MINNESOTA POLLUTION CONTROL AGENCY
SITE REMEDIATION SECTION

GROUND WATER POLICY DOCUMENT

WORKING DRAFT, August, 1998

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194
Fax (651) 296-9707

NOTICE

THIS DOCUMENT IS AN INTERNAL REVIEW DRAFT. The Site Remediation Section of MPCA is developing guidelines for evaluating risks to human health and the environment at sites that may require investigation or response actions pursuant to the Minnesota Environmental Response and Liability Act, Minn. Stat. § 115B.01 to 115B.24 (MERLA).

DEVELOPMENT OF A SITE REMEDIATION SECTION SITE EVALUATION MANUAL. The attached document and other documents not yet developed will be incorporated into a Site Remediation Risk-Based Site Evaluation Manual which will contain guidelines for conducting MERLA-related evaluations, including risk evaluations under the State Superfund program and the MPCA Voluntary Investigation and Cleanup (VIC) Program.

MPCA staff intend to use the policies and procedures in the proposed manual as guidelines to evaluate the need for investigation or remedial actions to address releases and threatened releases of hazardous substances or pollutants or contaminants under MERLA, and the scope and nature of such actions. These policies and procedures are not exclusive and do not have the force and effect of law. MPCA staff may use other policies or procedures to evaluate the outstanding MPCA Requests for Response Action and Consent Orders. The final standard for all such evaluations is the MERLA statutory requirement that such actions must be reasonable and necessary to protect the public health and welfare and the environment.

FOR PURPOSE OF INTERNAL REVIEW ONLY. This document is being distributed to specific persons listed below for the purpose of receiving internal review only. At this time, only written comments regarding this draft document shall be accepted. During guideline development, application of these guidelines or procedures shall be site specific, conducted in consultation with and upon approval of MPCA Site Remediation Section (SRS) staff assigned to the specific site.

INTERIM CHANGES TO DRAFTS. Document users are responsible for contacting MPCA staff assigned to the site to get the latest unpublished changes to the document.

GROUND WATER POLICY
WORKING DRAFT

MINNESOTA POLLUTION CONTROL AGENCY
SITE REMEDIATION SECTION

TABLE OF CONTENTS

LIST OF TABLES

Internal Review Draft, October 3, 1997
Draft Ground Water Risk-Based
Decision-Making Guidance
Comment Period Ends November 14, 1997
Send comments to: Mark Rys

Minnesota Pollution Control Agency
Site Response Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

EXECUTIVE SUMMARY

The Site Remediation Section of the Minnesota Pollution Control Agency (MPCA) has developed this Ground Water Policy document as part of a program wide guidance development effort. The intent of this policy document is to develop a consistent framework through which ground water contamination problems are evaluated and remedial actions decisions are managed in the state. The framework is based on managing risk associated with ground water contamination and working with state and federal regulations that identifies both policy and statutory requirements through which ground water contamination is to be managed in the state. The document also elaborates on tasks which should be conducted and information collected or derived to develop effective remedial investigations which results in risk-based, site specific remedial actions.

State and federal regulations provide the statutory basis for conducting remedial investigations of environmental contamination. Minnesota Rules ch. 7060 outlines policy and identifies control measures which should be applied when managing contamination of state ground water. Minnesota Statutes Section 103H.201 identifies health risk limits/standards (HRLs) which should be implemented as site cleanup levels to protect human receptors from unacceptable risk associated with ground water contamination. These HRLs should be considered in conjunction with federal standards (Maximum Contaminant Levels (MCLs), 40 C.F.R. pts 141-143) and state standards developed to protect environmental receptors (Minn. Rules 7050.0220) when identifying cleanup levels to manage ground water contamination.

A remedial investigation is the process which facilitates the compilation and evaluation of information in an attempt to identify remedial actions and remediation requirements necessary to manage the risk ground water contamination poses to human and environmental receptors. The goal of ground water remedial actions is to manage ground water contamination in a manner which preserves the current and future use of ground water for its highest priority use as a potable supply and/or for food processing and culinary purposes. One of the first steps in a remedial investigation is to identify human and environmental receptors within an area surrounding a ground water contamination site. It is important to evaluate ground water use in an area extending far beyond the property boundaries of the site generating contamination, due to the tendency of ground water contamination to migrate various distances over time and be influenced by various forms and magnitude of ground water use within such an area beyond the site property boundary.

