Recommendations Of The Nitrogen Fertilizer Task Force On

THE NITROGEN FERTILIZER MANAGEMENT PLAN

To The Minnesota Commissioner of Agriculture

August 1990

RECOMMENDATIONS

OF THE

NITROGEN FERTILIZER TASK FORCE

ON

THE NITROGEN FERTILIZER MANAGEMENT PLAN

TO THE

MINNESOTA COMMISSIONER OF AGRICULTURE

AUGUST 1990

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ABBREVIATIONS AND SELECTED DEFINITIONS

ABBREVIATIONS

Agencies and Organizations:

BWSR..........Minnesota Board of Water and Soil Resources
FFA...........Future Farmers of America
LSP...........Land Stewardship Project
MDA...........Minnesota Department of Agriculture
MDH...........Minnesota Department of Health
MDNR..........Minnesota Department of Natural Resources
MES...........Minnesota Extension Service
MPCA..........Minnesota Pollution Control Agency
MSPA..........Minnesota State Planning Agency
SWCD..........Soil and Water Conservation District
UM............University of Minnesota

Technical:

BMP...........Best Management Practices (voluntary)
HRL...........Health Risk Levels
M.S...........Minnesota Statute
NFMP..........Nitrogen Fertilizer Management Plan
UAN...........Urea Ammonium Nitrate (fertilizer)
WRPR..........Water Resource Protection Requirements (regulatory)

SELECTED DEFINITIONS

Coarse-Textured Soils ... For the purpose of this document, coarse textured soils refer to sandy loam, loamy sand and and sands. The term is used as a general description of soils with this type of texture.

Vadose Zone ... The vadose zone is that area between the root zone and the water table.

EXECUTIVE SUMMARY

The Nitrogen Fertilizer Task Force was established by the Legislature in the 1989 Comprehensive Groundwater Protection Act to

> "...study the effects and impact on water resources from nitrogen fertilizer use so that best management practices, a fertilizer management plan and nitrogen fertilizer use regulations can be developed."

The Commissioner of Agriculture appointed a task force to make recommendations on the structure of the Nitrogen Fertilizer Management Plan based upon review of the effects of nitrogen fertilizer use on the water quality. The task force membership was established by statute to include a diverse group of representatives from agriculture, environmental groups, local government and state government.

The Nitrogen Fertilizer Task Force met ten times and held two public meetings in St.Cloud and Rochester over the period of six months. They reviewed information related to the nitrogen cycle, nitrate contamination of ground and surface water, Minnesota hydrogeologic conditions, crop production, nitrogen management, and nitrogen research. The task force also reviewed programs of other midwestern states and received an overview of the status of existing state and federal programs.

The Nitrogen Fertilizer Management Plan, as defined in statute, must include components which (a) promote the prevention of contamination of water resources by inorganic nitrogen fertilizer, and (b) develop appropriate responses to the detection of inorganic nitrogen from fertilizer sources in ground or surface water.

The task force, after reviewing information and considering testimony, made recommendations for voluntary Best Management Practices (BMPs) which form the cornerstone of the Nitrogen Fertilizer Management Plan. In addition, it was necessary that the Management Plan complement the statutory language regarding regulatory action when voluntary BMPs are proven ineffective. The Groundwater Protection Act requires that if voluntary BMPs are proven ineffective, the MDA may promulgate rules for the establishment of Water Resource Protection Requirements (WRPRs).

The task force recommends that the Nitrogen Fertilizer Management Plan consist of three phases: (1) Promotion of BMPs, (2) Evaluation of BMP adoption and effectiveness, and (3) Response to the evaluation phase [to include non-regulatory and regulatory components]. These three phases apply at the state, regional or local level.

The task force discussed who should be involved in the implementation of the Nitrogen Fertilizer Management Plan. While the MDA is ultimately responsible for addressing the impacts of nitrogen fertilizer on water resources and has the responsibility to administer and coordinate the Nitrogen Fertilizer Management Plan, the University of Minnesota, other local, state, and federal agencies are crucial to the successful implementation of the plan. The roles and responsibilities of these groups are listed in the report.

The primary goal of the Nitrogen Fertilizer Management Plan is to prevent degradation of Minnesota's water resources by efficiently managing nitrogen inputs to maintain farm profitability. The key prevention component in this plan is the promotion and adoption of voluntary BMPs which are based upon total nitrogen management.

Minnesota's varied farming systems require a flexible format of BMPs developed to be adapted to any farming system. In addition to environmental considerations, the BMPs will have been demonstrated to be economically viable.

The Task force recommended a three tier system of BMPs for Minnesota. The first tier is a set of state-wide BMPs that are not crop- or region-specific. The second tier consists of five sets of regional BMPs; each is tailored to one of five general regions in Minnesota. The third tier consists of BMPs for special situations that exist across the state and that present a unique set of management concerns.

This three tier system enables the BMPs to be applied to any specific situation or farm. By combining the statewide BMPs with an appropriate regional or special situation BMPs, a specific set of BMPs can be developed for any given field or situation. The specifics of the BMPs can be varied because each field history or management situation is different, yet the process for arriving at a specific set of BMPs for any situation is uniform.

The state-wide BMPs can be considered generic in that they apply to all areas of the state. The eight state-wide BMPs are listed below; a more detailed description of the BMPs can be found in the report.

1) Develop realistic yield goals.

2) Develop and utilize a comprehensive record keeping system to record field specific information.

3) Adjust nitrogen rate according to soil organic matter content, previous crop and manure applications.

4) Use a soil nitrate test when appropriate.

5) Use prudent manure management to optimize nitrogen credit.

6) Credit second year nitrogen contributions from alfalfa and manure.

7) Do not apply nitrogen above recommended rates.

8) Plan nitrogen application timing to achieve high efficiency of nitrogen use.

The second and third tiers tailor the BMPs to a region or situation. Each succeeding tier enhances or refines the previous tier and serves to match the BMPs to the prevailing climatic and soil conditions. The specific BMPs of the second and third tiers are listed in the report.

The second tier consists of regionalized Best Management Practices. The regions are based on general climatic conditions, soil characteristics and resulting sensitivity to groundwater contamination. The regional BMPs refine the prescriptions of the statewide BMPs. Five regions where identified: (1) Southeastern, (2) South Central, (3) Southwest and West-Central, (4) East-Central and Central, and (5) Northwest.

The third tier of BMPs are referred to as Special Situations BMPs. The special situations are a result of certain combinations of management and environmental conditions that may render an area or site more susceptible to groundwater contamination than would be predicted by the general characteristics of the surrounding region. The third tier accounts for those management situations or sites which are interspersed throughout the state. The four situations that the task force defined as warranting special BMPs are: (1) Irrigated soils, (2) Coarse textured [non-irrigated] soils, (3) Turf, and (4) Areas near surface water.

The task force determined that the effectiveness of the BMPs needs to be evaluated on two important aspects: implementation of the practices in a voluntary system and effect on nitrate contamination of water resources. If either the implementation of BMPs or the nitrate concentrations are not being positively affected then, those factors need to be modified.

It is also recognized that even excellent and immediate implementation of BMPs may not have immediate effects on nitrate contamination of water resources due to a lag effect. The task force listed a number of methods with which evaluation of both BMP effectiveness and implementation could be accomplished at the state, regional or local level. Both of these factors need to be evaluated because of the potential time lag between implementation of BMPs and actual measurement of the impact in the water resource.

The most difficult issue for the task force to resolve was how to respond to areas where there has been significant degradation of the water resource due to nitrates. The task force reacted to this issue by proposing a mitigation and regulation framework for the MDA. This framework is based upon appropriate response to the extent of the problem and can be applied at the local, regional or state level.

In addition, a specific structure was developed to respond to local conditions where significant nitrate contamination exists and where nitrogen fertilizer practices have been implicated. This structure relies on local units of government and Soil and Water Conservation Districts (SWCDs) working in cooperation with the MDA to resolve the problem. Voluntary BMPs will be applied prior to implementing a regulatory program in this structure. Concurrent with the voluntary efforts, an evaluation will be conducted to identify the potential source(s) of the nitrate problem to adapt mitigation efforts to the source. If the voluntary BMPs are not effective, the MDA will rule development for WRPRs to be applied to the area.

CHAPTER 1

INTRODUCTION

1.1 The Groundwater Protection Act

The Comprehensive Groundwater Protection Act of 1989 (Minnesota Statute 1989 Chapter 326) significantly altered the direction of water resource protection with regard to nitrogen fertilizer management. This was a result of three separate but related components of the Act: (1) the development of a groundwater protection goal, (2) the enhanced regulatory authority for fertilizer practices within the Minnesota Department of Agriculture (MDA) and, (3) the responsibility for development of a Nitrogen Fertilizer Management Plan (NFMP) by the Minnesota Department of Agriculture.

Because of the complexity of nitrogen fertilizer effects on water resources, and the controversial nature of associated management decisions, the Legislature authorized the MDA to establish a Nitrogen Fertilizer Task Force to make recommendations to the Commissioner of Agriculture on the structure of the Nitrogen Fertilizer Management Plan.

1.2 The Nitrogen Fertilizer Task Force

Minnesota Statute (1989) Chapter 326 requires the Commissioner of the MDA to appoint a Nitrogen Fertilizer Task Force (Article 6, Section 33, Subd. 2):

> "The commissioner shall: ... appoint a task force to study the effects and impact on water resources from nitrogen fertilizer use so that best management practices, a fertilizer management plan, and nitrogen fertilizer use regulations can be developed."

Task force membership is also defined by Minnesota Statute (1989) Chapter 326 (Article 6, Section 33, Subd. 2):

> "The task force must include farmers, representatives from farm organizations, the fertilizer industry, University of Minnesota, environmental groups, representatives of local government involved with comprehensive local water planning, and other state agencies, including the pollution control agency, the department of health, the department of natural resources, the state planning agency, and the board of water and soil resources."

Organizations or agencies named in the Act were contacted and asked to select representatives and alternates to the task force. Where the Act was not specific, (for example, "environmental groups") organizations which were closely involved in development of the legislation and which fit the organization description were selected. In addition, two farmers were named to the task force by the MDA; one represented irrigated agriculture, the other was involved in a nitrogen research project. The MDA supplied staff support to the task force. The members of the task force and the organizations they represent are listed below.

NAME	**GROUP/AGENCY/REPRESENTING**
Mr. John Anderson	Local Government Soil and Water Conservation District
Mr. Bill Aultfather	Environmental Group/Izaak Walton League
Mr. Greg Buzicky (Chair)	Minnesota Department of Agriculture
Mr. Doug Frazeur	Farm Group/Minnesota Farm Bureau Federation
Ms. Kris Juliar	Farmer/Region IX Development Commission
Mr. Tomas Klaseus	Minnesota Department of Health
Mr. Don Knutson	Farm Group/Minnesota Farmer's Union
Mr. Greg Larson	Minnesota Board of Soil and Water Resources
Mr. Tom Larson	Fertilizer Industry/Cenex - Land O' Lakes Agronomy Company
Mr. Bob Minks	Fertilizer Industry/Minnesota Plant Food and Chemical Association
Ms. Deb Pile	Minnesota State Planning Agency
Dr. Gyles Randall (Vice-Chair)	University of Minnesota - Experiment Stations
Mr. Herbert Schewe	Local Government/Freeborn County Commissioner
Dr. Mike Schmitt	University of Minnesota - Minnesota Extension Service
Ms. Sam Sunderlin	Environmental Group/Clean Water Action
Mr. Dave Wall	Minnesota Pollution Control Agency
Mr. Mike Wingard	Farmer/Irrigators Association of Minnesota
Dr. David Wright	Minnesota Department of Natural Resources

The activities of the task force were guided by Minnesota Statute (1989) Chapter 326 (Article 6, Section 33, Subd. 3):

> "The task force shall review existing research including pertinent research from the University of Minnesota and shall develop recommendations for a nitrogen fertilizer management plan for the prevention, evaluation, and

mitigation of nonpoint source occurrences of nitrogen fertilizer in waters of the state. The nitrogen fertilizer management plan must include components promoting prevention and developing appropriate responses to the detection of inorganic nitrogen from fertilizer sources in ground or surface water."

Ten task force meetings were held between February 23 and August 10, 1990. In addition, two public meetings on task force issues were held in Rochester and St. Cloud during this time. Presentations and discussion at each meeting centered around a specific topic. Meeting testimonies are summarized in the appendix. Attendance at the meetings was good; a majority of task force members was present at all meetings.

In summary, the Nitrogen Fertilizer Task Force was responsible for reviewing current information regarding the effects of nitrogen fertilizer on water resources and for making recommendations on means to minimize these effects. In addition, the task force addressed the related issues of turf fertilization and manure management. These are all difficult issues to address, in part because of the ubiquitous nature of nitrogen, the multitude of nitrogen sources, and in part because of the importance of nitrogen to crop production.

1.3 The Nitrogen Fertilizer Management Plan

Minnesota Statute (1989), Chapter 326, Article 6, Section 33, Subd. 2b gave responsibility to the task force for the development of recommendations on a nitrogen fertilizer management plan for the prevention, evaluation and mitigation of nonpoint source occurrences of nitrogen fertilizer in waters of the State. The nitrogen fertilizer management plan must include components promoting the prevention, and developing appropriate responses to, the detection of inorganic nitrogen from fertilizer sources in ground or surface water.

The Nitrogen Fertilizer Management Plan must also take into account Minnesota Statute (1989), Chapter 326, Article 1, Chapter 103H Section 1, which discusses the degradation prevention goal:

> " It is the goal of the state that ground water be maintained in its natural condition, free from any degradation caused by human activities. It is recognized that for some human activities the degradation prevention goal cannot be practicably achieved. However, where prevention is practicable, it is intended that it be achieved. Where it is not currently practicable, the development of methods and technology that will make prevention practicable is encouraged."

The Ground Water Protection Act also lays out a framework for the response to the identification of contamination and introduces the concept of Best Management Practices (BMPs) and Water Resource Protection Requirements (WRPRs) M.S.326, Art. 1, Sec. 10:

> "(a)... If ground water pollution is detected, a state agency or political subdivision that regulates an activity causing or potentially causing a contribution to the pollution identified shall promote implementation of best management practices (BMP) to prevent or minimize the source of pollution to the extent practicable. (b) The pollution control agency, or for agricultural chemicals and practices, the commissioner of agriculture, may adopt water resource protection requirements under subdivision 2 that are consistent with the goal of section 103H.001 and are commensurate with the ground water pollution if the implementation of best management practices has proven to be ineffective."

Best Management Practices are voluntary and are also defined in statute:

> "... Best Management practices means practicable voluntary practices that are capable of preventing and minimizing degradation of ground water, considering economic factors, availability, technical feasibility, implementability, effectiveness, and environmental effects. Best management practices apply to schedules of activities; design and operation standards; restrictions of practices maintenance procedures; management plans; practices to prevent site releases, spillage, or leaks; application and use of chemicals; drainage from raw material storage; operating procedures; treatment requirements and other activities causing ground water degradation."

Water resource protection requirements may be adopted by the commissioner of agriculture if the best management practices have proven ineffective. The water resource protection requirements cannot be adopted until January 1, 1991 and are defined as:

> "... requirements adopted by rule for one or more pollutants intended to prevent and minimize pollution of ground water. Water resource protection requirements include design criteria, standards, operations and maintenance procedures, practices to prevent releases, spills leaks and incidents, restrictions on use and practices and treatment requirements."

The Nitrogen Fertilizer Management Plan is the State's blueprint for prevention or minimization of the impacts of nitrogen fertilizer on the water resources of the state. The Nitrogen Fertilizer Management Plan must include both voluntary components and provisions for the development of nitrogen fertilizer use regulations if BMPs are proven ineffective.

All sources of nitrates and related compounds which may have an adverse impact on water resources will be examined by the MPCA and the MDA, in a "Nitrogen Compounds in Groundwater Study" as directed in M.S. 326, Art.1, Sec.12. This study, which will incorporate the results of the Nitrogen Fertilizer Task Force Report, is being conducted in cooperation with the Board of Water and Soil Resources and the Minnesota Experiment Stations. This report is to be submitted to the Legislative Water Commission by July 1, 1991.

1.4 The Purpose of This Document

This document represents the recommendations of the task force to the MDA for the formulation of the overall Nitrogen Fertilizer Management Plan as directed by statute. The recommendations and background information contained in this report were summarized by MDA staff from task force testimony and materials supplied by the task force.

Chapter 2

BACKGROUND

2.1 Introduction

Nitrogen is an essential plant nutrient; it is required in substantial amounts in order to support crop growth; crop growth must be adequate to produce economically sufficient yields. When the amount of soil-supplied nitrogen is considered to be deficient for satisfactory crop yields, nitrogen fertilizer is added to supplement the soil-supplied nitrogen. If nitrogen is supplied in excess of crop needs, a surplus is created.

Nitrogen is largely converted to the nitrate form and this form is soluble and readily moves with the soil solution. This surplus nitrogen may be available to leach to groundwater. Alternately, nitrogen can also contribute in the nitrate, ammonium or organic form to surface water contamination by means of surface water runoff. The goal of sound nutrient management is to provide sufficient nitrogen to optimize crop yields while minimizing losses of nitrogen to ground or surface water.

2.2 Health Effects of Nitrate-Contaminated Drinking Water

The contamination of ground or surface water by nitrate presents a potential health threat to any human population which relies on that water resource as a source of drinking water. Most Minnesotans rely upon groundwater for their drinking water source and are thus potentially prone to exposure to nitrate contaminated drinking water. Surface water supplies are also commonly used for drinking water in Minnesota.

The primary health concern associated with exposure to nitrate is methemoglobinemia, commonly known as "blue baby disease". This condition occurs when nitrite is absorbed into the blood stream where it reacts with hemoglobin to produce methemoglobin, thus impairing the blood's ability to carry oxygen. Nitrate is reduced to nitrite in the gastrointestinal tract of infants (the high pH characteristic of the infant GI system permits nitrate-reducing bacteria to thrive). Infants afflicted with methemoglobinemia actually suffer from an oxygen deficiency, and consequently their extremities may become blue. As infants develop, their stomachs become more acidic and no longer provide a supportive environment for the conversion of nitrate to nitrite. Methemoglobin rarely affects adults.

Methemoglobinemia is the only verified toxic effect associated with exposure to nitrate. The current Minnesota Recommended Allowable Limit (RAL) for nitrate-nitrogen (NO_3-N) is 10 mg/L (45 mg/L as nitrate) based upon the potential occurrence of methemoglobinemia in infants.

A second health hazard potentially associated with exposure to nitrate is the possible reaction of nitrate with other nitrogen containing compounds to produce N-nitrosamine compounds, especially under acidic conditions, such as those in the stomach. Many N-nitrosamine compounds have been shown to be carcinogenic in animal tests. It is assumed that exposure to nitrosamine-compounds may increase the risk of cancer in humans, although to date there is no direct evidence of this being true. Epidemiological studies have indicated a possible association between exposure to nitrite/nitrate and increased incidence of stomach and esophageal cancer.

Contamination of surface water by nitrate may harm aquatic ecosystems or pose a potential threat to the health of livestock or wildlife. Current evidence, however, suggests that these deleterious impacts occur at higher nitrate levels than the current Recommended Allowable Limit set for the protection of human health.

2.3 The Nitrogen Cycle

The behavior of nitrogen in the environment is governed by a complex of interrelated chemical and biological transformations. These reactions are summarized in the "nitrogen cycle." The nitrogen cycle describes the sinks, pathways and transformations of nitrogen in the environment.

The nitrogen cycle reactions are influenced by the interaction of several chemical, biological, environmental and management factors. The dynamic interplay of these factors complicates predictions of the behavior of nitrogen introduced into the environment. A knowledge of the dynamics of the nitrogen cycle permits an understanding of how this body of factors will interact to influence nitrogen behavior at a given site. Sound nitrogen management decisions can then be made based upon this knowledge.

