESPECIALLY REGION 11*
/EOR

AN 0000Z004248*
ID DATA*
NU SWIM-D-007001*
NU MNDH-D-5*
AU MINNESOTA DEPARTMENT OF HEALTH*
IN MINNESOTA DEPARTMENT OF HEALTH,
HEALTH RISK ASSESSMENT SECTION, ENVIRONMENTAL HEALTH DIVISION,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
TI HEALTH RISK ASSESSMENT: GROUNDWATER QUALITY; HOWE CHEMICAL COMPANY
FIRE*
RS THE PURPOSE OF THIS STUDY WAS TO DETERMINE THE POSSIBLE HEALTH
HAZARDS REESULTING FROM POTENTIAL SOIL AND GROUNDWATER CONTAMINATION
FOLLOWING THE FIRE AT THE HOWE CHEMICAL COMPANY IN BROOKLYN CENTER
MN. THE COMPANY MANUFACTURES PESTICIDES WHICH WERE RELEASED DURING
A FIRE IN THEIR STORAGE FACILITY IN JANUARY 1979. SURFACE SNOW,
ICE AND SOIL WERE CONTAMINATED AND RUNOFF DISCHARGED TO RYAN CREEK
TO THE CITY OF MINNEAPOLIS.*
AC THE DATA WAS USED TO DEVELOP A SERIES OF MEASURES DESIGNED TO
PREVENT THE FIRE, WATER, CHEMICAL RUNOFF FROM REACHING THE NEARBY
MISSISSIPPI RIVER AND NEARBY RESIDENTIAL WELLS. A REPORT WAS ISSUED:
HOWE INC. FIRE: GROUNDWATER AND SOIL CONTAMINATION INVESTIGATIONS IN
BROOKLYN CENTER AND MINNEAPOLIS MN (1980)*
TY PRIMARY*
NT OTHER COOPERATING AGENCIES WERE: MINNESOTA POLLUTION CONTROL AGENCY,
MINNESOTA DEPARTMENT OF TRANSPORTATION, MINNESOTA DEPARTMENT OF
NATURAL RESOURCES, MINNESOTA GEOLOGICAL SURVEY, CITY OF MINNEAPOLIS,
CITY OF BROOKLYN CENTER, SOO LINE RAILROAD, HOWE INC., AND BARR
ENGINEERING*
SN MINNESOTA DEPARTMENT OF HEALTH*
YR 1979 - 1980*
MT (SOURCE)
SAMPLES OF SNOW, ICE, PONDED WATER, AND SOIL WERE TAKEN TO DETERMINE
THE EXTENT OF CONTAMINATION FROM PESTICIDES AND FERTILIZERS;
(METHODS)
SAMPLES WERE COLLECTED BY BARR ENGINEERING AND ANALYZED IN THE
MINNESOTA DEPARTMENT OF HEALTH (MDH) LABORATORY;
(CLASSES)
NOT INDICATED*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
MONITORING WELLS SAMPLED DAILY;
(SIZE)
23 BORING LOCATIONS, 18 WELLS*
FT MANUAL FILES, MAPS, GEOLOGIC CROSS-SECTIONS*
DE GROUNDWATER, SURFACE WATER, WATER QUALITY, POLLUTION, PESTICIDES,
FERTILIZERS, GEOLOGY, HYDROLOGY, SURFICIAL AQUIFERS, WATER SUPPLY,
WELLS, SOIL SAMPLES*

LO MINNESOTA DEPARTMENT OF HEALTH,
HEALTH RISK ASSESSMENT SECTION, ENVIROMENTAL HEALTH DIVISION,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
AV NO RESTRICTIONS, CONTACT DAVID GRAY (612-296-5352)*
GC (REFERENCE)
SITE LOCATIONS ON MAPS;
(AREA)
MN, REGION 11, HENNEPIN COUNTY, BROOKLYN CENTER, MINNEAPOLIS, RYAN CREEK, MISSISSIPPI RIVER*
/EOR

AN 0000Z004249*
ID DATA*
NU SWIM-D-007001*
NU MNDH-D-6*
AU MINNESOTA DEPARTMENT OF HEALTH*
IN MINNESOTA DEPARTMENT OF HEALTH,
HEALTH RISK ASSESSMENT SECTION, ENVIRONMENTAL HEALTH DIVISION,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
TI HEALTH RISK ASSESSMENT: GROUNDWATER QUALITY; CREOSOTE CONTAMINATION IN THE GROUNDWATER IN ST LOUIS PARK MN*
RS THE PURPOSE OF THIS STUDY WAS TO DETERMINE THE POSSIBLE HEALTH HAZARDS RESULTING FROM GROUNDWATER CONTAMINATION AT THE FORMER REPUBLIC CREOSOTE PLANT SITE IN ST LOUIS PARK MN. AN INITIAL STUDY WAS DONE ON A VARIETY OF HEALTH RELATED FACTORS AND IT WAS FOLLOWED BY MONITORING IN A NUMBER OF MUNICIPAL WELLS IN ST LOUIS PARK AND OTHER SUBURBAN AREAS WHICH SHARE THE AQUIFER.*
AC THE DATA WAS COLLECTED TO DETERMINE WHAT MITIGATION MEASURES WOULD BE NECESSARY TO PROTECT THE HUMAN HEALTH.
(PUBLICATIONS)
ASSESSMENT OF POSSIBLE HUMAN HEALTH EFFECTS RESULTING FROM THE CONTAMINATION OF THE FORMER REPUBLIC CREOSOTE SITE (1977);
HEALTH IMPLICATIONS OF POLYNUCLEAR AROMATIC HYDROCARBONS IN ST LOUIS PARK DRINKING WATER (1978)*
TY PRIMARY*
NT AN INTERAGENCY COMMITTEE WORKED WITH THE HEALTH DEPARTMENT ON THIS ISSUE. AS 1981 WELLS IN HOPKINS, ST LOUIS PARK AND EDINA ARE STILL BEING MONITORED*
SN MINNESOTA DEPARTMENT OF HEALTH*
YR 1977 - 1981 (TO PRESENT)*
MT (SOURCE)
WATER SAMPLES FROM A NUMBER OF MUNICIPAL WELLS AND SURFACE WATER SOURCES;
(METHODS)
STANDARD METHODS;
(CLASSES)
LEVELS OF POLYNUCLEAR AROMATIC HYDROCARBONS*
MS (UNITS)
NOT INDICATED;
(FREQUENCY)
APPROXIMATELY WEEKLY, ALTHOUGH SCHEDULE DEPENDS ON LOCATION;

(SIZE)
14 WELLS IN ST LOUIS PARK, 8 WELLS IN EDINA, 6 WELLS IN HOPKINS, 1 WELL IN FRIDLEY, 3 WELLS IN ROBBINSDALE, 1 WELL IN WHITE BEAR LAKE, MINNEAPOLIS AND ST PAUL MUNICIPAL SYSTEMS (FROM SURFACE WATER)*
FT MANUAL FILES*
DE GROUNDWATER, SURFACE WATER, WATER QUALITY, HAZARDS, WATER POLLUTION, WELLS, CARCINOGENS, MUNICIPAL ENGINEERING, GEOLOGY, HYDROLOGY, ENVIRONMENTAL MONITORING, HYDROGEOLOGY*
LO MINNESOTA DEPARTMENT OF HEALTH,
HEALTH RISK ASSESSMENT SECTION, ENVIRONMENTAL HEALTH DIVISION,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
AV NO RESTRICTIONS, CONTACT DAVID GRAY (612-296-5352)*
GC (REFERENCE)
NOT INDICATED;
(AREA)
MN, REGION 11, HENNEPIN COUNTY, RAMSEY COUNTY, WASHINGTON COUNTY, ST LOUIS PARK, EDINA, HOPKINS, FRIDLEY, ROBBINSDALE, WHITE BEAR LAKE, MINNEAPOLIS, ST PAUL*
/EOR

AN 0000Z004244*
ID DATA*
NU SWIM-D-008001*
NU MNDH-D-1*
AU MINNESOTA DEPARTMENT OF HEALTH*
IN MINNESOTA DEPARTMENT OF HEALTH,
PUBLIC WATER SUPPLY UNIT,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
TI SAFE DRINKING WATER ACT: WATER QUALITY MONITORING*
RS THE FUNCTION OF THIS PROGRAM IS TO MONITOR THE WATER QUALITY OF ALL PUBLIC WATER SUPPLIES. PUBLIC WATER SUPPLIES ARE DEFINED IN THREE CATEGORIES: COMMUNITY MUNICIPAL (LARGE SYSTEMS SERVING A MUNICIPALITY), COMMUNITY NON-MUNICIPAL (THOSE SERVING 25 OR MORE YEAR ROUND RESIDENTS SUCH AS NURSING HOME, OR THOSE WITH 15 OR MORE SERVICE CONNECTIONS SUCH AS A RURAL WATER SYSTEM), AND NON-COMMUNITY SYSTEMS (SUCH AS RESTAURANTS OR SERVICE STATIONS)*
AC (PUBLICATIONS)
PUBLIC WATER SUPPLY DATA 1977 (SUMMARY OF MUNICIPAL DATA AND A GENERAL WATER SUPPLY REPORT)*
TY PRIMARY*
NT LAWS: MINNESOTA STATE STATUTE 66.3(C) (MINNESOTA SAFE DRINKING WATER ACT), AND PULIC LAW 93-523 (NATIONAL SAFE DRINKING WATER ACT). RULES: 6MCAR 1.145 - 1.149. PRIVATE DOMESTIC WELLS ARE NOW TESTED THROUGH HEALTH DEPARTMENTS OR PRIVATE LABORATORIES*
SN MINNESOTA DEPARTMENT OF HEALTH*
YR 1900 - 1981 (TO PRESENT)*
MT (SOURCE)
FOR DAILY MONITORING, THE STAFF OF THE WATER SUPPLY TAKES THE WATER SAMPLE. THE MINNESOTA HEALTH DEPARTMENT (MHD) DOES THEIR OWN MONITORING ON A 15 MONTH CYCLE AND AT THAT TIME THE MHD STAFF TAKES THE WATER SAMPLE;

(METHODS)
FOR DAILY MONITORING, THE WATER SUPPLIER DOES HIS OWN LAB WORK OR SENDS IT OUT TO A PRIVATE LAB THAT MEETS ENVIRONMENTAL PROTECTION AGENCY STANDARDS. FOR MHD 15 MONTH MONITORING THE SAMPLES GO TO THE MHD LAB FOR ANALYSIS;
(CLASSES)
TEMPERATURE, COLIFORM, ORGANISMS, TOTAL SOLIDS, TURBIDITY, COLOR, HARDNESS, ALKALINITY, PH, IRON, MANGANESE, CHLORIDE, RESIDUAL CHLORINE, SULFATE, FLUORIDE, NITRATE, NITRITE NITROGEN, CALCIUM, SODIUM, POTASSIUM, MAGNESIUM, ARSENIC, BARIUM, CHROMIUM, CADMIUM, LEAD, MERCURY, SELENIUM, SILVER, ZINC, COPPER, NICKEL, TOTAL ORGANIC CARBON, AMMONIA NITROGEN, ORGANIC NITROGEN, PHENOL, OIL, GREASE, ENDRIN, LINDANE, METHOXYCHLOR, TOXAPHENE, 2,4-D, 2,3,5-TP (SILVEX), RADIOCHEMICAL*

MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
DEPENDING ON THE FACILITY MONITORING TAKES PLACE 20 TIMES PER DAY TO WEEKLY, THE MHD MONITORS EITHER EVERY 15 OR EVERY 30 MONTHS;
(SIZE)
10000 NON-COMMUNITY SYSTEMS, 700 MUNICIPAL COMMUNITY SYSTEMS, AND 250 NON-MUNICIPAL COMMUNITY SYSTEMS*

FT MANUAL FILES; COMPLIANCE AND VIOLATION REPORTS GO TO THE US ENVIRONMENTAL PROTECTION AGENCY NATIONAL COMPUTER SYSTEM*

DE SURFACE WATER, GROUNDWATER, WATER QUALITY, WATER SUPPLY, POTABLE WATER, WATER POLLUTION, WELLS, CHEMICAL ANALYSIS, DRINKING WATER*

LO MINNESOTA DEPARTMENT OF HEALTH,
PUBLIC WATER SUPPLY UNIT,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*

AV NO RESTRICTIONS, CONTACT GARY ENGLUND (612-296-5330)*

GC (REFERENCE)
STREET ADDRESS, MINNESOTA UNIQUE WELL NUMBER;
(AREA)
MN*

/EOR

AN 0000Z004245*

ID DATA*

NU SWIM-D-008001*

NU MNDH-D-2*

AU MINNESOTA DEPARTMENT OF HEALTH*

IN MINNESOTA DEPARTMENT OF HEALTH,
PUBLIC WATER SUPPLY UNIT,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*

TI SAFE DRINKING WATER ACT: INVENTORY OF PUBLIC WATER SUPPLIES*

RS THE PURPOSE OF THIS PROGRAM IS TO KEEP AN INVENTORY OF PUBLIC WATER SUPPLIERS AND CERTAIN CHARACTERISTICS. IT IS DONE UNDER THE REQUIREMENTS OF THE STATE AND FEDERAL SAFE DRINKING WATER ACTS.*

TY PRIMARY*

SN MINNESOTA DEPARTMENT OF HEALTH*

YR 1974 - 1981 (TO PRESENT)*

MT (SOURCE)
WATER SUPPLIERS PROVIDE THE DATA;
(METHODS)
NOT INDICATED;
(CLASSES)
NAME OF SUPPLIER, ADDRESS, POPULATION SERVED, WATER USE INFORMATION (TYPE OF USE IN PERCENT), SYSTEM DESIGN (LOCATION OF WATER TOWERS AND WATER MAINS ON MAPS), EMERGENCY PLANS IF REQUIRED*
MS (UNITS)
NOT INDICATED;
(FREQUENCY)
UPDATED ANNUALLY;
(SIZE)
950*
FT MANUAL FILES*
DE SURFACE WATER, GROUNDWATER, WATER QUALITY, WATER POLLUTION, WATER SUPPLY, POTABLE WATER, DRINKING WATER, WELLS, CHEMICAL ANALYSIS, WATER USE*
LO MINNESOTA DEPARTMENT OF HEALTH,
PUBLIC WATER SUPPLY UNIT,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
AV NO RESTRICTIONS, CONTACT GARY ENGLUND (612-296-5330)*
GC (REFERENCE)
STREET ADDRESS, MINNESOTA UNIQUE WELL NUMBER;
(AREA)
MN*
/EOR

ID DATA*
NU SWIM-D-009001*
AU MINNESOTA DEPARTMENT OF HEALTH*
IN MINNESOTA DEPARTMENT OF HEALTH,
ENVIRONMENTAL HEALTH DIVISION,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
TI SOUTHEASTERN MINNESOTA GROUNDWATER STUDY (KARST STUDY): GROUNDWATER QUALITY DATA*
RS TO DETERMINE WHETHER OR NOT ACTIONS RELATED TO PROPER CONSTRUCTION OF NEW WELLS AND SEALING OF ABANDONED WELLS, ALONG WITH IMPROVED LAND USE AND POLLUTION CONTROL PRACTICES, SHOULD BE TAKEN TO MANAGE LONG TERM KARST PROBLEM, WHICH WILL EFFECTIVELY PROTECT THE GROUNDWATER QUALITY FOR USE AS THE PRIMARY WATER SUPPLY IN SOUTHEASTERN MINNESOTA.*
AC (PUBLICATIONS)
SOUTHEASTERN MINNESOTA GROUNDWATER STUDY REPORT; PROBLEMS RELATING TO SAFE WATER SUPPLY IN SOUTHEASTERN MINNESOTA (1976); SOUTHEASTERN MINNESOTA GROUNDWATER STUDY: FINAL REPORT (1979)*
TY SECONDARY*
NT MINNESOTA STATE STATUTES 455.55.5B; OTHER AGENCIES INVOLVED: MINNESOTA GEOLOGICAL SURVEY, US GEOLOGICAL SURVEY, COLLEGE OF VETERINARY MEDICINE UNIVERSITY OF MINNESOTA*
SN LEGISLATIVE COMMISSION ON MINNESOTA RESOURCES (LCMR)*
YR JUNE 1977 - DECEMBER 1978*

MT (SOURCE)
PRIMARILY OTHER DATA COLLECTIONS;
(METHODS)
DATA COLLECTIONS OF MINNESOTA DEPARTMENT OF HEALTH, COLLEGE OF VETERINARY MEDICINE, US GEOLOGICAL SURVEY, AND MINNESOTA GEOLOGICAL SURVEY;
(CLASSES)
NOT INDICATED*
MS NOT INDICATED*
FT MANUAL FILES, COMPUTER FILES*
DE MODELING, GROUNDWATER, EPIDEMIOLOGY, GEOLOGY, SUBSURFACE DRAINAGE, KARST, WATER POLLUTION, WATER SUPPLY, WATER QUALITY*
LO MINNESOTA DEPARTMENT OF HEALTH,
ENVIRONMENTAL HEALTH DIVISION,
717 DELAWARE STREET SOUTHEAST,
MINNEAPOLIS MN 55440*
AV NO RESTRICTIONS, CONTACT ED ROSS (612-296-5338)*
GC (REFERENCE)
NOT INDICATED;
(AREA)
MN, REGION 10, FILLMORE COUNTY, HOUSTON COUNTY, GOODHUE COUNTY, MOWER COUNTY, OLMSTED COUNTY, WABASHA COUNTY, WINONA COUNTY*
/EOR

AN 0000Z001489*
ID DATA*
NU SWIM-D-025001*
NU DNRM-D-18*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
MINERALS DIVISION,
ENVIRONMENTAL SERVICES,
CENTENNIAL OFFICE BUILDING,
ST PAUL MN 55155*
TI HEAVY METALS LEACHING STUDIES*
RS THE PURPOSE OF THIS PROGRAM IS TO LOOK AT POTENTIAL ENVIRONMENTAL IMPACTS OF RUNOFF FROM DULUTH/GABBRO MINING STOCKPILES AND TO DEVELOP METHODS TO CONTROL POTENTIALLY HARMFUL RUNOFF AND LEACHING.*
AC (PUBLICATIONS)
MINNAMAX: LABORATORY TESTING, INTERIM REPORT (1977);
WATER RESOURCES (1979);
METAL SULFIDE LEACHING POTENTIAL IN THE DULUTH GABBRO COMPLEX: A LITERATURE SURVEY (1976);
PROGRESS REPORT TO COPPER NICKEL REGIONAL TASK FORCE: RATES, MECHANISM AND CONTROL OF METAL SULFIDE LEACHING FROM GABBRO MINING RELATED SOLIDS (1977);
KINETICS AND MECHANISMS OF METAL SULFIDE RELEASE FROM MINING DERIVED SOLIDS (1977);
KINETICS AND MECHANISMS OF THE OXIDATIVE DISSOLUTION OF METAL SULFIDE AND SILICATE MINERALS PRESENT IN THE DULUTH GABBRO (NO DATE);
ENVIRONMENTAL LEACHING OF DULUTH GABBRO UNDER LABORATORY AND FIELD CONDITIONS: OXIDATIVE DISSOLUTION OF METAL SULFIDE AND SILICATE MINERALS (1980);

ENVIRONMENTAL LEACHING OF TRACE METALS FROM WASTE ROCK AND LEAN ORE STOCKPILES (1980);
MECHANISMS AND RATES OF LEACHING FROM DULUTH GABBRO WASTE ROCK (1980);
FIELD STUDIES: LEACHING, METAL TRANSPORT, AND METAL PATHWAYS (1977);
LEACHING AND CHEMICAL TRANSPORT AT THE ERIE MINING COMPANY DUNKA SITE (1981);
TRANSPORT OF CHEMICAL CONSTITUENTS PRESENT IN MINING RUNOFF THROUGH A CREEK SYSTEM (1980);
PEAT BOGS AND METAL INTERACTIONS (1978);
TRACE METAL REMOVAL BY PEAT: RESULTS OF A FIELD STUDY CONDUCTED AT THE ERIE MINING COMPANY DUNKA SITE (1980);
TRACE METAL UPTAKE BY PEAT: INTERACTION OF WHITE CEDAR BOG AND MINING STOCKPILE LEACHATE (1980);
TRANSPORT OF TRACE METALS AND OTHER CHEMICAL COMPONENTS IN MINING RUNOFF THROUGH A SHALLOW BAY (1981);
TRACE METAL CONCENTRATIONS IN NUPHAR VARIEGATUM FROM THE REGIONAL COPPER NICKEL STUDY AREA IN NORTHEASTERN MINNESOTA (1981);
FIELD LEACHING SUMMARY REPORT (1977);
1978 DNR/AMAX FIELD LEACHING AND RECLAMATION PROGRAM (1979);
LEACHING AND REVEGETATION OF LOW GRADE MINERALIZED STOCKPILES, A STATUS REPORT (1980);
HEAVY METALS STUDY: 1979 PROGRESS REPORT ON THE FIELD LEACHING AND RECLAMATION PROGRAM AND THE REMOVAL OF METALS FROM STOCKPILE RUNOFF BY PEAT AND TAILINGS (1980);
HYDROLOGY OF STOCKPILES OF SULFIDE BEARING GABBRO IN NORTHEASTERN MINNESOTA (1980);
HYDROLOGY OF WASTE ROCK STOCKPILES IN NORTHEASTERN MINNESOTA: CONCEPTUAL MODEL (1981);
HYDROLOGY OF WASTE ROCK STOCKPILES IN NORTHEASTERN MINNESOTA: FIELD RESULTS (1981)*

TY PRIMARY*

NT THIS PROGRAM CONTINUES WATER QUALITY STUDIES BEGUN UNDER THE REGIONAL COPPER NICKEL STUDY WHICH ASSESSED THE POTENTIAL ENVIRONMENTAL EFFECTS OF FUTURE MINING ACTIVITIES IN NORTHEASTERN MINNESOTA*

SN MINNESOTA DEPARTMENT OF NATURAL RESOURCES, LEGISLATIVE COMMISSION ON MINNESOTA RESOURCES, US BUREAU OF MINES, ENVIRONMENTAL PROTECTION AGENCY, IRON RANGE RESOURCES AND REHABILITATION BOARD, AMAX, ERIE MINING COMPANY*

YR 1976 - 1981 (TO PRESENT)*

MT (SOURCE)
WATER SAMPLES FROM OUTFLOW STREAMS, LAKES, WETLANDS AND WELLS;
(METHODS)
WATER SAMPLES TESTED BY ENVIRONMENTAL PROTECTION AGENCY APPROVED LABORATORY METHODS: SURFACE AND GROUNDWATER SAMPLES FROM THE ERIE SITE AND SURFACE WATER SAMPLES ONLY FROM THE AMAX SITE. MINNESOTA DEPARTMENT OF NATURAL RESOURCES COLLECTS SAMPLES AT AMAX SITE AND ERIE SITE;
(CLASSES)
PH, ALKALINITY, SPECIFIC CONDUCTIVITY, CALCIUM, MAGNEISUM, SODIUM, ZINC, POTASSIUM, COPPER, NICKEL, COBALT, IRON, MANGANESE, SULFATE, CHLORIDES*

MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
CONTINUOUS AT AMAX, EVERY TWO WEEKS AT ERIE DURING STORM SEASON
(APRIL TO NOVEMBER);
(SIZE)
ABOUT 100 SAMPLES PER YEAR AT ERIE, ABOUT 150 - 200 SAMPLES PER YEAR
AT AMAX*
FT MANUAL FILES*
DE SURFACE WATER, GROUNDWATER, WATER QUALITY, MINING, RUNOFF, HEAVY
METALS, LEACHING, PEAT*
LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
MINERALS DIVISION,
ENVIRONMENTAL SERVICES,
CENTENNIAL OFFICE BUILDING,
658 CEDAR STREET,
ST PAUL MN 55155*
AV NO RESTRICTIONS, CONTACT PAUL EGER (612-296-4807)*
GC (REFERENCE)
NOT INDICATED;
(AREA)
MN, REGION 3, ST LOUIS COUNTY, DULUTH, BABBITT, ERIE-DUNKA MINE,
AMAX TEST SITE*
/EOR