Once current and future human and environmental receptors have been identified in an area, promulgated standards can be identified and used as site specific cleanup levels to manage risk associated with a ground water contamination plume. A compliance monitoring well network can then be installed to evaluate the nature, extent, and stability of the plume in order to evaluate impacts the plume may have on current and future receptors. An effective compliance monitoring well network should establish monitoring locations placed within all ground water exposure pathways identified within the horizontal and vertical extent of the plume. Compliance point locations should be established upgradient of a potential receptor at a distance which provides a minimum advance warning of at least two years with respect to arrival of the plume at the receptor point in order to provide an adequate period of time for a contingency remedial action to be developed and implemented.

Ground water remedial actions should be based on requirements which provide both: interim response actions to control and eliminate exposure to contamination which poses an immediate risk to human and environmental receptors and actions which control and eliminate long-term risk to current and future receptors. If ground water monitoring data indicates that a contaminant plume is stable and not impacting receptors, remediation requirements should focus on a long term plan to monitor plume stability and demonstrates the effectiveness of natural attenuation to restore aquifer quality. If data indicates that an unstable plume is migrating through an aquifer at concentrations which exceed site cleanup levels, remediation requirements should focus on managing

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

risk within the extent of the plume and provide remedial measures which, at a minimum, will establish plume stability in order to control and eliminate impacts to current and future human and environmental receptors.

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

DRAFT GROUND WATER POLICY

1.0 INTRODUCTION

The MPCA is responsible for evaluating sites where ground water is affected by the release or threatened release of pollutants and contaminants or hazardous substances into the environment. Associated ground water remedial activities in Minnesota are managed under the statutory requirements outlined in the Minnesota Environmental Response, Compensation and Liability Act (MERLA) and the Comprehensive Environmental Response and Compensation and Liability Act (CERCLA). Ground water remediation decisions will be based on protection of human health and the environment as determined using a risk-based decision making process taking into account the following factors:

a) an evaluation of current and future human and environmental receptors;

b) current and future land-use;

c) a preference for detoxification and treatment; and

d) a minimization of cross media transfer of contaminant.

Ground water remedial actions under MERLA must meet the threshold criteria of providing overall protection for the public health, welfare, and the environment. Remedial action alternatives are evaluated by applying the following balancing criteria: long-term effectiveness, implementability, short-term risks, and cost-effectiveness. Remedial actions must also be evaluated for community acceptance (see Remedy Selection document).

In a risk-based approach to the management of ground water contamination, remedial action decisions are driven by an evaluation of the contaminated media, exposure pathways, and impacts to current and future receptors. Ground water cleanup levels will be based on promulgated standards such as the Health Risk Limits (HRLs), Maximum Contaminant Levels (MCLs), and aquatic life standards. Where promulgated standards do not exist for contaminants of concern, the MPCA, in consultation with the Minnesota Department of Health, may develop site-specific cleanup levels. Remedial actions will be designed to reduce, control, and/or eliminate exposure to both human and environmental receptors.

This document is intended to assist program users in determining how the risk-based decision process will be applied to ground water at sites. The remaining portions of this document are divided into the following sections:

- Section 2.0, State and Federal Regulations: outlining the state and federal statutes, rules, and regulations which govern ground water investigations and remedial actions;
- Section 3.0, Components of Ground Water Contamination Management: providing an overview of the components of a ground water investigation and remedy selection process necessary to make ground water remedial action and cleanup decisions; and
- Section 4.0, Evaluating Ground Water Contamination: discussing the application of a risk-based approach to ground water contamination management.

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

2.0 STATE AND FEDERAL REGULATIONS

Ground water investigations and cleanups must be administered in compliance with the legal framework of the state, which includes statutory and regulatory provisions. Statutory and regulatory provisions are considered to be directly applicable (i.e., permits, concentration exceedances of applicable state and federal standards) and appropriate in determining whether a remedial action adequately protects public health and the environment. State and federal laws pertaining to ground water and site remediation activities in Minnesota include:

State Laws/Rules:

- Minnesota Environmental Response and Liability Act (MERLA): Minn. Stat. §§ 115B.01 - .241;
- Underground Waters: Minn. Rules ch. 7060;
- Waters of the State: Minn. Rules ch. 7050;
- Ground Water Protection Act: Minn. Stat. ch. 103H;
- Water Pollution Control Act: Minn. Stat. ch. 115;
- Pollution Control Agency: Minn. Stat. ch. 116;
- Health Risk Limits (HRLs): Minn. Rules pts. 4717.7100 to 4717.7800;
- Public Water Supplies: Minn. Rules pts. 4720.0200 to 4720.3970;
- Special Well Construction Area Designation: Minn. Rules pt. 4725.3650;
- Monitoring Wells: Minn. Rules pts. 4725.0210 to 4725.3875;
- MERLA Site Listing and Scoring Rules: Minn. Rules ch. 7044.