The processes summarized by the nitrogen cycle are biological, chemical or physical in nature. Figure 2.1 depicts the major reactions of the nitrogen cycle. Although several nitrogen species are involved in the cycle, the species which are of primary importance in the soil are nitrate-nitrogen (NO_3-), ammonium-nitrogen (NH_4+), and organic nitrogen. The characteristics of these species are summarized below:

> **organic nitrogen:** Organic nitrogen is the predominant nitrogen species in the soil profile. Organic nitrogen is not readily available for release into solution but must first be transformed by microbial action (mineralization). Organic nitrogen may be the primary source of nitrogen in surface runoff but rarely contributes to groundwater contamination.

nitrate (NO_3^-): Nitrate is extremely soluble in water and its negative charge excludes it from adsorption onto sites in the soil colloid exchange complex. These characteristics render it highly susceptible to leaching.

nitrite (NO_2^-): Nitrite is an intermediate product in the conversion of ammonium to nitrate in the soil and is the species of toxicological concern in the human system. Although nitrate is highly soluble, it is also very unstable and is rarely detected in groundwater except at very low levels.

ammonia (NH_3) /ammonium (NH_4^+): Ammonia is the primary form of nitrogen applied in fertilizers. It reacts to form ammonium immediately upon contact with water. Ammonium binds tightly to soil colloid surfaces and clay interlayers; it thus is not directly available for transport in the subsurface.

The primary chemical and biological processes of the nitrogen cycle include:

Mineralization: the microbial degradation of organic nitrogen to produce the inorganic forms of nitrate and ammonium (ammonification).

Nitrification: the microbial mediated oxidation of ammonium to nitrite and then to nitrate. This is the primary nitrate-producing reaction in the cycle. It is also a key to potential nitrogen loss in the cycle since nitrate can be lost by leaching or by denitrification.

Immobilization: The assimilation of inorganic forms of nitrogen by plants and microbes, producing various organic nitrogen species.

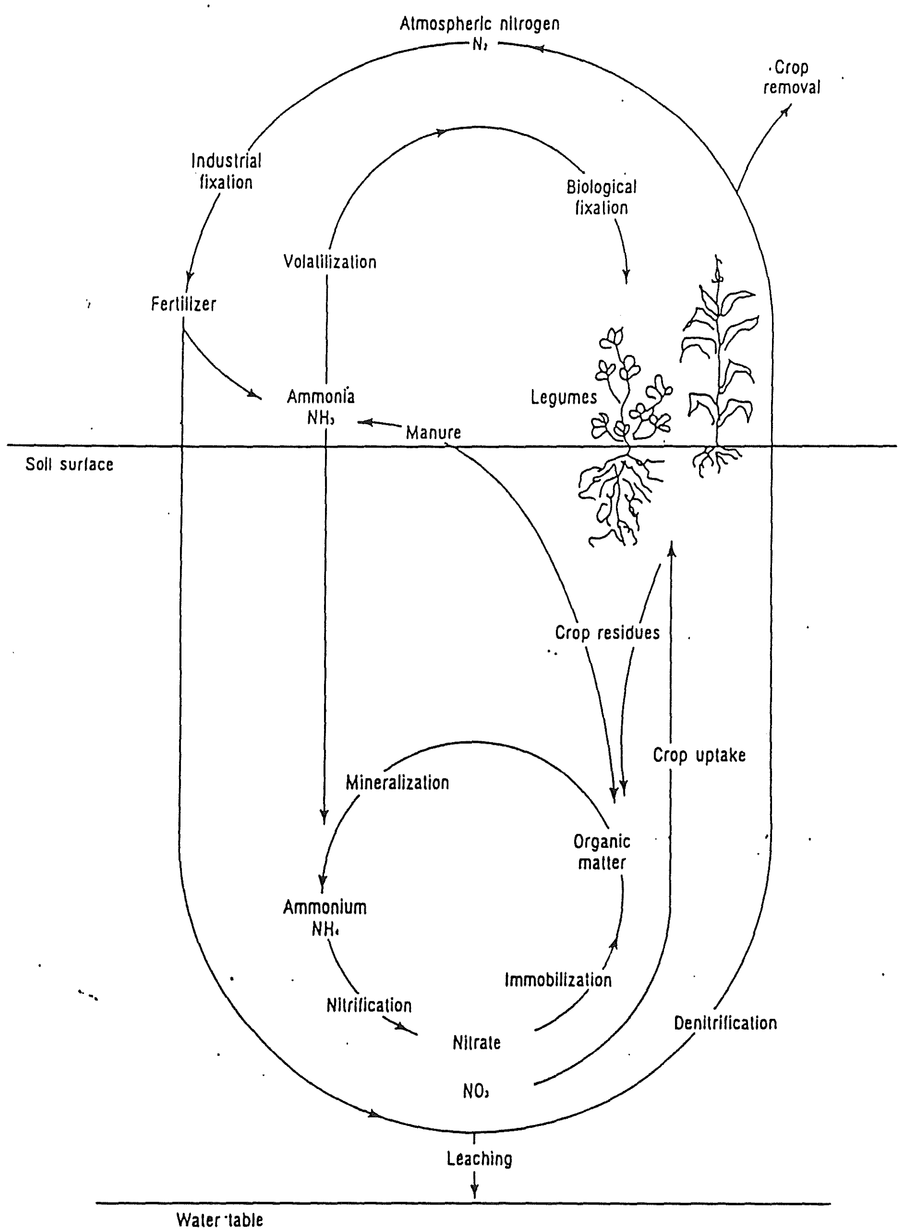
Denitrification: The conversion, by anaerobic microbes, of nitrate to nitrogen and nitrogen oxide gasses. This is a primary volatile loss pathway.

Volatilization: The loss of ammonia to the atmosphere. This occurs primarily in the case of surface-applied urea fertilizers or animal wastes (which also contain urea).

Leaching: The process of mass- and diffusive- transport of solutes in water percolating through the soil. Nitrate is the principal nitrogen species transported in subsurface water due to its solubility and exclusion from adsorption onto soil colloid surfaces. Leaching of nitrate is one of the primary avenues of nitrogen removal from agricultural fields in addition to plant uptake and volatilization.

FIGURE 2.1

THE NITROGEN CYCLE



The environmental fate of any potential contaminant is determined, in large part, by natural cycles that can be modified but not halted. These include the hydrologic cycle, and natural cycles of pests and nutrients such as the nitrogen cycle depicted here. A major obstacle to mitigating groundwater contamination by agrichemicals is incomplete understanding of how natural cycles and artificial inputs operate as a system.

SOURCE: Adapted from College of Agriculture, "Groundwater and Agriculture in Pennsylvania," Circular 341, Pennsylvania State University, College Station PA, 1988.

2.4 Sources of Nitrogen

The potential sources of nitrogen to the soil system are many and varied. In the agronomic setting, all nitrogen sources applied to a field should be taken into account in determining the appropriate nitrogen fertilizer rate. This multitude of potential sources greatly complicates the calculation of a nitrogen budget. For the purposes of this discussion, nitrogen sources will be defined in terms of agronomic (crop growth) inputs and external sources. The agronomic inputs are those sources which may be considered in a nitrogen budget for the purposes of crop production. The external sources are nitrogen sources which may contribute to groundwater contamination but which are dissociated from crop growth.

Agronomic Inputs:

1. Atmospheric sources

   a) Biological fixation
   b) Atmospheric fixation
   c) Precipitation

2. Commercial fertilizers

3. Soil organic matter

4. Crop residues

5. Manure and other organic wastes

Other External Sources Include:

1. Septic systems

2. Feed lots (concentrated animal wastes)

3. Golf course, parks or other non-lawn green space receiving fertilizer applications

4. Lawn fertilizer application

   a) homeowner
   b) professional lawn care company

5. Municipal waste water treatment

6. Landfills

Two notes should be made on the subject of nitrogen sources. First, all nitrogen sources perform the same function in the context of the nitrogen cycle, although they may enter the cycle at different points. This means that all nitrogen sources are potential nitrate sources and could contribute to groundwater contamination. Secondly, it is important to recognize that nitrate occurs naturally in the soil system. Theoretically, this means that the threat of nitrate-contaminated groundwater is ubiquitous regardless of external inputs. However, in Minnesota there are no known cases of elevated nitrate levels in groundwater in an undisturbed situation.

Commercial nitrogen fertilizer is the major source of supplemental nitrogen on cropland. Several forms of nitrogen fertilizer are available for use. The most commonly used fertilizer forms include anhydrous ammonia (gas), urea (solid) and 28%-nitrogen urea ammonium nitrate (UAN)(liquid). The form used at any given site varies depending upon price, availability, equipment and prevailing climatic conditions.

In Minnesota, the majority of nitrogen fertilizer use occurs on corn and wheat acreage. Total Minnesota nitrogen fertilizer use (as measured by total pounds of nitrogen used in the state) increased steadily during the 1960s and 1970s but leveled out in the 1980s. The average nitrogen application rate continued to increase throughout this period. This would imply that the likelihood of creating a nitrogen surplus at any given application site has increased. These trends are illustrated by Table 2.1, which contains total fertilizer nitrogen use data for the period ranging from 1965 through 1988. Table 2.2 contains information regarding corn and wheat acreage nitrogen use and yields.

Manure application can be a major source of nitrogen in livestock production areas. Data on the total pounds of manure applied to Minnesota farm land are not available. Table 2.3 provides estimates of the total amount of manure and manure-nitrogen available for use in 1989 based upon the number of livestock in the state. The crop-yield and water quality effects of manure are less predictable than those of fertilizer because less research has been conducted on manure utilization. Nutrient losses from manure may occur due to storage, handling and application techniques. Generally, manure as a nutrient source has been under appreciated.

Legumes, such as alfalfa and soybeans, can "fix" atmospheric N_2 through a symbiotic relationship with nitrogen-fixing Rhizobium bacteria. Any portion of a legume crop that is left on a field after harvest, including roots and nodules, supplies nitrogen to the soil system; this nitrogen should be accounted for in the nitrogen budget. The residue from a legume crop can provide up to 150 pounds of nitrogen per acre to the succeeding crop.

Soils contain approximately one thousand pounds of nitrogen per acre for each percent of soil organic matter. Approximately one to three percent of this total is released yearly upon decomposition of the organic matter. Because of the complex nature of the nitrogen cycle it is very difficult to predict precise amounts of nitrogen available in any given circumstance. Soil conditions and agronomic practices greatly affect the amount released. Nitrogen fixation by non-symbiotic organisms and nitrogen originating from precipitation can account for 10 to 20 pounds of nitrogen per acre per year.

2.5 Groundwater Contamination and Sensitive Areas

The susceptibility of a particular site or region to groundwater contamination is referred to as the "sensitivity" of the region. Several environmental factors determine the sensitivity of an area. These environmental factors include: (1) physical and chemical properties of the soil and geologic materials, and (2) climatic effects. These factors vary widely throughout Minnesota, making sensitivity very site-specific.

Further complicating the site-specific nature of sensitivity is the fact that nitrogen may move in several pathways. The dominant pathways include: plant uptake, volatilization, adsorption, leaching to the subsurface, and surface runoff. The prevailing environmental and management conditions at a given site may favor one of these competing pathways over another. As a practical example, sandy soils may lose nitrogen through leaching while heavy, poorly drained soils, may lose nitrogen primarily through denitrification. This has implications for the amount of nitrate available to leach to groundwater.

2.5.1 Physical and Chemical Properties of Soil and Geological Materials

The primary geologic and soil factors affecting groundwater susceptibility to contamination are:

a) Depth to Groundwater

The depth to groundwater directly affects the time required for the nitrate to travel from the root zone to groundwater. Shallow groundwater has a greater potential for contamination than does deep groundwater.

b) Soil Type

Soil texture, structure, organic matter content, bulk density, and clay content contribute to either determining how much nitrate is available to leach to groundwater, or to determining the ease with which nitrate can leach to groundwater. These characteristics all vary with soil type. In general, coarse texture, low organic matter content, low bulk density and low clay content all contribute to increased ease of nitrate leaching.

TABLE 2.1
TRENDS IN MINNESOTA FERTILIZER NITROGEN USE

Crop Year	Total Minnesota N Use (by tons)
1965	104,000
1970	284,000
1975	450,000
1980	618,000
1985	643,000
1986	553,000
1987	573,000
1988	576,000

Fertilizer Use Summary
TVA - 1989

TABLE 2.2
CORN AND WHEAT ACREAGE, YIELD AND N USE

	---------- Corn ----------			---------- Wheat ----------		
Year	Acres[1] 1000's	Yield[1] bu/acre	Avg. N[2] lbs/acre	Acres[1] 1000's	Yield[1] bu/acre	Avg. N[2] lbs/acre
1965	4428	61	35	797	28	12
1970	4521	85	91	849	28	31
1975	5820	70	85	2867	31	49
1980	6290	97	99	3169	32	64
1985	6300	115	106	2683	53	63
1986	5800	122	102	2814	36	75
1987	5000	127	115	2519	41	73
1988	4700	74	113	2250	23	103

1 MN Ag. Stats. 1989.
2 Livestock Waste Facilities, MWPS - 18. 1985.

TABLE 2.3
ESTIMATED MANURE NITROGEN PRODUCTION FROM MINNESOTA LIVESTOCK - 1989

	Livestock Number[1] (1,000's)	Yearly Manure Per Animal[2] (lbs)	N In Manure (ton/year)
Dairy	1,180	150	88,500
Beef	935	124	57,970
Swine	4,690	25	58,625
Sheep	225	16	1,800
Turkey	38,500	.70	13,475
Poultry	44,000	.14	3,080
		TOTAL	**223,450**

1 MN Ag. Stats. 1989
2 Livestock Waste Facilities Handbook, MWPS - 18. 1985.

c) Vadose Zone Materials and Aquifer Materials

The hydraulic conductivity of the vadose zone and aquifer materials is a measure of their ability to transmit water and solutes. The porosity of the vadose zone and aquifer materials also determines their ability to transport solutes by mass flow. The greater the porosity and hydraulic conductivity, the shorter the time required for mass flow of water to travel a given distance within the aquifer. The presence of earthworms or root-channels may alter the conduction of contaminants in certain situations.

The presence of cracks and fissures can alter the ability of an aquifer to hold and transmit water. Special mention must be made of karst topography, which is a condition of fractured limestone bedrock and sinkholes. Karst areas are highly susceptible to groundwater contamination because the fractures and sinkholes act as conduits for rapid surface-to-subsurface movement of water and dissolved contaminants.

These factors all vary widely throughout the state. In addition these factors can vary significantly in a very limited geographic area. Because of this variability, maps such as those mentioned in 2.5.3 can have limitations regardless of scale.

2.5.2 Climatic Conditions

Generally, groundwater recharge occurs in Minnesota on an annual basis in the spring and fall. The most important climatic factors in determining susceptibility of a site to groundwater contamination are the timing, frequency and intensity of precipitation events. These three factors are all probabalistic functions and are thus not easily represented by a single value. The average annual rainfall is often used as an index. In general, when soils are at or near saturation, there is a greater likelihood that nitrates will leach below the root zone.

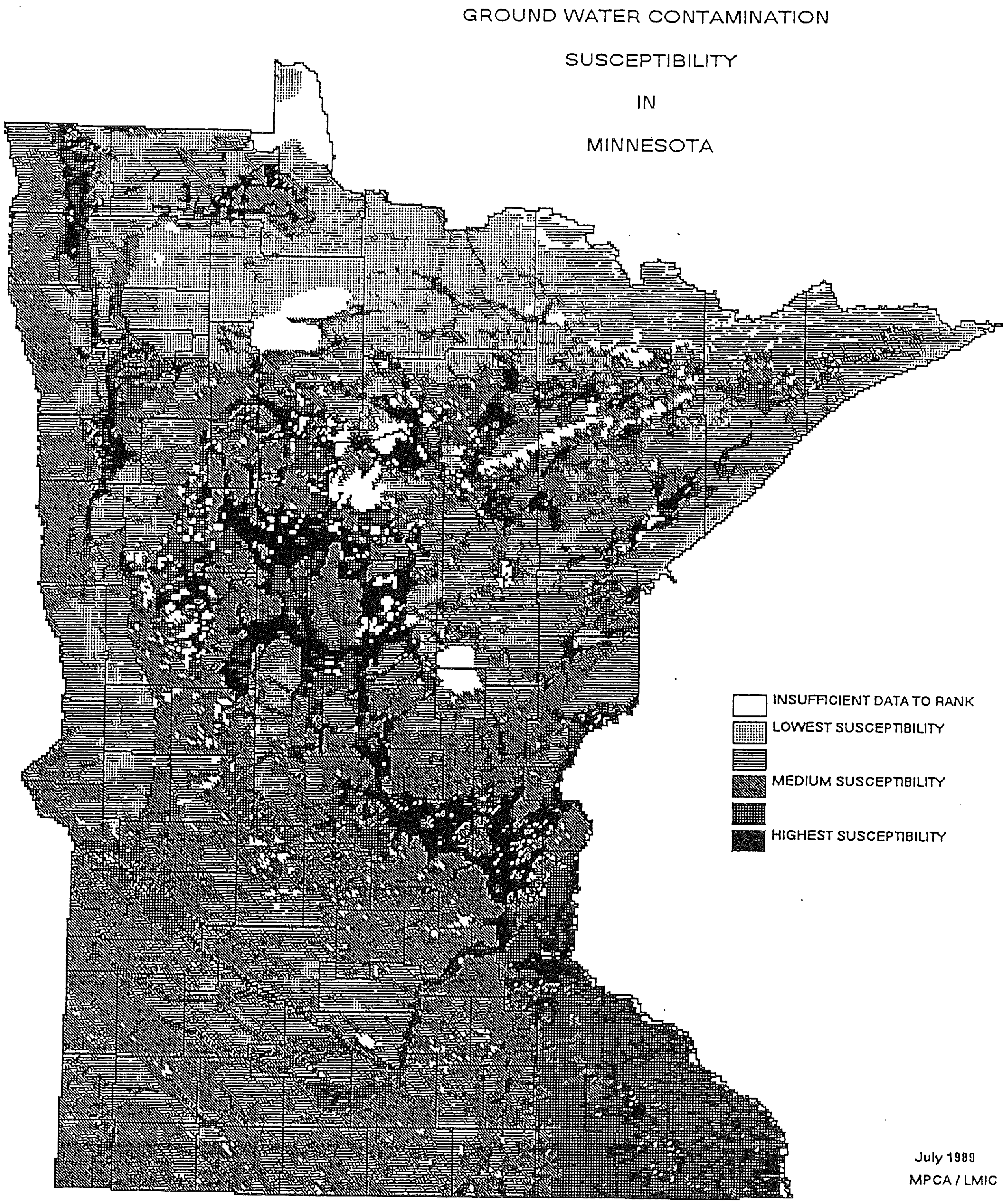
Other climatic properties of concern include evapo-transpiration rate and temperature. Evapotranspiration is the amount of applied water removed by plant uptake or surface evaporation and thus not available for subsurface drainage. The amount of evapo-transpiration relative to the amount of applied water (whether precipitation or irrigation) affects the mass flow of water and entrained solutes below the root zone. Temperature affects all nitrogen transformation processes, and thus the amount of nitrogen in the nitrate form available to leach to groundwater; however, whether an increased temperature causes an increase or decrease in the amount of nitrate available is poorly understood.

2.5.3 Sensitive Areas in Minnesota

A statewide groundwater contamination susceptibility map was constructed by the Minnesota Pollution Control Agency (MPCA) with funding from the LCMR (MPCA, 1989). This map was based on four component data sets: aquifer materials, recharge potential, soil materials and vadose zone materials. The product was a map of surficial aquifer susceptibility (Figure 2.2). The areas of the state which received a high susceptibility rating are primarily those which are characterized by sand and gravel aquifers. The map has several limitations. By focusing only on the near-surface environment, the mapping criteria did not include deeper aquifers. Other limitations include: lack of data to define component maps, use of generalized component maps, inability to present the map at a more appropriate grid cell size

Figure 2.2

SENSITIVE AREAS



(i.e., the map is not as accurate as it looks), and its limited use for interpretation of relatively small areas.

In an effort to resolve some of these limitations, the LCMR has funded a two year project to prepare guidelines and criteria for mapping geologically sensitive areas. A seven-agency work group has prepared draft guidelines as a result of this project. These draft guidelines will be evaluated in test areas prior to issuing final guidelines in 1991. The draft guidelines propose three levels of assessment. The choice of assessment level or levels would depend upon the available information. The second level rates the materials in the vadose zone. The third level rates each deeper aquifer. The draft guidelines are intended to be used primarily as a screening tool.