AN 0000Z001474*
AN 0000Z001877*
ID DATA*
NU SWIM-D-026001*
NU DNRM-D-1*
NU DCAT-D-19*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF MINERALS,
CENTENNIAL OFFICE BUILDING,
ST PAUL MN 55155*
TI IRON RANGE INFORMATION SYSTEM (IRIS): WATER RELATED DATA*
RS TO ESTABLISH AN IN-HOUSE SOURCE OF INFORMATION CONCERNING THE IRON
RANGE AND TO ASSIST MINING OPERATORS AND THE STATE IN DEVELOPING AND
EVALUATING MINING PROPOSALS UNDER THE RULES AND REGULATIONS FOR
MINELAND RECLAMATION.*
AC (PUBLICATIONS)
DATA MANUAL (1980)*
TY PRIMARY*
NT NECESSARY FOR THE OPERATION OF THE MINELAND RECLAMATION PROGRAM,
MINNESOTA STATE STATUTE 93.44 - 93.51*
SN MINNESOTA DEPARTMENT OF NATURAL RESOURCES; LEGISLATIVE COMMISSION
ON MINNESOTA RESOURCES (1977-1980); IRON RANGE RESOURCES AND
REHABILITATION BOARD*
YR 1959 - 1981 (TO PRESENT)*
MT (SOURCE)
TOPOGRAPHIC MAPS, COUNTY HIGHWAY MAPS, AIR PHOTOS, STATE
COMPREHENSIVE OUTDOOR RECREATIION PLAN MAPS, RAILROAD MAPS, UTILITY
MAPS, MINING COMPANY MAPS;

(METHODS)
GRID OVERLAY;
(CLASSES)
PUBLIC LAND SURVEY REFERENCE SYSTEM, BEDROCK GEOLOGY, SOIL ASSOCIATIONS, WATERSHEDS, SURFACE HYDROLOGY, URBAN AND RURAL DEVELOPMENT, UNIQUE NATURAL AREAS, ULTIMATE MINE PIT LIMITS, VEGETATION, ROADS, APPROPRIATION AND DISCHARGE POINTS, MINING LAND USE. THE FOLLOWING DATA WILL BE AUTOMATED BY JULY 1981: LAKE SURVEYS (FROM DNR FISH AND WILDLIFE DIVISION) - PHYSICAL, BIOLOGICAL, CHEMICAL, RECREATIONAL, AND INDUSTRIAL CHARACTERISTICS, STORET WATER QUALITY INFORMATION FOR THE SITE, WATER APPROPRIATION AND DISCHARGE AMOUNTS (FROM DNR WATER DIVISION), AND NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT DISCHARGE DATA*

MS (UNITS)
ONE HECTARE CELLS (2.47 ACRES);
(FREQUENCY)
INFREQUENT;
(SIZE)
300,000 CELLS COVERING 1100 SQUARE MILES*

FT MANUAL FILES, COMPUTER FILES (UNIVERSITY COMPUTER CENTER)*

DE GEOLOGY, MINING, LAND RECLAMATION, MINERAL INDUSTRY, SURFACE WATER, GROUNDWATER, WATER QUALITY, WATER QUANTITY, DATA, INFORMATION RETRIEVAL*

LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF MINERALS,
THIRD FLOOR CENTENNIAL OFFICE BUILDING,
658 CEDAR STREET,
ST PAUL MN 55155*

AV NO RESTRICTIONS, CONTACT PATRICIA LANG (612-296-4807)*

GC (REFERENCE)
UTM, PUBLIC LAND SURVEY, WATERSHED, LAKE NAME, STREAM NAME, DNR LAKE NUMBER;
(AREA)
MN, REGION 3, IRON RANGE, ITASCA COUNTY, ST LOUIS COUNTY, GRAND RAPIDS, BABBITT*

/EOR

AN 0000Z001891*

ID DATA*

NU SWIM-D-027001*

NU DNRM-D-15*

NU DCAT-D-36*

AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*

IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF MINERALS,
CENTENNIAL OFFICE BUILDING,
ST PAUL MN 55155*

TI MINELAND RECLAMATION PROGRAM (PERMIT TO MINE)*

RS AUTHORIZATION OF MINING PERMITS.*

TY PRIMARY*

NT REQUIRED BY MINNESOTA STATE STATUTE 93.44-93.51, RULES: 6MCAR 1.0401*

SN MINNESOTA DEPARTMENT OF NATURAL RESOURCES*

YR NEW PROGRAM TO BEGIN MARCH 1981*

MT (SOURCE)
AIR PHOTOS, USGS TOPOGRAPHIC MAPS, MINNESOTA DEPARTMENT OF NATURAL RESOURCES FIELD SURVEYS;
(METHODS)
MINING COMPANY MUST SUBMIT DETAILED MAPS, PLANS AND ENGINEERING DRAWINGS;
(CLASSES)
GENERAL MATERIALS RELATED TO THE MINING COMPANY AND LOCATION OF FACILITIES AND LAND USE, ENVIRONMENTAL SETTING MAPS (BEDROCK GEOLOGY, WATER BASINS, COURSES AND WETLANDS WHICH MIGHT BE AFFECTED BY MINING OPERATIONS), WATERSHED BOUNDARIES, DETAILS OF GROUNDWATER CONDITIONS BASED ON BEST AVAILABLE INFORMATION AND EXPLORATORY DRILL HOLES, NATURAL RESOURCE SITES (FROM MINESITE), FOREST AND SOIL INVENTORIES, INVENTORY OF PAST MINING FACILITIES, MINING AND RECLAMATION MAPS (MINERAL RESERVES), DETAILED DRAINAGE PATTERNS FOR WATERS WHICH MAY CONTAIN LEACHABLE MATERIALS, DETAILS ON WATERSHED MODIFICATIONS (INCLUDING CHANGES IN THE BOUNDARIES, DIVERSIONS, DISPOSITION OF SURFACE WATER FLOWS AND RUNOFF), CONSTRUCTION OF ANY MINING FACILITIES (RESERVOIRS, TAILINGS BASINS, DAMS, DRAINAGE CONTROLS, SETTLING BASINS), ALSO INCLUDED MUST BE THE FINAL TOPOGRAPHY PROPOSED, THE POST-MINING DRAINAGE SYSTEM INCLUDING THE AMOUNTS AND LOCATIONS OF DISCHARGE TO RECEIVING WATERS, EXTENT AND TYPE OF VEGETATION, EXISTING AND EXPECTED LEVEL OF PIT WATER*
MS (FREQUENCY)
IRREGULAR*
FT MANUAL FILES*
DE GEOLOGY, MINERAL INDUSTRY, MINING, SURFACE WATER, GROUNDWATER, WATER QUALITY, WATER QUANTITY, TAILINGS BASINS, RECLAMATION, RUNOFF*
LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF MINERALS,
THIRD FLOOR CENTENNIAL OFFICE BUILDING,
658 CEDAR STREET,
ST PAUL MN 55155*
AV INFORMATION MAY BE REVIEWED IN OFFICE, CONTACT PAUL POJAR OR ARLO KNOLL (612-296-4807)*
GC (REFERENCE)
UTM COORDINATES;
(AREA)
MN, REGION 3*
/EOR

AN 0000Z001892*
ID DATA*
NU SWIM-D-028002*
NU DNRM-D-16*
NU DCAT-D-35*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF MINERALS,
CENTENNIAL OFFICE BUILDING,
ST PAUL MN 55155*
TI MINERAL EXPLORATION REGISTRATION: BORE HOLE DATA*

RS TO FIND OUT WHICH COMPANIES ARE ACTIVELY EXPLORING IN THE STATE AND
EVENTUALLY WHAT THEY ARE FINDING. RELATED TO PROTECTING THE
PUBLIC'S HEALTH AND WELFARE, ESPECIALLY TO CONTROL THE POSSIBLE
ADVERSE EFFECTS OF MINING ON WATER SUPPLIES. AN ABANDONMENT REPORT
IS REQUIRED WHEN WORK IS COMPLETED AT THE DRILLED HOLE. THIS REPORT
CONTAINS VARIOUS PIECES OF WATER RELATED INFORMATION.*
TY PRIMARY*
NT REQUIRED BY MINNESOTA STATE STATUTE CHAPTER 535*
SN MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
YR MAY 1980 - 1981 (TO PRESENT, NEW PROGRAM)*
MT (SOURCE)
REGISTRATION FORMS, DRILLERS LOGS OF EXPLORATION HOLES;
(METHODS)
TABULATION AND LOCATION ON MAPS BY 40 ACRE PARCELS;
(CLASSES)
DRILLING COMPANIES AND REPRESENTATIVES, LOCATION OF BORINGS,
SOME BORING DATA; CLASSES FROM ABANDONMENT REPORT: LOCATION OF DRILL
HOLE, TYPE AND THICKNESS OF OVERBURDEN AND ROCK ENCOUNTERED,
IDENTIFICATION OF WATER BEARING FORMATIONS ENCOUNTERED,
IDENTIFICATION OF HYDROLOGIC CONDITIONS ENCOUNTERED, METHOD OF
ABANDONMENT, METHODS OF CONSTRUCTION AND DRILLING, AVERAGE
SCINTILLOMETER READING OF WASTE DRILL CUTTINGS (ACTUAL BORING
MATERIALS ARE SUBMITTED TO THE DNR REGIONAL OFFICE IN HIBBING)*
MS (UNITS)
40 ACRE PARCELS;
(FREQUENCY)
ANNUALLY*
FT MANUAL FILES, MAPS*
DE GEOLOGY, MINERAL INDUSTRY, MINING, HYDROLOGY, GROUNDWATER, WATER
QUALITY, WATER QUANTITY*
LO REGISTRATION INFORMATION:
MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF MINERALS,
THIRD FLOOR CENTENNIAL BUILDING,
ST PAUL MN 55155*
LO TEST HOLE DATA:
MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF MINERALS,
1525 THIRD AVENUE EAST,
HIBBING MN 55746*
AV DATA IS RESTRICTED BY LAW, CONTACT MORRIS ENG (612-296-4807)*
GC (REFERENCE)
COUNTY NAME, GEOMORPHIC REGION, LATITUDE/LONGITUDE, PUBLIC LAND
SURVEY;
(AREA)
MN, REGION 3, REGION 7E, REGION 8, CARLTON COUNTY,
ST LOUIS COUNTY, KANABEC COUNTY, PINE COUNTY, MURRAY COUNTY*
/EOR

AN 0000Z001883*
ID DATA*
NU DNRM-D-7*
NU DCAT-D-81*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*

IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF MINERALS,
CENTENNIAL OFFICE BUILDING,
ST PAUL MN 55155*

TI PEAT STUDY: GENERAL DESCRIPTION*

RS THE PEAT PROGRAM IS A COMPREHENSIVE STUDY OF THE PEATLANDS WHICH INCLUDES STUDY OF THE SOCIOECONOMIC AND ENVIRONMENTAL IMPACTS OF THE PEATLANDS, AN EVALUATION OF PEAT RESOURCES, AN EVALUATION OF RECLAMATION FEASIBILITY, AND AN ASSESSMENT OF THE POTENTIAL USES OF PEATLANDS. THE PROGRAM WILL ALSO MAKE POLICY RECOMMENDATIONS TO THE LEGISLATURE CONCERNING THE WISE USE OF PEATLAND RESOURCES.*

AC (RESEARCH)
PEAT INVENTORY PROGRAM;
EVALUATION OF PEATLAND TERRESTRIAL VERTEBRATE LITERATURE;
EVALUATION OF PEATLAND VEGETATION AND FORESTRY LITERATURE;
IMPORTANCE OF PEATLAND HABITATS TO SMALL MAMMALS IN MINNESOTA;
BIRD POPULATION STRUCTURE AND SEASONAL HABITAT AS INDICATORS OF ENVIRONMENTAL QUALITY OF PEATLANDS;
UTILIZATION OF MINNESOTA PEATLAND HABITATS BY LARGE MAMMALS AND BIRDS;
RELATIONSHIP OF AMPHIBIANS AND REPTILES TO PEATLAND HABITATS IN MINNESOTA;
ECOLOGICAL AND FLORISTIC STUDIES OF THE PEATLAND VEGETATION OF NORTHERN MINNESOTA;
VEGETATION ANALYSIS OF SELECTED BELTRAMI, KOOCHICHING, AND ST LOUIS COUNTY PEATLANDS BY REMOTE SENSING METHODS;
PEATLAND WATER RESOURCE;
EVALUATION OF HYDROLOGIC LITERATURE AND PRELIMINARY WATER BUDGET MODEL;
MONITORING WATER QUALITY AND QUANTITY OF DISTURBED AND UNDISTURBED PEATLANDS;
POTENTIAL AIR QUALITY IMPACTS OF HARVESTING PEAT IN NORTHERN MINNESOTA;
SOCIOECONOMIC IMPACTS OF PEAT DEVELOPMENT OF NORTHERN MINNESOTA;
PEAT UTILIZATION AND THE RED LAKE INDIAN RESERVATION;
CHEMICAL/INDUSTRIAL UTILIZATION OF PEAT;
ANALYSIS OF MINNESOTA PEAT FOR POSSIBLE INDUSTRIAL/CHEMICAL USES;
AGRICULTURAL/HORTICULATURAL USES OF PEAT;
FEASIBILITY STUDY OF PEAT AS A POWER PLANT FUEL;
EVALUATION OF GASIFICATION RESEARCH;
AGRICULTURAL RECLAMATION OF PEATLANDS;
FORESTRY RECLAMATION OF PEATLANDS;
PEATLAND RECLAMATION DEMONSTRATION AT WILDERNESS VALLEY FARMS;
POTENTIAL OF PEAT AS A POWER PLANT FUEL;
PEATLAND POLICY STUDY;
PEAT TAXATION STUDY;
PEAT LEASE FORMAT;
ROYALTIES FOR EXTRACTED PEAT*

TY PRIMARY, SECONDARY*

NT THIS PROGRAM IS A SERIES OF ONE TIME RESEARCH PROJECTS DONE PRIMARILY BY CONTRACTORS FROM THE UNIVERSITY OF MINNESOTA, BEMIDJI STATE UNIVERSITY, MINNESOTA COOPERATIVE SOIL SURVEY, AREA REGIONAL DEVELOPMENT COMMISSIONS AND OTHERS. SOME OF THE ORIGINAL WATERS DATA ARE AVAILABLE, OTHERS ARE AVAILABLE THROUGH PUBLISHED LCMR REPORTS*

SN LEGISLATIVE COMMISSION ON MINNESOTA RESOURCES; MINNESOTA DEPARTMENT
OF NATURAL RESOURCES*
YR 1976 - 1981*
MT (SOURCE)
PEATLANDS;
(METHODS)
NOT INDICATED;
(CLASSES)
PEATLAND WATER QUALITY: PHYSICAL, CHEMICAL PARAMETERS INCLUDING
METALS; SURFACE WATER CHARACTERISTICS: TEMPERATURE, DISCHARGE;
GROUNDWATER LEVELS: WELLS, WATER TABLE, PIEZOMETERS;
METEOROLOGICAL DATA: PRECIPITATION, TEMPERATURE, EVAPORATION,
SNOW SURVEY*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
PROGRAM IS A SERIES OF ONE TIME RESEARCH PROJECTS*
FT MANUAL FILES, COMPUTER FILES*
DE PEAT, PEATLANDS, WATER QUALITY, METEOROLOGY, GROUNDWATER, SURFACE
WATER, WATER TABLE, LAND USE PLANNING*
LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF MINERALS,
THIRD FLOOR CENTENNIAL OFFICE BUILDING,
658 CEDAR STREET,
ST PAUL MN 55155*
AV NO RESTRICTIONS, CONTACT DENNIS ASMUSSEN (612-296-4807)*
GC (REFERENCE)
COUNTY NAME;
(AREA)
MN, REGION 1, REGION 2, REGION 3, RED LAKE COUNTY, BELTRAMI COUNTY,
CARLTON COUNTY, ITASCA COUNTY, ST LOUIS COUNTY, KOOCHICHING COUNTY*
/EOR

AN 0000Z001884*
ID DATA*
NU SWIM-D-030003*
NU DNRM-D-8*
NU DCAT-D-85*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF MINERALS,
CENTENNIAL OFFICE BUILDING,
ST PAUL MN 55155*
TI PEAT STUDY: GROUNDWATER QUANTITY*
RS THE PEAT PROGRAM IS A COMPREHENSIVE STUDY OF THE PEATLANDS WHICH
INCLUDES STUDY OF THE SOCIOECONOMIC AND ENVIRONMENTAL IMPACTS OF THE
PEATLANDS, AN EVALUATION OF PEAT RESOURCES, AN EVALUATION OF
RECLAMATION FEASIBILITY, AND AN ASSESSMENT OF THE POTENTIAL USES OF
PEATLANDS. THE PROGRAM WILL ALSO MAKE POLICY RECOMMENDATIONS TO THE
LEGISLATURE CONCERNING THE WISE USE OF PEATLAND RESOURCES.*
AC DATA WILL BE SUMMARIZED IN A PUBLICATION: WATER RESOURCES OF
PEATLANDS (1981)*
TY PRIMARY*

NT THIS STUDY IS ONE OF A NUMBER OF STUDIES SPONSORED BY THE PEAT
   PROGRAM. SEVERAL OF THESE HAVE WATER RELATED COMPONENTS. THIS IS A
   ONE TIME FOUR YEAR RESEARCH EFFORT WHICH WILL END IN 1981*
SN MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
YR 1978 - 1981*
MT (SOURCE)
   MEASUREMENTS FROM WELLS;
   (METHODS)
   PIEZOMETERS, DROP LINES, WELLS INSTALLED BY MINNESOTA DEPARTMENT
   OF NATURAL RESOURCES FOR THIS PURPOSE;
   (CLASSES)
   WATER LEVELS*
MS (UNITS)
   FEET;
   (FREQUENCY)
   CONTINOUS READINGS AT SOME SITES AND MONTHLY READINGS AT OTHERS;
   (SIZE)
   100 WELLS AT THREE AREAS*
FT MANUAL FILES*
DE GROUNDWATER, ATMOSPHERE, WATER QUALITY, WELLS, WATER LEVELS,
   PEATLANDS, LAND USE PLANNING*
LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
   DIVISION OF MINERALS,
   THIRD FLOOR CENTENNIAL OFFICE BUILDING,
   658 CEDAR STREET,
   ST PAUL MN 55155*
AV NO RESTRICTIONS, CONTACT JACK CLAUSEN (612-296-4807)*
GC (REFERENCE)
   PUBLIC LAND SURVEY;
   (AREA)
   MN, REGION 3, ST LOUIS COUNTY, CARLTON COUNTY, TOIVOLA BOG,
   CORONA BOG, FENS PEATLAND*
/EOR

AN 0000Z001470*
ID DATA*
NU SWIM-D-039001*
NU DNRW-D-28*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
   WATERS DIVISION,
   GROUNDWATER GROUP,
   HYDROLOGY SECTION,
   SPACE CENTER BUILDING,
   ST PAUL MN 55101*
TI GROUNDWATER PROGRAM: AQUIFER CHARACTERISTICS AND TESTS*
RS TO DELINEATE, QUANTIFY AND EVALUATE THE STATE'S GROUNDWATER
   RESOURCES. OBJECTIVE OF THE PROGRAM IS FOCUSED ON GROUNDWATER DATA
   COLLECTION, ANALYSIS, AND PRESENTATION OF RESULTS SO THAT RESOURCE
   MANAGEMENT DECISIONS CAN BE BASED ON THE BEST AVAILABLE INFORMATION.
   THESE TESTS ARE REQUIRED IN CERTAIN INSTANCES BEFORE A PERMIT TO
   APPROPRIATE WATER MAY BE ISSUED.*
AC (PUBLICATIONS)
   SELECTED AQUIFER TESTS IN MINNESOTA (1980);
   AQUIFER TEST LOCATIONS (1979)*

TY PRIMARY AND SECONDARY*
NT LAWS: MINNESOTA STATE STATUTE 105.38.1 - 2, 105.39.1, 105.39.26, 105.405.1, 105.44, 105.416, 105.51. ADMINISTRATIVE RULES ALSO BEING PROMULGATED. MINNESOTA DEPARTMENT OF NATURAL RESOURCES WORKS WITH AND EXCHANGES DATA WITH US GEOLOGICAL SURVEY, MINNESOTA GEOLOGIC SURVEY (IF GEOLOGIC INTERPRETATION IS REQUESTED). IN ADDITION TO ISSUING PERMITS, THE DATA IS ALSO USED FOR AQUIFER ANALYSIS, ESTIMATES OF DRAWDOWNS AND RECHARGE AND IN QUESTION REGARDING INTERFERENCE WITH NEIGHBORING WELLS, IMPACT ON SURFACE WATERS.*
SN MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
YR 1960 - 1981 (TO PRESENT)*
MT (SOURCE)
AQUIFER TESTS REQUIRED AND FILED BY APPLICANTS FOR CERTAIN APPROPRIATION PERMITS. US GEOLOGIC SURVEY STUDIES. OLD PERMIT FILES WHICH HAD AQUIFER TESTS ATTACHED;
(METHODS)
MAY BE PERFORMED BY MINNESOTA DEPARTMENT OF NATURAL RESOURCES STAFF, US GEOLOGICAL SURVEY OR PRIVATE CONSULTANTS - STANDARD METHODS ARE USED;
(CLASSES)
AQUIFER TEST NUMBER, LOCATION (PUBLIC LAND SURVEY), COUNTY, ELEVATION, STRATIGRAPHIC UNIT, DEPTH TO TOP OF AQUIFER, HYDROLOGIC CONDITION, SATURATED THICKNESS, DATE DRILLED, WELL DEPTH, CASING DEPTH, DIAMETER, SCREEN TYPE, STATIC WATER LEVEL, TOTAL DRAWDOWN, RESIDUAL DRAWDOWN, DISTANCE TO PRODUCTION WELL, DATE CONDUCTED, PUMPING TIME, RECOVERY TIME, DISCHARGE QUANTITY, SPECIFIC CAPACTITY, TRANSMISSIVITY, STORAGE COEFFICIENT, GEOLGIC/STRATIGRAPHIC DATA (AQUIFER NAME)*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
ONE TIME AT EACH WELL;
(SIZE)
220 TESTS*
FT MANUAL FILES, MAPS*
DE AQUIFERS, HYDROLOGY, GROUNDWATER, WATER ALLOCATION, WATER WELLS, GROUNDWATER RECHARGE*
LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
GROUNDWATER GROUP,
HYDROLOGY SECTION,
SPACE CENTER BUILDING,
444 LAFAYETTE ROAD,
ST PAUL MN 55101*
AV NO RESTRICTIONS, CONTACT DENNIS BEISSEL (612-296-0430)*
GC (REFERENCE)
PUBLIC LAND SURVEY, COUNTY NAME, AQUIFER NAME;
(AREA)
MN*
/EOR