Federal Laws/Rules:

- Comprehensive Environmental Response Compensation and Liability Act (CERCLA): 42 U.S.C. §§ 9601 et it. seq;
- National Contingency Plan (NCP): 40 C.F.R. pt. 300;
- Safe Drinking Water Act: 42 U.S.C. §§ 300f to 300j-26;
- National Primary and Secondary Drinking Water Regulations: (40 C.F.R. pts. 141-143); and
- Clean Water Act: (33 U.S.C. §§ 1251 et it.).

Statutes, rules, and policies affecting ground water quality continue to be developed. These future developments will be taken into account in determining whether future proposed cleanup actions are reasonable and necessary to protect the public health, welfare, and the environment.

3.0 GROUND WATER CONTAMINATION MANAGEMENT

This section outlines concepts and processes used in addressing and managing ground water contamination problems under the jurisdiction of the Site Remediation Section of the MPCA. The concepts are

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

meant to provide the building blocks upon which a site specific risk-based decision making process may be implemented to evaluate ground water contamination which may pose a threat to human health, public welfare, and the environment. If results from an initial site assessment suggest that a contamination release may pose an unacceptable risk to ground water, a remedial investigation must be implemented to evaluate the problem further. The goals of a remedial investigation are to define the nature and extent of contamination in all media of concern by focusing on exposure pathways, identifying all current and potential receptors associated with contamination, evaluating the risk contamination may pose to each receptor, and developing a remedial action plan to control or eliminate unacceptable impacts to human health and the environment. The remaining portions of this document will focus on concepts and processes which should be considered when evaluating risk associated with ground water contamination. Section 3.1 describes elements which should be considered in evaluating ground water use in an area. Section 3.2 provides criteria for evaluating plume stability and establishing compliance monitoring locations for ground water plumes. Section 3.3 discusses standards to consider when establishing cleanup levels and remediation requirements for a site. Section 3.4 discusses institutional controls which may be available as effective components to a remedial action decision. Section 3.5 introduces issues necessary to develop effective community participation during the development of remedial action decisions made on a site-specific basis.

3.1 Evaluating Ground Water Use

It is the goal of the MPCA to develop and manage ground water remedial actions in a manner which preserves the current and future use of ground water for its highest priority use as a potable supply and/or for food processing and culinary purposes. Identification of ground water use in an area is made through an assessment of aquifer characteristics, an evaluation of potential human and environmental receptors, and an evaluation of current and future ground water use. Ground water use is evaluated within an area surrounding the site referred to as the review area.

The review area is the area surrounding a site within which ground water use and the risk to human and environmental receptors are evaluated. The review area will generally be the larger of a circle with a radius of two miles centered on the site or the area within a 10 year ground water travel distance of the site. Establishing a 10 year travel time will require some knowledge of the hydrogeologic conditions in the area. For compounds which do not degrade readily, or for rapid ground water flow conditions, a ground water travel time of 20 years may be more appropriate. If the ground water flow direction is known for the aquifer of concern and other potentially impacted aquifers in the region, it may be prudent to focus the review to areas downgradient of the site. It is important to evaluate ground water use in a larger area than the site generating ground water contamination, because the nature and extent of ground water contamination can change with time and be influenced by various forms and magnitude of ground water use within an area. The hydrogeologic setting, the chemical and physical properties of the contaminant, and ground water and contaminant transport times need to be considered when evaluating boundaries for a review area.

Factors which should be considered in assessing ground water use within a review area include:

- presence of domestic, public, or industrial wells;
- productivity and yield of all aquifers of concern;
- evaluation of sole-source aquifers;
- locations/types of wellhead protection areas;
- nature and extent (horizontal and vertical) of ground water contamination; and
- natural or background ground water quality.

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

An evaluation of current ground water use and potential impacts to human and environmental receptors will require the production of a ground water receptor survey as described in Section 4.2 of this document.

Determining future ground water use may require an evaluation of:

- local water resource planning;
- contingency planning for public drinking water supplies;
- zoning ordinances, land-use planning, and demographic trends;
- institutional controls established to regulate aquifer use in an area; and
- feedback from the public on the use of the ground water within an area of concern.