2.5.4 Effect of Crop and Soil Management Practices on Nitrate Leaching Losses

Crop and soil management factors also play an important role in determining whether nitrate will leach to groundwater at any given site. Management practices which are associated with nitrate leaching include: irrigation, application rate, form and placement of fertilizer nitrogen, timing of application relative to plant uptake and precipitation events, and residue management practices.

Method of irrigation, timing of irrigation relative to fertilizer application, volume and frequency of application are the irrigation practices most directly influencing nitrate movement in the subsurface.

Irrigation of intensively fertilized and shallow rooted crops on permeable soils would represents the worst-case scenario for irrigation effects on groundwater contamination potential.

A) Application Rate

Nitrogen fertilizer application rate is directly related to the risk of groundwater contamination. Use of split and banded application techniques may increase nitrogen uptake efficiency and reduce total loading, thus decreasing the groundwater contamination risk.

B) Timing of Application

Timing of nitrogen application relative to precipitation, irrigation, and plant uptake plays a major role in governing potential leaching of nitrate to groundwater. Application prior to irrigation or precipitation events greatly increases the subsurface leaching potential. If applied nitrogen is efficiently used during crop development, the risk of subsurface nitrate movement is eliminated.

C) Nitrogen Fertilizer Formulation

Soluble-nitrogen formulations, especially those with nitrate are more susceptible to leaching than ammonium or organic-nitrogen (crop residues or manure). Slow release forms and nitrification inhibitors provide some control over the release of nitrate prior to plant utilization.

D) Application Technique

Broadcast application of nitrogen poses a greater risk of groundwater contamination than do banded or split, or other incorporation application techniques. Incorporation techniques increase nitrogen-use efficiency and increase nitrogen contact with adsorptive soil surfaces.

E) Irrigation

The effects of irrigation on subsurface nitrate transport parallel those of precipitation. Irrigation increases the soil water content of the root zone, and thus may enhance mass and diffusive transport of nitrate in the subsurface past the effective crop uptake zone, especially in combination with a heavy rainfall event and in permeable soils.

F) Residue Management

The effects of surface residue management on nitrate movement are complex. While surface residues reduce runoff and surface transport, they increase infiltration and thus potentially increase the likelihood of nitrate leaching. However, the increased levels of organic carbon and microbial activity provided by surface residues help to counteract the increased infiltration. The effects of previous crop on soil nitrogen should be acknowledged when calculating nitrogen application rates.

2.6 Current Nitrogen Programs Within Minnesota

There is a large number of state and locally initiated programs and projects in Minnesota that address nitrogen management or nitrogen contaminated waters. These programs range from local diagnostic studies, such as those conducted under grants from the Minnesota Pollution Control Agency's Clean Water Partnership Program, to the regulatory requirements of the Minnesota Department of Health for new well sampling and reporting of nitrates.

The University of Minnesota has for many years conducted a great deal of research on nitrogen in the context of crop production. This is not surprising as it has long been recognized that nitrogen is the most important soil derived plant nutrient that is likely to be in short supply. While some University research was conducted on nitrogen losses due to leaching prior to the mid 1970s, the most significant studies have been conducted since that time. Since the mid 1980s, research has focused increasingly on nitrogen management and leaching losses of nitrate. The results of some of these more recent efforts are just now beginning to become available.

While the task force was not able to review all the available research, due to constraints of time and capabilities, an overall review of many of the exiting programs in the state were presented to the task force to provide a basis on which to understand the components of the issue. Much of this information is summarized in the minutes (available upon request) or more succinctly in the testimony found in the appendix.

2.7 Evidence of Nitrate Contamination of Groundwater In Minnesota

Contamination of Minnesota groundwater by nitrate has long been recognized as a potential threat to public health. An early study conducted by A.E. Rosenfield and R. Huston (1950) reported on 146 infant methemoglobinemia cases (including fourteen deaths) which had occurred in Minnesota due to nitrates in farm well water supplies. In all cases, the infants had been exposed to elevated nitrate levels (generally > NO_3-N 20 ppm) in drinking water via dry, evaporated or diluted cows' milk formulas.

Recent data on nitrate-N concentrations in Minnesota groundwater have been collected by the Minnesota Department of Health (MDH), the Minnesota Department of Agriculture (MDA) and the Minnesota Pollution Control Agency (MPCA). The efforts of each of these agencies are directed toward a unique feature of the nitrate/groundwater problem.

The MDH has monitored community and non-community public-supply wells for a number of chemical and biological parameters, including nitrate since 1947. Summary data compiled by the MDH from the past three years of 938 community and groundwater supplies show that 17 had concentrations between five and ten ppm nitrate-N and 8 had concentrations greater than the Recommended Allowable Limit (RAL) of 10 ppm NO_3-N. Records of the MDH also show that 1.4 percent of 3,658 new wells drilled between June 25, 1988 and December 30, 1989 contained nitrate-N levels greater than 10 ppm.

In addition to their regular monitoring programs, the MDH and the MDA conducted one-time, baseline surveys of public, private, monitoring and irrigation wells in Minnesota for pesticides and nitrate from 1985 to 1987 (MDH, MDA, 1988). This data was generated following a season of very wet conditions statewide and prior to the onset of the recent drought. While these studies focused on susceptible regions of the state, the results indicate that nitrates may contaminate water in a variety of situations. The results of the MDH private well survey are shown in Table 2.3 and Figure 2.3 (MDH, 1989). In this study, it was found that 112 out of 199 private wells contained nitrate-N in excess of 0.4 ppm, while 84 of those wells contained nitrate-N at levels greater than of 10 ppm. Nearly all of these wells were located in rural areas.

The MPCA collects groundwater nitrate data through a number of programs, including its Ambient Groundwater Quality Monitoring Program and several diagnostic monitoring studies on specific regions. Through the Ambient Groundwater Monitoring Program, the MPCA collects water quality data from all the major aquifers in Minnesota (MPCA, 1989). The ambient program shows that the aquifers most greatly affected by nitrate in Minnesota are the surficial sand aquifer (15% of the surficial sand wells show nitrate concentrations greater than 10 ppm NO_3-N), the upper carbonate aquifer (10% > 10 ppm nitrate), and the Prairie du Chien-Jordan (10% > 10 ppm NO_3-N).

The MPCA has conducted several studies on specific regions to assess the groundwater quality in those regions and to evaluate the relationship between various land uses and groundwater quality, along with other goals. An example of one such study is the Benton County study which was conducted in conjunction with Benton County Health Services and completed in 1989 (MPCA, 1989). Fifty-two percent of all wells sampled for the study had nitrate-N concentrations exceeding the state health risk limit of 10 ppm while background nitrate-N concentrations were less than 1 ppm. An analysis of the data indicated that agricultural activity was the primary source of nitrate-N in the surficial aquifer. The results of another study, conducted near Beardsley, Minnesota, suggested that nitrate-N from fertilized and irrigated corn fields was contaminating downgradient wells two miles away. These wells were in the surficial sand aquifer.

A large body of University of Minnesota research has indicated that agricultural practices can influence the occurrence and level of nitrate-N in groundwater. A University of Minnesota study conducted by Carl Rosen investigated the movement of soil nitrate in irrigated potato/corn rotations (Rosen, 1989). The results of this study indicated that residual nitrates and nitrate-N leaching below the root zone are most likely to occur when yields are low and when high or excessive N fertilizer applications are used. The study also indicated that growers must carefully manage nitrogen fertilizer and adjust yield expectations in order to prevent nitrate-N losses to the subsurface.

Research conducted by the University of Minnesota in the southeastern karst region at the Lawler farm indicates that over application of nitrogen, either as fertilizer or manure, can result in movement of nitrates beneath the root zone. Similarly, research conducted at the Waseca, Lamberton and Morris experiment stations have demonstrated that application of nitrogen, in excess of crop needs can result in movement of nitrates beneath the root zone in these " heavier" soil conditions (University of Minnesota, 1989). Tile drainage studies at Waseca demonstrate that significant leaching losses can also occur from soybeans fields.

These issues are not unique to Minnesota; most midwestern states continue to experience nitrate-contaminated groundwater problems. As an example, Iowa conducted a one-time State-Wide Rural Well-Water Survey between April, 1988 and June 1989. During the course of this study, 686 rural private wells were sampled from every county in Iowa. The results of this survey indicated that 18.3 percent of rural, private drinking water wells in Iowa are contaminated above the recommended health advisory level of 10 ppm NO_3-N. Shallow wells were more likely to be found to be contaminated that deeper wells.

2.8 Existing Nitrogen Contamination Management Programs in Other States

The task force reviewed other states' programs which address the relationship between agriculture and nitrate contamination of groundwater. While many states are concerned about nitrate contamination in ground and surface water, few states have addressed the issue at a significant level. Among the states which maintain well developed programs with regard to nitrogen fertilizer and water quality include Nebraska, Iowa, Wisconsin and Arizona.

The task force reviewed these states' efforts and heard from Nebraska and Iowa program representatives. In addition, Dr. Roland Hauck of the Tennessee Valley Authority (TVA) presented a national overview of the nitrogen fertilizer issue and provided an analysis of the various states' programs.

TABLE 2.4

NITRATE (NO_3-N) RESULTS BY SURVEY AREA ONE-TIME SURVEY PRIVATE WELLS

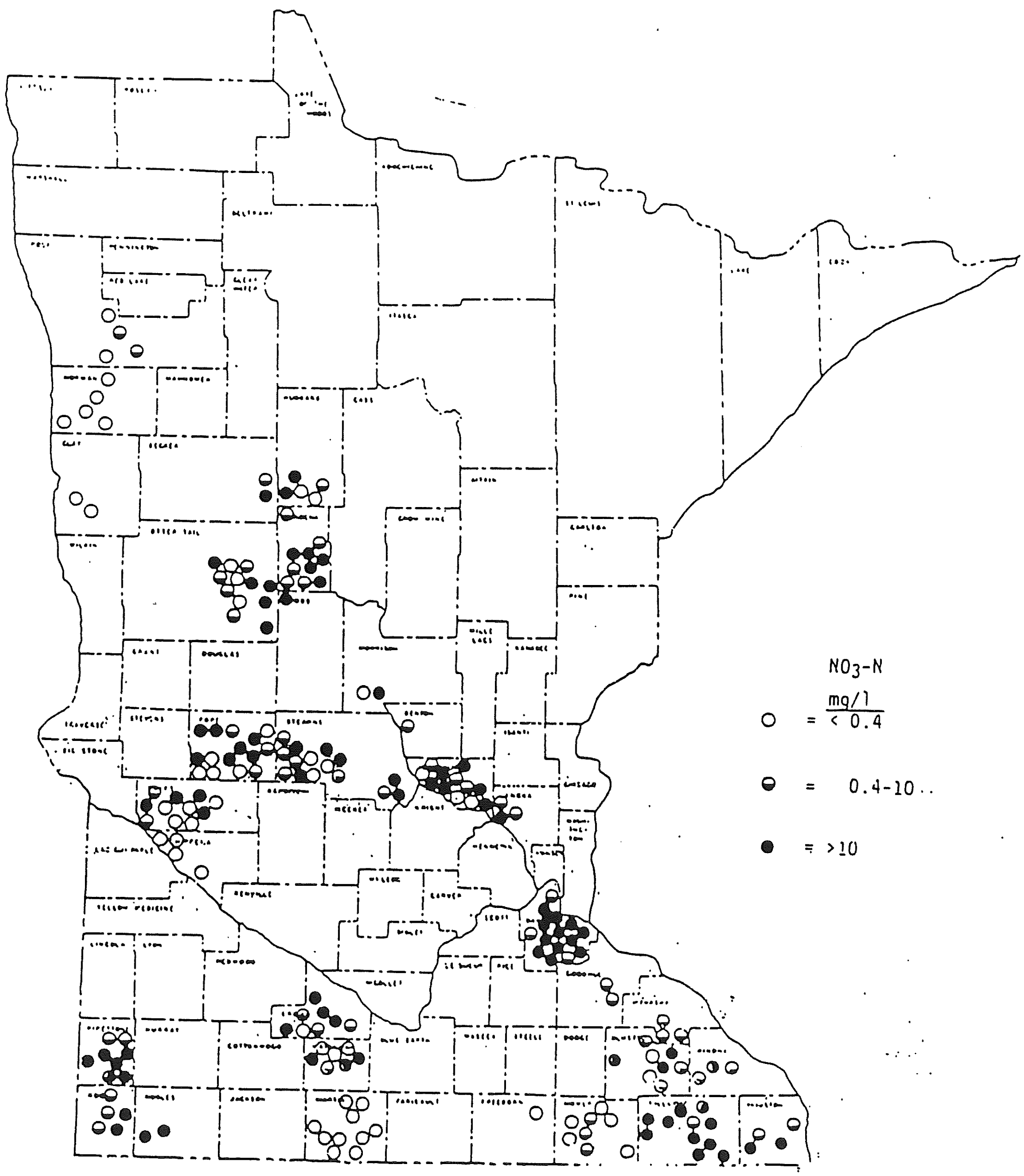
(MDH, 1989)

Survey Area	No. Wells Sampled	No. of Wells with Nitrate (mg/l)			Range (mg/l)	Median (mg/l)
		<0.4	0.4-10	>10		
1 Southwest	15	0	5	10	0.56-35.	13.
2 West Central	19	12	2	5	<0.4 -63.	< 0.4
3 Central	26	5	9	12	<0.4 -35.	8.5
4 North Central	30	5	11	14	<0.4 -27.	11.
5 Northwest	11	9	2	0	<0.4 - 2.6	< 0.4
6 East Central	18	4	6	8	<0.4 -50.	9.8
7 Dakota Co.	15	0	3	12	3.3 -46.	18.
8 Southeast	40	8	16	16	<0.4 -35.	9.2
9 South Central	15	4	4	7	<0.4 -83.	7.2
10 Martin Co.	10	10	0	0	N/A	< 0.4
TOTAL	199	57	58	84	<0.4 -83	9.2

FIGURE 2.3

OCCURRENCE OF NITRATES (NO_3-N) ONE-TIME SURVEY PRIVATE DRINKING WATER WELLS

(MDH, 1989)



The Iowa approach is almost exclusively one of education and demonstration. Research has been funded and accelerated through groundwater legislation. Demonstration projects on efficient nitrogen management techniques are planned for all Iowa counties.

The Nebraska program, established in 1985, addresses nitrate contamination primarily associated with intense irrigation agriculture. The state is divided into locally controlled Natural Resource Districts that can initiate voluntary or mandatory BMPs. The state can also intervene in this process to study an area and subsequently designate Special Protection Areas following a public hearing process. The Special Protection Areas are similar to the Natural Resource Districts but are under state, rather than local, control. There are currently two regions designated as special protection areas in Nebraska.

The Arizona program is more regulatory in nature in comparison to the other states' programs. Each of the roughly 2,000 farms in the state must develop a farm management plan which accounts for nitrogen use. Each farm plan is to be designed using an extensive set of BMPs developed by the state.

The Wisconsin program is similar to the Iowa program in that it concentrates on education and information dissemination. The Wisconsin program, however, is not funded to the extent of the Iowa program. Wisconsin has recently accelerated its efforts to disseminate and promote voluntary practices that reduce the potential for nitrates to contaminate groundwater.

Chapter 3

NITROGEN FERTILIZER MANAGEMENT PLAN

3.1 Definition and Structure of the Nitrogen Fertilizer Management Plan (NFMP)

Minnesota Statute 1989, Chapter 326, Article 6, Section 33, Subd. 2b directed the nitrogen task force to develop recommendations for a nitrogen fertilizer management plan (NFMP) for the prevention, evaluation and mitigation of nonpoint source occurrences of nitrogen fertilizer in waters of the State. The nitrogen fertilizer management plan must include components which promote the prevention of contamination of water resources by inorganic nitrogen and develop appropriate responses to the detection of inorganic nitrogen from fertilizer sources in ground or surface water.

The NFMP must allow for evaluation of, and response to, nitrogen contamination of water resources on a state, regional, or local basis. The structure of the NFMP must be flexible, in order to address the site specific nature of water resource contamination problems, and dynamic, to allow for adjustments to advancements in soil and crop management technology as well as water resource monitoring technology. The Act mandates that the NFMP contain both a voluntary BMP component and a component which allows for regulatory action in the form of Water Resource Protection Requirements (WRPRs).

In response to the legislative mandate, the task force developed a nitrogen fertilizer management plan with a coordinated, three-phased structure. The three phases of the nitrogen fertilizer management plan are: (1) promotion of the voluntary adoption and implementation of BMPs; (2) evaluation of the adoption and effectiveness of the voluntary BMPs; and (3) response to instances wherein voluntary BMPs have not been adopted or are ineffective in mitigating the occurrence of nitrate in ground or surface water (this potentially includes regulatory action).

3.2 The Promotion Phase: Voluntary Best Management Practices and Promotion Strategies

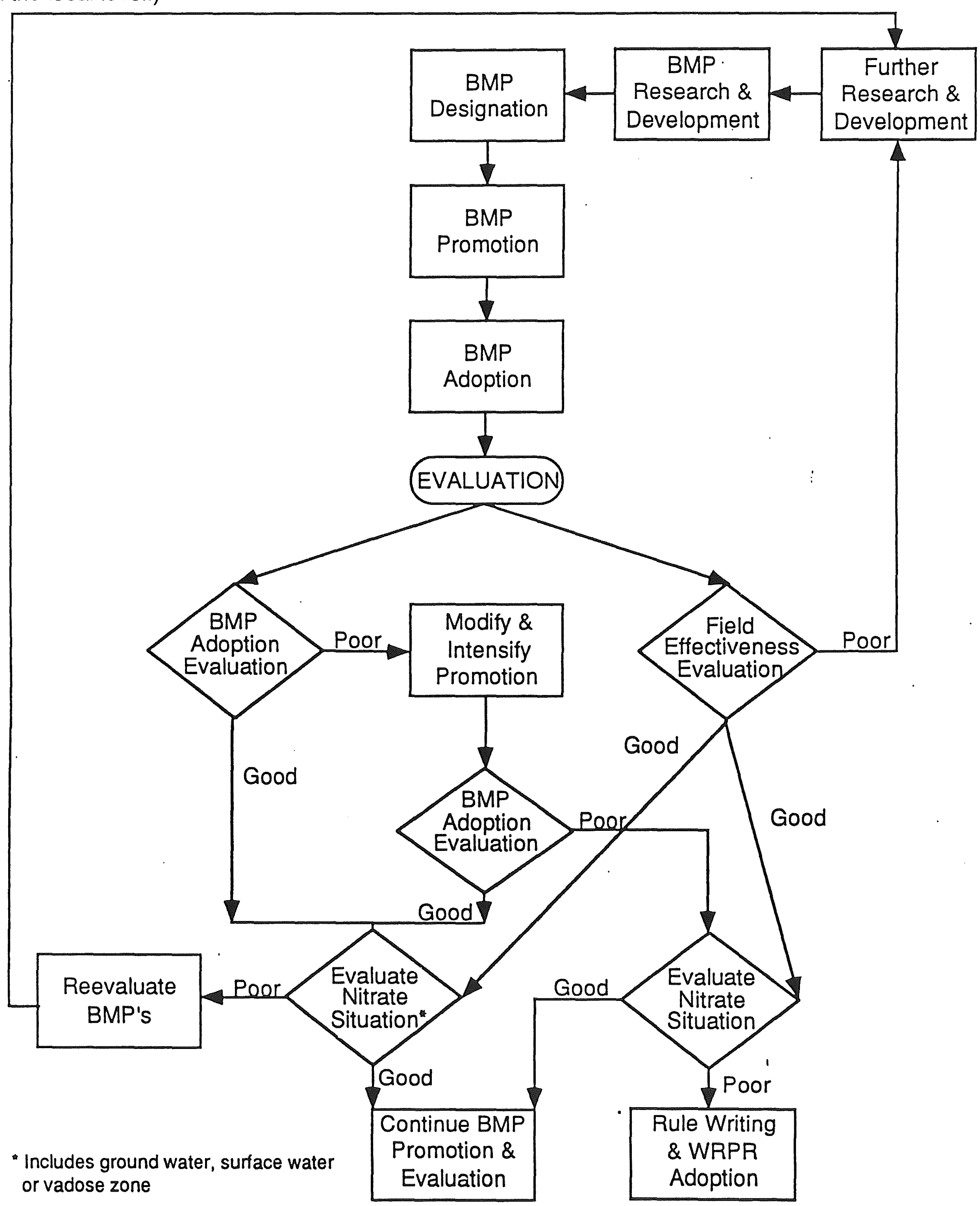
3.2.1 Voluntary Best Management Practices

Best Management Practices are the cornerstone of the Nitrogen Fertilizer Management Plan; if effective BMPs are adopted widely by fertilizer users, nitrate levels in groundwater should decrease on a both a local and statewide basis. The individual BMPs promoted by the NFMP are based upon field research and practicality.

