

Guidance and Submittal Requirements for Rapid Infiltration Basin Wastewater Treatment Systems



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Table of Contents

	Page
Table of Contents	i.
List of Figures and Tables	ii.
Purpose and Scope	1
Acknowledgments	1
I. Introduction	3
II. The Permitting Process.	4
III. Nitrogen Analysis and Considerations	4
IV. Preliminary RIB Design	6
V. Requirements for Site, Soils and Hydrogeologic Site Evaluation	8
VI. Determining Hydraulic Loading Rates	8
VII. Ground Water Mounding	10
VIII. Operational Criteria	10
IX. Engineering Design Report Submittal Requirements	12
X. Example Problem	12
XI. Summary and Conclusions	15
References	15
Appendix I (The Permitting Process)	17
Appendix II (Preliminary Site Suitability Evaluation)	19
Appendix III (Site Soils Evaluation)	23
Appendix IV (Hydrogeologic Report Requirements)	29
Appendix V (Limited Hydrogeologic Report Requirements)	33
Appendix VI (Engineering Report Requirements)	35

List of Figures and Tables

Figure Number	Page
1 Photograph of a Rapid Infiltration Basin System	4
2 Simplified RIB Permitting Process Flow Chart	4
Table Number	
1 Suggested Loading and Resting Cycles	11
2 Phosphorous Impact Evaluation	26

Purpose and Scope of this Document

The purpose of this guidance document is to assist the Minnesota Pollution Control Agency (MPCA) and consulting technical staff (engineers, soil scientists, and geologists) in the design, permitting and operation of Rapid Infiltration Basin (RIB) wastewater dispersal systems (systems). This document presents discussions on the various technical requirements, and provides an overview of what is required to obtain an MPCA permit for an RIB system.

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Rapid Infiltration Basins

I. Introduction

What are Rapid infiltration Basins?

Rapid Infiltration Basins (RIBs) are permeable earthen basins, designed and operated to treat and disperse municipal wastewater. RIBs are typically operated in conjunction with either a primary wastewater pond, or a primary and secondary wastewater pond system.

How do they operate?

A RIB system is managed by repetitive cycles of flooding, infiltration and drying. Rapid infiltration of wastewater is based on a relatively high rate of wastewater infiltration into the soil followed by rapid percolation, either vertically or laterally away. The best soils for rapid infiltration are relatively coarse textured, with moderate to rapid permeabilities (1).

Particulates, BOD, trace metals and suspended solids are removed at least in part at or near the soil surface. Pathogen removal by RIB systems may be as high as 99.99%, with less attenuation occurring in coarser sands and gravel. Limited studies indicate that some degree of treatment may be afforded to volatile organic compounds by RIBs, by volatilization, sorption and degradation.

Nitrification-denitrification is the primary nitrogen removal process. Total nitrogen removal efficiencies for RIB systems are approximately 50% (2), and more nitrogen may be removed by using special management practices. Air temperatures between 86°F-95°F are the optimal temperatures for nitrogen removal with the microbiologically mediated processes greatly slowing around 55°F, and stopping at or near freezing temperatures. Aerobic bacteria deplete soil oxygen during flooding periods, so resting/re-aerating the system is required for the system to properly function.

A RIB drying cycle is typically five to ten times longer than the wetting cycle and in Minnesota RIB systems are usually not operated in the winter (120-150 days). These criteria need to be considered when proposing RIB hydraulic loading rates.