3.2 Compliance Monitoring Points and Plume Stability

Compliance monitoring points (compliance points) are monitoring well locations established to provide analytical and hydrogeologic data necessary to evaluate the risk a contaminant plume may pose to human and environmental receptors. The location and the manner in which data is used is what distinguishes compliance points from other monitoring locations. A site-specific compliance monitoring well network is designed to generate data which can be used to evaluate plume stability, and to determine whether contaminants are migrating toward receptors at concentrations which exceed cleanup levels established for the site. Because they are used to assess the risk posed by ground water contamination, compliance points must be placed within all ground water exposure pathways upgradient of potential receptors within the horizontal and vertical extent of the plume.

In order to demonstrate that risk to receptors is being properly evaluated and controlled, a compliance monitoring well network should define and contain the portion of a contaminant plume which exceed cleanup levels. Compliance point locations should be established in the downgradient portion of a plume and upgradient to any potential human or environmental receptors. Hydrogeologic and contaminant transport characteristics of the aquifer and contaminants comprising the plume should be considered to establish compliance point locations which provide a minimum advance warning of at least two years with respect to arrival of contaminated ground water at a receptor point; i.e., the compliance point should be located at least two years travel time upgradient of the receptor or potential receptor. Actual compliance point locations will be site-specific. However, in many cases, an advance warning distance associated with a two year travel time within the impacted aquifer will be advisable.

Compliance points should be used in conjunction with other monitoring locations to evaluate plume stability relative to the cleanup levels established for the site. The objective of determining plume stability relative to a cleanup level is to evaluate the risk which the contaminant plume may pose to current and potential receptors within and downgradient of the plume. Plume stability can be assessed by collecting analytical data from compliance points and other monitoring locations for a period of time and evaluating trends in contaminant concentrations over time relative to the cleanup levels established for the site. Increasing trends in ground water contaminant concentrations observed at compliance points is often an indication that a plume may be unstable and migrating toward a potential receptor. In situations where an unstable plume is migrating toward a potential receptor at concentrations which exceed cleanup levels , to prevent risk to exposure and maintain compliance with statutory requirements of the State as described in the following section, remedial actions will be necessary to stabilize the plume, to control or eliminate the risk to receptors, and to prevent further degradation of ground water.

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

The length of time needed to monitor and determine plume stability should be based on an evaluation of the hydrogeologic characteristics of the aquifer (hydraulic conductivity, primary and secondary porosity, and hydraulic gradients) and the geochemical properties of the contaminant (adsorption-distribution coefficients and degradation rates). If initial sampling events indicate that contaminant transport is influenced by seasonal variations in ground water flow, then it may be necessary to conduct quarterly ground water monitoring for a number of years in order to evaluate seasonal trends which may effect plume stability. Therefore, the total amount of time needed to evaluate plume stability can be expected to vary from site to site depending upon the factors mentioned above.

Property owners who may be impacted by ground water contamination as well as local units of government, and other state agencies should be consulted to evaluate future land use and future ground water use before compliance points are established beyond site property boundaries. This type of community participation is an essential component in establishing compliance points.

3.3 Cleanup Levels and Remediation Requirements

Cleanup levels for ground water contamination plumes will be based on managing risk by applying promulgated health risk ground water standards for human receptors and promulgated aquatic life standards for environmental receptors.

Minnesota Rules Chapter 7060 entitled MPCA, Water Quality Division, Underground Waters, establishes state policy and imposes regulations on pollution of all ground waters in the state. The policy of ch. 7060 is to preserve these waters for their highest resource value defined as a source of drinking, culinary, or food processing water. The Health Risk Limits (HRLs), adopted under Minnesota Statutes Section 103H.201, are the appropriate cleanup levels for managing ground water contamination and risk to human receptors in compliance with Minn. Rules ch. 7060. The individual HRL values have been derived to correspond to the target risk levels. When multiple contaminants exist at a site, a mixtures evaluation is required to determine whether the target risk limit for the mixture is exceeded (Minn. R., ch. 4717, pt. 4717.7800).

The following equation should be used to determine whether the health risk from multiple contaminants with similar toxic endpoints exceeds the target risk level for that endpoint (e.g., cancer, liver toxicity, etc.):

$$\text{Hazard Index}_{TE} = C_1 / HRL_1 + C_2 / HRL_2 + ... + C_n / HRL_n$$

where:

Hazard Index_{TE} = the HI of the specific toxic endpoint under evaluation;

C_n = the concentration of the first, second, ... , nth contaminant detected; and

HRL_n = the health risk limit of the first, second, ... , nth contaminant detected.