FIGURE 3.1

The Nitrogen Fertilizer Management Plan Process

(This process can be used for state, region, or local level; the response phase may be most effective at the local level.)



The practicality makes adoption of the BMPs more attractive while the research basis ensures that management practices which are adopted will minimize nitrate contamination of Minnesota water resources.

A three-tier approach was taken in the development of BMPs. The first tier consists of a set of statewide BMPs to be applied in a variety of agronomic situations. The second tier consists of BMPs tailored to regions defined primarily by very general soil characteristics and climatic conditions. The third tier addresses the existence of special situations which present unique management problems. These include such situations as irrigation agriculture, turf, areas near surface water, and coarse textured, non-irrigated soils. The BMPs of all three tiers are discussed in detail in Chapter 4.

3.2.2 Strategies for the Promotion of BMPs

The goal of the first phase of the NFMP is the promotion of the BMPs by various government and private entities. Successful promotion should result in the concomitant adoption of the BMPs by fertilizer users. Ideally, the promotion of the BMPs to fertilizer users should use existing delivery mechanisms when possible. This avoids the creation of new bureaucracies and allows fertilizer users to deal with known entities. It is important that all promotion activities be coordinated in order to ensure program consistency. The MDA and the University of Minnesota, with the local Soil and Water Conservation Districts (SWCD) providing a local coordination role especially in significantly contaminated regions, will act as the lead agencies in coordinating promotion efforts.

The benefit of including various groups in the promotion of BMPs is that each group has a traditional audience and will be most effective at reaching that audience. Repetition of a common or identical message will encourage BMP adoption. Furthermore, different individuals and user groups are more receptive to certain information sources than others. By providing a number of channels for education and information dissemination, there is an increased likelihood that most fertilizer users will be reached. A list of the recommended government agencies and private entities who will have a role in BMP information dissemination is included in the list of participants in section 3.5.

The task force recommends a variety of strategies be used by the various groups to promote the adoption of the BMPs. BMP adoption will be increased if there is wide demonstration of the BMPs to nitrogen fertilizer users. The following is a list of strategies that can be used in cooperative efforts among private groups, state agencies, local government and the UM.

a) **Develop voluntary training programs for farmers, dealers, homeowners and gardeners**

These programs should be incorporated into existing adult or citizen education programs. If no adult education programs are available in a given area, an alternative forum should be identified. Also, incentives should be offered to dealers and fertilizer users to encourage attendance at the courses.

b) **Establish demonstration projects in conjunction with research on the effects of agricultural impacts on water quality on Agricultural Experiment Stations. Develop demonstrations of proven BMPs based on agronomic and fertilizer research on farms and develop model farms to conduct research, evaluate and demonstrate. Identify a similar formats for turf demonstration projects in urban areas.**

The Experiment Stations provide a recognized research entity at which BMPs can be developed, evaluated and demonstrated under controlled field research conditions. Model farms such as the Lawler farm in Olmsted county provide an opportunity to research and demonstrate BMPs in various soil and hydrologically sensitive conditions. The model farms are also valuable because they are highly visible in regions of groundwater sensitivity. Demonstration farms and model farms should be highly visible to fertilizer users in the same region or sensitive area. By using local farms to demonstrate BMPs, the peer review system is brought into play.

It is important to distinguish between demonstration farms and model farms. Both may be established on private farms with fertilizer users working closely with Extension and/or the MDA. Each demonstration or model farm will follow a set of operating protocol which will be established by the University in conjunction with the MDA.

The primary goal of the demonstration farm is to demonstrate BMPs that have been developed through research and designated as BMPs by the MDA. The demonstration farms are intended to be highly visible to a the public. These can be organized by the University, the Extension Service, or farm organizations.

The primary purpose of model farms is the evaluation of BMPs with proper scientific controls . The information gained from model farm operation will be used to modify or endorse BMPs as well as develop research opportunities in a farm system. Model farms should be maintained longer than are demonstration farms because of the investment in the research capacity. Model farms are discussed further in Section 3.3.2.

c) **Integrate nitrogen fertilizer BMPs into PAT programs. Include BMPs in related regulatory activities, such as mailings to restricted-use pesticide licence holders.**

This essentially provides another avenue by which to inform a variety of fertilizer users.

d) **Include promotion of nitrogen fertilizer BMPs in the proposed crop consultant certification program to be administered by the MDA.**

e) **Develop a package of promotional materials directed at the fertilizer user. This information will be distributed by all promotional groups. This should include many media forms, including fliers, slide shows, and video demonstrations.**

By using identical materials in promoting BMPs, program consistency is ensured and incorrect interpretation of NFMP intent is avoided. Also, the repetition of a common message will encourage adoption.

f) **Educate the non-regulated (non-agricultural) public about the efforts being made toward minimizing nitrogen fertilizer affects on water quality.**

Make press releases to newspapers and radio stations with local or statewide audiences. Encourage attendance of citizen groups at demonstration farms and model farms.

3.3 Evaluation Phase: Effectiveness and Adoption of BMPs

The Nitrogen Fertilizer Management Plan evaluation phase has two components: (1) evaluation of BMP adoption, and (2) evaluation of BMP effectiveness. Each component must be evaluated individually, and their combined effect must be evaluated as well. Evaluation of either component will be a complex process.

The results of BMP implementation may not be discernable at the level of changes in nitrate concentration of ground or surface water for a long period of time. Furthermore, changes in nitrate concentration observed over the course of a single year may or may not be related to the adoption of BMPs. In view of these difficulties, it is recognized that BMP adoption must be evaluated as well as BMP effectiveness in preventing or reversing the degradation of water quality.

BMP promotion and water quality must be evaluated on an ongoing basis so that promotion methods can be modified as necessary and so that the need for response to water quality degradation is identified. Evaluation is also important once the response phase is enacted to judge the effectiveness of the response action and to adjust and direct response activities.

The evaluation methods that follow are intended to be used at the state, regional and local level; movement from one level to another depends upon the scale and severity of the problem that is identified through evaluation. The methods can be used individually or in consort.

3.3.1 Evaluation of BMP Adoption

Evaluation of BMP adoption is important on a number of levels. Information on BMP adoption success can be collected in the interim following inception of BMP promotion but prior to completing full investigations of water resource quality. Adoption evaluation results at this point will provide feedback on promotion and information dissemination techniques and responsibilities. This can then provide an opportunity for modification and refinement of the promotion strategy. Adoption success information, interpreted at the regional level, may indicate areas where adoption rate is poor. These areas would then require intensified BMP promotion.

Although several strategies have been proposed, the task force has not produced final recommendations on BMP adoption evaluation strategies. The following are possible BMP adoption evaluation methods which have been discussed by the task force (these could be used concurrently or individually):

a) <u>Mail Survey:</u> **A BMP adoption mail survey could be used prior to the initiation of BMP promotion and again at the end of a designated time period. This survey would indicate change in adoption rate over**

time and the percent of growers using BMPs both before and after NFMP implementation. Surveys could be designed to address each BMP tier; state, regional and special situation. The survey would be conducted by the MDA, for statewide surveys, or the appropriate Soil and Water Conservation District, for localized surveys.

The survey should be statistically designed. It is recommended that fertilizer user surveys be designed to ask questions regarding rate, timing and form of nitrogen fertilizer applications rather than questions on implementation of specific BMPs. The answers to these questions would be translated to reflect whether BMPs are or aren't being adopted. This method ensures greater accuracy than asking questions specifically on adoption of specific BMPs.

b) <u>Applicator and Dealer Survey:</u> **Private applicators (farmers), commercial applicators and dealers could be surveyed on awareness and implementation of BMPs at the certification and licensing training programs administered by the MDA.**

Testing, required as a condition for certification for applicators of Restricted Use Pesticides, could be used as an opportunity to survey this segment of growers and applicators. Specific BMP training programs could also be developed.

c) <u>Interviews:</u> **Farmers, dealers and extension agents selected as representative of a region or local area could be interviewed on adoption of BMPs. This information could supplement the survey data but would be available sooner and with greater frequency. Results would be extrapolated to represent a region or area. This could also occur on a statewide level.**

This option would evaluate on-farm practices at a more personal level and would allow for interpretation of why BMPs had or had not been adopted at a state, region or local level. A potential problem may be the cost and/or the intrusive nature of an on-farm visit.

3.3.2 Evaluation of BMP Effectiveness

The intent of the NFMP is to prevent, reduce and mitigate the contamination of water resources by fertilizer nitrogen. The evaluation of BMP effectiveness, via water quality, vadose zone monitoring, and soil solution monitoring, is, in effect, a check on whether the NFMP is achieving this goal. Evaluation of BMP effectiveness is thus the critical juncture of the NFMP. The results of this evaluation provide a point of departure from which to refine BMP promotion strategies, launch further research or regulatory action, or define additional Special BMP Protection Areas.

Ground and surface water quality monitoring for effectiveness evaluation must take two directions:

1) Monitoring the effectiveness of individual BMPs by monitoring soil nitrate, and water quality through field research conducted by University personnel and in possible cooperation with other investigative units; and

2) Monitoring water quality on a state-wide and region-wide basis, and monitoring water quality and soil nitrates in Special BMP Promotion Areas, to provide an index of the overall effectiveness of BMP implementation.

   The task force did not produce final recommendations on effectiveness monitoring methods, but did discuss some general directions for the effectiveness monitoring component; these are discussed below.

   a) Monitoring Water Quality at Model Farms (see section 3.2.2) and Agricultural Experiment Stations (AES).

   This provides a secondary check on whether BMPs are effective at the field level and under specific conditions. Such systems could be established in each region and Special BMP Promotion Area. The monitoring for this purpose could include soil analysis and vadose zone monitoring; these would provide indicators of nitrate movement in the soil profile prior to the time that effects would be noticed in groundwater.

   Agricultural Experiment Stations present an obvious location for effectiveness evaluation of individual or multiple BMPs. The AES offer an established status and research role for this purpose.

   Model Farms can be used to evaluate the effectiveness of BMPs in a relatively controlled environment, while maintaining high visibility to fertilizer users in the vicinity of the model farm. Model farms may include individual farms or clusters of farmers in a given area. Participation in a model farm program requires assessment and preparation of a nitrogen inventory, adherence to BMPs and carefully designed groundwater and soil solution monitoring. Cooperative efforts between the landowner/operator, research institutions and the various agencies and organizations is to be encouraged. Such farms would have a secondary purpose of demonstrating BMPs to neighboring farmers and other interested parties.

The model farm program would be designed to include representative farms for an area and would provide a method for evaluation of BMP effectiveness. A single model farm could demonstrate individual or multiple BMPs.

b) Water Resource Monitoring

Ground and surface water monitoring provides the field data necessary to judge whether nitrate concentrations in ground and surface water are increasing, decreasing, or staying the same. This information will be used to make decisions within the NFMP framework. Because this is perhaps the most important aspect of the evaluation phase, **it is crucial that a strict and detailed protocol is developed for the design of monitoring networks, the collection and analysis of water samples and analysis of water quality data.**

All monitoring participants must then adhere closely to this protocol. In selecting wells for inclusion in groundwater quality monitoring networks, it is important to identify wells which are vulnerable to contamination by alternative nitrogen sources (septic systems, livestock yards, etc.) and to eliminate such wells from the network. For sites where surface water is monitored, it is important to select appropriately representative sampling sites. If surface water sampling sites are selected in mixing zones, it is necessary to inventory potential alternative sources of nitrate which could contribute nitrate to the drainage system node above the mixing zone.

Many state and local agencies maintain or are developing various ground and surface monitoring networks. Existing nitrate data sources include municipal well testing programs, private well sampling programs, the MDA monitoring programs, the MPCA ambient monitoring programs and local monitoring efforts. **It is desirable to use these existing data to the extent possible, yet it is also important to coordinate participating monitoring activities.**

When existing monitoring efforts indicate areas where nitrate contamination is a problem, these areas are designated as Special BMP Promotion Areas (see section 3.4.1). Monitoring in these areas must then be intensified and a monitoring network specific to that area must be designed. Concurrently, BMP promotion is also intensified. Existing ambient monitoring programs can continue to address overall water quality. Ongoing monitoring can be used to add, subtract, or modify the special BMP promotion area.

A nitrogen inventory of potential nitrogen sources, storage and use practices should be compiled by farmers in the Special BMP Promotion Area. This inventory would include on-farm septic systems, fertilizer storage, manure storage, feedlots, and nitrogen fertilizer use. Also, as part of the assessment of these areas, an inventory of other potential non-agricultural nitrate sources must be conducted. The inventories essentially allow for accounting of point-sources of nitrates.

The monitoring program described recognizes that there are areas which warrant greater concern than others and uses existing efforts to identify these areas. This approach also presents an opportunity for immediate action in areas which warrant it.

3.4 Response Phase: Mitigation and Regulation

The general intent of the NFMP is to attempt, initially, to resolve nitrogen contamination problems by voluntary action and utilize a regulatory approach if the voluntary approach is ineffective. The framework for this philosophy is established by the Groundwater Protection Act of 1989 which mandates that Water Resource

Protection Requirements (WRPRs) may be promulgated by rule by the MDA if the voluntary BMP approach is proven to be ineffective. If WRPRs are determined to be necessary, they should be based on proven agronomic or turf management BMPs and should be incorporated into the regional concept proposed. Adoption of WRPRs for fertilizer is prohibited by the legislature until after January 1, 1991.

Mitigation efforts may begin in response to either of two indicators: (1) ground and surface water quality monitoring results [effectiveness evaluation], and (2) the combined effects of BMP adoption evaluation and water quality monitoring. The response phase is intimately associated with the evaluation phase as reflected by its presentation in this section.

The structure of the response phase was an area of much discussion on the part of the task force. The task force discussion indicated that the structure must answer the following needs:

a) Response must be appropriate to the scale of the problem.

b) It must be possible to take response action, as appropriate, on a statewide, regional, or local level.

c) It must be possible to take response action in instances of intense or pervasive surface water contamination as well as instances of intense or pervasive groundwater contamination.

d) In instances where there is intense contamination the structure must allow for immediate action.

e) The structure must allow for regulatory action, when appropriate.

f) If regulatory action is taken, the structure must assure that only the area which acts as the source of the problem is regulated.

g) The structure must assure that all possible alternative nitrogen sources are accounted for and investigated prior to taking regulatory action.

h) The structure must allow for local input into response decisions in the case of local-level responses.

These components need to be considered at the state, regional, local or special situation level. The response may include voluntary or regulatory actions as stipulated in statute.

3.4.1 Recommended Structure for Local Nitrate Contamination Problems

The task force recognized that the most acute and immediate need for response will likely occur at a local level. Therefore, a more detailed framework was discussed and recommended for this situation. This framework is described in Figure 3.2.

The same aspects of the recommendations for the Nitrogen Fertilizer Management Plan were applied to this framework. This framework is not meant to be applied at the state, regional or special situation level.

(A) In areas where significant nitrate contamination of ground or surface water exists or could potentially exist in geographically contiguous areas, and where the source is thought to originate from agricultural sources, special attention and efforts should be focussed. These areas may be recognized as warranting concern due to monitoring efforts of the MDA, water quality data provided to the MDA, or by the mapping of sensitive areas by the DNR.

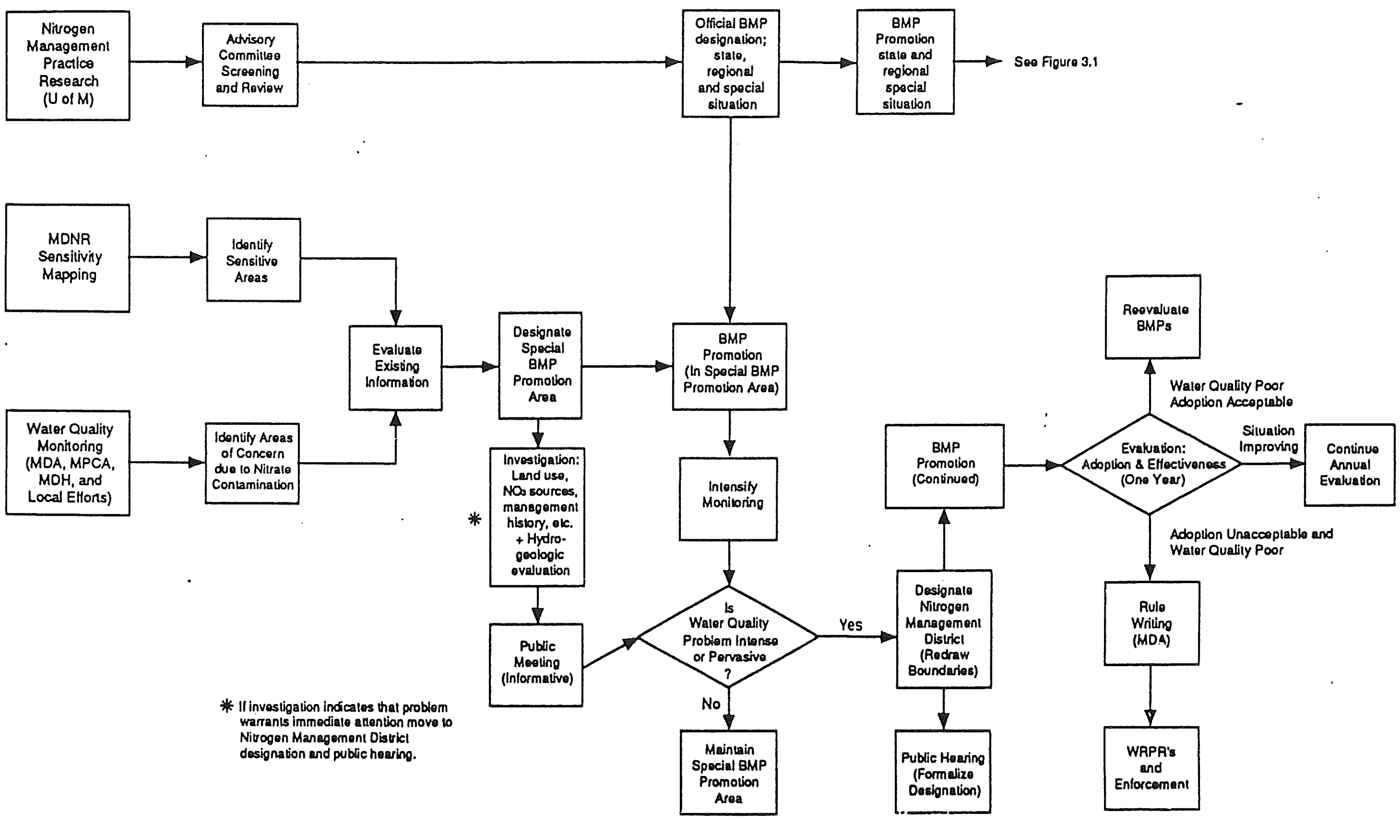
(B) The MDA should evaluate the information that indicates where these areas of significant nitrate contamination exit and determine the validity of the information. If the information indicates that legitimate concerns exist, the MDA, in consultation with the local SWCD and the appropriate county water planning authority, should designate a **Special BMP Promotion Area.**

(C) The Special BMP Promotion Area boundaries should follow township boundaries and should encompass only the area of concern due to significant nitrate contamination. The number of townships included in the Special BMP Promotion Area should be kept to a minimum to enable special focus of and efforts onto the most important areas of concern.

(D) Following establishment of the Special BMP Promotion Area, the MDA, in cooperation with the appropriate SWCD(s), should conduct an initial evaluation regarding the land use, sources of contamination, nitrogen management practices, water quality information, trends in contamination and other related factors. A hydrogeologic evaluation should be conducted in the area by the MDA. Information from and cooperation with local, state or federal agencies would be utilized.

FIGURE 3.2

RECOMMENDED STRUCTURE FOR LOCAL NITRATE CONTAMINATION PROBLEMS



❋ If investigation indicates that problem warrants immediate attention move to Nitrogen Management District designation and public hearing.