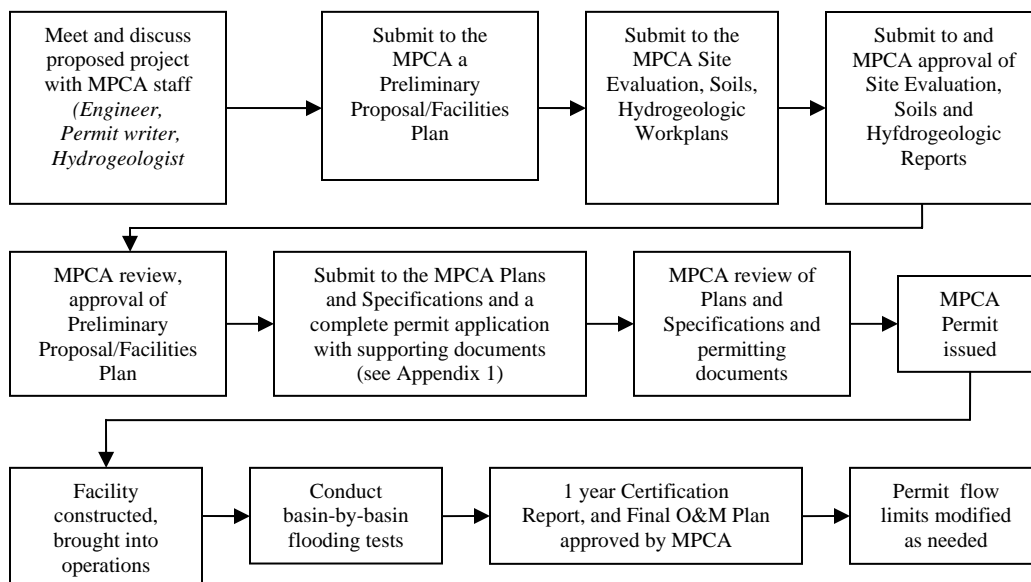


Figure 1: Rapid Infiltration Basins.

II. The Permitting Process

The following flow chart describes the typical sequence for obtaining an MPCA State Disposal System (SDS) Permit for a RIB. More detailed information on the permitting process is included in Appendix A.

Figure 2: Simplified RIB Permitting Process



III. Nitrogen Management Options

Although there are several constituents of concern in wastewater one of the main constituents of concern that influences RIB system design is nitrate-nitrogen. In terms of nitrogen treatment and system design there are two options for obtaining an MPCA SDS Permit as described below. Irrespective of which track is selected at least a preliminary phosphorous setback evaluation will be required (see bottom of Appendix II).

Option One

If the effluent going to the RIBs (verified by on-going effluent monitoring) contains a maximum of 10 mg/L total nitrogen and there is adequate (a minimum of 100') separation between the RIBs and the property line/and or the nearest receptor (surface water or potable water supply well) then only a limited hydrogeologic investigation, and no ground-water monitoring will be required. The requirements for a limited hydrogeologic investigation are included in Appendix V.

Option Two

If the conditions described in Option One above cannot be met then a complete hydrogeologic investigation and ground-water monitoring will be required. If the hydrogeologic evaluation demonstrates little potential for ground water impacts (e.g., the RIBs are in a ground-water discharge zone, no proximal water supply wells etc.) then a limit of 10 mg/L for nitrate-N will be assigned to down-gradient monitoring wells. If the hydrogeologic evaluation determines that the ground water has the potential for being impacted by the RIBs then a limit of 5 mg/L will be assigned to down-gradient monitoring wells.

To reflect ambient conditions where existing ground water nitrate nitrogen concentrations are already elevated nitrate-N limits will be set at the mean of a minimum of three up-gradient ground water samples. In order to set limits an up-gradient well will have to have been sampled at least three times prior to public noticing the permit. Due to discharge flow dynamics more monitoring wells will usually be required the further the monitoring wells are placed from the RIBs.

Normally RIBs should be located as far hydraulically up-gradient from the property line as possible. Any amount of land may be used as a treatment zone between the RIBs and the property line, but this land must not be used in any manner other than as an undeveloped treatment zone.

Several nitrogen reduction methods may be employed at the same site to reduce ground water impacts from RIBs. Nitrogen reduction methods include:

- (1) initially locating the system where natural soil and/or ground water conditions promote denitrification (anoxic and reducing conditions with some dissolved organic carbon);
- (2) locating the RIB system near a downgradient wetland, river or stream that captures, and has the ability to further attenuate the discharge plume;
- (3) the RIBs being located as far up-gradient as possible, with the downgradient property maintained as green space;

- (4) the RIBs designed as long as practical and perpendicular to the ground water contour;
- (5) (clean) stormwater infiltration downgradient of an RIB;
- (6) for suitable soils and shallower ground water using hybrid poplar trees to evapotranspire the discharge;
- (7) installation of downgradient recovery wells for non-potable (E.G. irrigation) use;
- (8) selecting loading and resting cycles that promote denitrification; and
- (9) control of downgradient land to the ground water discharge point which prohibits the installation and use water supply wells.