AN 0000Z001471*
ID DATA*
NU SWIM-D-039002*

NU DNRW-D-29*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
GROUNDWATER GROUP,
HYDROLOGY SECTION,
SPACE CENTER BUILDING,
ST PAUL MN 55101*
TI GROUNDWATER PROGRAM: OBSERVATION WELL DATA BASE*
RS THE PURPOSE IS TO OBTAIN DATA ON GROUNDWATER LEVEL CHANGES IN AQUIFERS THROUGHOUT THE STATE, FOR BOTH RESEARCH AND WATER MANAGEMENT.*
AC (PUBLICATIONS)
LOCATIONS OF GROUNDWATER OBSERVATION WELLS (1979) - UPDATED ANNUALLY IN PUBLICATION TITLED HYDROGRAPHIC YEAR DATA;
WILL BE PUBLISHING SELECTED HYDROGRAPHS*
TY PRIMARY*
NT INCLUDES DATA ON ALL ACTIVE OR INACTIVE OBSERVATION WELLS DRILLED BY THE MINNESOTA DEPARTMENT OF NATURAL RESOURCES, US GEOLOGICAL SURVEY, MINNESOTA DEPARTMENT OF TRANSPORTATION OR PRIVATE WELL DRILLER*
SN MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
YR 1942 - 1981 (TO PRESENT)*
MT (SOURCE)
MINNESOTA DEPARTMENT OF NATURAL RESOURCES AND US GEOLOGICAL SURVEY STAFF MEASURES WATER LEVELS FROM OBSERVATION WELLS. STAFF ALSO OBTAINS WATER LEVEL DATA FROM A NETWORK SET UP BY THE SOIL AND WATER CONSERVATION DISTRICTS, IRRIGATOR'S ASSOCIATION, SOIL CONSERVATION SERVICE AND MINNEGASCO;
(METHODS)
MEASURED BY TAPE, SOME WELLS HAVE AUTOMATIC RECORDERS;
(CLASSES)
LOCATION OF WELL, NAME OF OBSERVER, UNIQUE WELL NUMBER, WELL CONSTRUCTION DATA, GEOLOGIC LOG, PERIOD OF RECORD, FREQUENCY OF MEASUREMENT, AQUIFER BEING MEASURED, WELL ELEVATION, WELL DEPTH, METHOD OF MEASUREMENT, ACTUAL WATER LEVELS, TYPE OF AQUIFER (CONFINED OR UNCONFINED), TOPOGRAPHIC SETTING, WELL NAME, COUNTY NAME*
MS (UNITS)
DEPTH TO WATER IN FEET;
(FREQUENCY)
VARIOUS, SOME ARE CONTINUOUS, SOME SEMI-ANNUALLY, MAJORITY ARE MONTHLY;
(SIZE)
17 METRO AREA SITES, 136 US GEOLGICAL SURVEY NETWORK GAUGES AND ABOUT 100 OTHER WELLS*
FT COMPUTER FILES (UNIVERSITY COMPUTER CENTER), MANUAL FILES, MICROFICHE*
DE GROUNDWATER, HYDROLOGY, WATER WELLS, AQUIFERS, HYDROGEOLOGY, WATER MANAGEMENT*
LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
GROUNDWATER GROUP,
HYDROLOGY SECTION,
SPACE CENTER BUILDING,
444 LAFAYETTE ROAD,
ST PAUL MN 55101*

AV NO RESTRICTIONS, CONTACT GIL GABANSKI (612-296-0431)*
GC (REFERENCE)
CITY/TOWNSHIP NAME, COUNTY NAME, PUBLIC LAND SURVEY;
(AREA)
MN*
/EOR

AN 0000Z001472*
ID DATA*
NU SWIM-D-039003*
NU DNRW-D-30*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
GROUNDWATER GROUP,
HYDROLOGY SECTION,
SPACE CENTER BUILDING,
ST PAUL MN 55101*
TI GROUNDWATER PROGRAM: HIGH CAPACITY WELL INVENTORY, IRRIGATION WELLS*
RS TO DELINEATE, QUANTIFY AND EVALUATE THE STATE'S GROUNDWATER RESOURCES. OBJECTIVE OF THE PROGRAM IS FOCUSED ON GROUNDWATER DATA COLLECTION, ANALYSIS AND PRESENTATION OF RESULTS SO THAT RESOURCE MANAGEMENT DECISION CAN BE BASED ON THE BEST AVAILABLE INFORMATION. THESE TESTS ARE REQUIRED IN CERTAIN INSTANCES BEFORE A PERMIT TO APPROPRIATE WATER MAY BE ISSUED. THE SPECIFIC PURPOSE OF THIS DATA BASE IS TO INVENTORY LOCATIONS, CONSTRUCTION INFORMATION, AQUIFER UTILIZED, AND OTHER DATA FOR WELLS CAPABLE OF PRODUCING GREATER THAN 70 GPM.*
AC INFORMATION IS USED IN THE EVALUATION OF APPLICATIONS FOR WATER APPROPRIATION PERMITS. REPORTS ARE PLANNED BUT NOT YET PUBLISHED*
TY SECONDARY*
NT RELATED TO THE MINNESOTA GEOLOGICAL SURVEY WATER WELL LOG DATA BASE, LAWS: MINNESOTA STATE STATUTES CHAPTER 105, A DATA BASE FOR INDUSTRIAL AND COMMERCIAL WELLS WILL BE ESTABLISHED IN 1981*
SN MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
YR 1930 - 1981 (TO PRESENT)*
MT (SOURCE)
MINNESOTA DEPARTMENT OF NATURAL RESOURCES WATER APPROPRIATION PERMIT FILES, MINNESOTA GEOLGICAL SURVEY SUBSURFACE GEOLOGY DATA BASE, SOME FIELD INVESTIGATIONS;
(METHODS)
INTERPRETED FROM WELL LOG DATA, SOME TAKEN FROM PERMIT APPLICATION;
(CLASSES)
SOME DATA IS ALSO IN THE MINNESOTA DEPARTMENT OF NATURAL RESOURCES WATER USE DATA BASE. UNIQUE WELL NUMBER, PERMIT APPLICATION NUMBER, OWNER AND ADDRESS, APPROPRIATION DEPTH, APPROPRIATION DIAMETER, ALLOWED PUMPING RATE, YEAR CONSTRUCTED, ALLOWED ANNUAL PUMP RATE, PUMPING START AND STOP MONTH, NAME AND ADDRESS OF WELL DRILLER, LAND SURFACE ELEVATION MEASURING POINT ELEVATION, STATIC WATER LEVEL AND DATE MEASURED, RECOVERY DATA, WELL DEPTH, WELL HEAD, WELL LOCATION (PUBLIC LAND SURVEY), COUNTY NUMBER, MEASURING POINT ABOVE LAND SURFACE, INSTALLATION CODE, RECORD NUMBER FOR DNR COUNTY MAPS, MAP PLOT CHECK, DISPOSITION OF PERMIT APPLICATION, DUG PIT FLAG, CASING DESCRIPTION OR TYPE, CASING DIAMETER AND DEPTH, OPEN HOLE TOP AND

BOTTOM, SCREEN DIAMETER (MAKE, TYPE, LENGTH, GAUGE), PUMP CAPACITY MANUFACTURER, MODEL, HORSEPOWER, VOLTS, TYPE), LENGTH OF DROP PIPE, DATE PUMP INSTALLED, CONTAMINANTS (DISTANCE, TYPE, DIRECTION), GROUTING (VOLUME, TYPE), AQUIFER LITHOLOGY, AQUIFER STRATIGRAPHIC UNIT, AQUIFER TOP DEPTH, AQUIFER BOTTOM DEPTH, CONFINING BED DATA, IRRIGATION DATA (LOCATION, AREA, CURRENT CROP, NEXT CROP), DRILLER DYNAMIC GROUP (DYNAMIC WATER LEVEL, TEST DATE, LENGTH, PUMPAGE TEST RATE), ANNUAL REPORT DATA (YEAR PUMPED, VOLUME IN MILLIONS OF GALLONS PER YEAR, MONTHLY REPORT), GEOLOGIC FORMATION LOG (TYPE OF FORMATION, HARDNESS, TOP OF FORMATION, STRATIGRAPHIC UNIT, LITHOLOGIC UNIT)*

MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
ONE TIME FOR EACH WELL;
(SIZE)
3000 RECORDS*

FT COMPUTER FILES (UNIVERSITY COMPUTER CENTER)*

DE GROUNDWATER, WATER WELLS, HYDROLOGY, HYDROGEOLOGY, IRRIGATION, AQUIFERS, WATER ALLOCATION*

LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
GROUNDWATER GROUP,
HYDROLOGY SECTION,
SPACE CENTER BUILDING,
444 LAFAYETTE ROAD,
ST PAUL MN 55101*

AV NO RESTRICTIONS, CONTACT DENNIS BEISSEL (612-296-0430)*

GC (REFERENCE)
PUBLIC LAND SURVEY;
(AREA)
MN*

/EOR

AN 0000Z001473*

ID DATA*

NU SWIM-D-039004*

NU DNRW-D-31*

AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*

IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
GROUNDWATER GROUP,
HYDROLOGY SECTION,
SPACE CENTER BUILDING,
ST PAUL MN 55101*

TI GROUNDWATER PROGRAM: HIGH CAPACITY WELL INVENTORY, MUNICIPAL WELLS*

RS TO DELINEATE, QUANTIFY AND EVALUATE THE STATE'S GROUNDWATER RESOURCES. OBJECTIVE OF THE PROGRAM IS FOCUSED ON GROUNDWATER DATA COLLECTION, ANALYSIS AND PRESENTATION OF RESULTS SO THAT RESOURCE MANAGEMENT DECISION CAN BE BASED ON THE BEST AVAILABLE INFORMATION. THESE TESTS ARE REQUIRED IN CERTAIN INSTANCES BEFORE A PERMIT TO APPROPRIATE WATER MAY BE ISSUED. THE SPECIFIC PURPOSE OF THIS DATA BASE IS TO INVENTORY LOCATIONS, CONSTRUCTION INFORMATION, AQUIFER UTILIZED, AND OTHER DATA FOR WELLS CAPABLE OF PRODUCING GREATER THAN 70 GPM.*

AC INFORMATION IS USED IN THE EVALUATION OF APPLICATIONS FOR WATER
APPROPRATION PERMITS. REPORTS ARE PLANNED BUT NOT YET PUBLISHED*
TY SECONDARY*
NT LAWS: MINNESOTA STATE STATUTES CHAPTER 105, RELATED TO THE MINNESOTA
GEOLOGICAL SURVEY WATER WELL LOG DATA BASE, A DATA BASE FOR
INDUSTRIAL AND COMMERICAL WELLS WILL BE ESTABLISHED IN 1981*
YR 1880 - 1981 (TO PRESENT)*
MT (SOURCE)
WATER APPROPRIATION PERMITS, MINNESOTA GEOLOGICAL SURVEY SUBSURFACE
GEOLOGIC DATA BASE, PERSONAL CONTACT WITH MUNICIPALITIES;
(METHODS)
STAFF EXTRACTS INFORMATION FROM SOURCES LISTED ABOVE;
(CLASSES)
COUNTY, MUNICIPALITY, OPERATOR, WELL NUMBER, MINNESOTA UNIQUE WELL
NUMBER, STATUS OF WELL, AVAILABILITY AS OBSERVATION WELL, AQUIFER,
LOCATION (PUBLIC LAND SURVEY), PERMIT APPLICATION NUMBER, PERSON
CONTACTED AND ADDRESS, DRILLING AND ENGINEERING FIRMS AND ADDRESSES,
DEPTH, ALTITUDE, DROP PIPE DEPTH, SCREENED OR OPEN, SCREEN TYPE
(SLOT/GAUGE), PUMP TYPE AND POWER TYPE, AVERAGE DISCHARGE, STATIC
WATER LEVEL AND DATE MEASURED, DURATION, DYNAMIC WATER LEVEL,
PUMP RATE, TRANSMISSIVITY, STORATIVITY, SPECIFIC CAPACITY, WELL LOG
(INTERVAL, LITHOLOGY, STRATIGRAPHY), HYDROGEOLOGIC UNIT (AQUIFER
NAME*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
ONE TIME AT EACH WELL;
(SIZE)
APPROXIMATELY 1000 NOW, OVER 3000 WHEN DATA BASE IS COMPLETED*
FT COMPUTER FILES (UNIVERSITY COMPUTER CENTER)*
DE GROUNDWATER, HYDROLOGY, WATER WELLS, HYDROGEOLOGY, WATER ALLOCATION,
MUNICIPAL ENGINEERING*
LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
GROUNDWATER GROUP,
HYDROLOGY SECTION,
SPACE CENTER BUILDING,
444 LAFAYETTE ROAD,
ST PAUL MN 55101*
AV NO RESTRICTIONS, CONTACT DENNIS BEISSEL (612-296-0430)*
GC (REFERENCE)
COUNTY NAME, MUNICIPALITY, PUBLIC LAND SURVEY;
(AREA)
MN*
/EOR

AN 0000Z001675*
ID DATA*
NU DNRW-D-12*
NU DCAT-D-65*
NU SWIM-D-5*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
SPACE CENTER BUILDING,
ST PAUL MN 55101*
TI WATER USE PROGRAM: APPROPRIATION PERMIT FILES*

RS TO ALLOCATE WATER AMONG USERS. MINNESOTA STATUTES PROHIBIT ANYONE FROM APPROPRIATING AND USING ANY WATERS OF THE STATE WITHOUT FIRST OBTAINING A PERMIT FROM THE DEPARTMENT OF NATURAL RESOURCES COMMISSIONER EXCEPT FOR DOMESTIC USES SERVING LESS THAN 25 PERSONS.*
AC INFORMATION HAS BEEN ENTERED INTO THE MASTER PERMIT INDEX SYSTEM; REPORTS: ESTIMATED WATER USE IN THE US (1965, 1970, 1975), VARIOUS DIVISION OF WATERS PUBLICATIONS*
TY PRIMARY*
NT LAWS: MINNESOTA STATE STATUTE 105.37 - 105.64, 106D. RULES: 6MCAR SECTION 3.021. RULES FOR APPROPRIATION OF WATERS OF THE STATE ARE IN THE PROCESS OF PROMULGATION*
SN MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
YR 1930 - 1981 (TO PRESENT)*
MT (SOURCE)
APPLICANT FOR WATER USE PERMIT;
(METHODS)
STAFF OBTAINS INITIAL INFORMATION FROM APPLICATION FOR PERMIT TO APPROPRIATE OR USE WATERS. CALLS OR LETTERS REQUESTING FURTHER INFORMATION ARE THEN MADE. FIELD INSPECTION MAY FOLLOW;
(CLASSES)
SOURCE OF WATER, LEGAL DESCRIPTION OF POINT OF TAKING, SPECIFIC USE OF WATER, STATEMENT OF ENVIRONMENTAL IMPACT AND PROJECT JUSTIFICATION, LAND DESCRIPTION, CROP TYPE AND FIELD LOCATION FOR IRRIGATION, MAP, 6 TYPES OF ENGINEERING DATA, NAME OF SOIL AND WATER CONSERVATION DISTRICT, NAME OF WATERSHED DISTRICT*
MS (UNITS)
NOT INDICATED;
(FREQUENCY)
ONE TIME;
(SIZE)
APPROXIMATELY 10500 APPROPRIATION PERMITS*
FT MANUAL FILES, MAPS, MICROFICHE (1930 - 1973)*
DE IRRIGATION WATER, WATER WELLS, WATER SUPPLY, INDUSTRIAL WATER, SURFACE WATERS, POTABLE WATER, GROUNDWATER, WATER CONSUMPTION, WATER RIGHTS*
LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
THIRD FLOOR SPACE CENTER BUILDING,
444 LAFAYETTE ROAD,
ST PAUL MN 55101*
AV NO RESTRICTIONS, CONTACT HEDIA RIEKE (612-296-4803)*
GC (REFERENCE)
COUNTY NAME, CITY NAME, STREET, STREET ADDRESS, ROAD CROSSING, RIVER BASIN, STREAM NAME, LAKE NAME, DEPARTMENT OF NATURAL RESOURCES LAKE NUMBER, PUBLIC LAND SURVEY, LEGAL DESCRIPTION, PERMIT NUMBER, SITE DESCRIPTION, DISTANCE FROM NEARBY STRUCTURE, SURVEYORS METES AND BOUNDS, WATERSHED;
(AREA)
MN*
/EOR

AN 0000Z001469*
ID DATA*
NU SWIM-D-048003*
NU DNRW-D-27*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*

IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
SPACE CENTER BUILDING,
ST PAUL MN 55101*
TI WATER USE PROGRAM: WATER APPROPRIATION PERMIT MAILING LIST*
RS TO MAIL OUT WATER PUMPAGE RECORD FORMS TO PERMIT HOLDERS.*
AC USEFUL IN TABULATING INFORMATION REGARDING CURRENT WATER
APPROPRIATION ACTIVITIES IN THE STATE*
TY PRIMARY*
NT RELATED TO THE MASTER PERMIT INDEX SYSTEM AND THE STATE WATER USE
DATA BASE*
SN MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
YR 1970 - 1981 (TO PRESENT)*
MT (SOURCE)
WATER APPROPRIATION FILES;
(METHODS)
COLLECTED BY THE MINNESOTA DEPARTMENT OF NATURAL RESOURCES STAFF;
(CLASSES)
COUNTY, PERMIT APPLICATION NUMBER, NAME AND ADDRESS OF PERMIT
HOLDER RESOURCE CODE (WELL, LAKE, STREAM OR DITCH, OTHER BASIN SUCH
AS PIT, POND, OR SLOUGH), USE CODE - DNR APPROPRIATION CODE FROM
PERMIT INDEX (POWER GENERATION, WATERWORKS, AIR CONDITIONING,
PROCESSING, TEMPORARY, LEVEL CONTROL, DEWATERING, WILD RICE
IRRIGATION, GOLF COURSE IRRIGATION, OTHER IRRIGATION)*
MS (UNITS)
NOT INDICATED;
(FREQUENCY)
ANNUALLY;
(SIZE)
5500 PERMIT HOLDERS*
FT COMPUTER FILES (UNIVERSITY COMPUTER CENTER)*
DE WATER ALLOCATION, GROUNDWATER, IRRIGATION, SURFACE WATER*
LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
SPACE CENTER BUILDING,
444 LAFAYETTE ROAD,
ST PAUL MN 55101*
AV NO RESTRICTIONS, CONTACT ELAINE TOURVILLE (612-296-1423)*
GC (REFERENCE)
COUNTY, STREET ADDRESS OF PERMIT HOLDER;
(AREA)
MN*
/EOR

AN 0000Z001677*
ID DATA*
NU SWIM-D-048004*
NU DNRW-D-14*
NU DCAT-D-66*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
SPACE CENTER BUILDING,
ST PAUL MN 55101*
TI WATER USE PROGRAM: WATER APPROPRIATOR'S ANNUAL PUMPAGE RECORDS*

RS TO DETERMINE AMOUNT OF WATER APPROPRIATED ANNUALLY FROM VARIOUS
WATER SOURCES. PERMITS ARE SUPPOSED TO BE CANCELLED IF PUMPAGE IS
NOT REPORTED BUT THIS LAW HAS NOT BEEN ENFORCED.*
AC WATER USE ESTIMATES FOR STATE AND FEDERAL GOVERNMENT*
TY PRIMARY*
NT LAWS: MINNESOTA STATE STATUTE 105.37 - 105.74, 106D. RULES: 6MCAR
SECTION 3.021. RULES FOR APPROPRIATION OF WATERS OF THE STATE ARE
IN THE PROCESS OF PROMULGATION*
SN MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
YR 1952 - 1981 (TO PRESENT)*
MT (SOURCE)
INDIVIDUAL WATER ESTIMATES (PROBABLY ABOUT 75 ARE ACCURATE);
(METHODS)
FORMS ARE SENT OUT ANNUALLY TO COLLECT PUMPAGE RECORD DATA. IN
CASES OF NO RESPONSE, A FOLLOW-UP AND THEN FINAL WARNING ARE SENT
OUT. PERMITS ARE CANCELLED IN CASE OF NO RESPONSE;
(CLASSES)
PUMPAGE (DAILY, MONTHLY YEARLY), ADDRESS, COUNTY, WATER SOURCE*
MS (UNITS)
GALLONS PER MINUTE, TOTAL GALLONS;
(FREQUENCY)
ANNUALLY (ESTIMATES ARE VERY GENERAL);
(SIZE)
85 TO 90 PERCENT OF ACTIVE PERMIT HOLDERS REPORT ANNUAL PUMPAGE*
FT MANUAL FILES, MICROFICHE (1976 - 1978), COMPUTER FILES FOR 1978
(WILL BE UPDATED ANNUALLY - UNIVERSITY COMPUTER CENTER)*
DE WATER SUPPLY, WATER WELLS, POTABLE WATER, WATER DEMAND, WATER
FLOW, SURFACE WATER, IRRIGATION WATER, GROUNDWATER, INDUSTRIAL
WATER, WATER CONSUMPTION*
LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
THIRD FLOOR SPACE CENTER BUILDING,
444 LAFAYETTE ROAD,
ST PAUL MN 55101*
AV NO RESTRICTIONS, CONTACT ELAINE TOURVILLE (612-296-1423)*
GC (REFERENCE)
COUNTY NAME, STREET, STREET ADDRESS, ROAD CROSSING, RIVER BASIN,
WATERSHEDS, STREAM NAME, LAKE NAME, DEPARTMENT OF NATURAL RESOURCES
LAKE NUMBER, PUBLIC LAND SURVEY, LEGAL DESCRIPTION, PERMIT NUMBER,
SITE DESCRIPTION, DISTANCE FROM NEARBY STRUCTURE, SURVEYORS METES
AND BOUNDS;
(AREA)
MN*
/EOR

AN 0000Z001678*
ID DATA*
NU SWIM-D-048005*
NU DNRW-D-15*
NU DCAT-D-68*
AU MINNESOTA DEPARTMENT OF NATURAL RESOURCES*
IN MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
SPACE CENTER BUILDING,
ST PAUL MN 55101*

TI WATER USE PROGRAM: STATE WATER USE ESTIMATES*
RS TO MAKE STATE WATER USE ESTIMATES FOR THE NATIONAL PROGRAM OF THE US GEOLOGICAL SURVEY.*
AC REPORTS: STATE AND NATIONAL WATER USE ESTIMATES FOR WATER MANAGEMENT PLANNING; ESTIMATED WATER USE IN THE US (1980)*
TY SECONDARY*
NT PART OF A PROGRAM BEING DEVELOPED BY THE US GEOLOGICAL SURVEY: NATIONAL WATER USE DATA SYSTEM. DATA BASE WILL INCLUDE INFORMATION ON PERMIT HOLDER AND WELL IN ADDITION TO ANNUAL PUMPAGE RECORDS. NOT A PART OF THE MASTER PERMIT INDEX SYSTEM*
SN US GEOLOGICAL SURVEY*
YR 1980 - 1983*
MT (SOURCE)
ANNUAL PUMPAGE RECORDS AND INITIAL WATER APPROPRIATION PERMIT;
(METHODS)
PERMIT APPLICANT TURNS IN APPLICATION AND HIS ANNUAL PUMPAGE (EITHER METERED OR ESTIMATED);
(CLASSES)
PERMIT APPLICATION NUMBER, PERMIT HOLDERS NAME AND ADDRESS, COUNTY NUMBER, MINNESOTA DEPARTMENT OF NATURAL RESOURCES CODE FOR TYPE OF USE LISTED IN PERMIT INDEX, INSTALLATION CODE, PUBLIC LAND SURVEY DESCRIPTION (TO QUARTER QUARTER QUARTER SECTION), USE PUMP RATE IN GALLONS PER MINUTE FROM PUMPAGE RATE, ACCURACY ESTIMATE BASED ON HOW PUMPAGE WAS RECORDED (METER, HOURLY), INSTALLATION ANNUAL PUMPAGE REPORT, YEAR PUMPED, INSTALLATION VOLUME IN MILLIONS OF GALLONS, MONTHLY REPORT, IRRIGATION REPORT, YEAR IRRIGATED, TYPE OF IRRIGATION SYSTEM, NUMBER OF ACRES IRRIGATED AND CROP TYPE, POLLUTION CONTROL AGENCY DISCHARGE REPORT (CORRELATION WITH APPROPRIATION PERMIT), NPDES CODE, DISCHARGE WATER BODY*
MS (UNITS)
GALLONS, MILLIONS OF GALLONS;
(FREQUENCY)
MEASURED MONTHLY, COLLECTED ANNUALLY;
(SIZE)
NOT INDICATED*
FT COMPUTER FILES (UNIVERSITY COMPUTER CENTER)*
DE WATER SUPPLY, SURFACE WATER, WATER USE, IRRIGATION, WATER APPROPRIATION, GROUNDWATER*
LO MINNESOTA DEPARTMENT OF NATURAL RESOURCES,
WATERS DIVISION,
THIRD FLOOR SPACE CENTER BUILDING,
444 LAFAYETTE ROAD,
ST PAUL MN 55101*
AV NO RESTRICTIONS, CONTACT DENNIS KIM OR ELAINE TOURVILLE (612-296-1423)*
GC (REFERENCE)
GEOGREFERENCE, PUBLIC LAND SURVEY;
(AREA)
MN*
/EOR