(E) Concurrent with the evaluation (in D above), the SWCD(s) should provide leadership in the promotion of applicable BMPs for the Special BMP Promotion Area. This should be done in cooperation with local extension agents and county local water planning authorities. BMP promotion should include information transfer and BMP demonstration projects. There should be an opportunity for the BMPs for all appropriate sources to be implemented before any additional efforts are directed to this area of concern. The time allotted for the BMPs to be implemented should be in proportion to the degree of the problem identified.

(F) A public meeting, chaired by the MDA, the local SWCD and the smallest appropriate unit of government should be held. The purpose of this meeting is to provide information on the degree of nitrate contamination and the status of the efforts to mitigate the problem. This meeting should be held following the completion of the evaluation by the MDA and the local entities.

(G) If a significant number of wells exceed the drinking water standard for nitrate in the Special BMP Promotion Area or if nitrate levels are increasing in ground or surface water throughout the area and over time (at least a four year period), the area should be reclassified as a **Nitrogen Management District.** Boundaries could be redrawn (larger or smaller) at this point based on additional information. The designation of a Nitrogen Management District initiates the process of change from a voluntary to regulatory situation.

(H) A public hearing should be held to discuss the design and delineation of the Nitrogen Management District. If there is a reason to proceed rapidly, the public hearing could be combined with the public meeting discussed in (F) above. (The public meeting is for information exchange and the public hearing is to formalize the designation of a Nitrogen Management District).

(I) The SWCD and MDA should continue to promote and evaluate the adoption of BMPs. Following the public hearing, an evaluation of BMP adoption and the water quality information should be made on an annual basis. If the BMP adoption is unacceptable, and the water quality does not improve, the MDA shall begin the process to implement Water Resource Protection Requirements. If the BMP adoption is acceptable, the SWCD(s) should continue the promotion and evaluation should continue on an annual basis.

3.5 NFMP Participants and Their Respective Roles

The following is a list of the various participants and their roles in the various phases of the Nitrogen Fertilizer Management Plan. The compilations of both the participants and their roles are dynamic and subject to adjustment.

3.5.1 Minnesota Department of Agriculture (MDA)

a) **BMP Development: The MDA shall, as designated by statute, develop and promote the nitrogen fertilizer BMPs, as well as coordinate the implementation of the NFMP.**

The MDA serves as the statutory authority for the protection of ground and surface water from degradation by agricultural chemicals.

b) **BMP Promotion: The MDA should incorporate nitrogen fertilizer BMPs into the Pesticide Applicator Training (PAT) program. Additional certification programs regarding nitrogen fertilizer should be developed in cooperation with the Minnesota Extension Service.**

The PAT program is an effective dissemination tool which reaches many pesticide users who also use nitrogen fertilizer. The incorporation of nitrogen fertilizer BMPs into the PAT was supported in testimony by farmers and dealers to the task force.

c) **Evaluation Phase: The existing MDA water quality monitoring program is central to the effectiveness evaluation stage and to the identification of Special BMP Promotion Areas. The MDA will also play a central role in adoption evaluation.**

d) **Response Phase: The MDA is ultimately responsible for the regulation of fertilizer and therefore would be the lead agency in a response at the state, regional or local level.**

3.5.2 University of Minnesota (UM) and the University of Minnesota Agricultural Experiment Station (AES)

a) **Research and Development: The UM should continue basic and applied research on nitrogen movement and**

management in the environment, including agricultural and urban settings.

The UM has the experience and resources to continue to research nitrogen. This should include research on nitrogen fertilizer and other sources of nitrogen as well. **[Note: Other institutions of higher education can complement and enhance this role.]**

b) **The branch Agricultural Experiment Stations should distribute and demonstrate the results of their research.**

The Experiment Station are visible, regional research institutions which can evaluate and demonstrate BMPs for nitrogen fertilizer.

3.5.3 Minnesota Extension Service (MES)

a) **BMP Information and Education: The MES shall distribute information and develop educational programs regarding nitrogen fertilizer through existing Extension Service programs at the county and specialist level.**

Much of the nitrogen fertilizer research on BMPs will occur at the UM; thus, this strategy will enhance the coordination and the credibility of the BMPs. Task force testimony supported the MES as an effective and independent source of information.

b) **Target Audiences: In addition to those efforts directed at the farmer, the MES should target homeowners, spouse programs and 4-H programs for providing information on nitrogen fertilizer.**

These programs can focus on unique groups using nitrogen fertilizers or having influence on management decisions effecting nitrogen fertilizer.

3.5.4 State of Minnesota

Nitrogen Fertilizer BMPs: The State of Minnesota shall use turf BMPs in state parks, preserves, property, right-of-ways, etc.

The state should implement nitrogen fertilizer BMPs to utilize the technology, set an example and to demonstrate the BMP's effectiveness.

3.5.5 Regional Development Commission (RDCs)

BMP Distribution: The RDCs should serve as an additional resource in distributing information about BMPs.

The RDCs can assist in the distribution of BMP information because of their contacts with various organizations and groups at the local level.

3.5.6 County Government

a) **BMP Implementation and Demonstration: Counties should assist in distributing and demonstrating BMP information. In addition, they have a role in assessing the effectiveness of BMP implementation.**

County government is a recognizable, local entity. Regional boundaries for BMPs may use county political boundaries for administrative ease.

b) **Local Water Planning (LWP) Initiatives: Counties should include nitrogen fertilizer BMP education projects in LWP.**

Nitrates have been identified by many counties as a concern through local water planning efforts. Many counties have expressed an interest in developing educational programs to address the agricultural chemical problems from a local perspective.

3.5.7 Township Governments

BMP Implementation: Township government should aid in distributing BMP information and evaluating the effectiveness of the BMPs.

Township government has the closest proximity to farmers in the rural areas. Iowa has used township boundaries in delineating sensitive areas for atrazine use. Township boundaries may be useful in delineating unique BMP areas within regions.

3.5.8 City Governments

BMP Implementation: City government should help distribute nitrogen fertilizer information to lawn care industries, homeowners, municipal parks and golf courses. It should also evaluate the effectiveness of turf BMPs.

Some cities currently license or otherwise monitor fertilizer use. Nitrogen fertilizer usage in an urban setting requires additional monitoring. There is not a pre-emption statute for local ordinances regulating the sale and use of fertilizers.

3.5.9 Nitrogen Fertilizer Dealers

a) **Agricultural Dealer/Commercial Applicator Information and Education: The agricultural fertilizer dealers should promote the adoption of nitrogen fertilizer BMPs by their clientele. The dealers should also utilize BMPs in commercial applications and recommendations.**

b) **Urban Fertilizer Dealer/Commercial Applicator Information and Education: The urban fertilizer dealers should promote the adoption of nitrogen fertilizer BMPs by their clientele. The dealers should also utilize BMPs in commercial applications (lawn care services) and in recommendations to the homeowner.**

Identified as a pivotal information group for farmers, the delivery of BMPs by the farm or urban dealer will greatly aid in the credibility of the BMPs and increase their adoption. Many dealers already promote some BMPs and nitrogen management concepts. Endorsement by dealers, who have the most contact and the best relationship with the fertilizer user, will greatly increase voluntary use of the practices.

3.5.10 Soil and Water Conservation Districts (SWCD)

BMP Promotion. SWCDs should promote local BMPs in a coordinated manner with other organizations and groups. The SWCD should be involved in demonstrations and model farm programs. SWCDs have an important function in local areas with significant nitrate contamination.

Local SWCDs are in frequent contact with growers and can provide an immediate contact and source of information regarding local BMPs. This is especially important in Special BMP Promotion Areas. In these areas the SWCD is responsible for information gathering and BMP implementation evaluation as well as co chairing public meetings and hearings.

3.5.11 Soil Conservation Service (SCS)

BMP Promotion: The SCS should promote BMPs through their traditional role of technical advisors to the farmer. Existing programs such as the Anoka Sand Plains

Initiative, cost shares and other water quality programs can be used to provide this information.

The SCS has a long standing role of providing technical assistance to the farmer. Water quality initiatives are now joining with soil conservation in the non-regulatory approach the SCS offers.

3.5.12 Minnesota Board of Water and Soil Resources (BWSR)

a) **BMP Promotion: The BWSR should continue to promote BMPs through its local government clientele, which include SWCDs, county government, watershed districts, and water management organizations.**

These local government entities listed are in frequent contact with land users and public officials. They can provide broad-based support for BMPs and can offer or refer requests for technical assistance.

b) **BMP Implementation: The BWSR should require planning authorities to consider BMPs as a part of their implementation strategy.**

The BWSR is responsible for directing, and ultimately approving, the development of various local water and land management plans. These plans include: county comprehensive local water plans (110B plans); metropolitan surface water management plans (509 plans); metropolitan groundwater plans; watershed district overall plans (112 plans); and SWCD plans.

These plans deal with water quality and quantity issues, including land use and institutional changes necessary to manage water in a hydrologically and environmentally sound manner. As an example, many counties have committed to adopt local ordinances or programs to resolve nitrogen related problems.

c) **BMP Demonstrations: The BWSR should continue to fund efforts to promote wise nitrogen management through on-farm demonstrations.**

The BWSR currently funds projects through the Environmental Agriculturalist Program to demonstrate the benefits of proper nitrogen management. Although these efforts are technically not BMP demonstrations (because they have not been funded as such) they are oriented in a manner consistent with the BMP discussions of the task force.

3.5.13 MPCA, MDNR, MDH And Other State and Federal Agencies

BMP Promotion: The MPCA and MDNR should be involved in the promotion and demonstration of BMPs in urban and rural areas.

These and other state and federal agencies have research and demonstration capabilities which can be used to communicate BMPs and to further promote their adoption.

BMP Evaluation: Existing water quality monitoring efforts conducted by these agencies are central to effectiveness monitoring.

3.5.14 Vocational Agriculture, FFA Programs and Adult Education

BMP Promotion and Demonstration. FFA participation should be encouraged in programs involving BMP promotion and demonstration. Vocational-agricultural and adult education courses can also complement these efforts.

FFA projects can provide a method of training future farmers in the use of nitrogen fertilizer BMPs. Vocational-agricultural and adult education programs can be utilized to influence farmers and homeowners to adopt BMPs.

3.5.15 Land Stewardship Project (LSP), Soil and Water Conservation Society (SWCS) And Other Private Education Groups

BMP Promotion and Demonstration: Private, profit and nonprofit organizations should involved in the promotion and demonstration of BMPs, especially when focusing on groups or individuals unwilling to deal with existing education structures.

Crop consultants, sustainable agriculture and environmental groups, community, service and religious organizations, educational consultants, etc. can be incorporated into BMP promotion to reach their respective audience.

3.5.16 Trade Associations and General Farm Organizations

BMP Promotion and Demonstration: These groups should be involved in the promotion and demonstration of nitrogen fertilizer BMPs, particularly to their membership.

Membership in these associations consists of fertilizer dealers, corn and soybean growers' associations, promotion councils, co-ops, vegetable processors, turf specialists, and others. Other associations can be incorporated as educators for their own members.

3.6 Additional Nitrogen Fertilizer Management Recommendations

The Nitrogen Fertilizer Management Plan should complement other state and federal programs where possible. Programs that affect shoreland management and crop production, such as Reinvest in Minnesota (RIM), Conservation Reserve Program (CRP), and Shoreland Regulations need to be coordinated with the management plan. Efforts underway to provide technical expertise or funding such as the MPCA's Clean Water Partnership Program, or the Anoka Sandplain Project should be utilized and coordinated.

Programs currently under development, such as the Pesticide Management Plan and Well Head Protection need to consider the Fertilizer Management Plan. The programs may need to coordinate efforts significantly so as not to duplicate groundwater protection efforts. Finally, the Fertilizer Management Plan needs to incorporate the sensitivity mapping effort of the DNR when completed as appropriate and mandated by the Groundwater Protection Act.

Chapter 4

BEST MANAGEMENT PRACTICES

4.1 Introduction

The primary goal of the Nitrogen Fertilizer Management Plan (NFMP) is to manage nitrogen inputs to crop production so as to prevent degradation of Minnesota water resources while maintaining farm profitability. The central tool for achievement of this goal is the adoption of **best management practices (BMPs)** which must be based upon the concept of **total nitrogen management**. Because of the ability to manage and control plant nutrients, the primary focus of the BMPs is nitrogen fertilizer. However, consideration of other nitrogen sources and agronomic practices is necessary for an effective and practical total nitrogen management system.

In order to both optimize crop yields and minimize environmental impacts, the BMPs prescribed for any given site must be tailored to fit the prevailing climatic, soil and hydrogeologic conditions. In administrative interests, the regional BMP zones should conform to existing county boundaries. A three tier system of BMPs has been developed to fit both of these needs. The first tier is a set of state-wide BMPs. The second tier consists of a set of regional BMPs for each of five regions in the state. The regions are defined by general soil and climatic conditions and the BMPs are tailored to these characteristics. The third tier provides BMPs for areas of unique conditions that result in a special nitrogen management situation. Each tier enhances and refines the previous tier.

The three tier system allows for flexibility yet maintains a consistent process for BMP selection. By combining the statewide BMPs with appropriate regional or special situation BMPs, a specific set of BMPs can be developed for any given field or situation. The specific set of the BMPs can vary between fields or sites because each field history and management situation is different, yet the process for selecting at a specific set of BMPs for any situation is uniform.

4.2 BMPs and Total Nitrogen Management

Best Management Practices (BMPs) are defined in Minnesota Statute 1989 Chapter 326, Article 1, Section 1, Subd. 4 as:

> "... voluntary practices that are capable of preventing and minimizing degradation of ground water, considering economic factors, availability, technical feasibility, implementability, effectiveness, and environmental effects. BMPs may be schedules of activities, design and

operation standards, restrictions of practices, maintenance procedures, management plans, practices to prevent site releases, spillage or leaks, application and use of agricultural chemicals, drainage from raw material storage, operating procedures, treatment requirements, and other activities causing groundwater degradation."

The nitrogen BMPs recommended by the task force are based upon research, particularly that which has been conducted at the University of Minnesota and other land grant universities, and upon practical considerations. This ensures that the BMPs are technically sound and, at the same time, likely to be adopted by growers.

The BMPs are based, in part, upon the concept of total nitrogen management. Total nitrogen management consists of accounting for all forms of on-farm nitrogen in the development of crop management plans. All aspects of the Nitrogen Fertilizer Management Plan, and of any associated program, must promote this concept and remain consistent with it.

4.3 The Three-Tier BMP Strategy

The prescription of BMPs is based upon a three-tier strategy. Each succeeding tier enhances or refines the previous tier. The three tiers are: (1) State-wide BMPs, (2) Regional BMPs, and (3) Special Situation BMPs.

4.3.1 Statewide BMPs

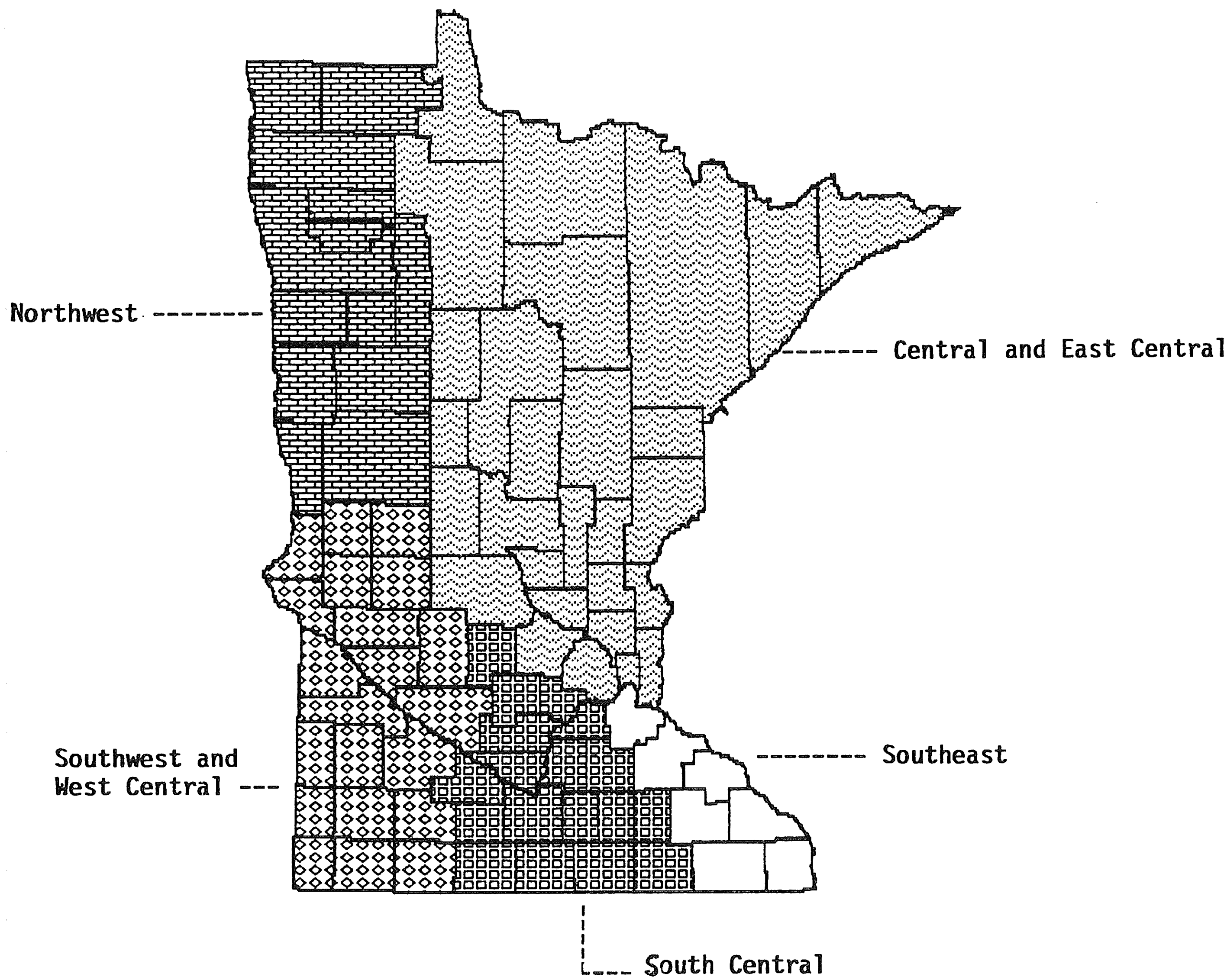
Statewide BMPs can be considered to be "generic" in that they apply to all areas in the state. The succeeding tiers refine the statewide recommendations. The application of these BMPs results in field- and farm-specific practices that are uniquely tailored to a given situation. In general, statewide BMPs are applicable to all cropping systems and agronomic practices.

4.3.2 Regional BMPs

In order to achieve a goal of minimizing environmental impacts while optimizing agricultural profits, BMPs must account, to some extent, for local variation in soils, hydrogeologic conditions, and climatic conditions. In this interest, the state has been divided into five regions based upon general climatic conditions, soil characteristics and the resulting sensitivity to groundwater contamination. Figure 4.1 depicts the locations of the five regions in the state. BMPs were developed specific to the conditions defining each region. The regional BMPs refine the prescriptions of the statewide BMPs.

FIGURE 4.1

THE FIVE MINNESOTA REGIONS FOR WHICH BMPs ARE FORMULATED



4.3.3 Special Situation BMPs

It is recognized that certain combinations of management and environmental conditions may render an area or site more susceptible to groundwater contamination than would be predicted by the general characteristics of the surrounding region. In order to account for this phenomenon, a third tier of BMPs were developed. The third BMP tier accounts for special situations which present unique management considerations. Four situations were defined as warranting special protective measures. These conditions are: (1) irrigated soils, (2) coarse textured (non-irrigated) soils, (3) turf, and (4) areas near surface water.

4.4 Tier 1: Statewide Nitrogen BMPs

Accurate determination of crop nitrogen needs is essential for profitable and environmentally sound nitrogen management decisions; the statewide BMPs were based upon this concept. Nitrogen needs should be determined using University of Minnesota recommendations or appropriate research from other land grant universities.

[Refer to Fertilizer Recommendations For Agronomic Crops In Minnesota, AG-MI-3901, 1990, MES for specific crop information.]