IV. Preliminary RIB Design

Suitable Locations

A RIB system located on a relatively level site with deep, uniform, unsaturated moderately permeable soils, a deep water table, and is adjacent to a ground water discharge area should increase the performance of the system and reduce associated environmental impacts. Areas with steep slopes, shallow water tables, are adjacent to wetlands, or are in soils that are too coarse or too fine may make siting RIBs more difficult, or may reduce the performance of the RIB system.

Unsuitable Locations

Systems that are within wellhead protection areas, are proposed to be located in areas with shallow bedrock, are above sole-source aquifers, are located on a flood plain, or are in karst areas are most likely not suitable locations for RIB systems.

Number of RIBs

The minimum number of RIBs in a system is 3, but the number of basins can vary from 3-17 depending on whether continuous wastewater discharge is required. Individual basin size can range from 0.5-5 acres for small to medium-sized systems, to 5-20 acres for larger systems. The EPA has provided guidance on the number of basins needed, based on the projected number and duration of loading and resting cycles (3).

Dimensions

To maximize land use basins should adjoin, and be square or rectangular in shape. Long, narrow basins with their length perpendicular to ground water flow direction may reduce ground water mounding. The potential that basins will cause unacceptable mounding in adjacent basins needs to be evaluated during system design.

Dikes

Each basin should be constructed at least 12 inches deeper than the maximum design wastewater depth (4). Dikes need to be compacted to prevent seepage through them, and should be sloped so storm water runoff is routed away from the site. Extra freeboard is not recommended for routine wastewater containment (5). Dikes must be protected from erosion both during and after construction to keep fines from washing in and reducing basin infiltration.

Solutions for Less Favorable Soil Conditions

Whenever possible basins should not be constructed on backfilled materials, and soil compaction during construction must be minimized. At sites where the infiltration rate is slow (finer, structureless soils) then more and larger basins with lower loading rates may be required.

At sites with coarser soils, the soils may not provide uniform basin loading, or the soil based treatment (aerobic/anaerobic conditions) necessary to protect ground water. In Section 4.7.3. on page 48 of the United States Environmental Protection Agency (EPA) document Process Design Manual, Supplement on Rapid Infiltration and Overland Flow it states “In all cases, uniform wastewater application over the entire basin surface is necessary”. In more coarse soils to ensure uniform distribution “The distribution system might range from a network of pipes and troughs to sprinklers in the extreme case”.

At RIB sites where the infiltration rate is too fast several options may be considered including the following:

- Having smaller basins and multiple inlets;
- Carefully removing and stockpiling approximately 12” of the basin soil and then blending finer textured soils (silt, 5%-10%) into the stockpiled soil, and then placing this reworked soil on top of a Geotextile material laid out in the basins;
- Placing a Geotextile material that sufficiently slows down infiltration directly on top of the RIBs (possibly using sandbags as anchors), and then placing 12” of clean sand on top of the reduced hydraulic conductivity Geotextile material;
- Installing a (very) level matrix of troughs made of concrete or pipe cut lengthwise that is installed and kept level so uniform distribution within the RIBs is maintained. A part of the Operations and Maintenance (O&M) Plan will require that the operator must routinely observe drainage, and re-level the drainage channels as necessary;
- Installing a matrix of pressure-distributed distribution lines (i.e. drain tile) with the orifices sized and positioned optimally (sideways or upright) so as to ensure uniform loading and reduced basin scouring;
- Spraying into the basins using a fixed set (overhead or vertical uprights) sprinkler system;
or
- Finding a more suitable site, or selecting an alternative treatment technology.

It should be noted that these are only some examples of possible solutions that may or may not work at a particular site. Other solutions may be possible, and calculations and bench and/or field testing of the selected design should be considered to ensure system viability, uniform distribution of the effluent, and optimally so that the predicted dosing periods would be long enough to induce anaerobic conditions for at least some portion of the load/rest cycle.