AN 0000Z001448*
ID DATA*
NU SWIM-D-049002*
NU MDOT-D-16*
AU MINNESOTA DEPARTMENT OF TRANSPORTATION*

IN MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES,
HYDRAULIC UNIT, WATER QUALITY GROUP,
2226 TERMINAL ROAD,
ROSEVILLE MN 55113*
TI AMBIENT WATER QUALITY PROGRAM: WATER QUALITY CHEMICAL PARAMETERS*
RS TO ESTABLISH CHEMICAL CHARACTERISTICS OF WATER SYSTEMS ADJACENT TO PROPOSED AND EXISTING TRANSPORTATION PROJECTS.*
AC ENVIRONMENTAL IMPACT STATEMENTS; WATER QUALITY REPORTS*
TY PRIMARY*
NT MINNESOTA POLLUTION CONTROL AGENCY, MINNESOTA DEPARTMENT OF TRANSPORTATION, ENVIRONMENTAL PROTECTION AGENCY, AND METROPOLITAN WASTE COMMISSION COLLECT SIMILAR DATA BUT AT DIFFERENT LOCATIONS. MINNESOTA DEPARTMENT OF TRANSPORTATION COLLECTS WATER QUALITY INFORMATION ONLY IF SITES DO NOT HAVE DATA; IS INTERESTED IN COLLECTING DATA DURING STORM RUNOFFS. LAWS: PUBLIC LAW TITLE 23, NEPA OF 1969 FEDERAL AID HIGHWAY PROGRAM, SECTION 109. FEDERAL HIGHWAY ADMINISTRATION MEMO N 5020.8 MAY 18, 1976. TECHNICIANS ARE TRAINED BY USGS, EPA AND MINNESOTA DEPARTMENT OF HEALTH IN WATER QUALITY SAMPLE COLLECTION AND PRESERVATION AND STREAM MEASUREMENT. DATA MEETS EPA AND USGS STANDARDS*
SN MINNESOTA DEPARTMENT OF TRANSPORTATION*
YR NOVEMBER 1976 - 1981 (TO PRESENT)*
MT (SOURCE)
SURFACE WATERS;
(METHODS)
STAFF ENGINEER DETERMINES SAMPLING LOCATION AT THE PROJECT SITE. TECHNICIANS ARE SENT OUT TO COLLECT SAMPLES. FIELD NOTES, DATA LAB SHEET, AND FIELD LOGS ARE FILLED OUT FOR EACH SITE. SAMPLES ARRIVE WITHIN SIX HOURS TO THE MINNESOTA DEPARTMENT OF HEALTH LABS FOR ANALYSIS. STAFF USES PROCEDURES BASED ON EPA, USGS AND HWB PROCEDURAL MANUALS FOR COLLECTING WATER QUALITY SAMPLES;
(CLASSES)
SAMPLE NUMBER, DATE COLLECTED, TIME COLLECTED, TEMPERATURE, DATE RECEIVED BY LAB, COLIFORM, FECAL COLIFORM, AMMONIA NITROGEN, ORGANIC NITROGEN, NITRITE NITROGEN, FECAL STREPTOCOCCI, NITRATE NITROGEN, CALCIUM AS CACO3, MAGNESIUM AS CACO3, ALAKLINITY AS CACO3, CHLORIDE, SULFATE, SODIUM, POTASSIUM, ALKALINITY AS CACO3, FLUORIDE, REACTIVE SILICA, TOTAL PHOSPHORUS, BORON, SELENIUM, METHYLENE, CYANIDE, CHLOROPHYLL A, BIOCHEMICAL OXYGEN DEMAND (5 DAY), COD, OIL AND GREASE, TOTAL ORGANIC CARBONS, SUSPENDED SOLIDS, FREE CARBON DIOXIDE, TOTAL DISSOLVED SOLIDS, SUSPENDED VOLATILE, KJEDAHL NITROGEN, BICARBONATE ALKALINITY AS CACO3, CARBONATE ALKALINITY AS CACO3, MANGANESE, CHROMIUM, COPPER, IRON, LEAD, ZINC, NICKEL, CADMIUM, MERCURY, ALUMINUM, BARIUM, ARSENIC, PHENOLS*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
VARIES FROM HOURLY TO MONTHLY TO SEASONALLY DEPENDING ON PROJECT;
(SIZE)
100 SITES, 15 PROJECTS*
FT MANUAL FILES, COMPUTER FILES*
DE WATER QUALITY, MICROORGANISMS, ROAD CONSTRUCTION, WATER ANALYSIS, SURFACE WATERS, STORM WATER RUNOFF, CHEMISTRY ANALYSIS, WATER POLLUTION, WATER EROSION, BACTERIA, HIGHWAY CONSTRUCTION, GROUNDWATER*

LO MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES,
HYDRAULIC UNIT, WATER QUALITY GROUP,
2226 TERMINAL ROAD,
ROSEVILLE MN 55113*
AV NO RESTRICTIONS, CONTACT DAVE PEDERSON (612-296-0830)*
GC (REFERENCE)
COUNTY NAME, CITY/TOWNSHIP NAME (MCD), STREAM NAME, LAKE NAME,
LATITUDE/LONGITUDE, DEPARTMENT OF TRANSPORTATION SITE NUMBER
IDENTIFICATION, PIEZOMETER NUMBER;
(AREA)
MN*
/EOR

AN 0000Z001450*
ID DATA*
NU SWIM-D-049003*
NU MDOT-D-18*
AU MINNESOTA DEPARTMENT OF TRANSPORTATION*
IN MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES,
HYDRAULIC UNIT, WATER QUALITY GROUP,
2226 TERMINAL ROAD,
ROSEVILLE MN 55113*
TI AMBIENT WATER QUALITY PROGRAM: STREAM FLOW*
RS TO ESTABLISH CHEMICAL CHARACTERISTICS OF WATER SYSTEMS ADJACENT TO
PROPOSED AND EXISTING TRANSPORTATION PROJECTS.*
AC ENVIRONMENTAL IMPACT STATEMENTS; WATER QUALITY REPORTS*
TY PRIMARY*
NT MINNESOTA POLLUTION CONTROL AGENCY, US GEOLOGICAL SURVEY,
ENVIRONMENTAL PROTECTION AGENCY, AND METROPOLITAN WASTE COMMISSION
COLLECT SIMILAR DATA BUT AT DIFFERENT LOCATIONS. MINNESOTA
DEPARTMENT OF TRANSPORTATION COLLECTS WATER QUALITY INFORMATION ONLY
IF SITES DO NOT HAVE; IS INTERESTED IN COLLECTING DATA DURING STORM
RUNOFFS; LAWS: P.L. TITLE 23, NEPA OF 1969 FEDERAL AID HIGHWAY
PROGRAM, SECTION 109; FEDERAL HIGHWAY ADMINISTRATION MEMO N 5020.8,
MAY 18 1976. TECHNICIANS ARE TRAINED BY USGS, EPA, MDH IN WATER
QUALITY SAMPLE COLLECTION AND PRESERVATION AND STREAM MEASUREMENT.
DATA MEETS EPA AND USGS STANDARDS*
SN MINNESOTA DEPARTMENT OF TRANSPORTATION*
YR NOVEMBER 1976 - 1981 (TO PRESENT)*
MT (SOURCE)
SURFACE WATERS AND GROUNDWATERS;
(METHODS)
STAFF ENGINEER DETERMINE SAMPLING LOCATIONS AT THE PROJECT SITE.
DISCHARGE MEASUREMENTS ARE TAKEN BY GAUGES AND BY CURRENT METERS;
(CLASSES)
STATION NUMBER, DATE, PARTY, WIDTH, AREA, VELOCITY, GAUGE HEIGHT,
DISCHARGE, METHOD, NUMBER OF SECONDS, GAUGE HEIGHT CHANGE,
SUSPENSION, HORIZONNTAL ANGLE COEFFICENT, METHOD COEFFICIENT,
SUSPENSION COEFFICIENT, METER NUMBER, METER TYPE, DATE RATED, METER
HEIGHT ABOVE WEIGHT, SPIN BEFORE MEASUREMENT, SPIN AFTER
MEASUREMENT, MEASUREMENT PLOTS, METHOD OF MEASURING, DISTANCE
FROM GAUGE, CHECK BAR FOUND, CHECK BAR CHANGED TO, CORRECT, LEVELS
OBTAINED GAUGE READING TIME, MGH, MEASUREMENT RATING, ANGLE
COEFFICIENT, DISTANCE FROM INITIAL POINT, WIDTH, DEPTH, OBSERVATION
DEPTH, REVOLUTIONS, TIME, VELOCITY AT POINT, VELOCITY MEAN IN
VERTICAL, ADJUSTED FOR HORIZONTAL ANGLE, AREA, DISCHARGE*

MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
VARIES FROM HOURLY TO MONTHLY TO SEASONALLY DEPENDING ON THE PROJECT;
(SIZE)
100 SITES, 15 PROJECTS*
FT MANUAL FILES*
DE SURFACE WATERS, STORM WATER RUNOFF, RIVERS, ROAD CONSTRUCTION, STREAM FLOW, STREAMS, HIGHWAY CONSTRUCTION, WATER FLOW, HYDROLOGY, RUNOFF, SURFACE WATER RUNOFF, GROUNDWATER*
LO MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES,
HYDRAULIC UNIT, WATER QUALITY GROUP,
2226 TERMINAL ROAD,
ROSEVILLE MN 55113*
AV NO RESTRICTIONS, CONTACT DAVE PEDERSON (612-296-0830)*
GC (REFERENCE)
COUNTY NAME, CITY/TOWNSHIP NAME, STREAM NAME, LAKE NAME, LATITUDE/LONGITUDE, DEPARTMENT OF TRANSPORTATION SITE NUMBER IDENTIFICATION, PIEZOMETER NUMBER;
(AREA)
MN*
/EOR

AN 0000Z001413*
ID DATA*
NU SWIM-D-050001*
NU MDOT-D-17*
NU DCAT-D-107*
AU MINNESOTA DEPARTMENT OF TRANSPORTATION*
IN MINNESOTA DEPARTMENT OF TRANSPORTATION,
OFFICE OF ENVIRONMENTAL SERVICES,
ENVIRONMENTAL PLANNING AND DEVELOPMENT SECTION,
807 TRANSPORTATION BUILDING,
ST PAUL MN 55155*
TI PROJECT DEVELOPMENT AND WETLAND MITIGATION; ENVIRONMENTAL IMPACT ASSESSMENT: WETLAND AND LAND TYPE CLASSIFICATION*
RS THE FUNCTION OF THIS PROGRAM IS TO IMPLEMENT REQUIREMENTS SET BY NEPA AND PRESIDENTIAL ORDERS. TO REVIEW PROPOSED PROJECTS AND THEIR IMPACTS UPON WETLANDS, DRAINAGES, RIVERS, LAKES, FLOODPLAINS, AND OTHER WATER RESOURCES. TO INTERPRET DATA REGARDING STORM WATER RUNOFF AND TO PREPARE RECOMMENDATIONS.*
AC MANY ENVIRONMENTAL IMPACT STATEMENTS, SPECIAL STUDIES, MINNESOTA DEPARTMENT OF TRANSPORTATION PLANS, MANUALS, BIOLOGICAL, WETLAND AND STREAM CLASSIFICATIONS, ESTIMATES OF IMPACT AND ACREAGE LOSS, WATER QUALITY ANALYSIS, DATA IS ALSO USED IN LITIGATION*
TY PRIMARY, SECONDARY*
NT MINNESOTA DEPARTMENT OF NATURAL RESOURCES, MINNESOTA POLLUTION CONTROL AGENCY, US ARMY CORPS OF ENGINEERS, US SOIL CONSERVATION SERVICE, US GEOLOGICAL SURVEY, MINNESOTA GEOLOGICAL SURVEY, MINESOTA DEPARTMENT OF HEALTH, AND UNIVERSITY OF MINNESOTA ALSO COLLECT INFORMATION WHICH IS INTEGRATED INTO THE ENVIRONMENTAL IMPACT ASSESSMENT. LAWS: PUBLIC LAW 91-190 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969, PRESIDENTIAL ORDERS: 11990 (WETLANDS) AND 11988 (FLOODPLAINS)*

SN MINNESOTA DEPARTMENT OF TRANSPORTATION*
YR 1968 - 1981 (TO PRESENT)*
MT (SOURCE)
FIELD STUDIES, VISUAL ESTIMATES, AIR PHOTOS, PLANT AND SOIL
SAMPLES PIEZOMETRIC MEASUREMENTS;
(METHODS)
TRAINED PROFESSIONAL STAFF ARE ASSIGNED PROJECT AREAS TO SURVEY.
FIELD WORK IS DONE. NO MANUALS ARE USED IN THE FIELD. STAFF USES
WELL KNOWN FEDERAL AND STATE ENVIRONMENTAL DATA COLLECTION
PROCEDURES (E.G. EPA, DEPARTMENT OF THE INTERIOR, CORPS OF
ENGINEERS, ETC.). STAFF ALSO OBTAINS INFORMATION FROM THESE
AGENCIES AND FROM DOT HYDRAULIC ENGINEERS, GEOLOGISTS AND
MAINTENANCE PEOPLE. NO STANARDIZED COLLECTION FORM IS USED. EIS
OR SPECIAL REPORT IS THEN TAILORED MADE FOR REVIEW BY OTHER STATE
AND FEDERAL AGENCIES;
(CLASSES)
WETLAND AND LAND TYPE CLASSIFICATION: GROUNDWATER HYDROLOGY, SOILS,
FLORA, FAUNA, HYDRAULICS, TOPOGRAPHY, GEOGRAPHY, GEOLOGY, ECOLOGY*
MS (FREQUENCY)
ONGOING PROGRAM OF ONE TIME PROJECTS;
(SIZE)
500 SITES*
FT MANUAL FILES, MAPS*
DE WETLANDS, GEOLOGY, ROAD CONSTRUCTION, SURFACE WATER, ECOLOGY,
HIGHWAY CONSTRUCTION, GROUNDWATER, TOPOGRAPHY, ENVIRONMENTAL IMPACT
STATEMENTS, HYDROLOGY, BIOLOGY*
AV NO RESTRICTIONS, CONTACT LARRY FOOTE (612-296-1637)*
LO MINNESOTA DEPARTMENT OF TRANSPORTATION,
OFFICE OF ENVIRONMENTAL SERVICES,
ENVIRONMENTAL PLANNING AND DEVELOPMENT SECTION,
807 TRANSPORTATION BUILDING,
ST PAUL MN 55155*
GC (REFERENCE)
MINNESOTA DEPARTMENT OF TRANSPORTATION PROJECT NUMBER;
(AREA)
MN*
/EOR

AN 0000Z001414*
ID DATA*
NU SWIM-D-052001*
NU MDOT-D-18*
NU DCAT-D-108*
AU MINNESOTA DEPARTMENT OF TRANSPORTATION*
IN MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES DIVISION,
SOIL AND FOUNDATIONS UNIT,
132 TRANSPORTATION BUILDING,
ST PAUL MN 55155*
TI SOIL ENGINEERING PROGRAM: SOIL PROFILE*
RS TO DETERMINE SOIL AND WATER CONDITIONS FOR SUBGRADE AND BASE
DESIGNS FOR HIGHWAYS. ALSO USED IN THE DESIGN OF SUBSURFACE
DRAINAGE SYSTEMS FOR HIGHWAY CONSTRUCTION.*
AC DATA IS USED IN ENGINEERING DESIGNS FOR HIGHWAY PROJECTS*
TY PRIMARY*

NT LAWS: MINNESOTA STATE STATUTE 160.11, 161.10, 161.20, 161.42,
PUBLIC LAW 23 USC SECTION 109 (SEE 23UFR SECTION 626); DATA IS
COLLECTED AS PER MINNESOTA DEPARTMENT OF TRANSPORTATION SOIL MANUAL
AND ASMT MANUAL; SOIL PROFILE IS STORED AT DISTRICT OFFICE ON STRIP
CHARTS*

SN MINNESOTA DEPARTMENT OF TRANSPORTATION*

YR 1930 - 1981 (TO PRESENT)*

MT (SOURCE)
SOILS;
(METHODS)
STAFF TECHNICIANS TAKE CHECK SAMPLES AND MAKE FIELD NOTES. SOIL
BORING AND PIEZOMETRIC MEASUREMENTS (IF WATER PROBLEM EXISTS) ARE
MADE;
(CLASSES)
SOIL PROFILE DESCRIPTION: VISUAL, TEXTURAL CHARACTERISTICS, SOIL
MOISTURE, PIEZOMETRIC MEASUREMENTS*

MS (FREQUENCY)
ONGOING PROGRAM OF ONE TIME PROJECTS;
(SIZE)
200 SOIL LETTER PER YEAR*

FT MANUAL FILES, STRIP CHARTS*

DE SOIL CLASSIFICATION, ROAD CONSTRUCTION, HYDROLOGY, SOIL EROSION,
HIGHWAY CONSTRUCTION, SOILS, GROUNDWATER, RUNOFF, GROUNDWATER
MOVEMENT*

AV NO RESTRICTIONS, CONTACT GEORGE COCHRAN (612-296-7134)*

LO MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES DIVISION,
SOIL AND FOUNDATIONS UNIT,
132 TRANSPORTATION BUILDING,
ST PAUL MN 55155*

GC (REFERENCE)
COUNTY NAME, PUBLIC LAND SURVEY, MINNESOTA DEPARTMENT OF
TRANSPORTATION PROJECT NUMBER, MINNESOTA DEPARTMENT OF
TRANSPORTATION STATION NUMBER, MINNESOTA DEPARTMENT OF
TRANSPORTATION DISTRICT NUMBER;
(AREA)
MN*

/EOR

AN 0000Z001409*

ID DATA*

NU SWIM-D-053001*

NU MDOT-D-10*

NU DCAT-D-58*

AU MINNESOTA DEPARTMENT OF TRANSPORTATION*

IN MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES DIVISION,
MATERIAL ENGINEERING SECTION,
TRANSPORTATION BUILDING,
ST PAUL MN 55155*

TI UNDISTURBED BORING PROGRAM: FIELD BORING LOGS; FOUNDATION BORING
PROGRAM*

RS TO OBTAIN SUBSURFACE SOIL AND ROCK DATA AS WELL AS WATER DATA FOR
USE IN DESIGNING STATE BUILDINGS AND TRANSPORTATION PROJECTS.*

TY PRIMARY*

NT MINNESOTA STATE DEPARTMENT OF ADMINISTRATION OBTAINS BORINGS FOR USE IN DESIGNING STATE BUILDINGS; LAWS: MINNESOTA STATE STATUTE 160, 161, 174, 454, STANDARDIZATION: AASHTO, ASTM, FHWA REQUIREMENTS IN HIGHWAY GRANT FUNDS*
SN MINNESOTA DEPARTMENT OF TRANSPORTATION*
YR 1958 - 1981 (TO PRESENT)*
MT (SOURCE)
SOIL AND ROCK UNITS;
(METHODS)
TRAINED DRILLING CREW ARE ASSIGNED SPECIFIC PROJECTS. CREW RETRIEVES SOIL SAMPLES USING FIELD PROCEDURAL MANUAL. FIELD NOTES ARE MADE AND INFORMATION IS RECORDED ON STANDARDIZED FIELD LOG AND WORK SHEET;
(CLASSES)
DRILLING DATA AND SUBSURFACE MATERIAL DESCRIPTION; SOIL TYPE, SOIL STRATA, SOIL SHEAR STRENGTH, SOIL PENETRATION RESISTANCE, ROCK CORE, CONSOLIDATION TEST (COMPRESSION AND RATE OF CONSOLIDATION), ORGANIC MATERIAL, ATTERBERG LIMITS, HYDROMETER ANALYSIS, WATER LEVEL, ELEVATION, LOCATION, LABORATORY SAMPLE NUMBER, SUPERVISIOR, OPERATOR, MACHINE USED, TIME OF DRILLING, HAMMER USE (POUNDS), DROP HEIGHT (INCHES), OD (INCHES), DEPTH (FEET, INCHES), SOIL TYPE, ROCK TYPE, COLOR, BLOWS PER FOOT, WATER TABLE, CORE RECOVERY (PERCENT), ROCK QUALITY DESCRIPTION (PERCENT)*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
ONGOING PROGRAM OF ONE TIME PROJECTS;
(SIZE)
4000 SITES, 9000 BORINGS*
FT MANUAL FILES, COMPUTER FILES (UNIVERSITY COMPUTER CENTER)*
DE SOIL CLASSIFICATION, HIGHWAY CONSTRUCTION, SOILS, ROCK TYPE, SOIL WATER, GEOLOGY, GROUNDWATER*
LO MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES DIVISION,
TRANSPORTATION BUILDING,
ST PAUL MN 55155*
AV NO RESTRICTIONS, CONTACT VIRGIL MIKKELSEN (612-296-2304)*
GC (REFERENCE)
DISTANCE ALONG, FROM CENTERLINE, MINNESOTA DEPARTMENT OF TRANSPORTATION PROJECT NUMBER, MINNESOTA DEPARTMENT OF TRANSPORTATION STATION NUMBER, MINNESOTA DEPARTMENT OF TRANSPORTATION DISTRICT NUMBER, MINNESOTA DEPARTMENT OF TRANSPORTATION ROAD NUMBER, PUBLIC LAND SURVEY;
(AREA)
MN*
/EOR

AN 0000Z001411*
ID DATA*
NU SWIM-D-053002*
NU MDOT-D-15*
NU DCAT-D-63*
AU MINNESOTA DEPARTMENT OF TRANSPORTATION*
IN MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES DIVISION,
MATERIAL ENGINEERING SECTION,
TRANSPORTATION BUILDING,
ST PAUL MN 55155*