4.4.1 Develop realistic yield goals.

Unrealistically high yield goals can cause over-application of nitrogen, resulting in reduced profitability and potential nitrogen loss to groundwater. Accurate farm records should be used to calculate yield averages for each field. The yield goal should be based on past five year average, excluding the worst year. The exclusion of the worst year accounts for the possible catastrophic events that significantly damage yield potential.

Technological advances that can influence yield need to be considered in determining yield potential. The use of the most recent five years of crop yields integrates the management practices and other factors that are specific to a field or farm crop production potential.

In cases where rotation practices limit recent yield information, yield goals should be based on farm-specific soil, management, and cropping situations from the previous five years or from a 3- or 4- year average for the specific crop to be fertilized.

Although maximum yield potential may be occasionally limited using this approach, long term economic analysis indicates maximum profitability is gained by using past average yields, without adding an insurance amount of nitrogen, as a guide to crop nitrogen needs. This reduces the potential for nitrate contamination and enhances long term profitability. An average yield approach will provide a sound basis for a field-specific nitrogen recommendation that is environmentally sensitive and agronomically sound.

4.4.2 Develop and utilize a comprehensive record-keeping system to record field specific information.

Accurate field records should be kept by farmers for use in their crop management decisions since they are essential to the development of realistic yield goals and attainment of maximum profitability. This farm-specific information should be used to evaluate past experience and to plan future nitrogen management programs. At a minimum, farmers are encouraged to accurately and systematically keep information on crop yields, nitrogen fertilizer and manure applications and soil test results. The information can be used to monitor and adjust nitrogen management in a precise fashion for profit and environmental benefits.

4.4.3 Adjust nitrogen rates according to soil organic matter content, previous crop, and manure application.

Mineralization of soil organic matter releases nitrogen that is useable by crops. Nitrogen recommendations in Minnesota should be adjusted for soil organic matter content as determined by a soil test.

Legumes in a crop system can supply substantial amounts of nitrogen to subsequent crops. For example, first year credits for N can range from 40 lb/a for soybeans to 150 lb/A for alfalfa. Similarly, nitrogen application rates can be significantly adjusted to account for manure application.

By failing to account for these sources of nitrogen in determining the correct application rate, a surplus of nitrogen may be created; this surplus can potentially leach to groundwater.

4.4.4 Use a soil nitrate test when appropriate.

The use of a deep soil test to measure residual soil nitrate in the root zone can substantially improve nitrogen recommendations in regions of Minnesota where average annual precipitation is approximately 25 inches or less. University of Minnesota research indicates that soil nitrate test results are inconsistent in predicting nitrogen needs in more humid regions of Minnesota. With appropriate interpretation, soil nitrate sampling may provide useful information where average annual rainfall is greater than 25 inches. This interpretation must be tailored to each field based on exact past and current conditions.

4.4.5 Use prudent manure management to optimize nitrogen credit:

a) **Test manure for nutrient content.**

b) **Calibrate manure application equipment.**

c) **Apply manure uniformly throughout a field.**

d) **Injection of manure is preferable, especially on strongly sloping soils.**

e) **Avoid manure application to sloping, frozen soils.**

f) **Incorporate broadcast applications whenever possible.**

Manure management programs should be planned to optimize nutrient utilization. The amount of nitrogen supplied by manure will vary with the source of manure (type of livestock), handling, application rate, and method of application. Because the nitrogen form and content of manures varies widely, a nitrogen analysis of manure is recommended to improve nitrogen management.

4.4.6 Credit second year nitrogen contributions from alfalfa and manure.

Alfalfa and manure can supply nitrogen for more than one crop year. Recent University of Minnesota research indicates a credit of 75 pounds nitrogen per acre can be adopted for second-year corn following a good stand of alfalfa on medium and fine textured soils. The organic nitrogen in manure is transformed to plant-available nitrogen over a period of several years. Between 33 and 50 percent of the organic nitrogen remaining will be converted to plant-available nitrogen each year after the manure is applied.

4.4.7 Do not apply nitrogen fertilizer above recommended rates.

Nitrogen application rates higher than current University of Minnesota and other land grant universities recommendations have been shown to significantly increase nitrate leaching losses and subsequent contamination of groundwater. A high degree of confidence can be placed in University of Minnesota and neighboring land grant universities' recommendations because they are based on long-term field research. Environmental impacts will be reduced if recommendations are followed.

4.4.8 Plan nitrogen application timing to achieve high efficiency of nitrogen use.

Nitrogen application timing can significantly affect the efficiency of nitrogen use and the potential for nitrate contamination of groundwater. Generally, the greater the time between application and crop uptake, the greater the chances for nitrogen loss. However, if sidedressed nitrogen is applied too late for crop use and/or to dry soils (wherein root activity is limited), nitrogen not used by the crop can leach to groundwater. Regional recommendations should be used to achieve high nitrogen use efficiency.

4.5 Tier 2/Regional BMPs: Southeastern Minnesota

Southeastern Minnesota is characterized by permeable, silt loam soils with underlying fractured limestone bedrock. This karst region is very susceptible to groundwater contamination. Average annual precipitation in the region is greater than 30 inches. Cropping systems include corn, forages, oats and soybeans. Livestock production consists primarily of dairy, beef and hogs.

4.5.1 Do not apply fertilizer nitrogen in the fall.

The risk of leaching loss of nitrate from fall nitrogen application is heightened in southeastern Minnesota due to the high average annual precipitation, the well-drained and permeable nature of the soils and the presence of karstic terrain. Spring pre-plant or sidedress nitrogen applications provide for more efficient use of nitrogen.

4.5.2 Spring pre-plant applications of anhydrous ammonia or urea are encouraged. Broadcast urea should be incorporated within three days of application.

For pre-plant applications, use of ammonium forms of nitrogen fertilizer (anhydrous ammonia and urea) instead of nitrate-nitrogen forms reduces the potential for nitrogen leaching loss.

4.5.3 Apply sidedress applications to corn prior to the V4 stage of development.

Limiting sidedress applications to the pre-V4 stage of development in corn will help insure nitrogen availability during peak nitrogen demand which occurs during the V12 to V16 development stage. This strategy will also decrease the probability that nitrogen will be unavailable to the crop in instances of dry soil surface conditions or lack of timely rainfall.

4.5.4 Inject or incorporate sidedress applications of urea and UAN-28 to a minimal depth of four inches.

Incorporation of urea and urea-containing fertilizers reduces the potential for volatilization losses. Since materials which are surface applied under dry conditions are prone to positional unavailability, yields may suffer. Injection or incorporation to a four inch depth decreases the chance of this occurring. Positional unavailable nitrogen often remains in the soil profile after harvest and thus is highly susceptible to leaching loss before the next year's crop utilization.

4.5.5 Use a nitrification inhibitor with pre-plant nitrogen applications if soils are poorly drained and soil moisture levels are high in the upper portion of the profile.

Denitrification losses can be substantial on soils that remain saturated for extended periods of time. Nitrification inhibitors limit denitrification and leaching by keeping nitrogen in the ammonium form for an extended period of time. Use of a nitrification inhibitor in these situations is preferred over insurance nitrogen applications.

4.5.6 Minimize direct movement of surface water runoff to sinkholes.

Direct movement of surface water carries nutrients and dissolved nitrates that can adversely affect water quality over a large region. Minimize the movement through erosion control, berms and filter strip around sinkholes.

4.6 Tier 2/Regional BMPs: South Central Minnesota

South central Minnesota is characterized by fine-textured soils formed in glacial till and sediments. Most south central soils have naturally poor-to-moderate internal drainage and are tiled to improve drainage. Average annual precipitation in the region is 25 to 30 inches. Cropping systems are predominantly corn and soybeans.

4.6.1 Spring pre-plant applications of nitrogen are highly recommended.

University research conducted in this region indicates that spring nitrogen applications are used more efficiently by the crop and result in decreased nitrate loss to tile line flow than fall applications. The potential for nitrogen loss by denitrification is also reduced with spring application.

4.6.2 If some nitrogen is to be fall applied, delay application until the soil temperature is below 50° F at a six inch depth. The use of anhydrous ammonia is encouraged for fall applications.

Delaying application until soil temperatures reach 50° F will minimize nitrification; this will reduce, but not eliminate, the potential for nitrogen loss. Research conducted in this area also indicates that anhydrous ammonia is the most efficient nitrogen form for fall use.

4.6.3 Spring pre-plant applications of anhydrous ammonia or urea are encouraged. Broadcast urea should be incorporated within three days of application.

Refer to 4.5.2

4.6.4 Apply sidedress applications to corn prior to the V4 stage of development.

Refer to 4.5.3

4.6.5 Inject or incorporate sidedress applications of urea and UAN-28 to a minimal depth of four inches.

Refer to 4.5.4

4.6.6 Use a nitrification inhibitor with fall and pre-plant nitrogen applications if soils are poorly drained and soil moisture levels are high in the upper portion of the profile.

Refer to 4.5.5

4.6.7 Carefully manage nitrogen applications on soils characterized by a high leaching potential.

a) **Do not apply fertilizer nitrogen in the fall to coarse textured soils.**

Many soils in East Central and Central Minnesota are coarse textured and subsequently well drained. Fall application of nitrogen to coarse textured soils greatly increases the potential for leaching loss of nitrate.

b) **When soils have a high leaching potential, application of nitrogen in a sidedress or split application program is preferred. Use a nitrification inhibitor with early sidedressed nitrogen on labeled crops.**

4.7 Tier 2/(Regional Fertilizer Nitrogen BMPs): Southwest and West-Central Minnesota

The Southwest/West Central region of Minnesota is characterized by soils of medium-to-fine texture which were formed in glacial till. Many soils in the region have naturally poor to moderate internal drainage and are consequently tiled to improve drainage. Average annual precipitation is less than 26 inches. Cropping systems are dominated by corn, soybeans and small grains.

4.7.1 Use a soil nitrate test with a two to four foot depth to determine nitrogen needs. Soil samples should be taken in the fall, after the soil temperature is below 50° F at the six inch depth, or in early spring.

4.7.2 Spring pre-plant applications of anhydrous ammonia or urea are recommended. Anhydrous ammonia and urea can also be applied in the fall; UAN-28 should not be fall applied. Broadcast urea and pre-plant applications of UAN-28 should be incorporated within three days of application.

The southwest and west/central regions of Minnesota experience lower average annual precipitation than the rest of the state. Consequently, fall nitrogen applications have less potential to leach to groundwater than in other regions of the state. However, spring applications may result in higher nitrogen use efficiency than fall applications.

UAN-28 should not be fall applied due to the high nitrate concentration of the material and subsequent higher potential for loss.

4.7.3 In cases where fall nitrogen applications are used, delay application until the soil temperature is below 50° F at a six inch depth. (Reminder: Nitrogen should not be fall applied on coarse textured soils.)

4.7.4 Apply sidedress nitrogen to corn prior to the V4 stage of development.

Refer to 4.5.3

4.7.5 Inject or incorporate sidedress applications of urea and UAN-28 to a minimal depth of 4 inches.

Refer to 4.5.4

4.8 Tier 2/Regional BMPs: East-Central and Central Minnesota

The Central/East Central region of Minnesota is characterized by soils of coarse-to-medium texture. Most soils in the region were formed in glacial till. Outwash plains are common in this region. Many central/east central soils are moderately- to excessively-drained. Average annual precipitation in the region is greater than 25 inches. Cropping systems are dominated by corn and forages.

4.8.1 Carefully manage nitrogen applications on soils that have a high leaching potential.

Refer to 4.6.7

4.8.2 Spring pre-plant applications of anhydrous ammonia or urea are encouraged for fine and medium textured soils. Broadcast urea should be incorporated within three days of application.

Refer to 4.5.2

4.8.3 Inject or incorporate sidedress applications of urea and UAN-28 to a minimal depth of four inches.

Refer to 4.5.4

4.9 Tier 2/Regional BMPs: Northwest Minnesota

The northwest region is generally characterized by fine textured soils formed in lacustrine deposits. The annual average precipitation in the region is less than 24 inches. The major cropping systems in the region are small grain, soybeans and sugar beets.

4.9.1 **Use a soil nitrate test to a two or four foot depth to determine nitrogen needs. Soil samples should be taken in the fall after the soil temperature is below 50° F at the six inch depth or early spring.**

4.9.2 **Delay fall nitrogen application until the soil temperature is below 50° F at a six inch depth. Use of anhydrous ammonia or urea is encouraged for fall applications. UAN-28 should not be fall applied. Broadcast urea and spring pre-plant applications of UAN-28 should be incorporated within three days of application.**

4.9.3 **Nitrification inhibitors are not recommended on fine textured soils but are recommended on coarse-textured soils with high leaching potential.**

4.10 Tier 3/Special Situation BMPs: Irrigated Soils

Irrigation, especially on coarse textured (sandy) soils and shallow rooted crops, may increase the leaching potential of applied nitrogen. Irrigation increases the soil water content of the root zone, thus enhancing mass and diffusive transport of nitrate in the subsurface past the zone of effective crop utilization. The process of pumping water for irrigation also alters the hydraulic gradient in the area of the extraction well. This can also enhance mass transport of water and solutes within the aquifer or aquifers tapped by the extraction well.

Irrigated soils in Minnesota were typically formed in outwash plains or alluvium and are consequently of coarse texture. Localized areas of irrigation occur throughout the state and water use in these areas is variable depending upon soil and geologic conditions and average yearly precipitation. Commonly irrigated cropping systems include corn and potatoes.

4.10.1 **Do not apply fertilizer nitrogen in the fall.**

4.10.2 **Follow proven water management strategies to provide effective irrigation and minimize leaching.**

4.10.3 **Test irrigation water for nitrogen content and adjust nitrogen fertilizer rates accordingly.**

4.10.4 **Application of nitrogen in a sidedress or split application program is preferred on irrigated soils. Use a nitrification inhibitor with pre-plant or early sidedressed nitrogen on labeled crops. For corn, include a nitrification inhibitor with all nitrogen applications prior to the V4 growth stage. (Split applications utilizing fertilizer chemigation techniques require**

compliance with MDA regulations for spill and back flow prevention.)

4.10.5 Include a small amount of nitrogen in starter fertilizer in most situations (10-20 pounds/acre).

For most crops the optimum nitrogen uptake period occurs several weeks after planting. A small amount of nitrogen in the form of starter fertilizer can provide sufficient nitrogen for early plant growth.

4.10.6 Do not delay nitrogen applications past optimum uptake period.

Nitrogen applications applied after the target crop's active uptake period are unlikely to be used efficiently by the crop. Nitrate leaching loss is likely in this situation. Optimum uptake periods will vary with the crop and even with the variety.

4.10.7 Establish a cover crop following early harvest of crops.

When the length of the remaining growing season permits, a cover crop can scavenge residual nitrate, prevent the loss to groundwater and minimize wind erosion.

4.11 Tier 3/Special Situation BMPs: Coarse-Textured (non-irrigated) Soils

Coarse textured soils need special management to prevent leaching losses. Coarse-textured soils are present in many different regions and can be found throughout the state in outwash plains, alluvial river valleys and ancient beach ridges. These soils have considerable leaching loss potential due to rapid infiltration characteristics and low water holding capacities which can easily be exceeded. Furthermore, these soils are often associated with unconsolidated sand and gravel aquifers that may have water tables that are near the soil surface.

4.11.1 Do not apply nitrogen fertilizer in the fall to coarse textured soils.

Fall nitrogen application to coarse textured soils greatly increases the potential for nitrate leaching loss.

4.11.2 Apply nitrogen in a sidedress or split application program.

It has been demonstrated repeatedly that, in coarse-textured soils, sidedress or split applications are the most profitable methods of nitrogen application. These methods also reduce the opportunity for nitrogen loss due to leaching. "Insurance nitrogen" applications result in poor economic return and greatly increased risk to the groundwater.

4.11.3 Use a nitrification inhibitor with early sidedressed nitrogen.

Nitrification inhibitors limit leaching losses under these soil conditions by keeping the nitrogen in the ammonium form for extended periods of time. The nitrogen is thus available for the crop either in the ammonium form or the nitrate form at the time of crop need. Nitrification inhibitors should be used on all applications to corn prior to the V4 stage and on other crops indicated on the inhibitor label.

4.12 Tier 3/Special Situation BMPs: Turf

As a source of nitrates to groundwater, the lawn care industry has historically received less attention than the agricultural community. This is due, in part, to the reliance of rural populations on groundwater as a source of drinking water. However, fertilizer application rates to turf may be comparable to agronomic crops and urban fertilizer use is quite widespread. The resulting intensity of nitrogen application warrants the development and prescription of BMPs specifically for lawn care.

Turf management presents its own unique nitrogen fertilizer concerns. The following BMPs are applicable to a variety of turf situations, including private lawns, commercial properties and most golf course turf.

4.12.1 Avoid off-target applications.

Off-target applications of nitrogen fertilizer may be avoided by using appropriate equipment. This includes spreaders with side deflectors, and sprayers and guns which provide a greater degree of placement control.

4.12.2 With fall nitrogen applications, spring nitrogen applications can be reduced or discontinued. Light applications of nitrogen may be applied in mid-summer to high-use areas.

The optimal time of year for lawn fertilization is late summer/early fall. This is contrary to optimal spring timing for annual, agronomic crops. Turf is a perennial crop. In the fall, top growth is minimal but soil temperatures are still warm enough for nitrogen absorption, which stimulates root growth and carbohydrate accumulation. Spring applications cause excessive shoot growth, resulting in a deceptively green spring lawn but a depletion of carbohydrate reserves. Consequently, during the summer stress periods (mid June through early August), plants are weaker and more susceptible to disease and drought. Fall applications are most likely to be fully taken up by the plant and thus less likely to leach below the root zone.

4.12.3 **Utilize a soil test to determine organic matter content which can be used to aid in determination of nitrogen needs; use the results of this test to adjust applications to the individual lawn.**

Task force testimony indicated that soil tests are not currently performed with any regularity. When tests are used, the available application programs allow for rate adjustments to different sites.

4.12.4 **Leave grass clippings on mowed lawns and account for residue nitrogen content in determining nitrogen load rates for subsequent applications.**

By accounting for lawn clippings in fertilizer credits, at least one fertilizer application can be eliminated each year.

4.12.5 **Use a slow release fertilizer formulation when possible.**

Slow release formulations are more likely to provide nitrogen to the turf during its peak period of need and less likely to result in nitrogen being leached below the root zone where it becomes unavailable to the turf roots. Few slow release fertilizer formulations are currently available to the homeowner, and the average homeowner has not been educated to evaluate and select the most appropriate lawn fertilizers.

4.12.6 **Account for soil type in determining appropriate nitrogen application rate and frequency.**

Soil type is not currently considered in determining application rate by the lawn care industry. Sandy soils should be treated with split applications at one half the usual rate.

4.12.7 **Select (homeowners) and promote the selection of (lawn care industry) low-maintenance turf varieties which require fewer fertilizer applications and less watering.**

High maintenance turf varieties require three to four pounds of nitrogen per 1,000 ft^2 (120-174 lbs/acre) per year while low maintenance varieties require 1 to 2 pounds of nitrogen per 1000 ft^2 per year. Furthermore, the MES recommends that all fertilizer be applied in the fall for low maintenance varieties while high maintenance varieties generally require at least one spring/early summer application.

4.12.8 Do not apply insurance nitrogen to turf. Apply only the amount of nitrogen necessary to maintain plant nutrition.

4.13 BMPs For Areas Near Surface Water Bodies

Nitrogen from fertilizer as well as from other sources can have a direct impact on water quality of rivers and lakes. Nitrogen can move either through direct runoff, by means of erosion, via tile line drainage, subsurface flow, and shallow groundwater flow. Surface water is used for a public drinking water in a number of communities in Minnesota. The BMPs for the remaining sections will also protect surface water in areas where subsurface flow enters the surface water.

BMPs for areas near surface water primarily control erosion and runoff from agricultural fields to streams and lakes. These BMPs focus on control of areas in the vicinity of the surface water bodies.

4.13.1 Filter strips should be developed and maintained between open bodies of water and agricultural fields.

Filter strips are effective at minimizing erosion and movement of soil, and sorbed and soluble nitrogen compounds into surface water.