An HI greater than 1 exceeds the acceptable risk level. The MPCA has developed a spreadsheet which will make the appropriate calculations and which identifies chemical-specific target endpoints for assessing site-specific mixtures. An electronic version of the spreadsheet can be obtained by contacting Trudy Cramlet in Site Remediation Division of the MPCA.

The Maximum Contaminant Levels (MCLs, National Primary and Secondary Drinking Water Regulations, 40 C.F.R. pts 141-143) are federally promulgated standards which must be considered when

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

contaminated ground water poses a risk to community/municipal drinking water supplies. MCLs are based on both human health risk assessment and best available technology. Where municipal well fields are impacted by a contaminant plume, cleanup levels should be based on the more conservative standard relative to the MCL and HRL for all compounds of concern.

Health Based Values (HBVs) should be used or established for compounds for which HRLs or MCLs do not exist. If such compounds do not have an established HBV, MPCA staff should work with MDH to derive an appropriate HBV for the contaminant of concern. Please refer to the document glossary for a more formal definition of the HRLs, MCLs, and HBVs.

In situations where surface water bodies or ecologically sensitive areas are impacted or potentially impacted by ground water contamination, aquatic life standards identified in Minn. Rules ch. 7050 should be considered as appropriate cleanup levels. Minn. Rules pt. 7050.0220 defines specific standards of quality for the designated classes of water in the State. General water classifications which exist in Minnesota are defined in Minn. Rules pt. 7050.0400, while the classifications for waters in major surface water drainage basins, as defined in Minn. Rules pt. 7050.0465, are provided in Minn. Rules pt. 7050.0470. Cleanup levels which are based on impacts to surface water will vary with the classification of the impacted surface water body and should be evaluated through Surface Water Toxic Impact Assessments performed by the MPCA project team. For further information regarding an evaluation of risk to surface water bodies and associated environmental receptors, refer to the Surface Water Guidance document.

Variances from the statutory requirements and the application of promulgated standards discussed above may be considered in situations where a remedial investigation and an evaluation of risk associated ground water contamination suggests that application of the HRLs, MCLs, HBVs, or aquatic life standards are not necessary to manage associated risk . In situations described above, alternative cleanup levels may be considered and established following consultation with MPCA staff. The parties pursuing a variance must also adhere to the requirements specified in the Rules of the State.

Remediation requirements should focus on remedial actions which:

- provide immediate interim response actions necessary to eliminate unacceptable risk exposure to contaminated ground water and supply safe drinking water to human receptors whose drinking water supply is no longer potable due to detrimental impacts from a contaminant plume;
- stabilize or remediate plumes which continue to migrate through aquifers at concentrations which exceed site cleanup levels;
- provide a permanent source of safe drinking water to receptors whose drinking water supply has been detrimentally impacted by a contaminant plume;
- promote remediation of potable aquifer supplies which have been exposed to contaminant concentrations at levels which make them unsuitable as a safe drinking water supply or for culinary and food processing purposes;
- eliminate and control risk to environmental receptors; and
- establish long-term monitoring plan to evaluate the effectiveness of the remedial action.

Remediation requirements should include site specific remedial action plans which have been presented to the local community and meet the threshold criteria of providing overall protection of public health, welfare, and the environment and are evaluated by applying the following balancing criteria: long-term effectiveness, implementability, short-term risks, and total costs. When evaluating the economic factors associated with the feasibility of remediation, consideration should be given to detrimental effects contamination

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

may have on neighboring property value or property rights. The actual or potential risk posed by contaminated ground water must be evaluated and factored into identifying appropriate cleanup levels and finalizing a remedial action decision. Risk based ground water decisions must integrate the physical, technical, economic, and community acceptance factors which can be expected to vary greatly from one site to the next. Ground water remedies may incorporate active treatment to eliminate current risk, plume stabilization, or containment to manage future or potential exposure to contaminated ground water, and institutional controls to ensure the effectiveness of a remedial action.

3.4 Institutional Controls

Within the context of MERLA applications, institutional controls are "legally enforceable restrictions, conditions, or controls on the use of real property, ground water, or surface water located at or adjacent to a facility where response actions are taken that are reasonably required to assure that the response actions are protective of public health or welfare or the environment." Minn. Stat. § 115B.02, subd. 9a. These controls may be implemented by federal, state, or local units of government and may affect areas as small as a site or may apply to the entire state.

Institutional controls fall into two groups: those that apply to a specific site or property, and those that apply to broader areas. Real property notification/affidavits, environmental restrictive covenants, easements and other property use agreements are more appropriately applied to manage exposure to contaminated ground water within the property boundaries of a site which acts as a source of ground water contamination. Restrictions on ground water use or well construction can be applied to affected or potentially affected areas beyond the property boundaries of individual sites generating ground water contamination. For a more detailed discussion of the various types of institutional controls, please refer to the document entitled: *Guidance on Incorporation of Planned Property Use Into Site Decisions*.