TI UNDISTURBED BORING PROGRAM: LABORATORY LOG AND TEST RESULTS*
RS TO OBTAIN SUBSURFACE SOIL AND ROCK DATA AS WELL AS WATER DATA FOR
USE IN DESIGNING TRANSPORTATION PROJECTS.*
TY PRIMARY*
SN MINNESOTA DEPARTMENT OF TRANSPORTATION*
YR 1958 - 1981 (TO PRESENT)*
MT (SOURCE)
SOIL AND ROCK UNITS;
(METHODS)
TRAINED DRILLING CREWS ARE ASSIGNED SPECIFIC PROJECTS. CREW
RETRIEVES SOIL SAMPLES USING FIELD PROCEDURAL MANUALS. SAMPLES
ARE SEALED TO HOLD MOISTURE CONTENT AND ARE IMMEDIATELY SENT TO
MINNESOTA DEPARTMENT OF TRANSPORTATION FOUNDATION LABS. INFORMATION
IS RECORDED ON STANDARDIZED LAB SHEETS AND LATER ONTO STANDARDIZED
LABORATORY LOG;
(CLASSES)
MOISTURE CONTENT, DRY DENSITY, WET DENSITY, COHESION, ORGANIC
CONTENT, CACO3 CONTENT, PRESSURE, STRAIN RATE, TIME, WEIGHT, STRAIN,
PWP, DENSITY, STRESSES, SAMPLE HEIGHT, SAMPLE DEPTH, SAMPLE
DIAMETER, NORMAL LOAD, STRAIN RATE, WEIGHT OF SAMPLE, TIME, VERTICAL
DIAL READING, PROVING RING DIAL, PLASTICITY INDEX, LIQUID LIMIT,
GRAD, HYDRO, GRAIN SIZE DISTRIBUTION, SIH AMOUNT, CLAY AMOUNT,
CONSOLIDATION*
MS (UNITS)
STANDARD MEASURES (DIRECT SHEAR TEST, TRIAXIAL COMPRESSION);
(FREQUENCY)
ONE TIME;
(SIZE)
9000 BORINGS*
FT MANUAL FILES, COMPUTER FILES*
DE SOILS, SOIL WATER, SOIL BORING, ROAD CONSTRUCTION, SOIL TESTS,
HIGHWAY CONSTRUCTION, SOIL STRENGTH, SOIL CHEMISTRY, GROUNDWATER*
LO MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES DIVISION,
TRANSPORTATION BUILDING,
ST PAUL MN 55155*
AV NO RESTRICTIONS, CONTACT VIRGIL MIKKELSEN (612-296-2304)*
GC (REFERENCE)
DISTANCE ALONG, FROM CENTERLINE, MINNESOTA DEPARTMENT OF
TRANSPORTATION PROJECT NUMBER, MINNESOTA DEPARTMENT OF
TRANSPORTATION STATION NUMBER, MINNESOTA DEPARTMENT OF
TRANSPORTATION DISTRICT NUMBER, MINNESOTA DEPARTMENT OF
TRANSPORTATION ROAD NUMBER, LAB SAMPLE NUMBER, PUBLIC LAND SURVEY;
(AREA)
MN*
/EOR

AN 0000Z001410*
ID DATA*
NU SWIM-D-053003*
NU MDOT-D-11*
NU DCAT-D-59*
AU MINNESOTA DEPARTMENT OF TRANSPORTATION*
IN MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES DIVISION,
MATERIAL ENGINEERING SECTION,
TRANSPORTATION BUILDING,
ST PAUL MN 55155*

TI UNDISTURBED BORING PROGRAM: AUGER BORING NOTES*
RS TO OBTAIN SUBSURFACE SOIL AND ROCK DATA AS WELL AS WATER DATA FOR USE IN DESIGNING TRANSPORTATION PROJECTS.*
TY PRIMARY*
NT STATE DEPARTMENT OF ADMINISTRATION OBTAINS BORINGS FOR USE IN DESIGNING STATE BUILDINS; LAWS: MINNESOTA STATE STATUTE 160, 161, 174, 454; STANDARDIZATION: AASHTO, ASTM, FHWA REQUIREMENTS IN HIGHWAY GRANT FUNDS*
SN MINNESOTA DEPARTMENT OF TRANSPORTATION*
YR 1958 - 1981 (TO PRESENT)*
MT (SOURCE)
SOILS;
(METHODS)
TRAINED DRILLING CREWS ARE ASSIGNED TO SPECIFIC PROJECTS. CREW MAKES AUGER BORINGS AND MAKES FIELD NOTES ON SOILS;
(CLASSES)
LOCATION ALONG AND FROM LINE, DEPTH, SOIL TYPE, MOISTURE, COLOR*
MS (UNITS)
FEET;
(FREQUENCY)
ONE TIME;
(SIZE)
4000 SITES, 9000 BORINGS*
FT MANUAL FILES, COMPUTER FILES (UNIVERSITY COMPUTER CENTER)*
DE SOILS, HIGHWAY CONSTRUCTION, SOIL WATER, SOIL BORING, SOIL CLASSIFICATION, GROUNDWATER, ROAD CONSTRUCTION*
LO MINNESOTA DEPARTMENT OF TRANSPORTATION,
TECHNICAL SUPPORT SERVICES DIVISION,
TRANSPORTATION BUILDING,
ST PAUL MN 55155*
AV NO RESTRICTIONS, CONTACT VIRGIL MIKKELSEN (612-296-2304)*
GC (REFERENCE)
DISTANCE ALONG, FROM CENTERLINE, MINNESOTA DEPARTMENT OF TRANSPORTATION PROJECT NUMBER, MINNESOTA DEPARTMENT OF TRANSPORTATION STATION NUMBER, MINNESOTA DEPARTMENT OF TRANSPORTATION DISTRICT NUMBER, MINNESOTA DEPARTMENT OF TRANSPORTATION ROAD NUMBER, PUBLIC LAND SURVEY;
(AREA)
MN*

/EOR

AN 0000Z001876*
ID DATA*
NU SWIM-D-054001*
NU MNGS-D-3*
NU DCAT-D-105*
AU MINNESOTA GEOLOGICAL SURVEY*
IN MINNESOTA GEOLOGICAL SURVEY,
1633 EUSTIS STREET,
ST PAUL MN 55108*
TI WATER WELL AND ENGINEERING TEST BORING PROGRAMS: WATER WELL LOG DATA BASE*
RS TO ACQUIRE AND INTERPRET SUBSURFACE GEOLOGICAL AND HYDROGEOLOGICAL DATA, ESPECIALLY WITH REGARD TO GROUNDWATER ASSESSMENT AND AQUIFER DELINEATION.*
AC INFORMATION CIRCULARS AND COUNTY GEOLOGIC ATLAS SERIES. LIST OF PUBLICATIONS AVAILABLE ON REQUEST. DATA IS ALSO USED IN LOCAL, REGIONAL, AND STATE PLANNING PROGRAMS*

TY PRIMARY*
NT MINNESOTA DEPARTMENT OF HEALTH WATER WELL LOGS AND MINNESOTA DEPARTMENT OF NATURAL RESOURCES GROUNDWATER PERMITS PROGRAMS COLLECT WATER WELL LOG DATA AFTER 1975 USING IDENTICAL UNIQUE WELL NUMBER. THIS PROGRAM UTILIZES AND MAKES GEOLOGIC INTERPRETATIONS FROM WELL DRILLERS LOGS REQUIRED TO BE FILED WITH THE MINNESOTA DEPARTMENT OF HEALTH*
SN MINNESOTA STATE LEGISLATURE*
YR 1880 - 1981 (TO PRESENT)*
MT (SOURCE)
WATER WELL DRILLERS, SOIL AND ROCK UNITS;
(METHODS)
STAFF COLLECTS WELL LOG FORM FROM MINNESOTA DEPARTMENT OF HEALTH OR COPIES ORIGINAL WELL DRILLERS RECORDS THAT PREDATE THE 1975 WATER DRILLERS LICENSING ACT. STAFF FIELD CHECKS EACH WELL LOCATION ON USGS TOPOGRAPHIC MAPS. STAFF INTERPRETS GEOLOGY FROM WELL LOGS. STAFF TRANSFERS INFORMATION ONTO STANDARDIZED CODING FORMS. CUTTING SAMPLES MAY BE COLLECTED BY STAFF AS WELL IS DRILLED. WATER SAMPLES MAY ALSO BE COLLECTED BY STAFF AS NEEDED;
(CLASSES)
LOCATION, ELEVATION, DRILLING COMPANY, AQUIFER USED, WELL USE, DATE, WELL DEPTH, CASING, HOLE DIAMETER, SCREEN, STATIC WATER LEVEL, PUMPING LEVEL, WELL HEAD COMPLETION, GROUTING, SOURCE OF POSSIBLE CONTAMINATION, PUMP TYPE, FORMATION LOG, COLOR, HARDNESS, DEPTH TO TOP OF UNIT, STRATIGRAPHIC UNIT, LITHOLOGY*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
ONE TIME;
(SIZE)
80000 WELL LOGS (20000 ON COMPUTER)*
FT MANUAL FILES, COMPUTER FILES (UNIVERSITY COMPUTER CENTER), MAPS*
DE GEOLOGY, SOILS, HYDROGEOLOGY, SURFICIAL GEOLOGY, AQUIFERS, ROCK TYPE, GROUNDWATER, WATER TABLE*
LO MINNESOTA GEOLOGICAL SURVEY,
1633 EUSTIS STREET,
ST PAUL MN 55108*
AV CONFIDENTIALITY AS REQUESTED BY INDUSTRY OR OUTSIDE SOURCE, OTHERWISE, NO RESTRICTIONS, CONTACT BRUCE OLSEN (612-373-3591)*
GC (REFERENCE)
COUNTY NAME, PUBLIC LAND SURVEY, STREET ADDRESS, CITY/TOWNSHIP NAME (MCD);
(AREA)
MN*
/EOR
AN 0000Z001874*
ID DATA*
NU SWIM-D-054002*
NU MNGS-D-1*
NU DCAT-D-103*
AU MINNESOTA GEOLOGICAL SURVEY*
IN MINNESOTA GEOLOGICAL SURVEY,
1633 EUSTIS STREET,
ST PAUL MN 55108*
TI WATER WELL AND ENGINEERING TEST BORING PROGRAMS: ENGINEERING TEST BORING LOGS*

RS TO ACQUIRE AND INTERPRET SUBSURFACE GEOLOGIC AND HYDROGEOLOGIC
DATA.*
AC INFORMATION CIRCULARS AND COUNTY ATLAS SERIES. LIST OF
PUBLICATIONS AVAILABLE ON REQUEST*
TY PRIMARY*
SN MINNESOTA STATE LEGISLATURE*
YR 1880 - 1981 (TO PRESENT)*
MT (SOURCE)
TEST BORING DRILLERS, SOIL AND ROCK UNITS;
(METHODS)
STAFF COPIES EXISTING LOGS FROM LOCAL AND STATE GOVERNMENT
AGENCIES AND LOCATES THEM FROM MINNESOTA DEPARTMENT OF
TRANSPORTATION RIGHT OF WAY MAPS OR SKETCH MAPS INCLUDED WITH BORING
LOG. STAFF THEN DOES GEOLOGICAL INTERPRETATIONS;
(CLASSES)
LOCATION, ELEVATION, BORING DEPTH, WATER LEVEL, MATERIAL
DESCRIPTION, SOIL CLASSIFICATION, STRATIGRAPHIC UNITS, DEPTH TO
BEDROCK, MOISTURE CONTENT, LITHOLOGY, CORE PERCENT RECOVERED*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
ONE TIME AT EACH SITE;
(SIZE)
20000 TEST BORING LOGS*
FT MANUAL FILES, COMPUTER FILES (UNIVERISITY COMPUTER CENTER), MAPS*
DE SOILS, SOIL CLASSIFICATION, GEOLOGY, GROUNDWATER, HYDROGEOLOGY,
WATER TABLE, ROCK TYPE*
LO MINNESOTA GEOLOGICAL SURVEY,
1633 EUSTIS STREET,
ST PAUL MN 55108*
AV CONFIDENTIALITY AS REQUESTED BY INDUSTRY OR OUTSIDE SOURCE,
OTHERWISE NO RESTRICTIONS, CONTACT BRUCE OLSEN (612-373-3591)*
GC (REFERENCE)
COUNTY NAME, PUBLIC LAND SURVEY, STREET ADDRESS, CITY/TOWNSHIP
NAME (MCD);
(AREA)
MN*
/EOR

AN 0000Z001875*
ID DATA*
NU SWIM-D-054003*
NU MNGS-D-2*
NU DCAT-D-104*
AU MINNESOTA GEOLOGICAL SURVEY*
IN MINNESOTA GEOLOGICAL SURVEY,
1633 EUSTIS STREET,
ST PAUL MN 55108*
TI WATER WELL AND ENGINEERING TEST BORING PROGRAMS: WATER CHEMISTRY
ANALYSES SATA BASE*
RS THE PURPOSE OF THIS GEOCHEMICAL SAMPLING PROGRAM IS CHIEFLY TO
PREDICT GROUNDWATER MOVEMENT. PUBLIC HEALTH PARAMETERS ARE NOT
ENTERED INTO THIS DATA BASE.*
AC INFORMATION CIRCULARS AND COUNTY GEOLOGIC ATLAS SERIES. REPORT
FROM MINNESOTA URANIUM EVALUATION PROJECT OF THE NATIONAL URANIUM
RESEARCH EVALUATION*

TY PRIMARY*
MT MAJORITY OF SAMPLES WERE COLLECTED AS PART OF THE DEPARTMENT OF ENERGY'S NATIONAL URANIUM EVALUATION. REMAINDER ARE COLLECTED AS PART OF A COOPERATIVE PROGRAM WITH THE MINNESOTA DEPARTMENT OF HEALTH WHICH IS FUNDED TO DO 200 DETAILED WATER CHEMISTRY STUDIES PER YEAR. MINNESOTA GEOLOGICAL SURVEY COLLECTS ABOUT 100 OF THESE SAMPLES FOR THE MINNESOTA DEPARTMENT OF HEALTH*
SN MINNESOTA STATE LEGISLATURE*
YR 1976 - 1981 (TO PRESENT)*
MT (SOURCE)
WELL WATER SAMPLES;
(METHODS)
FOR THE URANIUM PROJECT THE MINNESOTA GEOLOGICAL SURVEY (MGS) COLLECTED SAMPLES FROM 5000 WELLS IN WESTERN AND EAST CENTRAL MINNESOTA. THESE SAMPLES WERE ANALYZED BY THE UNION CARBIDE CORPORATION AT OAKRIDGE TENNESSEE. DATA IS BEING RETURNED TO THE MGS. FOR ONGOING PROGRAMS WITH THE MINNESOTA DEPARTMENT OF HEALTH (MDH) THE MGS COLLECTS ABOUT 100 SAMPLES PER YEAR. THE MDH LABORATORY RUNS STANDARD WATER CHEMISTRY PARAMETERS (THE EPA STORET PARAMETER LIST). MGS RUNS RADIO-ISOTOPE STUDIES ON THESE SAME SAMPLES AND ALSO RECIEVES A COPY OF THE MDH ANALYSES;
(CLASSES)
RADIO-ISOTOPE MEASURES, DISSOLVED OXYGEN, WATER TEMPERATURE*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
ONE TIME AT EACH SITE;
(SIZE)
300 WELL SAMPLES IN CONJUNCTION WITH MDH, 5000 WELL SAMPLES FROM THE URANIUM PROJECT*
FT MANUAL FILES, COMPUTER FILES (UNIVERSITY COMPUTER CENTER), MAPS*
DE WATER CHEMISTRY, WATER WELLS, GROUNDWATER, GEOLOGY, WATER QUALITY, HYDROGEOLOGY, URANIUM*
LO MINNESOTA GEOLOGICAL SURVEY,
1633 EUSTIS STREET,
ST PAUL MN 55108*
AV CONFIDENTIALITY AS REQUESTED BY INDUSTRY OR OUTSIDE SOURCE, OTHERWISE NO RESTRICTIONS, CONTACT BRUCE OLSEN (612-373-3591)*
GC (REFERENCE)
COUNTY NAME, PUBLIC LAND SURVEY, STREET ADDRESS, CITY/TOWNSHIP NAME (MCD);
(AREA)
MN*
/EOR

ID DATA*
NU SWIM-D-055001*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI HAZARDOUS WASTE MANAGEMENT REGULATORY PROGRAM: GENERATOR'S WASTE DISCLOSURE AND EVALUATION OF WASTE GENERATED*

RS THE PURPOSE OF THIS PROGRAM IS TO IDENTIFY, PLAN FOR AND TRACK HAZARDOUS WASTE FROM CRADLE TO GRAVE. MONITORING BEGINS WITH THE GENERATOR OF THE HAZARDOUS MATERIAL WHO MUST PREPARE A DISCLOSURE STATEMENT AND FILE IT WITH THE MINNESOTA POLLUTION CONTROL AGENCY. TRANSPORTERS MUST ALSO REGISTER WITH THE PCA AND THE PCA INVESTIGATES ALL SPILLS OF HAZARDOUS MATERIALS IN TRANSIT. FINALLY, FACILITIES WHICH STORE, TREAT, OR DISPOSE OF HAZARDOUS MATERIALS MUST OBTAIN A PERMIT TO DO SO FROM THE PCA AND THE US ENVIRONMENTAL PROTECTION AGENCY. STATE RULES ARE IN THE PROCESS OF BEING CHANGED TO CONFORM WITH FEDERAL GUIDELINES. AT PRESENT, 30 APPLICATIONS FOR THE STATE PERMIT TO DISPOSE OF HAZARDOUS WASTE HAVE BEEN RECEIVED BY THE PCA BUT ONLY ONE PERMIT HAS BEEN ISSUED.*

AC THE DATA IS COLLECTED SO THAT THE STATE WILL KNOW EXACTLY HOW MUCH AND WHERE HAZARDOUS MATERIALS ARE BEING PRODUCED. THE GENERATOR MUST TURN IN A PLAN FOR MANAGEMENT AND DISPOSAL OF THE WASTE WHICH MUST BE UPDATED ANNUALLY*

TY PRIMARY*

NT MINNESOTA STATE STATUTES 116, 400, 473. REQUIRED UNDER PUBLIC LAW 94-580 (RESOURCE CONSERVATION AND RECOVERY ACT 1977) AND US ENVIRONMENTAL PROTECTION AGENCY RULES PROMULGATED IN 1980. NEW STATE RULES ALSO APPLY (6MCAR 4.9001-10)*

SN MINNESOTA POLLUTION CONTROL AGENCY, US ENVIRONMENTAL PROTECTION AGENCY*

YR 1978 - 1982 (TO PRESENT)*

MT (SOURCE)
WASTE GENERATOR PROVIDES THE DATA, HOWEVER THE MPCA MAY REQUEST AT ANY TIME THAT A GENERATOR SUBMIT THE RESULTS OF AN EVALUATION OF WASTE TO DETERMINE IF THAT SUBSTANCE IS HAZARDOUS. THE MPCA MAY ALSO ENTER THE PROPERTY TO ANALYZE OR EVALUATE THE WASTE;
(METHODS)
STANDARD METHODS;
(CLASSES)
TYPE OF WASTE, SOURCE OF WASTE, CHEMICAL COMPOSITION, ANTICIPATED FLUCTUATIONS IN COMPOSITION, CONCENTRATION OF HAZARDOUS COMPONENTS, HAZARDOUS PROPERTIES, SAMPLING METHOD, TEST RESULTS, TEST ACCURACY AND PRECISION, SPECIAL HANDLING PROCEDURES, MANAGER OF HAZARDOUS WASTE, SPILL RESPONSE PROCEDURES, AMOUNT PRODUCED, TRANSPORTERS UTILIZED, HAZARDOUS WASTE FACILITIES USED, HAZARDOUS WASTE FACILITY PERMIT NUMBER, WASTE FACILITIY ADDRESS, WASTEWATER TREATMENT WORKS USED, NPDES OR STATE DISPOSAL PERMIT NUMBER, SUMMARY OF SPILL DATA, PREDICTIONS FOR FOLLOWING YEAR*

MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
ANNUALLY;
(SIZE)
ABOUT 1800 GENERATORS HAVE PROVIDED DISCLOSURES*

FT MANUAL FILES, COMPUTER FILES (HENNEPIN COUNTY MANAGEMENT INFORMATION SYSTEM*

DE HAZARDOUS WASTE, HAZARDOUS MATERIALS, INDUSTRIAL WASTE, WATER POLLUTION, SURFACE WATER, GROUNDWATER, EXPLOSIVES, CORROSIVE LIQUIDS, FLAMMABLE LIQUIDS, CHEMICAL ANALYSIS, WASTE DISPOSAL*

LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*

AV CONFIDENTIALITY AS REQUESTED BY INDUSTRY OR OUTSIDE SOURCES
OTHERWISE NO RESTRICTIONS, CONTACT JIM WARNER (612)297-2722 OR MIKE
SOMMER (612) 297-2967*
GC (REFERENCE)
FIPS CODE, LATITUDE/LONGITUDE, LOCATION DESCRIPTION;
(AREA)
MN*
/EOR

ID DATA*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI HAZARDOUS WASTE MANAGEMENT REGULATORY PROGRAM: WASTE STORAGE
INFORMATION*
RS THE PURPOSE OF THIS PROGRAM IS TO IDENTIFY, PLAN FOR AND TRACK
HAZARDOUS WASTE FROM CRADLE TO GRAVE. MONITORING BEGINS WITH THE
GENERATOR OF THE HAZARDOUS MATERIAL WHO MUST PREPARE A DISCLOSURE
STATEMENT AND FILE IT WITH THE MINNESOTA POLLUTION CONTROL AGENCY.
TRANSPORTERS MUST ALSO REGISTER WITH THE PCA AND THE PCA
INVESTIGATES ALL SPILLS OF HAZARDOUS MATERIALS IN TRANSIT. FINALLY,
FACILITIES WHICH STORE, TREAT, OR DISPOSE OF HAZARDOUS MATERIALS
MUST OBTAIN A PERMIT TO DO SO FROM THE PCA AND THE US ENVIRONMENTAL
PROTECTION AGENCY. STATE RULES ARE IN THE PROCESS OF BEING CHANGED
TO CONFORM WITH FEDERAL GUIDELINES. AT PRESENT, 30 APPLICATIONS
FOR THE STATE PERMIT TO DISPOSE OF HAZARDOUS WASTE HAVE BEEN
RECEIVED BY THE PCA BUT ONLY ONE PERMIT HAS BEEN ISSUED.*
AC THE DATA IS COLLECTED SO THAT THE STATE WILL KNOW EXACTLY HOW MUCH
AND WHERE HAZARDOUS MATERIALS ARE BEING PRODUCED. THE GENERATOR
MUST TURN IN A PLAN FOR MANAGEMENT AND DISPOSAL OF THE WASTE WHICH
MUST BE UPDATED ANNUALLY*
TY PRIMARY*
NT MINNESOTA STATE STATUTES 116, 400, 473. REQUIRED UNDER PUBLIC LAW
94-580 (RESOURCE CONSERVATON AND RECOVERY ACT 1977) AND US
ENVIRONMENTAL PROTECTION AGENCY RULES PROMULGATED IN 1980. NEW
STATE RULES ALSO APPLY (6MCAR 4.9001-10)*
SN MINNESOTA POLLUTION CONTROL AGENCY; US ENVIRONMENTAL PROTECTION
AGENCY*
YR 1978 - 1982 (TO PRESENT)*
MT (SOURCE)
STORAGE FACILITY OPERATOR;
(METHODS)
OPERATOR IS REQUIRED TO MAINTAIN A LOG THAT RECORDS INFORMATION ON
EACH SHIPMENT AND ITS DISPOSAL AT THE FACILITY, A HAZARDOUS WASTE
SUMMARY IS THEN FILED WITH THE MINNESOTA POLLUTION CONTROL AGENCY;
(CLASSES)
AMOUNT OF HAZARDOUS WASTE, NAMES OF GENERATORS, IDENTIFY TYPES OF
HAZARDOUS WASTE*
MS (UNITS)
NOT INDICATED;
(FREQUENCY)
FILED MONTHLY, OR QUARTERLY IF ON SITE FACILITY ACCEPTING ONLY ITS
OWN WASTE;

(SIZE)
200 SITES*
FT MANUAL FILES, COMPUTER FILES*
DE HAZARDOUS WASTE, HAZARDOUS MATERIALS, INDUSTRIAL WASTE, WATER POLLUTION, SURFACE WATER, GROUNDWATER, EXPLOSIVES, CORROSIVE LIQUIDS, FLAMMABLE LIQUIDS, CHEMICAL ANALYSIS, WASTE DISPOSAL, LAND USE*
LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DISIVION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
AV CONFIDENTIALITY AS REQUESTED BY INDUSTRY OR OUTSIDE SOURCES OTHERWISE NO RESTRICTIONS, CONTACT JIM WARNER (612-297-2722)*
GC (REFERENCE)
FIPS CODE, LATITUDE/LONGITUDE, LOCATION DESCRIPTION;
(AREA)
MN*
/EOR