4.13.2 Establish tillage and erosion control techniques, such as conservation tillage systems and terraces, where erosion contributes to surface water contamination.

Research indicates that nitrate load to surface water can be increased significantly due to erosion, especially in the spring. Techniques developed and used by the SCS and the SWCD to control erosion should be incorporated into management practices near open water.

4.13.3 For lawns located adjacent to surface water bodies, construct a berm (roughly six inches high) between the lawn and water body. The berm may also be covered in grass or turf. In addition to berms, an unmanaged fringe of natural vegetation may be utilized as a filter strip.

The berm serves to minimize runoff from the lawn to the surface water body. It also encourages infiltration at the lawn's edge.

4.13.4 For all urban turf, avoid stray application of any fertilizer to sidewalks, streets or directly into water bodies that abut lawn areas.

Any fertilizer applied in these situations will end up in surface water bodies through direct runoff or through storm sewer collection and discharge.

4.14 Future BMP Development and Research needs

Research is continually providing new information and technology applicable to nitrogen management. Research needs to be supported in order to address the needs identified throughout this report. Procedures and policies must be developed to incorporate these new findings into the existing body of accepted BMPs. One possible mechanism for achieving this would be a technical advisory group to the MDA. This group would be responsible for the review of ongoing BMP development and would formulate recommendations to the MDA regarding the technical aspects of BMP development.

In the review and development of the BMP recommendations, the task force identified aspects of nitrogen management that required additional research. This research is necessary to further refine BMPs and enable the nitrogen users to more precisely apply the optimum environmental and agronomic nitrogen practices. Funds should be directed to total nitrogen management research for basic and field research especially that which incorporates water quality concerns. The following is a list of some of the needs identified by the task force. This list is not meant to be inclusive, but rather serves only to highlight some immediate needs.

(1) Nitrogen interactions and credits from non-fertilizer sources such as organic matter, legumes and manure need to be more thoroughly understood. Attention should be directed to initial and subsequent release of nitrogen and the impact on water quality.

(2) Soil testing correlation and research into techniques useful in humid conditions needs to be accelerated. Efforts to develop a "quick test" that meets Minnesota needs and conditions should be supported.

(3) Manure management research needs to be increased and accelerated due to the lack of research available and the potential major impact that manure management has on ground and surface water quality.

APPENDIX

MEETING TESTIMONY

NITROGEN FERTILIZER TASK FORCE

Testimony

Ten meetings of the Nitrogen Fertilizer Task Force were held during the spring of 1990. At eight of the meeting, members of the task force listened to and discussed presentations about nitrogen fertilizer and the environment. The presentations covered a variety of topics and subject areas from the perspectives of the University of Minnesota, federal and other state's efforts, state agencies, farm, urban, the fertilizer industry and sustainable agriculture.

February 9, 1990

Testimony at the introductory meeting of the task force focused on existing regulatory efforts by the Minnesota Department of Agriculture (MDA). Thirteen members and staff of the task force were present at the meeting held at the MDA.

TASK FORCE WELCOMED

Pat Jensen, at the time Deputy Commissioner of the MDA, currently Executive Director of the Legislative Water Commission (LWC).

Jensen welcomed the task force and noted the difficulty of dealing with the nitrogen issue. She commented, "That's quite a challenge for all of you. I'm pretty confident that if any group can do it, this group's going to be able to do it. I know that you'll have to work hard, but from what I've seen of the background of the folks sitting around this table ... it's probably going to be as good a product as you can find."

Jensen appointed Greg Buzicky as Chair of the task force and Dr. Gyles Randall as Vice-Chair. In appointing Randall, Jensen stressed the need to have the University of Minnesota involved in the task force, "there was an intense desire of the legislature to make sure that there was a recognition of what the Experiment Stations have done relative to nitrogen (N) and the feeling that it had to be incorporated in a very significant way to what was going on because of the background and the work that's gone on."

CHEMIGATION REQUIREMENTS

John Peckham, Facilities Unit Supervisor, MDA.

Peckham discussed regulation for chemigation (Defined in Minn. Statute 1989 Chapter 326, Ch. 18C.005, Subd. 4). There are about twenty permits for applying pesticides through irrigation (mainly greenhouses). Peckham stated, "Although we are in the process of putting together a regulation for fertilizer chemigation ... we understand from Jerry Wright, with the University of Minnesota, that there may be as many as 3,000 sites in Minnesota that have, or will, or want to have capabilities of applying fertilizers through irrigation systems."

FERTILIZER QUALITY CONTROL

Gregg Regimbal, Fertilizer Control Unit Supervisor, MDA.

Regimbal discussed types of fertilizer licenses; the agricultural fertilizer license, which has been in place for some time, and the lawn service fertilizer license, which is new, coming into effect on July 1, 1989. The have been approximately 600 lawn service licenses so far this year and approximately 1,000 agricultural fertilizer licenses.

Regimbal discussed inspections of fertilizer dealers and quality control efforts, "Everyone who has a fertilizer license is required to submit semi-annual percentage reports and report inspection fees based on those percentages ..." In addition, there are product labeling requirements, registration of products and anhydrous ammonia permitting.

FERTILIZER COMPLIANCE AND ENFORCEMENT

Paul Liemandt, Compliance and Enforcement Section Chief, MDA.

Liemandt presented a legislative and regulatory history on pesticides and fertilizers. Prior to 1989 with fertilizers, the MDA only had criminal authority to deal with fertilizer regulations, this was changed. In discussing changes in the law, Liemandt mentioned, "Under this (current) enforcement authority...there are three types of authority; one is administrative, one is civil, and one is criminal."

Liemandt also described the differences in the regulatory approach between pesticides and fertilizers, "As far as enforcement goes, if someone calls and makes a complaint about somebody using a fertilizer versus someone using a pesticide, with the pesticides we have the ability to look at the label ... but with fertilizer that is meaningless because there are no use directions that have legal impact."

FERTILIZER INCIDENT RESPONSE

Roger Mackedanz, Agricultural Chemical Consultant, Incident Response, MDA.

Mackedanz described how the MDA is the lead state agency for incident response with pesticide and fertilizer. There are staff on-call for 24 hours a day, seven days a week for the recording of these incidents, dealing with advising and cleanup. A pesticide or fertilizer incident must, by law, be reported to the MDA.

Mackedanz presented a series of graphs showing the number and type of agricultural chemical incidents in fiscal year 1988 and 1989.

February 23, 1990

Testimony at the second meeting of the task force included a review of nitrate (NO_3) in groundwater and nitrogen fertilizer impacts on groundwater. Twenty members, staff and interested parties of the task force were present at the meeting held at the University of Minnesota - St. Paul.

NITRATE MONITORING RESULTS

David B. Wall, Hydrologist, Water Quality Division, MPCA.

Wall described a number of studies in presenting MPCA groundwater information. Sampling data was presented from the Ambient Groundwater Monitoring program for the surficial sand aquifers, buried sands aquifers, Cretaceous aquifer, Cedar Valley-Maquoketa-Dubuque-Galena aquifer, St. Peter aquifer, Prairie du Chien-Jordan aquifer, Franconia-Ironton-Galesville aquifer, Mt. Simon-Hinckley aquifer and Precambrian aquifers.

Primary aquifers of concern were the surficial sands (15% > 10 ppm NO_3-N), Cedar Valley-Maquoketa-Dubuque-Galena (10% > 10 ppm NO_3-N), and the Prairie du Chien-Jordan (10% > 10 ppm NO_3-N). Several wells in the buried drift aquifers were also contaminated with nitrate.

Wall also presented information from the Garvin Brook Project in southeastern Minnesota, referencing a December 1989 MPCA report, "Of 160 wells analyzed in the 46,000 acre study area, over 36 percent exceeded the NO_3 drinking water standard ... Leaching under cultivated fields appeared to be the major contributor of groundwater NO_3 contamination in the area."

Wall discussed three additional MPCA studies on factors influencing nonpoint source pollution of glacial drift aquifers in central and west-central Minnesota. In al three studies, agricultural fields were found to contribute significantly to groundwater nitrate contamination. Hydrogeologic controls greatly affected nitrate concentrations in the various study wells.

NITROGEN FERTILIZER STUDIES

Dr. Michael Schmitt, Extension Soil Specialist, U of M.

Schmitt presented information about the nitrogen (N) cycle and public perception; identifying various sources of N and the nitrification process. Nitrapyrin was described as a way to stop the nitrification process. Immobilization and denitrification were also described. In regard to types of fertilizers, Schmitt stated, "Anhydrous ammonia is the number one fertilizer sold in Minnesota."

Schmitt described N movement to groundwater as depending on the depth to the aquifer, soil properties and the volume of drainage water. Schmitt continued with a discussion of tile line studies from Waseca and Lamberton which began in the early 1970s. The conclusions of these studies were:

1. NO_3 is dependent on the amount of fertilizer N applied and rainfall.

2. Higher than recommended N rates result in soil NO_3 levels higher than those that naturally occur in soil.

3. NO_3 concentrations exceeding 10 ppm are commonly found in water from tile lines.

4. Measurements of NO_3 in soil water are not the same as concentrations in groundwater.

Manure studies from Olmsted county were discussed. Schmitt was asked what N is available in manure. He replied, "Part is ammonium and is immobile, part is organic N; still in protein and plant matter and is still unavailable." The focus on manure has been on disposal, rather than fertilization

Dr. Carl Rosen, Extension Soil Specialist, U of M.

Rosen described a nitrogen study (conducted in Sherburne county on potato, sweet corn and field corn) designed to follow N movement and to use the data to improve upon N management. There has been a reduction in N use by potato farmers in area as a result of the study. Rosen described residual effects from manure applications which occurred 30 years ago. When asked about crop management practices, Rosen replied, "When growers consistently are getting a poor yield, you need to look at realistic yield goals."

March 9, 1990

Testimony at the third meeting of the task force consisted of a review of groundwater, NO_3 in groundwater, groundwater sensitivity criteria and the health impacts of NO_3. Nineteen members, staff and interested parties of the task force at the MDA.

NITRATE STUDIES

Tomas Klaseus, Minnesota Department of Health (MDH).

The MDH began routine monitoring for NO_3 in 1947 because of infant health concerns and as an "indicator" of contamination. There is not a clear cut relationship between NO_3 and pesticide detections. In the MDH/MDA study, only 82 of 187 wells had pesticide detections when NO_3 was present, and 32 wells were found to have pesticides, when NO_3 was not present. However, with an increase in NO_3 levels were more likely to be detected.

When asked if there was any correlation between depth and NO_3 detections, Klaseus replied, "Yes. The shallower the depth of the well, the more likely the detections. In the southwestern part of the state, where there more detections and higher levels of NO_3, there are a lot of augured wells. Older augured wells frequently do not have water-tight joints and are ungrouted.

In describing monitoring data, Klaseus stressed, that "the data is well specific. Results will vary according to well construction, location, maintenance, vulnerability, practices and climate." In sampling, the MDH was primarily concerned about health effects, therefore, they were interested in looking at aquifers and well construction.

GROUNDWATER STUDIES

Bruce Olson, Special Services Unit, Water Supply and Well Management, MDH

Olson began with a general discussion of groundwater and groundwater characteristics. He described how a lot of recharge areas are local. This means that what people do on their own land can affect their groundwater quality. The recharge area can often be within the same county as the farm.

He reasoned that the task force BMPs could be utilized in the MDH wellhead protection program. He followed with a description of the wellhead protection program, referencing a handout, "A wellhead protection area is defined using geologic and hydrologic criteria; such as ...".

GROUNDWATER SENSITIVITY

Jan Falteisek, Project Coordinator for the LCMR Sensitivity Project, Waters Division, Minnesota Department of Natural Resources (MDNR).

Falteisek presented an overview of the results of the geologic sensitivity project work group and the development of the empirical geologic sensitivity model for application statewide in Minnesota. The model is multi-level, and the intent is to have a flexible model so the assessment level needed can be used to fulfill a particular need. If you don't need to spend a lot of money to do an assessment, you don't have to you can do a lower level. Falteisek also presented the results of the LCMR work group to date.

Falteisek also described sensitivity criteria; a level one assessment evaluates soil, whereas a level two modifies a level one in areas where the water table is very close to the surface. A level three assessment considers the materials above the water table. Level four evaluates the deeper aquifers below a confining layer.

Explained how the rating scales are set up and showed a couple of maps of the resulting sensitivity assessments.

NITRATE HEALTH CONCERNS

Debra Petersen, MDH.

The primary health concern with NO_3 is methemoglobinemia or "Blue baby syndrome". Based on clinical studies of infants, the health advisory levels (HALs) are 10 ppm NO_3-N and 45 ppm NO_3. Methemoglobinemia can be treated through the use of methylene blue I.V. which reverses the conversion of NO_3 to nitrite (NO_2). In addition, if NO_3-N intake is discontinued, the system will reverse. As for treatment of water, NO_3 can not be removed by boiling; the MDH recommends that alternate drinking water sources be found. Petersen also noted that carcinogenicity is another concern, NO_3 may be combine with pesticides to form carcinogens.

March 23, 1990

Testimony at the fourth regular meeting of the task force focused on nitrogen best management practices (BMPs) from the University of Minnesota and fertilizer industry perspective. Seventeen members, staff and interested parties of the task force were present at the Sunwood Inn in St. Cloud.

BEST MANAGEMENT PRACTICES

Dr. Gyles Randall, South Central Agricultural Experiment Station, (Waseca), U of M.

Best Management Practices (BMPs) concepts from the U of M were introduced. Randall described climate and soil as major factors influencing N management decisions. These vary to a great degree across Minnesota. Precipitation is a major consideration because it influences the suitability of a soil NO_3 test because it varies for particular areas (the soil NO_3 test can be used when the rainfall level is 25 inches or less). In addition, yield goals are dependent on moisture and growing degree days.

Soil properties also have a great influence on BMPs; a specific BMP cannot be developed for each little situation, however, they can be grouped based on similar properties. Statewide BMPs are difficult to develop because of rainfall and soil differences, thus there is a need to look at regional BMPs. Randall commented, "It is difficult to address single farm specifics on a statewide level." Restriction and regulations would require more defined areas, a regional approach is for voluntary measures.

Dr. Michael Schmitt, Extension Soils Specialist, U of M.

Schmitt presented BMPs on a statewide and regional basis. The number one BMP for the state was to determine a realistic and appropriate yield goal. The U of M approach is to use a five (5) year average and add 10 to 15% to achieve the top yield 90% of the time. Second year alfalfa and manure N credits should be considered. Extra N should not be applied for risk insurance. Prudent manure management should be used. N should be applied to insure availability during the optimum uptake period of the plant.

Regional BMPs were described for southeastern, south central, southwest/west central, east-central/central, and northwestern regions of the state, as well as the central sands.

Thomas D. Larson, Director, Agronomy Services, Cenex / Land 'O Lakes (C/LOL).

Larson described the challenge of production agriculture to balance environmental issues, economic issues and global food needs. Larson stated, "Successful dealers will market knowledge in addition to agronomic products. Farmers rely on dealers for 80% of their information." The retail agronomic system is based upon three increments of professionalism; human expertise, information gathering and information delivery. Larson also indicated that the marketing strategies of the fertilizer industry are driven by agronomic facts.

John Alrichs, Agri Source Computer System, C/LOL.

The objective of this computer system is to provide expertise to the dealers. It has many programs for the various needs of crop production with one section specifically designed for maintaining field information (such as soil test information and fertilizer recommendations). Alrichs commented, "A major benefit of a system such as agri source is looking back at records which provide an impetus for change an adoption of new practices." Currently 80 dealers in Minnesota use the system with 10 to 50 customers each.

April 6, 1990

Testimony at the fifth regular meeting of the task force included presentations about Nebraska's approach to nitrogen fertilizer, sustainable agriculture and BMPs, and the land stewardship perspective. Seventeen members, staff and interested parties of the task force were present at the meeting at the Friedell Building in Rochester.

NEBRASKA GROUNDWATER PROTECTION

Dick Ehrman, Geologist, Water Quality Division, Nebraska Department of Environmental Control (NDEC).

In 1986 the Nebraska Legislature passed L.B. 894 establishing the Special Protection Areas (SPAs) to control nonpoint source groundwater contamination. Potential problem areas highlighted are where contamination is occurring or is likely to occur and when there is documentation of contamination. The priority of potential problem areas is based upon limited funding and must rank potential users (population in the area).

Nebraska Study Objectives:

1. Existence of Nonpoint Source (NPS) contamination.
2. Source of NPS pollution.
3. Contaminant concentration.
4. Areal extent of concentration.

In Nebraska there are 23 Natural Resource Districts (NRD) which are based on drainage and are funded by an additional tax on property. These are the preferred entity for implementation.

Components of a Nebraska Action Plan:

1. Education (mandatory)

   - makes the public aware that there is a problem
   - makes the public aware of solutions, it can not be targeted only at the farmers.

2. BMPs (option to require)

   - soil and water testing
   - fertilizer (pesticide also) application scheduling
   - irrigation scheduling and/or metering
   - use of nitrification inhibitors
   - integrated pest management (IPM)

3. Monitoring

   - assesses effectiveness
   - sample and monitoring quality of groundwater
   - evaluate effectiveness of action plan

4. Other necessary options.

The SPAs have been a success. They have been accepted by the NRD, the NRDs like funding from the state. Ehrman added, "The local participation has been fantastic." Funding has been a problem; preventing innovative technology because of the costs. The first action plan is still in development and boundary setting has become the most controversial.

Another approach in Nebraska is the groundwater quality management area (GMA). The GMA is analogous to the SPA, but different. In a GMA, all the work is done by the NRD with no involvement by the state (all of the central Platte River region is a GMA).

SUSTAINABLE AGRICULTURE PROGRAMS

Rick Gauger, Program Director, Energy and Sustainable Agriculture Program, MDA.

Gauger discussed some considerations for N management in sustainable systems. Referencing a MDA Sustainable Agriculture Program handout, he noted, the basic aim of sustainable soil management is to enhance the soil's ability to supply nutrients for plant growth, and to provide hospitable conditions for the life within the soil.

Some factors to consider for effective N management include crop rotation (3 or more crops), crop to be grown (reduce corn acreage), yield goals (set realistic yield goals), soil testing (test yearly prior to fertilization), take credits (existing NO_3, legumes, manure), pre-plant tillage (tillage for optimum soil structure), adjust planting date (slightly later than normal), split N applications (sidedress), and soil management (optimize soil structure or tilth).

LAND STEWARDSHIP PROJECT PROGRAMS

Richard Ness, On-Farm Practices Coordinator, S.E. Minnesota, Land Stewardship Project (LSP).

Ness described the formation and evolution of the LSP. Although originally formed to look at soil erosion, the LSP began getting involved in groundwater and profitability issues. On farm research and demonstration projects began in 1988 with volunteer farmers who wanted to evaluate the need for additional N applications after alfalfa for corn.

The Iowa State University (ISU) soil test kit has been used in LSP research projects beginning in 1988. The objective was not to promote one technology, but to engage the farmer about economic and environmental considerations. Ness also commented that manure should be looked at as a resource, rather than a waste.

Ness added, "Part of our mission is to influence the community and to change the parameters of success. Farmers are very excited, they are changing their discussion down at the coffee shop. They are looking at the definition of success differently."

April 20, 1990

Testimony at the sixth regular meeting of the task force included presentations by the Soil Conservation Service, Iowa's approach to nitrogen fertilizer, and the federal perspective. Twenty-two (22) members, staff and interested parties of the task force were present at the MDA.

SOIL CONSERVATION SERVICE PROGRAMS

Timothy A. Koehler, Water Quality Specialist, U.S. Department of Agriculture (USDA), Soil Conservation Service (SCS).

For over fifty (50) years the SCS has worked with private landowners, traditionally with technical assistance. When asked about regulation, Koehler replied, "The SCS suggests alternatives to landowners. They have no regulatory power to require. However, they may assist programs that have a regulatory focus."

The three main areas in which the SCS works are technical assistance, information and education, and resource/research/development. In technical assistance the core of the resource is the field office technical guide (Nutrient Management Specifications). In research and development, the SCS is involved with the Anoka Sand Plains Demonstration Project (ASPDP) and the Nonpoint Source Hydrologic Unit Project.