Examples of institutional controls which have been developed to restrict access to contaminated ground water include but are not limited to:

- *State well code*: The Department of Health enforces the well code (Minn. Rules ch. 4725) which prohibits well construction in some areas and imposes well construction requirements designed to protect wells and the aquifers from which they draw water; and
- *Special well construction or drinking water well advisory area designations*: The Department of Health may designate areas where contamination is detected as "special well construction areas" or "drinking water well advisory areas" and may ban well construction in these areas or impose special requirements for well construction, maintenance, sealing, and monitoring (Minn. Stat. § 103I.101, subd. 5(7); Minn. Rules pt. 4725.3650).

The use of institutional controls should be evaluated as a portion of the overall site remedy using the "balancing criteria" remedy selection process used under CERCLA and MERLA (see the portion of the guidance document on remedy selection). The intent of incorporating institutional controls is to ensure the effectiveness of a remedial action by eliminating or reducing unacceptable risk from exposure to contaminated ground water within the property boundaries of a site generating contamination or beyond by placing property notices and restrictions on future use of the property. As part of the balancing criteria, institutional controls should be evaluated for their community acceptance, implementability, cost of implementation, long-term reliability and short-term risks. Institutional controls will generally be selected as components of remedies when permanent remediation measures are not implementable or cost-effective to ensure restoration of contaminated media, or when a remedy is selected based upon a specific future land use such as industrial or commercial rather than unrestricted use. Since, by their nature, institutional controls require tracking in order to be effective, the

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

long-term costs of these activities should be included in the evaluation of their suitability as components of remedial actions.

3.5 Community Participation

Ground water contamination problems may often require a more aggressive approach to community participation than problems associated with soil contamination. Ground water contamination has a greater potential to migrate away from a source area, at times impacting areas much larger than the source of the contamination. Ground water contamination, which is migrating beyond the site boundaries, may cause detrimental impacts to the local water supply and neighboring property which in turn may affect development of neighboring property. A component of developing a successful remedial action plan to manage this type of ground water contamination will often involve developing timely and effective avenues of communication with the local community. This will provide an avenue through which information can be disseminated to the local community regarding general program information, site specific information about the nature of contamination at a site, the risk posed to the community by the contamination existing or migrating from the site, and the options associated with decisions that must be made at the site in order to manage any risk the contamination may pose on human health or the environment. For further guidance regarding the development of effective community communication techniques and action plans, please refer to the section of this guidance dedicated to this subject matter.

4.0 EVALUATING GROUND WATER CONTAMINATION

The nature and extent of ground water contamination, and the potential risk it may pose to human health and the environment, are often evaluated in a two phased approach. During an initial Phase 1, or Site Assessment (SA), analytical data is collected from all media which may act as a conduit or potential exposure route for the migration of contamination to ground water. The data is evaluated and compared to screening levels to facilitate a decision regarding the potential impact and risk contamination may pose to ground water. The second phase, the Remedial Investigation (RI), is initiated if conclusions derived from the Site Assessment suggest that ground water has been or may be impacted by a release of contamination. The following section and subsections incorporates the elements and processes discussed in Section 3.0 in outlining tasks associated with ground water RI activities. Table 1 presents a decision matrix table which summarizes compliance point strategies and remediation requirements for stable and unstable plumes.

4.1 Remedial Investigation (RI)

The goals of a RI are to define the nature and extent of ground water contamination, identify all current and future human and environmental receptors at risk to exposure, and identify a risk-based remedial action which will control or eliminate the exposure risks ground water contamination may pose. This section elaborates on data requirements associated with an RI, additional concepts regarding the application of plume stability, compliance monitoring points/wells, cleanup levels, and remediation requirements.

4.1.1 Remedial Investigation Activities

A remedial investigation should be designed to compile information which achieves the goals discussed above within a reasonable time frame. Some major activities associated with a RI include:

- *Receptor survey*: A receptor survey is performed as an initial step in a RI to evaluate aquifer use and identify human and environmental receptors within a review area (see Section 3.1 for discussion of review area). An

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

evaluation of aquifer use should include a review of the County Well Index, and the local Water Works Department for domestic and municipal wells. The local and state Health Departments should also be contacted for information regarding the location of potable wells within the review area. A house to house well search and review of local drillers' records may be necessary at many sites. The receptor survey should include an evaluation of wells in all aquifers of potential concern to evaluate the potential risk of cross contamination between interconnected aquifers. The county or city zoning department and other local officials should be contacted for information on likely future development in the area and the potential for new or increased future aquifer use. The Minnesota Department of Health and local units of government should be contacted for information on institutional controls on ground water use such as well advisory areas and well head protection areas.