ID DATA*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI HAZARDOUS WASTE MANAGEMENT REGULATORY PROGRAM: WASTE STORAGE SITE MONITORING*
RS THE PURPOSE OF THIS PROGRAM IS TO IDENTIFY, PLAN FOR AND TRACK HAZARDOUS WASTE FROM CRADLE TO GRAVE. MONITORING BEGINS WITH THE GENERATOR OF THE HAZARDOUS MATERIAL WHO MUST PREPARE A DISCLOSURE STATEMENT AND FILE IT WITH THE MINNESOTA POLLUTION CONTROL AGENCY. TRANSPORTERS MUST ALSO REGISTER WITH THE PCA AND THE PCA INVESTIGATES ALL SPILLS OF HAZARDOUS MATERIALS IN TRANSIT. FINALLY, FACILITIES WHICH STORE, TREAT, OR DISPOSE OF HAZARDOUS MATERIALS MUST OBTAIN A PERMIT TO DO SO FROM THE PCA AND THE US ENVIRONMENTAL PROTECTION AGENCY. STATE RULES ARE IN THE PROCEOF BEING CHANGED TO CONFORM WITH FEDERAL GUIDELINES. AT PRESENT, 30 APPLICATIONS FOR THE STATE PERMIT TO DISPOSE OF HAZARDOUS WASTE HAVE BEEN RECEIVED BY THE PCA BUT ONLY ONE PERMIT HAS BEEN ISSUED.*
AC THE DATA IS COLLECTED SO THAT THE STATE WILL KNOW EXACTLY HOW MUCH AND WHERE HAZARDOUS MATERIALS ARE BEING PRODUCED. THE GENERATOR MUST TURN IN A PLAN FOR MANAGEMENT AND DISPOSAL OF THE WASTE WHICH MUST BE UPDATED ANNUALLY*
TY PRIMARY*
NT MINNESOTA STATE STATUTES 116, 400, 473. REQUIRED UNDER PUBLIC LAW 94-580 (RESOURCE CONSERVATON AND RECOVERY ACT 1977) AND US ENVIRONMENTAL PROTECTION AGENCY RULES PROMULGATED IN 1980. NEW STATE RULES ALSO APPLY (6MCAR 4.9001-10)*
SN MINNESOTA POLLUTION CONTROL AGENCY; US ENVIRONMENTAL PROTECTION AGENCY*
YR 1978 - 1982 (TO PRESENT)*
MT (SOURCE)
HAZARDOUS WASTE FACILITY OPERATOR;

(METHODS)
FACILITY OPERATOR IS REQUIRED TO CONSTRUCT AND BEGIN OPERATING A SITE MONITORING SYSTEM THAT IS APPROVED BY THE AGENCY AS ADEQUATE TO DETERMINE THE EFFECT OF THE FACILITY ON THE SOIL, GROUNDWATER AND AIR BEFORE ACCEPTING OR STORING ANY HAZARDOUS WASTE AT THE FACILITY. THE SITE MONITORING RESULTS ARE THEN SUBMITTED;
(CLASSES)
SOIL, GROUNDWATER AND AIR QUALITY MEASUREMENTS AS APPROPRIATE FOR THE SITUATION*

MS (UNITS)
NOT INDICATED;
(FREQUENCY)
RESULTS SUBMITTED QUARTERLY;
(SIZE)
200 SITES*

FT MANUAL FILES, COMPUTER FILES*

DE HAZARDOUS WASTE, HAZARDOUS MATERIALS, INDUSTRIAL WASTE, WATER POLLUTION, SURFACE WATER, GROUNDWATER, EXPLOSIVES, CORROSIVE LIQUIDS, FLAMMABLE LIQUIDS, CHEMICAL ANALYSIS, WASTE DISPOSAL, SOIL ANALYSIS*

LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*

AV CONFIDENTIALITY AS REQUESTED BY INDUSTRY OR OUTSIDE SOURCES OTHERWISE NO RESTRICTIONS, CONTACT JIM WARNER (612)297-2722 OR MIKE SOMMER (612) 297-2967*

GC (REFERENCE)
FIPS CODE, LATITUDE/LONGITUDE, LOCATION DESCRIPTION;
(AREA)
MN*

/EOR

ID DATA*

NU SWIM-D-055001*

AU MINNESOTA POLLUTION CONTROL AGENCY*

IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*

TI HAZARDOUS WASTE MANAGEMENT REGULATORY PROGRAM: HAZARDOUS WASTE DISPOSAL FACILITY PERMIT APPLICATIONS*

RS THE PURPOSE OF THIS PROGRAM IS TO IDENTIFY, PLAN FOR AND TRACK HAZARDOUS WASTE FROM CRADLE TO GRAVE. MONITORING BEGINS WITH THE GENERATOR OF THE HAZARDOUS MATERIAL WHO MUST PREPARE A DISCLOSURE STATEMENT AND FILE IT WITH THE MINNESOTA POLLUTION CONTROL AGENCY. TRANSPORTERS MUST ALSO REGISTER WITH THE PCA AND THE PCA INVESTIGATES ALL SPILLS OF HAZARDOUS MATERIALS IN TRANSIT. FINALLY, FACILITIES WHICH STORE, TREAT, OR DISPOSE OF HAZARDOUS MATERIALS MUST OBTAIN A PERMIT TO DO SO FROM THE PCA AND THE US ENVIRONMENTAL PROTECTION AGENCY. STATE RULES ARE IN THE PROCESS OF BEING CHANGED TO CONFORM WITH FEDERAL GUIDELINES. AT PRESENT, 30 APPLICATIONS FOR THE STATE PERMIT TO DISPOSE OF HAZARDOUS WASTE HAVE BEEN RECEIVED BY THE PCA BUT ONLY ONE PERMIT HAS BEEN ISSUED.*

AC THE DATA IS COLLECTED SO THAT THE STATE WILL KNOW EXACTLY HOW MUCH AND WHERE HAZARDOUS MATERIALS ARE BEING PRODUCED. THE GENERATOR MUST TURN IN A PLAN FOR MANAGEMENT AND DISPOSAL OF THE WASTE WHICH MUST BE UPDATED ANNUALLY*

TY PRIMARY*

NT MINNESOTA STATE STATUTES 116, 400, 473. REQUIRED UNDER PUBLIC LAW 94-580 (RESOURCE CONSERVATON AND RECOVERY ACT 1977) AND US ENVIRONMENNTAL PROTECTION AGENCY RULES PROMULGATED IN 1980. NEW STATE RULES ALSO APPLY (6MCAR 4.9001-10)*

SN MINNESOTA POLLUTION CONTROL AGENCY; US ENVIRONMENTAL PROTECTION AGENCY*

YR 1978 - 1982 (TO PRESENT)*

MT (SOURCE)

HAZARDOUS WASTE FACILITY OPERATOR;

(METHODS)

AN APPLICATION FOR A PERMIT MUST BE SUBMITTED BY ANY PERSON WHO, 1) ESTABLISHES, CONSTRUCTS, OPERATES, CLOSES, OR ABANDONS A HAZARDOUS WASTE FACILITY, 2) MAKES ANY CHANGE IN, ADDITION TO, OR EXTENSION OF A PERMITTED HAZARDOUS WASTE FACILITY, 3) MAKES ANY EXPANSION, PRODUCTION INCREASE, OR PROCESS MODIFICATION THAT RESULTS IN NEW OR INCREASED CAPABILITIES OF A PERMITTED HAZARDOUS WASTE FACILITY, 4) OPERATES SUCH A PERMITTED FACILITY;

(CLASSES)

AREA PLAN HAVING A SCALE AND VERTICAL CONTOUR: COUNTY AND TOWNSHIP AND MUNICIPAL BOUNDARIES, NORTH ARROW AND TOWNSHIP, RANGE AND SECTION NUMBERS, SURFACE WATERS, FLOODPLAINS, WETLANDS, BOUNDARIES OF PARKS AND WILDLIFE REFUGES, HIGHWAYS, ROADS, RAILROADS, AND MAIN ACCESS TO FACILITY, APPROXIMATE DAILY UTILIZATION OF EACH ACCESS ROUTE BY VEHILES, SURFACE WATER DRAINAGE PATTERNS AND DRAINAGE DIVIDES, WATER FLOW DIRECTION, LAND USE PATTERNS AND ZONING, BUILDING WITHIN 1/4 MILE OF THE FACILITY AND THEIR USES, QUARRIES AND GRAVEL PITS, MAJOR ROCK OUTCROPS AND FAULT ZONES, SANITARY LANDFILLS AND DUMPS, LOCATION AND SURFACE ELEVATION OF ALL ACTIVE AND ABANDONED WELLS WITHIN 1/4 MILE, SITE PLOT PLAN OF EXISTING CONDITIONS AT THE LOCATION OF THE PROPOSED FACILITY WITH ALL THE ABOVE DESCRIPTIONS, ESTIMATE OF THE COST FOR THE PROPER REMOVAL: TRANSPORTATION AND DISPOSAL OF THE TOTAL AMOUNT OF HAZARDOUS WASTE THAT THE APPLICANT HAS REQUESTED TO STORE, CLOSURE OF THE FACILITY INCLUDING ANY LONG TERM MAINTENANCE, MONITORING AND SURVEILLANCE FOR A PERIOD OF THIRTY YEARS AFTER CLOSURE, REPORT ON THE SUBSURFACE CONDITIONS, SUMMARY OF FIELD INVESTIGATIONS ON SUBSURFACE CONDITIONS (LOGS OF BORINGS, PLOTS, MONITORING WELLS, CROSS SECTIONS, COMPARISON WITH LITERATURE, ESTIMATED WATER BALANCE, POROSITY AND PERMEABILITY OF SOIL TYPES, GROUNDWATER LEVELS, GROUNDWATER QUALITY), ENGINEERING REPORT ON THE CONSTRUCTION OF THE FACILITY (SITE PLOT PLAN, SPECIFICATIONS FOR STORAGE AREAS, TANKS, LINES, EQUIPMENT, DESIGN AND SPECIFICATIONS FOR THE REBATEMENT OF RUNOFF), REPORT ON OPERATION OF THE FACILITY (WASTE TYPES PROPOSED, ESTIMATED YEARLY QUANTITIES, INVENTORY CONTROL PROCEDURES, DESCRIPTION OF PROCESSING, MANAGEMENT OF WASTE, DESCRIPTION OF AIR EMISSIONS, WASTEWATER EFFLUENTS, HAZARDOUS WASTE, SOLID WASTES), OPERATIONS MANUAL (DAILY PROCEDURE, INVENTORY CONTROL, INSPECTIONS, MONITORING METHODS, HOLDING BASIN OPERATION, SPILL RESPONSE, MANAGEMENT PLAN FOR RESIDUALS), CLOSURE MANUAL, DESCRIPTION OF FINANCIAL ARRANGEMENTS*

MS (UNITS)
NOT INDICATED;
(FREQUENCY)
COLLECTED EVERY FIVE YEARS OR WHEN CHANGES OCCUR;
(SIZE)
30 APPLICATIONS RECEIVED, 1 PERMIT GRANTED*
FT MANUAL FILES*
DE WASTE MANAGEMENT, WASTE DISPOSAL, TOPOGRAPHIC FEATURES, WASTE TRANSFER STATIONS, TOXIC HAZARDS, GEOLOGY, SURFACE WATER, GROUNDWATER, LAND USE, INDUSTRIAL WASTE, WATER POLLUTION, HAZARDOUS WASTE*
LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
AV CONFIDENTIALITY AS REQUESTED BY INDUSTRY OR OUTSIDE SOURCES OTHERWISE NO RESTRICTIONS, CONTACT JIM WARNER (612)297-2722*
GC (REFERENCE)
FIPS CODE, LATITUDE/LONGITUDE, LOCATION DESCRIPTION;
(AREA)
MN*
/EOR

ID DATA*
NU SWIM-D-055003*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI HAZARDOUS WASTE MANAGEMENT REGULATORY PROGRAM: SPILLS IN TRANSIT DATA*
RS THE PURPOSE OF THIS PROGRAM IS TO IDENTIFY, PLAN FOR AND TRACK HAZARDOUS WASTE FROM CRADLE TO GRAVE. MONITORING BEGINS WITH THE GENERATOR OF THE HAZARDOUS MATERIAL WHO MUST PREPARE A DISCLOSURE STATEMENT AND FILE IT WITH THE MINNESOTA POLLUTION CONTROL AGENCY. TRANSPORTERS MUST ALSO REGISTER WITH THE PCA AND THE PCA INVESTIGATES ALL SPILLS OF HAZARDOUS MATERIALS IN TRANSIT. FINALLY, FACILITIES WHICH STORE, TREAT, OR DISPOSE OF HAZARDOUS MATERIALS MUST OBTAIN A PERMIT TO DO SO FROM THE PCA AND THE US ENVIRONMENTAL PROTECTION AGENCY. STATE RULES ARE IN THE PROCESS OF BEING CHANGED TO CONFORM WITH FEDERAL GUIDELINES. AT PRESENT, 30 APPLICATIONS FOR THE STATE PERMIT TO DISPOSE OF HAZARDOUS WASTE HAVE BEEN RECEIVED BY THE PCA BUT ONLY ONE PERMIT HAS BEEN ISSUED.*
AC THE MINNESOTA POLLUTION CONTROL AGENCY (MPCA) MONITORS ALL SPILLS OF HAZARDOUS SUBSTANCES TO PROTECT PUBLIC SAFETY AND HEALTH. THIS PROGRAM INVESTIGATES ACCIDENTS AND SHORT TERM EMERGENCIES.*
TY PRIMARY*
NT MINNESOTA STATE STATUTES 116, 400, 473. REQUIRED UNDER PUBLIC LAW 94-580 (RESOURCE CONSERVATON AND RECOVERY ACT 1977) AND US ENVIRONMENTAL PROTECTION AGENCY RULES PROMULGATED IN 1980. NEW STATE RULES ALSO APPLY. MPCA'S DSHW ENFORCEMENT SECTION ALSO HEADS A STRIKE FORCE WHIH HANDLES LONG TERM DISPOSAL SITUATIONS WHICH HAVE BECOME PUBLIC PROBLEMS*

SN MINNESOTA POLLUTION CONTROL AGENCY; US ENVIRONMENTAL PROTECTION
AGENCY*
YR 1978 - 1982 (TO PRESENT)*
MT (SOURCE)
WASTE GENERATOR;
(METHODS)
IN THE CASE OF A SPILL OR LEAK OF HAZARDOUS MATERIALS DURING TRANSIT, INFORMATION ON THE SPILL IS ATTACHED TO THE SHIPPING PAPERS BY THE TRANSPORTER. THE TRANSPORTER NOTIFIES THE GENERATOR. THE GENERATOR MAINTAINS A WRITTEN SUMMARY OF ALL SPILLS AND LEAKS THAT OCCUR DURING TRANSIT FOR A PERIOD OF FIVE YEARS;
(CLASSES)
AMOUNT SPILLED, AMOUNT RECOVERED, LOCATION OF SPILL SITE, DISPOSITION OF SPILLED WASTE, CONTAMINATED MATERIAL*
MS (UNITS)
NOT INDICATED;
(FREQUENCY)
COLLECTED FOR EACH SPILL;
(SIZE)
ABOUT 800 SPILL INCIDENTS ARE REPORTED OR INVESTIGATED ANNUALLY*
FT MANUAL FILES*
DE CHEMICAL SPILLS, GROUNDWATER, SURFACE WATER, HAZARDOUS WASTE, WATER POLLUTION, HAZARDOUS MATERIALS SPILLS, TRANSPORTATION, TOXIC HAZARDS, INDUSTRIAL WASTE, HAZARDOUS MATERIALS*
LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
AV CONFIDENTIALITY AS REQUESTED BY INDUSTRY OR OUTSIDE SOURCES OTHERWISE NO RESTRICTIONS, CONTACT DICK KABLE (612)296-7235 OR MIKE SOMMER (612) 297-2967*
GC (REFERENCE)
SPILL LOCATION DESCRIPTION, ROAD, CITY;
(AREA)
MN*
/EOR

ID DATA*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI HAZARDOUS WASTE MANAGEMENT REGULATORY PROGRAM: UNCONTROLLED SITES AND RCRA INSPECTIONS*
RS THE PURPOSE OF THIS DATA COLLECTION IS TO DETERMINE THE EXTENT AND MAGNITUDE OF CONTAMINATION RELEASED FROM UNCONTROLLED HAZARDOUS WASTE SITES AND FROM GENERATORS, TRANSPORTERS OR DISPOSERS OF HAZARDOUS WASTE INSPECTED FOR RCRA.*
AC THE DATA ACQUIRED IS USED TO DETERMINE COMPLIANCE WITH STATE AND FEDERAL POLLUTION LAWS, TO DETERMINE THE RISK TO PUBLIC HEALTH AND SAFETY, TO DETERMINE ELIGIBILITY FOR SUPERFUND AND AS EVIDENCE IN LEGAL AND ADMINISTRATIVE PROCEEDINGS*

TY PRIMARY*
NT RCRA DATA COLLECTED PURSUANT TO PUBLIC LAW 94-580 (RESOURCE CONSERVATION AND RECOVERY ACT 1977). STRIKE FORCE DATA COLLECTED PURSUANT TO MN STATUTES 115 AND 116 AND RULES 6MCAR 4.6, 4.8, 4.9*
SN MINNESOTA POLLUTION CONTROL AGENCY, US ENVIRONMENTAL PROTECTION AGENCY*
YR 1980 - 1982 (TO PRESENT)*
MT (SOURCE)
DOMESTIC WELLS, PUBLIC WATER SUPPLIES, MONITOR WELLS, SURFACE WATER, SOIL AT AND NEAR HAZARDOUS WASTE SITES, WASTE GENERATORS;
(METHODS)
MPCA STAFF TAKE GRAB SAMPLES FOR MDH ANALYSIS USING US EPA STANDARD TECHNIQUES MODIFIED FOR SAFETY AND HEALTH PROTECTION;
(CLASSES)
COLLECTORS NAME, DATE COLLECTED, PROGRAM ELEMENT NUMBER, FIELD NUMBER, SAMPLING POINT AND SOURCE, ANALYSES REQUESTED, PERSON TO REPORT ANALYSES TO; ANALYSES REQUESTED MAY INCLUDE ANY CHEMICAL PARAMETER WHICH MDH CAN ANALYZE*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
COLLECTED AS NEEDED;
(SIZE)
APPROXIMATELY 550 SAMPLES PER YEAR AT APPROXIMATELY 50 SITES*
FT MANUAL FILES*
DE GROUNDWATER, SURFACE WATER, SOIL, HAZARDOUS WASTE, TOXIC WASTE, INDUSTRIAL WASTE, PUBLIC HEALTH, REGULATORY ACTIVITIES*
LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
AV NO RESTRICTIONS, CONTACT JOHN E. AHO (612) 297-3354*
GC (REFERENCE)
SITE DESCRIPTION, MN, UNIQUE WELL NUMBER, STREET ADDRESS, CITY, COUNTY;
(AREA)
MN*
/EOR
AN 0000Z001443*
ID DATA*
NU SWIM-D-0560001*
NU MPCA-D-3*
NU DCAT-D-60*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI LAND APPLICATION OF WASTEWATER PROGRAM*
RS THE FUNCTION OF THIS PROGRAM IS TO EVALUATE APPLICATIONS FOR A PERMIT TO DISPOSE OF WASTEWATER EFFLUENT FROM A MUNICIPAL OR INDUSTRIAL FACILITY ON LAND. THE DATA IS COLLECTED AND SUBMITTED BY THE APPLICANT IN SUPPORT OF THE APPLICATION.*

AC NO REGULAR PUBLICATIONS RESULT FROM THIS PROGRAM. THE ISSUANCE OF A LAND DISPOSAL PERMIT IS THE ULTIMATE RESULT OF THIS PROGRAM*
TY PRIMARY*
NT THIS PROGRAM IS RELATED TO THE NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT REQUIREMENT OF THE US ENVIRONMENTAL PROTECTION AGENCY. AN NPDES PERMIT IS REQUIRED FOR WASTEWATER DISCHARGE TO A SURFACE WATER; A STATE PERMIT IS REQUIRED FOR LAND DISPOSAL OF EFFLUENT*
SN US ENVIRONMENTAL PROTECTION AGENCY FUNDS THIS PROGRAM THROUGH CONSTRUCTION GRANTS FOR MUNICIPAL FACILITIES; MINNESOTA STATE FUNDS COVER INDUSTRIAL FACILITIES*
YR 1975 - 1982 (TO PRESENT)*
MT (SOURCE)
CONSULTANTS FOR THE APPLICANT PROVIDE THE DATA WHICH INCLUDE SOIL SAMPLES, RESIDUAL SOLIDS FROM THE EFFLUENT, WATER QUALITY SAMPLES, METERED FLOW;
(METHODS)
STANDARD METHODS ARE USED IN THESE ANALYSES (EPA APPROVED);
(CLASSES)
APPLICANT'S NAME AND ADDRESS, APPLICANT'S TECHNICAL AGENT'S NAME AND ADDRESS, APPLICANT'S CONSULTING ENGINEER'S NAME AND ADDRESS, LOCATION OF WASTEWATER FACILITY (PUBLIC LAND SURVEY DESCRIPTION), REASON FOR APPLICATION, CURRENT OR PREVIOUS NPDES OR STATE DISPOSAL SYSTEM PERMIT NUMBER, PRODUCTS MANUFACTURED AND MONTHS OF OPERATION (INDUSTRIAL FACILITIES ONLY), FLOW CHART SHOWING ROUTE OF WASTEWATER FLOW THROUGH ALL TREATMENT PROCESSES FROM INTAKE TO THE POINT OF LAND TREATMENT OR DISPOSAL, BRIEF DESCRIPTION OF METHODS OF WASTEWATER TREATMENT, BRIEF DESCRIPTION OF TYPE AND AMOUNT AND FATE OF ALL RESIDUAL SOLIDS FROM PLANTS OPERATIONS AND WASTEWATER TREATMENT, SYSTEM CHANGES OR MODIFICATIONS, FLOW OF WASTEWATER TO BE LAND APPLIED (DAILY, MONTHLY, ANNUALLY IN GALLONS, PRESENT AND FUTURE), APPLICATION TIME (HOURS PER DAY, DAYS PER WEEK), APPLICATION AMOUNT (INCHES/ACRE/WEEK, INCHES/ACRE/YEAR), FIELD TILE (IS DRAINAGE WATER COLLECTED OR MONITORED), TYPE AND NUMBER AND DEPTH OF GROUNDWATER SAMPLES (WELLS, SUCTION CUP LYSIMETERS, ETC.), IRRIGATION EQUIPMENT (LAGOONS, PUMPS, TILES, IRRIGATION MAINS, DIKES, LYSIMETERS, MONITORING WELLS, DISCHARGE POINTS, ETC.), SOIL SAMPLES, FOR EACH DISPOSAL SITE, PUBLIC LAND SURVEY DESCRIPTION, ACREAGE USED, LAND OWNED OR LEASED, TYPE OF WASTEWATER APPLICATION SYSTEM (NUMBER AND SIZE OF PUMPS, CENTER PIVOT, TRAVELING GUN, RIDGE AND FURROW), VEGETATION ON SITE AND HOW MANAGED*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
PERMIT RUNS FOR FIVE YEARS, NEW DATA MUST BE SUBMITTED WITH RE-APPLICATION, AGENCY TRIED TO MONITOR ANNUALLY, IN ADDITION INDIVIDUAL APPLICANT MAY BE REQUIRED TO MONITOR WATER QUALITY AT VARIOUS INTERVALS DEPENDING ON CONDITIONS;
(SIZE)
15 MUNICIPAL SITES, 25 - 30 INDUSTRIAL SITES*
FT MANUAL FILES*
DE SURFACE WATER, GROUNDWATER, WASTEWATER, EFFLUENT, WATER QUALITY, MUNICIPAL FACILITIES, INDUSTRIAL DISCHARGE*

LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
AV NO RESTRICTIONS, CONTACT KEN LEVOIR (612)297-2714*
GC (REFERENCE)
STREET ADDRESS, COUNTY NAME, PUBLIC LAND SURVEY;
(AREA)
MN, PROPOSED SYSTEMS: ANNANDALE, BACKUS, BARRY, BATTLE LAKE, BELGRADE, BLACKDUCK, CASS LAKE, CROMWELL, CRYSTAL LAKE, EDEN VALLEY, FRAZEE, HENNING, KENSINGTON, KIMBALL, LAKE HENRY, MEDINA, NEW YORK MILLS, ORTONVILLE, PEQUOT LAKES, WATKINS, OPERATING SYSTEMS: BEARDSLEY, BREEZY POINT, ELYSIAN, HAYWARD, NEW AUBURN, PAYNESVILLE, WALKER, WYOMING*
/EOR

ID DATA*
NU SWIM-D-057001*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI ROUTINE AMBIENT GROUNDWATER QUALITY MONITORING PROGRAM*
RS THE FUNCTION OF THIS PROGRAM IS TO PROVIDE A COMPREHENSIVE HISTORICAL AND CURRENT WATER QUALITY DATA BASE TO BE USED FOR ROUTINE EVALUATION OF GROUNDWATER QUALITY TRENDS. DATA MAY ALSO BE USED FOR MINNESOTA POLLUTON CONTROL AGENCY REGULATORY ACTIVITIES.*
AC THE DATA IS USED TO ACCUMLUATE A HISTORICAL DATA BASE ON GROUNDWATER QUALITY IN THE STATE. THE DATA IS SUMMARIZED IN THE ANNUAL WATER QUALITY REPORT PUBLISHED BY THE MINNESOTA POLLUTION CONTROL AGENCY*
TY PRIMARY*
NT LAWS: MINNESOTA STATE STATUTE 115.03 (B), PUBLIC LAW 95-217 (CLEAN WATER ACT OF 1977, SECTION 106). THIS IS A COOPERATIVE PROGRAM OF THE MINNESOTA POLLUTION CONTROL AGENCY AND THE US GEOLOGICAL SURVEY WHO PICKS THE SITES. THE MINNESOTA HEALTH DEPARTMENT MONITORS MUNICIPAL WELLS*
SN US ENVIRONMENTAL PROTECTION AGENCY, MINNESOTA POLLUTION CONTROL AGENCY*
YR 1978 - 1982 (TO PRESENT)*
MT (SOURCE)
WATER SAMPLES FROM PRIVATE AND MUNICIPAL WELLS;
(METHODS)
MONITORING STATIONS AND BASIC PROGRAM IS CHOSEN BY THE US GEOLOGICAL SURVEY WHO ALSO HAS WATER LEVELS ON MOST OF THESE WELLS. THE MINNESOTA POLLUTON CONTROL AGENCY STAFF COLLECTS THE WATER SAMPLES WHICH ARE SENT TO THE DEPARTMENT LAB FOR ANALYSIS ACCORDING TO US ENVIRONMENTAL PROTECTION AGENCY STANDARDS;
(CLASSES)
MEASURED IN THE FIELD: TEMPERATURE, SPECIFIC CONDUCTIVITY, PH, ALKALINITY. LABORATORY ANALYSIS: CALCIUM, MAGNESIUM, CONDUCTIVITY, BICARBONATE ALKALINTY AS CACO3, HCO3, NITROGEN, FLUORIDE, SILICA, TOTAL HARDNESS AS CACO3, TOTAL ALKALINITY, CHLORIDE, SULFATE, SODIUM, POTASSIUM, NITRATE, PLUS NITRITE NITROGEN, TOTAL KJELDAHL NITROGEN, TOTAL PHOSPHORUS, TOTAL ORGANIC CARBON, PHENOL, TOTAL COLIFORM,

TY PRIMARY*
NT MINNESOTA POLLUTION CONTROL AGENCY SOLID WASTE PROGRAM REQUIRES DATA ON SLUDGE GOING TO LAND FILLS (MUNICIPAL SITES OR BURIED IN BURIAL OPERATION). FOOD AND DRUG ADMINISTRATION AND MINNESOTA DEPARTMENT OF AGRICULTURE MAY COLLECT SIMILAR DATA; LABS ANALYZING EFFLUENT SAMPLES USE US ENVIRONMENTAL PROTECTION AGENCY APPROVED METHODS*
SN MINNESOTA POLLUTION CONTROL AGENCY*
YR 1977 - 1982 (TO PRESENT)*
MT (SOURCE)
SLUDGE;
(METHODS)
CHEMICAL ANALYSES OF SLUDGE IS NECESSARY FOR ALL PROJECTS. THE DATA SHOULD CHARACTERIZE THE SLUDGE WHICH IS ACTUALLY LAND APPLIED AND BE REPORTED ON A DRY WEIGHT (105 DEGREES) BASIS;
(CLASSES)
PH, TOTAL SOLIDS, TOTAL VOLATILE SOLIDS, NITROGEN, NH3-N, NO3-N, KJELDAHL-N, TOTAL ZINC, TOTAL COPPER, TOTAL NICKEL, TOTAL LEAD, TOTAL CADMIUM, TOTAL MERCURY, TOTAL CHROMIUM, TOTAL PCB*
MS (UNITS)
STANDARD MEASURES (PERCENT, MG/KG);
(FREQUENCY)
QUARTERLY, SEMI-ANNUALLY OR ANNUALLY DEPENDING ON THE TREATMENT FACILITY CLASSIFICATION*
FT MANUAL FILES*
DE SLUDGE, FARMLAND, SLUDGES, POLLUTION, CHEMICAL ANALYSIS, WATER POLLUTION, SOLID WASTE, LAND USE, GROUNDWATER*
LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1936 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
AV NO RESTRICTIONS, CONTACT STEVE STARK (612)297-2702*
GC (REFERENCE)
COUNTY, PUBLIC LAND SURVEY, LEGAL DESCRIPTION;
(AREA)
MN*
/EOR

AN 0000Z001445*
ID DATA*
NU SWIM-D-058002*
NU MPCA-D-5*
NU DCAT-D-57*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI SLUDGE DISPOSAL PROGRAM: ROUTINE MONITORING*
RS THE PURPOSE OF THIS PROGRAM IS TO REVIEW PROPOSALS FOR THE DISPOSAL ON LAND OF SLUDGE FROM MUNICIPAL SEWAGE TREATMENT FACILITIES. THE AIM OF THIS PROGRAM IS TO ACHIEVE THE BEST UTILIZATION OF SLUDGE WHILE MAINTAINING QUALITY OF SURFACE AND GROUNDWATER AND THE QUALITY OF THE AGRICULTURAL LAND TO WHICH THE SLUDGE IS APPLIED. PERMITS OR LETTERS OF APPROVAL ARE REQUIRED OF THE METROPOLITAN WASTE CONTROL COMMISSION AND THE WESTERN LAKE SUPERIOR SANITARY DISTRICT. THE

FECAL COLIFORM, DISSOLVED SOLIDS, TOTAL VOLATILE SOLIDS, TOTAL CADMIUM, TOTAL COPPER, TOTAL CHROMIUM, TOTAL IRON, TOTAL LEAD, TOTAL MANGANESE, TOTAL MERCURY, TOTAL ZINC, TOTAL ARSENIC, TOTAL BORON, SELENIUM, BARIUM, CYANIDE, NICKEL, FECAL STREPTOCOCCI, CHEMICAL OXYGEN DEMAND, ORGANICS*

MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
ANNUALLY;
(SIZE)
400 SITES*

FT RAW DATA IN MANUAL FILES, COMPUTER FILES (STORET); WELLS LOCATED ON MAPS PRINTED VOLUMES PUBLISHED ANNUALLY*

DE GROUNDWATER, WATER QUALITY, WELLS, MUNICIPAL WELLS, WATER SUPPLY, WATER CHEMISTRY, WATER POLLUTION, BACTERIA*

LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*

AV NO RESTRICTIONS, CONTACT DALE TRIPPLER (612)297-3347*

GC (REFERENCE)
WATERSHED, RIVER BASIN NUMBER, PUBLIC LAND SURVEY DESCRIPTION, COUNTY, LATITUDE/LONGITUDE, MINNESOTA UNIQUE WELL NUMBER, AQUIFER NAME;
(AREA)
MN*

/EOR

AN 0000Z001460*

ID DATA*

NU SWIM-D-058001*

NU MPCA-D-8*

AU MINNESOTA POLLUTION CONTROL AGENCY*

IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*

TI SLUDGE DISPOSAL PROGRAM; SLUDGE ANALYSES*

RS THE PURPOSE OF THIS PROGRAM IS TO REVIEW PROPOSALS FOR THE DISPOSAL ON LAND OF SLUDGE FROM MUNICIPAL SEWAGE TREATMENT FACILITIES. THE AIM OF THIS PROGRAM IS TO ACHIEVE THE BEST UTILIZATION OF SLUDGE WHILE MAINTAINING QUALITY OF SURFACE AND GROUNDWATER AND THE QUALITY OF THE AGRICULTURAL LAND TO WHICH THE SLUDGE IS APPLIED. PERMITS OR LETTERS OF APPROVAL ARE REQUIRED OF THE METROPOLITAN WASTE CONTROL COMMISSION AND THE WESTERN LAKE SUPERIOR SANITARY DISTRICT. THE MWCC UTILIZES ABOUT 150 TO 200 SITES AND THE WLSSD HAS ABOUT 30 TO 50 SITES. ABOUT 275 SMALLER MUNICIPAL SEWAGE FACILITIES SPREAD SLUDGE ON PRIVATE FARMLAND BUT NO ACTUAL PERMIT IS REQUIRED. PRIOR TO THE PASSAGE OF THE WASTE MANAGEMENT ACT OF 1980 THE POLLUTION CONTROL AGENCY WAS IN THE PROCESS OF REQUIRING EACH MUNICIPAL FACILITY TO TURN IN A SOLIDS DISPOSAL PLAN. ABOUT 40 LARGER FACILITIES HAD TURNED IN PLANS WHEN THE ACT WAS PASSED WHICH REQUIRED THE PCA TO PROMULGATE BOTH TEMPORARY RULES (TO BE IN EFFECT FOR THE 6 MONTH PERIOD FOLLOWING APRIL 12, 1981 AND PERMANENT RULES FOR THE HANDLING OF ALL TYPES OF WASTE. NO NEW SOLIDS DISPOSAL PLANS WILL BE TURNED IN UNTIL THE RULES ARE PROMULGATED.*

NU MPCA-D-9*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI SLUDGE DISPOSAL PROGRAM; SOIL DATA*
RS THE PURPOSE OF THIS PROGRAM IS TO REVIEW PROPOSALS FOR THE DISPOSAL ON LAND OF SLUDGE FROM MUNICIPAL SEWAGE TREATMENT FACILITIES. THE AIM OF THIS PROGRAM IS TO ACHIEVE THE BEST UTILIZATION OF SLUDGE WHILE MAINTAINING QUALITY OF SURFACE AND GROUNDWATER AND THE QUALITY OF THE AGRICULTURAL LAND TO WHICH THE SLUDGE IS APPLIED. PERMITS OR LETTERS OF APPROVAL ARE REQUIRED OF THE METROPOLITAN WASTE CONTROL COMMISSION AND THE WESTERN LAKE SUPERIOR SANITARY DISTRICT. THE MWCC UTILIZES ABOUT 15 TO 200 SITES AND THE WLSSD HAS ABOUT 30 TO 50 SITES. ABOUT 275 SMALLER MUNICIPAL SEWAGE FACILITIES SPREAD SLUDGE ON PRIVATE FARMLAND BUT NO ACTUAL PERMIT IS REQUIRED. PRIOR TO THE PASSAGE OF THE WASTE MANAGEMENT ACT OF 1980 THE POLLUTION CONTROL AGENCY WAS IN THE PROCESS OF REQUIRING EACH MUNICIPAL FACILITY TO TURN IN A SOLIDS DISPOSAL PLAN. ABOUT 40 LARGER FACILITIES HAD TURNED IN PLANS WHEN THE ACT WAS PASSED WHICH REQUIRED THE PCA TO PROMULGATE BOTH TEMPORARY RULES (TO BE IN EFFECT FOR THE 6 MONTH PERIOD FOLLOWING APRIL 12, 1981 AND PERMANENT RULES FOR THE HANDLING OF ALL TYPES OF WASTE. NO NEW SOLIDS DISPOSAL PLANS WILL BE TURNED IN UNTIL THE RULES ARE PROMULGATED.*
TY PRIMARY*
NT MINNESOTA POLLUTION CONTROL AGENCY SOLID WASTE PROGRAM REQUIRES DATA ON SLUDGE GOING TO LAND FILLS (MUNICIPAL SITES OR BURIED IN BURIAL OPERATION). FOOD AND DRUG ADMINISTRATION AND MINNESOTA DEPARTMENT OF AGRICULTURE MAY COLLECT SIMILAR DATA; LABS ANALYZING EFFLUENT SAMPLES USE US ENVIRONMENTAL PROTECTION AGENCY APPROVED METHODS*
SN MINNESOTA POLLUTION CONTROL AGENCY*
YR 1977 - 1982 (TO PRESENT)*
MT (SOURCE)
SOILS, SOIL MAP;
(METHODS)
A DETAILED SOIL MAP SHOULD BE OBTAINED TO DETERMINE SOIL TYPES AT APPLICATION SITES. SLUDGE SHOULD NOT BE APPLED TO VERY COARSE SAND OR GRAVEL SOILS. ORGANIC SOILS (PEAT) SHOULD NOT BE USED FOR SLUDGE APPLICATION UNLESS WELL DRAINED. APPLICATION SITES SHOULD BE TESTED TO DETERMINE SPECIFIC SOIL CHARACTERISTICS. THE SITE SHOULD BE DIVIDED INTO AREAS SMALLER THAN 40 ACRES OF SIMILAR SOIL TYPE. TEN SAMPLES SHOULD BE TAKEN, EACH TO ONE FOOT DEEP, FROM EACH AREA. THE SAMPLES ARE MIXED TOGETHER AND A SAMPLE OF THIS COMPOSITE IS TESTED;
(CLASSES)
TEXTURE, ORGANIC MATTER, EXTRACTABLE PHOSPHORUS, EXCHANGEABLE POTASSIUM, PH, LIME REQUIREMENT TO PH 6.5, SOLUBLE SALTS*
MS (UNITS)
USDA CLASSIFICATION, PERCENT, BRAYS NUMBER ONE EXTRACTANT, AMMONIUM ACETATE EXTRACTANT, 1:1 SOIL WATER SUSPENSION, ELECTRICAL CONDUCTANCE, -MMHO/CM*
FT MANUAL FILES*
DE SOILS, SLUDGE DISPOSAL, SOIL TESTS, FARMLANDS, SOIL CHEMISTRY, CHEMICAL ANALYSIS, LAND USE, GROUNDWATER*

MWCC UTILIZES ABOUT 150 TO 200 SITES AND THE WLSSD HAS ABOUT 30 TO 50 SITES. ABOUT 275 SMALLER MUNICIPAL SEWAGE FACILITIES SPREAD SLUDGE ON PRIVATE FARMLAND BUT NO ACTUAL PERMIT IS REQUIRED. PRIOR TO THE PASSAGE OF THE WASTE MANAGEMENT ACT OF 1980 THE POLLUTION CONTROL AGENCY WAS IN THE PROCESS OF REQUIRING EACH MUNICIPAL FACILITY TO TURN IN A SOLIDS DISPOSAL PLAN. ABOUT 40 LARGER FACILITIES HAD TURNED IN PLANS WHEN THE ACT WAS PASSED WHICH REQUIRED THE PCA TO PROMULGATE BOTH TEMPORARY RULES (TO BE IN EFFECT FOR THE 6 MONTH PERIOD FOLLOWING APRIL 12, 1981 AND PERMANENT RULES FOR THE HANDLING OF ALL TYPES OF WASTE. NO NEW SOLIDS DISPOSAL PLANS WILL BE TURNED IN UNTIL THE RULES ARE PROMULGATED.*

TY PRIMARY*

NT MINNESOTA POLLUTION CONTROL AGENCY SOLID WASTE PROGRAM REQUIRES DATA ON SLUDGE GOING TO LAND FILLS (MUNICIPAL SITES OR BURIED IN BURIAL OPERATION). FOOD AND DRUG ADMINISTRATION AND MINNESOTA DEPARTMENT OF AGRICULTURE MAY COLLECT SIMILAR DATA; LABS ANALYZING EFFLUENT SAMPLES USE US ENVIRONMENTAL PROTECTION AGENCY APPROVED METHODS*

SN MINNESOTA POLLUTION CONTROL AGENCY*

YR 1977 - 1982 (TO PRESENT)*

MT (SOURCE)
NOT INDICATED;
(METHODS)
EXCEPT AS SPECIFICALLY EXEMPTED FOR SMALL SCALE GIVEAWAY AND INDIVIDUAL PICKUP PROGRAMS, ROUTINE MONITORING WILL BE NECESSARY OF ALL SLUDGE DISPOSAL PROGAMS. ALL NECESSARY MONITORING IS THE RESPONSIBILITY OF THE MUNICIPALITY;
(CLASSES)
SITES AND ACREAGES USED FOR APPLICATION, AMOUNT OF SLUDGE SPREAD PER SITE, CROPPING PRACTICES, PROBLEMS ENCOUNTERED, SOIL DATA, SLUDGE ANALYSIS, MAP OF NEW SITES, RUNOFF, LEACHATE, GROUNDWATER, SOIL, VEGETATION MONITORING, QUANTITIES DISPOSED OF BY OTHER MEANS*

MS (FREQUENCY)
COLLECTED YEARLY IN ANNUAL REPORT FOR LANDSPREADING;
(SIZE)
150 TO 200 SITES IN THE METROPOLITAN AREA, 30 TO 50 SITES NEAR DULUTH*

FT MANUAL FILES*

DE SLUDGE, SLUDGES, SLUDGE DISPOSAL, FARMLANDS, SOLID WASTES, POLLUTION, SOLID WASTE DISPOSAL, SOILS, SOIL TESTS, AGRICULTURE, GROUNDWATER*

LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*

AV NO RESTRICTIONS, CONTACT STEVE STARK (612)297-2702*

GC (REFERENCE)
COUNTY NAME, PUBLIC LAND SURVEY, LEGAL DESCRIPTION, MUNICIPALITIES;
(AREA)
MN*

/EOR

AN 0000Z001461*

ID DATA*

NU SWIM-D-058003*

(CLASSES)
QUANTITY OF SLUDGE GENERATED AND DISPOSED OF, TREATMENT USED FOR SLUDGE STABILIZATION, SOIL ANALYSIS, DESCRIPTION OF PRACTICES AND FACILITIES USED IN STORAGE OF SLUDGE, SOIL SURVEY MAP DELINEATING THE LOCATION OF STORAGE FACILITIES AND LANDSPREADING, NAMES AND ADDRESSES OF THE OWNERS OF PRIVATELY OWNED APPLICATION SITES, TYPE OF AGREEMENT OBTAINED FOR APPLICATION ON PRIVATE LAND, PROVISIONS FOR ALTERNATE DISPOSAL, APPLICATION ACREAGE AT EACH SITE, DETAILED DESCRIPTION OF EACH SITE INCLUDING: SEPARATION FROM CULTURAL FEATURES AND WELLS AND WATER BODIES, DEGREE (PERCENT) AND DIRECTION OF SLOPE, DEPTH TO GROUNDWATER AND BEDROCK, SOILS DATA, DURATION OF PAST SLUDGE APPLICATIONS AT PROPOSED SITE, ANNUAL APPLICATION RATES, METHODS OF APPLICATION, SITE MANAGEMENT PRACTICES, DESCRIPTION OF PROGRAM FOR SMALL SCALE SLUDGE GIVEAWAY AND PICKUP OR MARKETING, DISCUSSION OF HOW AN WHERE GRIT, SCREENINGS, AND SCUM ARE DISPOSED OF, INDICATION THAT ANY NECESSARY LOCAL AND COUNTY APPROVALS HAVE BEEN OBTAINED*

MS (FREQUENCY)
COLLECTED ONCE OR WHEN CHANGES OCCUR*

FT MANUAL FILES*

DE SLUDGE, SLUDGE DISPOSAL, SOLID WASTE DISPOSAL, FARMLANDS, GROUNDWATER*

LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*

AV NO RESTRICTIONS, CONTACT STEVE STARK (612)297-2702*

GC (REFERENCE)
COUNTY NAME, PUBLIC LAND SURVEY, LEGAL DESCRIPTION;
(AREA)
MN*

/EOR

ID DATA*

NU SWIM-D-059001*

AU MINNESOTA POLLUTION CONTROL AGENCY*

IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*

TI SOLID WASTE INVENTORY AND MONITORING SYSTEM: CHARACTERISTICS OF EACH MONITORING WELL*

RS THE FUNCTION OF THIS PROGRAM IS TO MAINTAIN FILES OF LAND DISPOSAL FACILITIES, INCLUDING LANDFILLS AND INDUSTRIAL WASTE SITES. ALSO STORED ARE THE SITE CHARACTERISTICS, CHARACTERISTICS OF MONITORING WELLS, AND THE ACTUAL WATER QUALITY MONITORING DATA.*

AC DATA IS USED IN THE SOLID AND HAZARDOUS WASTE PERMITTING PROGRAMS. NO REGULAR WRITTEN REPORTS ARE ISSUED*

TY PRIMARY*

NT SOLID WASTE PERMIT PROGRAM IS REQUIRED BY STATE LAW BUT IS NOT MANDATED BY FEDERAL LAW AT THIS TIME; MINN. RULE SW 6(2)*

SN MINNESOTA POLLUTION CONTROL AGENCY AND SOME ADDITONAL FEDERAL FUNDS*

YR 1971 - 1982 (TO PRESENT)*

MT (SOURCE)
WELL DRILLER FURNISHES THE DATA ON THE WELL AND ITS CONSTRUCTION, THE OPERATOR SENDS IT TO THE MPCA;

LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
AV NO RESTRICTIONS, CONTACT STEVE STARK (612)297-2702*
GC (REFERENCE)
COUNTY NAME, PUBLIC LAND SURVEY, LEGAL DESCRIPTION;
(AREA)
MN*