A third effort are cost share components, it could pay up to 20 farmers in each county to affect costs; such as soil tests and panting green manure. The cost share is $7.00 per acre for row crops and $14.00 per acre for truck crops. Koehler commented on the cost share, "The farmer feels, if we get the cost share...great, but if we don't get it we will still do the effort because we want to be involved. We need to harness those doing a good job."

Dave Breitbach, USDA, SCS.

Breitbach described SCS as meeting one on one with people, identifying problems and providing alternatives. The SCS does not do research on crop recommendations and relies on the university for that information. Traditionally, the SCS has used standards and specifications in nutrient management. Now the SCS is targeting vulnerable and sensitive areas and are targeting procedures and dollars to the area. Breitbach asked, "Some questions we have are ... how can we develop a nutrient management plan? How do we know the plan is followed? rate? time? placement? We don't have enough research." Breitbach concluded, "We would like to work together, we need a team effort."

IOWA NITROGEN FERTILIZER PROGRAMS

Dr. Randy Killorn, Extension Agronomist and Associate Professor of Soil Fertility, ISU Cooperative Extension Service.

Killorn began by stating that he doesn't like the term BMPs, "The term is goal specific; it may be interpreted differently by different people. BMPs are management options applied on a field by field basis. Don't use the term BMP, call it common sense agriculture."

ISU started working on the nitrogen problem in 1984, noting there is a need to start with a realistic yield goal and to take manure and legume credits into account. The recommendations prefer to avoid fall applications, but do understand the need to apply in some cases. Killorn added, "The bottom line is that extension is not enough. We need to work with the dealer, he sees more farmers in a week than I will in ten years. Need a dealer training school, there is talk of certified crop consultants or ag chem dealers. Also need to go into the field to demonstrate things to farmers."

Iowa started demonstration projects in 1987 to go into every county. Currently, the program has been in 90 out of 99 counties. The demonstration projects are for one year, but are replicated, and data is collected.

Iowa includes N management in it's private applicator training (PAT) program. Farmers who apply restricted use pesticides (RUP) must be certified in the PAT program to purchase the RUP (about 10% of the questions on the certification test deal with N management). N management has also been included in dealer training, but they currently do not get a continuing education unit (CEU) credit for it.

A livestock waste project is also being developed in Iowa to encourage the farmer to broaden the area to which manure is applied. Because of transportation issues, ISU is developing clusters of farmers and forming a network to reduce the hauling distance. Recommendations are based on P and applications are made to fields needing P and K first, then to the grower's field at a maintenance rate. More research is needed on manure equipment and calibration.

FEDERAL PERSPECTIVE ON NITROGEN FERTILIZER

Dr. Roland D. Hauck, National Fertilizer & Environmental Research Center, Tennessee Valley Authority (TVA).

Hauck provided a review of national water quality legislation since 1972. Hauck stressed the importance in needing a balance in meeting the growing world food needs and environmental stress, noting, "Zero stress is not possible, but a reasonable compromise is."

In discussing N response curves, Hauck described that the amount of added N needed to produce a bushel of grain can vary drastically from year to year. Profits decrease faster when fertilizing over optimum N rate than they do when under fertilizing. Hauck categorically stated, "Insurance N is a practice that should not be permitted," and suggested that insurance N practices can be addressed legislatively.

Hauck explained that insurance N is factored into applied N rates in three manners; unrealistically high yield goals, N rates are adjusted above what is needed on average to insure the highest possible yield every year, and factors for N needs per bushel are inflated.

Hauck promoted the idea of maximum acceptable yields, which would be a compromise between maximum profit and minimize environmental risk. Nitrification inhibitors are recommended in BMP plans in many states. Hauck called for additional research to more accurately predict N credits from legumes and in manure management. Record keeping of yields and N use could be required as a good management tool.

<u>**May 25, 1990**</u>

<u>NITRATE IN SURFACE WATER</u>

Gary Fandrei, MPCA

Fandrei described surface water sampling results with 10,739 observations collected (mostly since 1975). He discussed "least impacted streams" and EPA ecoregions, noting that the boundaries and boundary width of the ecoregions needs more definition.

The general direction of nitrate/nitrite detections over the last twelve years has been an increase in all regions, except the North Central Hardwood Forest Region. Fandrei also commented on studies in Illinois on buffer strips showing reduction in nitrate introduced to surface water. Fandrei noted that historically, most surface water concerns about nutrients have involved phosphorus, but there needs to be further study on nitrates. He stressed interconnections between surface water and groundwater.

Mike Meyer, Environmental Scientist, Quality Control, Metropolitan Waste Control Commission (MWCC).

Meyer discussed MWCC plants on the Minnesota River and the nonpoint source control projects that are underway. Meyer described how nitrate is far less toxic to aquatic life than ammonia. The MWCC plants are designed to convert ammonia to nitrate which is released into the river. Another concern is the dissolved oxygen content of the water which is influenced by the amount of organic matter present.

A nonpoint source control program (Minnesota River Assessment Project, MRAP) is designed to achieve a 40% reduction into the Minnesota River by 1996 ... he would like to see the MDA become involved in this project.

Meyer presented data on nitrates in surface water and described how nitrate concentration increase after the main water flow has passed, speculating tile lines as a source. He discussed 1990 preliminary sampling results of nitrate detections during spring runoff. Meyer discussed vegetative filter strips as being effective for sediment and organic nitrogen, but not as effective for nitrate and ammonia.

LAWN CARE FERTILIZER PRACTICES

Doug Madsen, President, Minnesota Professional Lawn Care Association.

Madsen described how fertilizer is applied by professional lawn care associations in Minnesota, noting better equipment for application and better personnel doing the applications. He discussed how some cities are licensing applicators, and regulating application timing or types of fertilizer.

He also described the use of slow release fertilizer and predicted their use will increase if their cost decreases. Madsen urged more education of the homeowner and more research on fertilizers in lawn care. He admitted though the university may suggest fall applications for turf, there is a real world where lawn care service demand has applications during the spring and summer.

He discussed changes in turf which require more applications and noted that if lawn clippings are kept on the lawn, at least one application could be eliminated. Soil testing may be utilized, but a generic mix is generally applied. Organic fertilizers are of interest now, but require a higher rate to get the same effect and are difficult to handle because of volume.

TURF MANAGEMENT AND GOLF COURSE FERTILIZER PRACTICES

Dr. Don White, Horticulture Department, University of Minnesota.

White described turf needs and growth factors, noting the best weed control is properly applied nutrients. He discussed how optimally fertilized turf is more disease resistant and recovers more rapidly from disease. Dense turf also provides good erosion control.

He observed that grass is a perennial crop and described its growth cycle. He noted most golf course superintendents are drastically reducing spring and summer applications and are applying more in the fall, because this is the time the plant can use the nutrients very productively.

In describing natural organics, he noted that they have some neat things about them, but they need to be developed before they can be used to a great advantage. Nitrogen is only released when the natural organic is decomposed. He also discussed slow release fertilizers which are being used by most golf courses.

He also pointed out that only about three to four percent of a Golf Course is in greens which receive the most attention while the fairways and roughs make up over ninety percent of the area.

June 20, 1990

DNR IRRIGATION PERMITS AND GROUNDWATER MONITORING

Jim Japs, Division of Waters, MDNR

Japs described the irrigation permitting system of the DNR and the responsibilities of the division of waters. He discussed the increased concern and comment from well owners regarding water quality and quantity near agricultural irrigation wells. He indicated that because of these increased complaints that the MDNR had decided to issues some conditional permits so that the permittee would be required to construct monitoring wells and conduct nitrate monitoring. This was being done under rules promulgated some years ago and was being done on a limited basis.

APPENDIX

PUBLIC TESTIMONY

NITROGEN FERTILIZER TASK FORCE REPORT

Testimony - Public Meetings

March 22, 1990 - Sunwood Inn, St. Cloud

Approximately forty-five (45) people attended a public hearing of the task force in St. Cloud. The meeting was publicized by press releases through the MDA and U of M Extension Service. Twelve task force member s were presented among those attending. Twelve members of the audience provided testimony to the task force.

Lynn Dokkebakken, General Manager, Farmers Union Oil Co-op, Willmar.

Dokkebakken said, "I have been working in this area for the last thirty years and have learned that practices must be profitable as well as environmentally sound." He stressed information and education as the keys to success, not regulation. He supported including nitrogen information in the certified applicator test (PAT), keeping good records, having an achievable yield goal and an efficient nitrogen program.

Cyril Scherer, President, Stearns County Farm Bureau, Freeport.

Scherer supported Low Input Sustainable Agriculture (LISA), as long as soil nutrient levels can be maintained. He also supported BMPs, requested more monitoring (water) be done and more accurate data about manure.

Gary Martens, Farm Bureau, Mora.

Martens expressed a concern for maintaining safe groundwater. Adequate consideration should be given to responsible practices.. Adequate research is needed to be followed up with an education program. He stressed research as the key and a need for demonstration projects, "We need to find a safe, economical and practical way to solve the problem."

Glen Moe, Agronomy Manager, Cenex/Land 'O Lakes, Montivideo.

Moe uses a soil nitrate test and maintains records for five years covering 18,000 acres plus 3-4,000 acres through contract sampling. In planning, they discuss yield goals, look at the cropping history and have manure samples analyzed (to make sure it is being credited). Fertilizer is sidedressed and an nitrogen stabilizer is used on lighter, water-logged soil. When asked how yield goals are set, Moe replied, "They sign up, work with the county agent and look at the average crop. Different managers shoot for higher yields. We go off from a five year average."

Norman Krause, Minnesota Irrigators Association, Staples.

Krause endorsed the use of fertigation as a tool, supported optimum BMPs and called for continued research on utilization and leaching, septic systems and lawn care. Krause described changes in nitrogen management as being according to price, application through fertigation is being done less and less, unless needed, "We still want the option to use fertigation." Krause knew of no fall applications.

Jim Freilinger, Ag Products Manager, Paynesville.

Freilinger described dealership as providing services of soil testing, manure testing and a full time agronomist. The soil test is based on organic matter and some nitrogen soil testing is done at 0 to 6" and 6 to 24" depths. Soil recommendations are kept on file by field for the farmer. Nitrogen stabilizers are also used and a free water well testing program is provided.

Paul Groneberg, Central Crop Consulting, Morris.

Three components for determining nitrogen fertilizer use are a NO_3 test for western Minnesota, yield goal and past crop. To fine-tune the recommendation, plant analysis is also used to get closer to what the crop really needs. Ten years of soil test records are maintained for the farmers.

Groneberg called for more promotion of the soil testing concept and for a more reliable way to monitor nitrogen in eastern Minnesota and in sandy soils for irrigation systems. He also called for a more reliable way to set yield goals, focusing on soil type rather than the field. Yield goals are currently set by looking at the history and the field.

William Cofell, citizen member Board of Soil and Water Resources (BWSR) and MPCA Feedlot Advisory Task Force, St. Joseph.

Cofell stated, "In central Minnesota, we need to be concerned about all areas of fertilizer application." He called for continued on-farm research, the necessity of demonstration projects, and for the need for education teams (with farmers on the team) at the local level.

Bruce Brummitt, citizen, Osage.

Brummitt objected to a lot of the testimony as being industry oriented. He lives near the Shell River where there is a lot of irrigation on potatoes. He described how a lot of wells have been condemned. He called for a mandatory, not a voluntary approach, looking at depth, rate and time of application. He stated, "We are sitting on a time bomb".

Boyd Sharp, citizen, Osage.

Sharp discussed the potato farming under irrigation by R.D. Offutt and presented fertilizer application records. He asked, "How could you drink the water?" He referenced concentrations of 30 to 60 ppm NO_3 in the water and a well being condemned in Hubbard county. He noted an irrigation well is 300 feet from his house.

Ewald Peterson, citizen, specialty crop farmer and irrigator, Big Lake.

Peterson is a specialty crop farmer who raises 35 different species of plants; fruits vegetables, and flowers. He explained that every crop requires a different level of nitrogen. He called for more research, "What are the potential reasons for finding nitrogen in the wells?"

D'Wayne DeZiel, Soil and Water Conservation Districts, St. Cloud.

DeZiel supported education, but worried that 70% of the people don't like to participate and 70% don't like to go to class. He expressed concern about nitrogen use on lawns at high rates and septic systems.

Bill Kiffmayer, farmer, irrigator, Clear Lake.

Kiffmayer called for additional water monitoring and said that the NO_3 soil test has to be pursued further. He explained there is a need to understand the difference between rates of fertilizer and the rates of nitrogen in the fertilizer.

Alan Peterson, Irrigators Association, Clear Lake.

Peterson uses three different forms of nitrogen fertilizer; dry urea, anhydrous and 28%, but will not be using 28% in the future because of the check vale requirements in chemigation. Nitrification inhibitors are used with all anhydrous applications. He does not apply nitrogen fertilizer in the fall and knows no one who does.

Additional discussion.

Requiring classes to apply nitrogen was supported by comments from the audience. Education was supported, noting a need to be new and innovative.

<u>April 5, 1990 - Olmsted County Courthouse, Rochester</u>

A total of fifty-three (53) people attended a public hearing of the task force in Rochester. The meeting was publicized by press releases through the MDA and U of M Extension Service. Seventeen task force members were present among those attending. Thirteen members of the audience provided testimony to the task force.

Dave Serfling, President, Fillmore County Farm Bureau, Land Stewardship Project Cooperator, Preston.

Serfling became interested in the NO_3 issue about five years ago with the birth of a child and they had to bring in drinking water. Using the ISU soil NO_3 test, he has reduced his nitrogen use from 13,000 # to 9,000 # and has experienced no significant difference in yield after reducing use. Serfling believes a lot of nitrogen is put on as an insurance policy.

<u>Handout 1. Soil Testing Helps Cut Fertilizer Bill.</u>

Producer: **Dave Serfling, Preston, Minn.**
Enterprise: **Corn**

Project: Determine Nitrogen Needs based on <u>soil nitrate nitrogen testing when corn is 6 to 12 inches tall</u>. Testing was part of Land Stewardship Project program. Five-year rotation includes corn (2 years) - oats (1 year) interceded with - alfalfa (2 years).

Results: 1987 -- Tested four different rates of actual nitrogen -- 50, 100, 125 and 150 lbs. per acre -- on 80 x 3-rod plots in 35-acre field. The field, used to winter 75-cow beef herd, had been in continuous corn for 20 years. Serfling expected yields to increase as nitrogen rates did. Wrong. Yields of test plots ranged from 152 bu. to 157 bu. per acre.

1988 -- When corn was 6 inches tall, sampled all corn ground to test soil for nitrate nitrogen. Results, "too good to be true," showed no need for more nitrogen in continuous corn. Also, except for test plots, cut intended side-dressed nitrogen rates for remaining corn round in half based on soil test results. Lowered rates in three test plots (from 125 to 100, 100 to 50 and 50 to 0 lbs.) and kept 150-lb rate on fourth plot. Again, higher nitrogen rates failed to produce higher yields, which, depressed by drought, varied from 122 to 117 bu. per acre.

1989 -- Discontinued test plots. Rates for nitrogen, all side-dressed, based on soil nitrate nitrogen test. Yields averaged 145 to 150 bu. per acre.

Conclusion: "Testing soil for nitrate nitrogen works," Serfling says. "It saves money." Here's how he's used the test to reduce nitrogen use:

Before Soil Testing	Total Corn Acres	Total Pounds Actual N Applied	Pounds Actual N per Acre
1986	143	13,455	94
1987	112	15,140	135*
After Soil Testing			
1988	124	4,126	33
1989	122	9,534	78

* Higher rate reflects less first-year corn following alfalfa than previous year.

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Serfling commented, "We need to fertilize based on soil tests, technology can benefit all. Agribusiness can benefit, it is a unique technology. If we have to mandate its use ... we have failed. This management practice sells itself."

Ralph Baumgartner, Southern Valley Co-op, Mankato.

Baumgartner described fertilizing on a prescription basis, looking at soil type and yield potential. He sees the use of nitrification inhibitors as another tool, based on trials and research from the Waseca Experiment Station. The co-op has provided water sampling to customers.

Robert Mead, Crop Production Specialist, Ellendale Co-op, Owatonna.

Mead descried his first step in making fertilizer or chemical recommendations as getting to know the farmer and making recommendations only when management, soils, goals and shortcomings are known. In setting a yield goal, the last five years of yields per acre are used for corn. The nitrogen recommendations considers one pound of nitrogen for one bushel of corn. Manure and rotation credits are also included. In a soybean/corn rotation, one bushel of soybeans accounts for one pound of nitrogen credit. For alfalfa, the stand is analyzed in the second and third years, for every percentage of alfalfa, there is a one pound nitrogen credit.

Mead offers manure testing, but only five to ten percent of the farmers are using it. He recommends the use of a soil NO_3 test and the use of nitrification inhibitors and discourages fall applications because you lose the nitrogen.

Don Farm, farmer, Southern Valley Co-op, St. Clair.

Fifty percent of the nitrogen sold at the co-op is in the fall and nitrification inhibitors are prescribed. An average application is 140 to 150 pounds nitrogen in a corn/soybean rotation with about 20 pounds less being applied when a nitrification inhibitor is used. Water sampling is provided for customers.

Jay Zielske, Minnesota Crop Consultants, Owatonna.

Manure is an under-utilized resource and growers are uncomfortable using nitrogen credits for manure because of differences in content. Fall application of nitrogen on coarse textured soils or hydrogeologically sensitive areas should be discouraged.

Craig Moore, Cannon Valley Co-op, Northfield.

Moore stressed the need to set realistic yield goals based on the field. Since 1981, consultations with the farmer begin in January to avoid at atmosphere of panic in decision making. Sidedressing and rotations are recommended, fall applications are not. Nitrogen recommendations are affected by soil type.

Bill Auburn, Concerned Citizens of Warsaw and Holden Township, Dennison.

Representing a concerned citizens group, Auburn explained we need to invest in water, any source of contamination is of concern. He expressed support for what had heard during the hearing.

George Bezold, Past President of the Irrigators Association, Farmington.

Bezold the concern over NO_3 has existed for may years. He called for more information on water and trends involving contamination. He stated, "We need to base decisions on fact or best available information, not feelings."

Bruce A Kahn, High Plains Co-op, Plainview.

The co-op has been taking water samples. Kahn thought farmers would accept no fall application of nitrogen. He also discussed manure management with farmers looking at P and K in the manure, but worrying about applying too much nitrogen. Kahn also foresees the sale or brokerage of manure in the near future.

Larry Bauer, Steering Committee of the Cannon River Watershed Project, Faribault.

Bauer stated, "We need to move toward better water quality and quality of life." County water plans are being developed in joint efforts. The Cannon River project will include monitoring and data collection to assess the watershed. He promoted land stewardship and sustainable land use; agricultural, urban and industrial.

Craig Sallstrom, Executive Director, Minnesota Plant Food and Chemical Association (MPFCA), St. Paul.

Sallstrom described how the MPFCA had supported the development of the nitrogen fertilizer task force, "We agreed in the legislation with the development of BMPs...rather than restrict use." He referenced well sampling results from the 1940s with high NO_3 levels in southeastern Minnesota water. He commented, "If we cut out nitrogen fertilizer, we will not have eliminated the problem." He described how fertilizer usage had decreased for crop year 1989 by ten percent, while acreage had increased ten percent. People are adopting BMPs.

Sallstrom stated, "If the task force would regulate the use of nitrogen fertilizers, they should carefully evaluate the impact. Regulations should be the last resort, not the first option." Sallstrom said including nitrogen information in the certification program "would not be a problem for the dealers."

Lyle Kuhlum, Byron Elevator Company, Byron.

Kuhlum supported looking at manure credits. The is very little fall nitrogen application in the area. He has not had very conclusive results with nitrification inhibitors. He described how the amount of nitrogen used has been reduced five to ten percent during the last few years. He stated, "The farmer wants to know how we can cut costs and maintain yields." Anhydrous is applied by the farmer (with very little over application), whereas dry use and 28% are custom applied.

When asked where he would draw the line if fall applications were banned, Kuhlum replied, "We have so little fall application, if it were banned ... it wouldn't be a problem." He noted there should be a line, but it depends on the definition; soil type or field type.

Pam Hunt, Executive Director, Zumbro and Root River Area Water Quality Task Force, Rochester.

Hunt stated, "I came here to promote the use of Comprehensive Water Management Plans. These plans are encouraging education, research and monitoring. Al plans should be incorporated into a fertilizer management plan."

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