- *Hydrogeologic evaluation*: Install and sample monitoring wells to evaluate the nature and extent (horizontal and vertical) of ground water contamination. Collect ground water analytical data for all chemicals of concern and all associated contaminant degradation products. Measure water levels in order to establish ground water flow direction, vertical and horizontal gradients, and associated ground water flow velocity. Log soil and/or bedrock borings to establish geologic conditions at the site. Published geologic information such as the County Geologic Atlas should be consulted for regional geologic information and this information should be evaluated for its applicability to the site. The hydrogeologic evaluation should include a description of the degree of contamination at the site, the physical and chemical nature of the contaminants, the likely presence or absence of LNAPL and DNAPL, aquifer capacity and use in the area, ambient water quality, current and future aquifer use practices within aquifers of concern, the potential for interconnection between aquifers, and the potential for aquifer discharge to surface water bodies, wetlands, or other ecological receptors. The plume should be evaluated for vertical and horizontal stability. Consideration should be given to an evaluation of the contaminants and aquifer for specific conditions which would promote natural attenuation of the contaminants along potential flow paths.

- *Ground water flow modeling:* Analytical and numerical ground water models may be used to evaluate the fate and transport of contaminants in ground water, develop preliminary travel times to potential receptors, and facilitate the proper placement of monitoring wells and compliance points during the development of a monitoring network. The choice of analytical and numerical techniques utilized to evaluate fate and transport should be based on widely accepted concepts of fluid flow (Darcy's Law) and contaminant transport as supported by the technical/professional literature. All flow models should incorporate site specific values of hydraulic conductivity. Generic values may be considered in the early stages of an investigation for other modeling parameters, such as distribution coefficients, retardation values, and dispersivity. Generic values, as referenced in the Site Screening guidance and Soil Leaching Pathway guidance document, applied to evaluate and derive screening levels in the SA should be considered when establishing modeling parameters. Parameter values published in professional literature should also be considered when determining the most appropriate model and modeling parameters to use in such an effort. Ground water flow models designed to evaluate remedial actions will require a more rigorous evaluation and application of site specific values for all modeling parameters being utilized in order to minimize error associated with numerical and analytical evaluations and to assure greater confidence in the remedial action conclusions derived from such a model. At a minimum, all modeling exercises must include steps of calibration and verification with field data to demonstrate the effectiveness and validity of a model. Whenever considering applications of models during an RI, MPCA and all parties involved should work together to identify the proper model, hydrogeologic factors, and geochemical properties of the contaminants which should be incorporated in the model, and to come to an agreement on the generic parameter values to incorporate into a model.

- *Interim Response Action (IRA)*: At some time during an RI a decision may be made to conduct an IRA. The purpose of the IRA is to provide an immediate response which will reduce or eliminate detrimental impacts contamination may pose to human receptors or the environment. Potential IRAs include: free product

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

removal, contaminated soil excavation, ground water treatment or containment, and supplying human receptors with an alternate source of safe drinking water.

- *Remedial action decision*: When the data from an RI indicates that the site poses a significant risk to human health or the environment, a decision must be made whether to complete a remedial action. Goals of a remedial action include plume stabilization; restoration of the aquifer quality to protective levels as defined by the site cleanup level; and/or to eliminate the exposure pathway to ground water contamination which remain above cleanup levels. Remedial action may consist of source removal, active ground water remediation, plume containment, natural attenuation, or a combination of these methods. For additional guidance on selecting and evaluating the effectiveness of potential remedial actions please refer to the following guidance documents: Remedy Selection and Natural Attenuation of Chlorinated Solvents in Ground Water. Institutional controls should also be considered as a component of a remedy to ensure the effectiveness of a remedial action.