AN 0000Z001446*
ID DATA*
NU MPCA-D-6*
NU DCAT-D-58*
NU SWIM-D-18*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI SLUDGE DISPOSAL PROGRAM: SOLIDS DISPOSAL PLAN*
RS THE PURPOSE OF THIS PROGRAM IS TO REVIEW PROPOSALS FOR THE DISPOSAL ON LAND OF SLUDGE FROM MUNICIPAL SEWAGE TREATMENT FACILITIES. THE AIM OF THIS PROGRAM IS TO ACHIEVE THE BEST UTILIZATION OF SLUDGE WHILE MAINTAINING QUALITY OF SURFACE AND GROUNDWATER AND THE QUALITY OF THE AGRICULTURAL LAND TO WHICH THE SLUDGE IS APPLIED. PERMITS OR LETTERS OF APPROVAL ARE REQUIRED OF THE METROPOLITAN WASTE CONTROL COMMISSION AND THE WESTERN LAKE SUPERIOR SANITARY DISTRICT. THE MWCC UTILIZES ABOUT 150 TO 200 SITES AND THE WLSSD HAS ABOUT 30 TO 50 SITES. ABOUT 275 SMALLER MUNICIPAL SEWAGE FACILITIES SPREAD SLUDGE ON PRIVATE FARMLAND BUT NO ACTUAL PERMIT IS REQUIRED. PRIOR TO THE PASSAGE OF THE WASTE MANAGEMENT ACT OF 1980 THE POLLUTION CONTROL AGENCY WAS IN THE PROCESS OF REQUIRING EACH MUNICIPAL FACILITY TO TURN IN A SOLIDS DISPOSAL PLAN. ABOUT 40 LARGER FACILITIES HAD TURNED IN PLANS WHEN THE ACT WAS PASSED WHICH REQUIRED THE PCA TO PROMULGATE BOTH TEMPORARY RULES (TO BE IN EFFECT FOR THE 6 MONTH PERIOD FOLLOWING APRIL 12, 1981 AND PERMANENT RULES FOR THE HANDLING OF ALL TYPES OF WASTE. NO NEW SOLIDS DISPOSAL PLANS WILL BE TURNED IN UNTIL THE RULES ARE PROMULGATED.*
TY PRIMARY*
NT MINNESOTA POLLUTION CONTROL AGENCY SOLID WASTE PROGRAM REQUIRES DATA ON SLUDGE GOING TO LAND FILLS (MUNICIPAL SITES OR BURIED IN BURIAL OPERATION). FOOD AND DRUG ADMINISTRATION AND MINNESOTA DEPARTMENT OF AGRICULTURE MAY COLLECT SIMILAR DATA; LABS ANALYZING EFFLUENT SAMPLES USE US ENVIRONMENTAL PROTECTION AGENCY APPROVED METHODS*
SN MINNESOTA POLLUTION CONTROL AGENCY*
YR 1977 - 1982 (TO PRESENT)*
MT (SOURCE)
PERMITTEES;
(METHODS)
IN ACCORDANCE WITH THE GENERAL CONDITION OF NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) STATE DISPOSAL SYSTEM PERMITS REGARDING REMOVED SUBSTANCES, ALL PERMITTEES MUST SUBMIT A SOLIDS DISPOSAL PLAN TO THE MINNESOTA POLLUTION CONTROL AGENCY. AS CHANGES ARE MADE IN WASTEWATER TREATMENT FACILITIES, THE NEW SOLIDS DISPOSAL PLAN SHOULD BE A PART OF THE FACILITIES PLANS;

SN MINNESOTA POLLUTION CONTROL AGENCY AND SOME ADDITIONAL FEDERAL
FUNDS*
YR 1971 - 1982 (TO PRESENT)*
MT (SOURCE)
WATER SAMPLES, MPCA SENDS THE OPERATOR THE PROPER FORMS, OPERATOR
COLLECTS THE SAMPLES AND SENDS THEM TO A PRIVATE LAB FOR ANALYSIS;
(METHODS)
PRIVATE LAB DOES THE ANALYSES AND SENDS THE RESULTS TO THE MPCA;
(CLASSES)
INFORMATION ABOUT SAMPLE COLLECTION: PERMIT NUMBER, FACILITY NAME,
MONITORING POINT NUMBER, MINNESOTA UNIQUE WELL NUMBER, COUNTY,
REGION, MONITOR IDENTIFICATION, DATA COLLECTED, DEPTH, TEMPERATURE,
GROUNDWATER SAMPLED BY, SAMPLE APPEARANCE, COLLECTED BY, TRANSPORTED
BY. INFORMATION ON SAMPLE ANALYSIS: LABORATORY NAME AND TELEPHONE
NUMBER, MONITORING REQUIREMENTS, PARAMETER NAME AND VALUE, ADDITIONAL
PARAMETERS MEASURED WERE NOT REQUIRED, LABORATORY COMMENTS,
LABORATORY NUMBER, DATE COMPLETED*
MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
95 PERCENT OF THE OPERATORS MUST REPORT QUARTERLY, OTHER CONDITIONS
ARE SET ON EACH PERMIT;
(SIZE)
ABOUT 150 SITES WITH 3 TO 20 WELLS EACH, 10 TO 12 SURFACE WATER
SITES*
FT MANUAL FILES, SUMMARY DATA ON COMPUTER FILES AT UNIVERSITY COMPUTER
CENTER (CYBER 172)*
DE SURFACE WATER, GROUNDWATER, WELLS, WATER QUALITY, WATER POLLUTION,
SOLID WASTE, LANDFILLS, HAZARDOUS WASTE PERMITS, CONTAMINANTS*
LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
AV NO RESTRICTIONS, CONTACT GRETCHEN SABEL (612)297-2708*
GC (REFERENCE)
COUNTY NAME, PUBLIC LAND SURVEY DESCRIPTION, REGION NAME, MINNESOTA
UNIQUE WELL NUMBER;
(AREA)
MN*
/EOR

ID DATA*
NU SWIM-D-059003*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI SOLID WASTE INVENTORY AND MONITORING SYSTEM (SWIFM): DATA FROM SOLID
WASTE FACILITY PERMIT APPLICATION*
RS THE FUNCTION OF THIS PROGRAM IS TO MAINTAIN FILES OF LAND DISPOSAL
FACILITIES, INCLUDING LANDFILLS AND INDUSTRIAL WASTE SITES. ALSO
STORED ARE THE SITE CHARACTERISTICS, CHARACTERISTICS OF MONITORING
WELLS, AND THE ACTUAL WATER QUALITY MONITORING DATA.*
AC DATA IS USED IN THE SOLID AND HAZARDOUS WASTE PERMITTING PROGRAMS.
NO REGULAR WRITTEN REPORTS ARE ISSUED*

(METHODS)
NOT INDICATED;
(CLASSES)
SAMPLING POINT IDENTIFICATION, PERMIT NUMBER, REGION, DATE ESTABLISHED, TYPE OF POINT, LOCATION (IN FEET REFERENCED TO ON SITE BENCHMARK), MONITORING POINT IDENTIFICATION (WELL NUMBER), MONITORING POINT NUMBER, MINNESOTA UNIQUE WELL NUMBER, SOIL PROFILE, SPECIFIC PARAMETERS TO BE MEASURED (PH, SULFATE, CHLORIDES, NITRATES, COD, IRON, CONDUCTIVITY), FREQUENCY OF MONITORING (MOST ARE QUARTERLY), WELL DESCRIPTION (INSIDE DIAMETER, TOP OF PIPE ELEVATION, GROUND ELEVATION, TOP AND BOTTOM OF SCREEN ELEVATION, INITIAL DEPTH TO WATER IN FEET, TYPE OF SCREEN, CASING AND PUMP), LYSIMETER (BOTTOM ELEVATION OF UNIT IN FEET), SURFACE WATER (SAMPLING POINT ELEVATION IN FEET), LEACHATE (MONITORING POINT ELEVATION IN FEET)*

MS (UNITS)
NOT INDICATED;
(FREQUENCY)
ONE TIME;
(SIZE)
ABOUT 150 OF THE 225 SITES HAVE MONITORING SYSTEMS MOST OF WHICH HAVE 3 TO 20 MONITORING WELLS PER SITE*

FT MANUAL FILES, SUMMARY DATA IS ON TAPE AT THE UNIVERSITY COMPUTER CENTER (CYBER 172)*

DE SURFACE WATER, GROUNDWATER, WELLS, WATER QUALITY, WATER POLLUTION, SOLID WASTE, LANDFILLS, HAZARDOUS WASTE PERMITS, CONTAMINANTS*

LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*

AV NO RESTRICTIONS, CONTACT GRETCHEN SABEL (612)297-2708)*

GC (REFERENCE)
COUNTY NAME, PUBLIC LAND SURVEY DESCRIPTION, REGION NAME, MINNESOTA UNIQUE WELL NUMBER;
(AREA)
MN*

/EOR

ID DATA*

NU SWIM-D-059002*

AU MINNESOTA POLLUTION CONTROL AGENCY*

IN MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*

TI SOLID WASTE FACILITY INVENTORY AND MONITORING SYSTEM: WATER QUALITY MONITORING DATA*

RS THE FUNCTION OF THIS PROGRAM IS TO MAINTAIN FILES OF LAND DISPOSAL FACILITIES, INCLUDING LANDFILLS AND INDUSTRIAL WASTE SITES. ALSO STORED ARE THE SITE CHARACTERISTICS, CHARACTERISTICS OF MONITORING WELLS, AND THE ACTUAL WATER QUALITY MONITORING DATA.*

AC DATA IS USED IN THE SOLID AND HAZARDOUS WASTE PERMITTING PROGRAMS. NO REGULAR WRITTEN REPORTS ARE ISSUED*

TY PRIMARY*

NT SOLID WASTE PERMIT PROGRAM IS REQUIRED BY STATE LAW BUT IS NOT MANDATED BY FEDERAL LAW AT THIS TIME; MINN. RULE SW 6(2)*

RS TO IDENTIFY LIVESTOCK OPERATIONS AND FEEDLOTS THAT HAVE POLLUTION PROBLEMS AND TO CONTROL THESE PROBLEMS. PERMIT PROGRAM WAS ESTABLISHED AS A WAY TO ACCOMPLISH SECTION 402 OF THE CLEAN WATER ACT OF 1977.*
AC ANIMAL WASTES, SEPTEMBER 1975, RULES AND REGULATIONS*
TY PRIMARY*
NT DEPARTMENT OF AGRICULTURE - AGRICULTURAL STATISTICS AND CENSUS OBTAINS FEEDLOT NUMBERS ON A COUNTY BASIS; LAWS: MINNESOTA STATE STATUTE 115.03.1.E; MINNESOTA STATE STATUTE 115.07.1; MINNESOTA STATE STATUTE 116.07.2, 4, 7; PUBLIC LAW 95 - 217 CLEAN WATER ACT OF 1977 SECTION 402; MPCA SW 51.6L*
SN MINNESOTA POLLUTION CONTROL AGENCY*
YR 1972 - 1982 (TO PRESENT)*
MT (SOURCE)
FEEDLOT OPERATORS;
(METHODS)
ANY LIVESTOCK OPERATOR PROPOSING MONETARY INVESTMENT (WHO PROPOSES TO BUILD A NEW, OR TO REHABILITATE AN EXISTING LIVESTOCK FACILITY) IS REQUIRED TO APPLY FOR A PERMIT BY SUBMITTING THE REQUIRED APPLICATION WITH THE APPROPRIATE DATA TO THE MINNESOTA POLLUTION CONTROL AGENCY. 2 TO 3 PERCENT OF THE PERMITS ARE INSPECTED ANNUALLY;
(CLASSES)
DISTANCE TO PUBLIC WATERS, POLLUTION CONTROLS, SIZE OF OPERATION, TYPE OF OPERATION, CHARACTERISTICS OF OPERATION, TOPOGRAPHY, SLOPE, SOIL, WATER TABLE DEPTH, WELLS, DRAINAGE PATTERN, DISTANCE TO WATER COURSE*
MS (FREQUENCY)
COLLECTED INITALLY OR WHEN IMPROVED;
(SIZE)
12,000 PERMITTED*
FT MANUAL FILES, COMPUTER FILES*
DE FEEDLOTS, RUNOFF, FEEDLOT WASTES, AGRICULTURAL RUNOFF, ANIMAL WASTES, GROUNDWATER, WATER POLLUTION, SURFACE WATERS*
LO MINNESOTA POLLUTION CONTROL AGENCY,
WATER QUALITY DIVISION,
PERMIT SECTION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
AV PUBLIC INFORMATION, CONTACT WAYNE ANDERSON (612-296-7326)*
GC (REFERENCE)
COUNTY NAME, DISTANCE FROM TOWN, MAILING ADDRESS, PUBLIC LAND SURVEY, LEGAL DESCRIPTION;
(AREA)
MN*
/EOR

ID DATA*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
DIVISION OF WATER QUALITY,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES) AND STATE DISPOSAL SYSTEM (SDS) PERMITS: WATER QUALITY MONITORING*

TY PRIMARY*
NT REQUIRED BY STATE LAW BUT NOT MANDATED BY FEDERAL LAW AT THIS TIME;
MINN RULE SW 6(2)*
SN MINNESOTA POLLUTION CONTROL AGENCY AND SOME ADDITIONAL FEDERAL
FUNDS*
YR 1971 - 1982 (TO PRESENT)*
MT (SOURCE)
PERMIT APPLICATION FORM IS FILLED OUT BY THE OPERATOR OF THE SOLID
WASTE FACILITY;
(METHODS)
NOT INDICATED;
(CLASSES)
PERMIT NUMBER, CENSUS FACILITY ID NUMBER, OWNERSHIP, COUNTY,
OPERATIONAL STATUS, FACILITY NAME, FACILITY TYPE, REGION, PERMIT
ISSUE DATE, BENCHMARK ID, LOCATION IN ACRES AND PUBLIC LAND SURVEY
DESCRIPTION, MONITORING POINTS (WELLS, LYSIMETERS, OTHERS),
PERMITTEE (NAME AND ADDRESS), LANDOWNER (NAME AND ADDRESS), OWNER AND
CONTRACTOR (NAME AND ADDRESS), ENGINEER (NAME AND ADDRESS),
LABORATORY (NAME AND ADDRESS)*
MS (UNITS)
NOT INDICATED;
(FREQUENCY)
UNTIL JULY 1979 A PERMIT WAS ISSUED IN PERPETUITY, AFTER THAT DATE
PERMITS ISSUED MUST BE RENEWED EVERY FIVE YEARS;
(SIZE)
225 SITES SINCE THE PROGRAM BEGAN*
FT MANUAL FILES AND COMPUTER FILES (UNIVERSITY COMPUTER SYSTEM)*
DE SURFACE WATER, GROUNDWATER, WELLS, WATER QUALITY, WATER POLLUTION,
SOLID WASTE, LANDFILLS, HAZARDOUS WASTE PERMITS, CONTAMINANTS*
LO MINNESOTA POLLUTION CONTROL AGENCY,
SOLID AND HAZARDOUS WASTE DIVISION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
AV NO RESTRICTIONS, CONTACT GRETCHEN SABEL (612)297-2708*
GC (REFERENCE)
COUNTY NAME, PUBLIC LAND SURVEY DESCRIPTION, REGION, MINNESOTA
UNIQUE WELL NUMBER;
(AREA)
MN*
/EOR

AN 0000Z001441*
ID DATA*
NU MPCA-D-1*
NU DCAT-D-59*
NU SWIM-D-23*
AU MINNESOTA POLLUTION CONTROL AGENCY*
IN MINNESOTA POLLUTION CONTROL AGENCY,
WATER QUALITY DIVISION,
PERMIT SECTION,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
TI AGRICULTURAL WASTE POLLUTION CONTROL PROGRAM; FEEDLOT PROGRAM*

DE SURFACE WATER, GROUNDWATER, WATER QUALITY MONITORING, WATER QUALITY, WASTEWATER DISCHARGE, EFFLUENT, MUNICIPAL SEWAGE, INDUSTRIAL WASTE, WATER CHEMISTRY, TOXIC SUBSTANCES, HEAVY METALS*
LO MINNESOTA POLLUTION CONTROL AGENCY,
DIVISION OF WATER QUALITY,
1935 WEST COUNTY ROAD B2,
ROSEVILLE MN 55113*
AV NO RESTRICTIONS, CONTACT PAT MADER (SURFACE WATER CONCERNS) (612) 296-7755 OR GRETCHEN SABEL (GROUNDWATER CONCERNS) (612) 297-2708*
GC (REFERENCE)
LATITUDE/LONGITUDE, TOWN RECEIVING WATER, SAMPLING POINT;
(AREA)
MN*
/EOR

AN 0000Z001685*
ID DATA*
NU SWIM-D-079001*
NU MSPA-D-7*
NU DCAT-D-98*
AU MINNESOTA STATE PLANNING AGENCY*
IN MINNESOTA STATE PLANNING AGENCY,
COPPER-NICKEL STUDY GROUP,
CAPITOL SQUARE BUILDING,
ST PAUL MN 55101*
TI REGIONAL COPPER-NICKEL STUDY: BIBLIOGRAPHIC MATERIALS*
RS TO DEVELOP A DATA BASE PREVIOUS TO ANY COPPER-NICKEL MINING, TO CONDUCT RESEARCH ON THE IMPACTS OF COPPER-NICKEL MINING AND FROM THAT RESEARCH AND REVIEW OF EXISTING LITERATURE MAKE PROJECTIONS ON POSSIBLE ENVIRONMENTAL AND SOCIOECONOMIC IMPACTS ASSOCIATED WITH COPPER-NICKEL DEVELOPMENT.*
AC 175 TECHNICAL REPORTS AND SECOND LEVEL SUMMARY REPORTS (1978 -1979); FINAL REPORT TO THE LEGISLATIVE COMMISSION ON MINNESOTA RESOURCES*
TY PRIMARY*
NT THE MINNESOTA POLLUTION CONTROL AGENCY CONTINUES TO MONITOR WATER QUALITY IN THE STUDY AREA. THE MINERALS DIVISION OF THE MINNESOTA DEPARTMENT OF NATURAL RESOURCES CONTINUES TO STUDY RUNOFF FROM DULUTH GABBRO WASTE ROCK PILES*
SN MINNESOTA ENVIRONMENTAL QUALITY BOARD (MEQB)*
YR 1976 - 1978*
MT (SOURCE)
FIELD DATA COLLECTION (SEE TECHNICAL REPORTS FOR DETAILS);
(METHODS)
STANDARD METHODS (SEE TECHNICAL REPORTS FOR DETAILS);
(CLASSES)
BIOLOGICAL SCIENCES, TECHNICAL ASSESSMENT, SOCIOECONOMIC STATISTICS, PHYSICAL SCIENCES*
MS (UNITS)
NOT INDICATED;
(SIZE)
NUMEROUS SITES SAMPLED FOR DIFFERENT PURPOSES*

RS THE FUNCTION OF THIS PROGRAM IS TO CONTROL THE DISCHARGE OF POLLUTANTS INTO THE SURFACE WATERS OF THE STATE THROUGH THE ISSUING OF PERMITS TO DISCHARGE. ITS ROLE IS TO INSURE THE PROPER CONSTRUCTON AND OPERATION OF WASTEWATER TREATMENT SYSTEMS, BOTH INDUSTRIAL AND MUNICIPAL AND TO INSURE THAT WASTEWATERS RECEIVE ADEQUATE TREATMENT IN ACCORDANCE WITH STATE AND FEDERAL REGULATIONS. SDS PERMITS ADDRESS ALL AREAS, WHILE NPDES PERMITS PRIMARILY ADDRESS POINT SOURCE DISCHARGES TO SURFACE WATERS. SDS PERMITS INCLUDE CLOSED SYSTEMS OR LAND APPLICATION SYSTEMS.*

AC THE MONITORING DATA IS USED TO DETERMINE THE CONDITIONS OF THE DISCHARGE PERMITS. BASED ON THIS DATA A DISCHARGER MIGHT BE REQUIRED TO UTILIZE BETTER TREATMENT OF THE WASTES. DEPENDING ON THE SIZE OF THE FACILITY AND THE TYPES OF WASTES, PERMITTEE ARE REQUIRED TO TAKE EFFLUENT SAMPLES ANYWHERE FROM DAILY TO QUARTERLY*

TY PRIMARY*

NT LAWS: MINNESOTA STATE STATUTE CHAPTER 115,116. ALSO REQUIRED BY THE FEDERAL CLEAN WATER ACT OF 1977 (PUBLIC LAW 95-217, SECTION 402). STATE DISPOSAL SYSTEM RULES: 6MCAR 4.8036*

SN MINNESOTA POLLUTION CONTROL AGENCY, US ENVIRONMENTAL PROTECTION AGENCY*

YR 1970 - 1982 (TO PRESENT)*

MT (SOURCE)
DISCHARGERS ARE REQUIRED TO SAMPLE EFFLUENT ANYWHERE FROM DAILY TO QUARTERLY DEPENDING ON WHETHER IT IS A MAJOR OR MINOR FACILITY. MINNESOTA POLLUTION CONTROL AGENCY ALSO DOES WATER QUALITY MONITORING AT EACH FACILITY EITHER ANNUALLY OR BIENNIALLY;
(METHODS)
EPA APPROVED METHODS, LABORATORY WORK IS DONE EITHER IN THE DISCHARGER'S LAB OR SENT TO AN OUTSIDE LAB;
(CLASSES)
OVER 175 SPECIFIC PARAMETERS MAY BE REQUIRED TO BE MONITORED INCLUDING A SPECIAL FEDERAL TOXIC POLLUTANTS LIST. EACH FACILITY WILL BE MONITORING A DIFFERENT SET OF PARAMETERS DEPENDING ON ITS FUNCTION. USUAL SAMPLING DATA: SAMPLE NUMBER, DATE COLLECTED, TIME COLLECTED, DATA RECEIVED BY LAB, TEMPERATURE, DISSOLVED OXYGEN, PH VALUE, TOTAL RESIDUE CHLORINE, FECAL COLIFORM, FECAL STREPTOCOCCI, TOTAL SOLIDS, SUSPENDED SOLIDS, TURBIDITY, CALCIUM AS CACO3, MAGNESIUM AS CACO3, TOTAL HARDNESS AS CACO3, CHLORIDE, BIOCHEMICAL OXYGEN DEMAND, NITRIFICATION INHIBITED BOD, TOTAL PHOSPHORUS, ORTHOPHOSPHORUS, ORGANIC NITROGEN, AMMONIA NITROGEN, NITRITE AND NITRATE NITROGEN, ARSENIC, CADMIUM, CHROMIUM, COPPER, IRON, LEAD, MANGANESE, ZINC, MERCURY, NICKEL, CYANIDE, PHENOLIC COMPOUNDS, OIL AND GREASE, CHLOROPHYLL*

MS (UNITS)
STANDARD MEASURES;
(FREQUENCY)
DAILY TO QUARTERLY;
(SIZE)
1400 PERMITS TO DISCHARGE: 45 COMMERCIAL AND MISCELLANEOUS, 23 STATE DISPOSAL SYSTEM PERMITS, 40 AGRICULTURAL, 530 INDUSTRIAL (DISPOSAL AND CLOSED SYSTEMS), 580 MUNICIPAL WASTEWATER PLANT (SEWAGE TREATMENT), 165 MUNICIPAL WATER TREATMENT PLANT*

FT MANUAL FILES, SUMMARY DISCHARGE DATA ON A WORD PROCESSOR AT THE MINNESOTA POLLUTION CONTROL AGENCY (NEXT YEAR THE DATA WILL PROBABLY BE ON A US ENVIRONMENTAL PROTECTION AGENCY SYSTEM CALLED PCS)*

FT MANUAL FILES, MAPS, MICROFICHE, COMPUTER FILES (UNIVERSITY COMPUTER
   CENTER)*
DE COPPER-NICKEL, MINING, SURFACE WATER, GROUNDWATER, ENVIRONMENTAL
   IMPACTS, AIR QUALITY, WATER QUALITY*
LO ENVIRONMENTAL CONSERVATION LIBRARY (ECOL),
   300 NICOLLET MALL,
   MINNEAPOLIS MN 55401*
AV NO RESTRICTIONS, CONTACT JULIE COPELAND (612-372-6637)*
GC (REFERENCE)
   MINNESOTA DEPARTMENT OF NATURAL RESOURCES LAKE NUMBER, COUNTY NAME,
   STREAM NAME, LAKE NAME, US GEOLOGICAL SURVEY STREAM GAUGING STATIONS;
   (AREA)
   MN, REGION 3, ARROWHEAD, ST LOUIS COUNTY, AURORA, ELY, FERNBERG,
   HIBBING, HOYT LAKES, KAWISHIWI, VIRGINIA, IRON RANGE*
/EOR