4.1.2 Plume Stability

During the course of an RI, data should be collected to distinguish between stable and unstable plumes. This distinction is intended to separate those plumes which continue to migrate and pose an unacceptable risk to receptors from those which have reached their maximum extent and do not present a risk to future receptors. Plume stability must be evaluated using data collected from multiple rounds of ground water monitoring data in consideration of other technical elements as discussed in Section 3.2 of this document. Since one of the goals of site remediation is to prevent the further migration of contaminated ground water at concentrations which exceed cleanup levels, it is important to make the distinction between stable and unstable plumes in order to identify the most appropriate remedial action to manage the plume and associated risk to human and environmental receptors. Ground water plumes may reach a point of stability when natural attenuation reduces contaminant concentrations at a rate which equals or exceeds the rate at which the contaminant leaches into the aquifer from contaminated soils or aquifer materials or the rate at which contaminants migrate through an aquifer. A remedy which reduces or eliminates the source of ground water contamination in soil may create a condition which creates a stable or declining plume. An evaluation of whether contaminants and aquifer conditions favor natural attenuation may also be prudent. In the case of chlorinated solvents, additional guidance on evaluating insitu biodegradation as a component of a natural attenuation remedy can be found in the MPCA guidance document entitled Natural Attenuation of Chlorinated Solvents in Ground Water.

4.2.3 Compliance Points

Monitoring wells used as compliance wells should be established at locations in consideration of the concepts discussed in Section 3.2 of this document. Consideration should be given to a thorough evaluation and understanding of both horizontal and vertical migration pathways within all aquifers of concern. The goal of establishing effective compliance points is to generate data which will evaluate plume stability and provide an early warning if contaminants are migrating within an aquifer toward potential receptors at concentrations which exceed the cleanup levels for the site. Potential receptors may include a domestic well, a municipal well, another aquifer, or a surface water body.

4.2.4 Cleanup levels and Remediation Requirements

Cleanup levels will be based on promulgated standards established to manage risk associated with ground water contamination in such a manner as to be protective of current and future human and

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

environmental receptors. Section 3.3 presents a discussion of promulgated standards which should be considered when determining cleanup levels for a site.

When the data from an RI indicates that ground water contamination continues to pose an unacceptable risk to human health or the environment, a remedial action must be implemented to control and/or eliminate exposure to such a risk. The proper identification and effectiveness of a remedial action will be evaluated based on components identified within threshold criteria and balancing criteria as well as other concepts outlined in Section 3.3 of this document. The goals of conducting the remedial action may vary dependent upon whether the contaminant plume is stable or unstable.

If ground water monitoring data and information about source areas and site hydrogeology indicates that a contaminant plume is stable, remediation requirements should focus on a long term plan which monitors plume stability, natural attenuation of the plume, and which eliminates exposure to contamination which may pose unacceptable risk to any human or environmental receptors within the extent of the plume. In cases where a portion of a stable plume impacts receptors at concentrations that pose an unacceptable risk, remediation requirements should include remedial actions which eliminate such an exposure. Such actions may include: supplying an alternate source of clean drinking water to human receptors, remediation of impacted ground water to levels which will no longer pose an unacceptable risk to receptors, and institutional controls to restrict ground water use and exposure to contaminated ground water in an area of concern. Consideration should be given to the evaluation and effectiveness of natural attenuation of contaminants in these situations.

If a an unstable plume is migrating through an aquifer at concentrations which exceed the cleanup levels established for a site, remediation requirements should focus on managing risk within the extent of the plume as discussed above, and provide remedial measures which will establish plume stability in order to control and eliminate impacts to the aquifer and potential human and environmental receptors.

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

Table 1: Ground Water Decision Matrix

Investigatory Phase	Plume Type	Compliance Point	Remediation Strategy
Remedial Investigation	Stable Plume Evaluate plume stability with long-term monitoring data.	The more conservative location relative to the site property boundary or 2 year ground water travel distance upgradient from nearest receptor or potential receptor Compliance locations will be necessary to monitor plume stability and potential impacts to current and future receptors by evaluating aquifer degradation relative to the HRL and other receptor-based criteria which may be applicable.	Implement a remedial action which controls and eliminates unacceptable risk to all current receptors. Evaluate need for interim response action. Evaluate the potential of natural attenuation if proven to be beneficial to managing future risk. Establish long-term monitoring plan and evaluate application of institutional controls to demonstrate effectiveness of remedial action. Supply an alternate, permanent source of water for receptors whose water supply source has been detrimentally impacted by contamination at levels which exclude future use of the water.
	Unstable Plume Long-term monitoring data indicates that contaminant plume is migrating at concentrations which exceed site-specific cleanup levels.	Same as above	Same as above. Enhance remedial action to prevent further degradation of an aquifer from contamination at concentrations which exceed the HRLs and other appropriate cleanup levels identified for the site.

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194

Minnesota Pollution Control Agency
Site Remediation Section
520 Lafayette Road
St. Paul, Minnesota 55155-4194