V. Requirements for Site Suitability, Soils, and Hydrogeologic Site Investigation

Irrespective of which of the two nitrogen management options that are selected the permittee must undertake a Site Suitability Investigation, a Soils Investigation, and some form of a Hydrogeologic Investigation. The scope of the Hydrogeologic Investigation will depend on which of the two nitrogen management options is selected. The purpose of these investigations

is to characterize the area where the system is proposed to be installed, and to characterize the site soils for design purposes.

Soils are critical for the treatment process. The person who prepares the soils report must certify by signature that they have expertise in Soil Science (defined by education and experience, especially soil morphology). They should have also have taken the Onsite Sewage Treatment Workshop Soils class or equivalent. Under some circumstances the person who designates where the soil pits are to be located may differ from the individual who actually logs the soil pits. If this occurs, then it must be noted in the Soils Report.

When designing the system a minimum of three feet of soil must exist between the bottom of the RIBs and the actual ground water mound height (including the capillary fringe). For systems where mounding may be an issue (based on the mounding analyses) piezometers must be installed, and on-going measurements must be made in the piezometers to ensure that at minimum three feet of separation is maintained during operation.

Appendices II, III and IV respectively provide more detailed discussions on what is required for the Site, Soils, and Hydrogeologic Investigations.

VI. Determining Hydraulic Loading Rates

The sequence for determining annual and individual hydraulic loading rates for RIB systems is as follows:

1. adequately characterize the site soils;
2. estimate annual and daily loading rates; and
3. verify the estimations with empirically-derived (actual) basin-by-basin flooding tests after the basins are constructed.

Hydraulic loading rates are estimated primarily on soil texture, consistence and structure of the most hydraulically limiting soil horizon above the seasonal high water table. A combination of these three soil properties will determine the most limiting soil horizon, and infiltration rates below the system.

Laboratory sieve and permeability measurements, and/or preferably *in-situ* measurements using a double ring infiltrometer or equivalent method (6) of the most transmissive (i.e. quantity) and the most hydraulically limiting (MHL) horizons especially on less favorable sites should be undertaken for estimating hydraulic loading rates (see example on page 12, section IX).

When working with RIBs the terms vertical hydraulic conductivity (K_v), horizontal hydraulic conductivity (K_h) and saturated hydraulic conductivity (K_{sat}) are used. Vertical hydraulic conductivity is used to estimate the rate of flow of water into and through the soil, in other words a “soil acceptance rate”. Horizontal hydraulic conductivity is used for mounding analysis. Mounding occurs when infiltrated wastewater (which is moving in a vertical direction) encounters the water table and cannot flow “away” from the application site fast enough. The direction of this saturated flow or subsurface drainage has to be in a lateral direction “away” from the application site. Therefore some combination of K_v and K_h are used for mounding analysis. The further from the center of the mound, the more the ground water is controlled by

K_h . Saturated hydraulic conductivity (K_{sat}) is a field-derived K_v . Saturated hydraulic conductivity typically represents the fastest rate that clean water will move through the soil, and wastewater infiltration rates are usually lower than the K_{sat} .

Field-scale flooding basin tests (test areas at least 75 ft²) should also be considered for design purposes. This is because field-scale flooding measurements are typically more accurate than laboratory-derived permeabilities or double ring infiltrometer measurements for estimating hydraulic acceptance rates and ultimately system performance. The primary purpose of a flooding basin test is to define K_v . Basin flooding tests are conducted by flooding the basin(s) at an estimated rate, to determine a rate such that no standing water is present at the end of the loading period. The EPA has provided guidelines that should be used for conducting flooding basins tests (7).

Depending on suspended and dissolved solids the performance of RIBs may decrease with time. The EPA's allowable hydraulic loading rate (incorporating a safety factor) is approximately an order of magnitude less than the actual "effective" hydraulic conductivity (8).

To expedite permit issuance annual basin hydraulic loading limits will be set at ten percent of the measured *in-situ* infiltration rates (9). Laboratory and *in-situ* measurements are estimates of hydraulic performance. The final annual loading rates will be obtained by taking ten percent of the effective infiltration rate(s) obtained by basin-by-basin flooding tests, conducted after the permit is issued and the RIBs are built. These final loading rates will be included in the revised Final O & M plan that must be submitted for MPCA review and approval at the completion of the performance certification period (twelve months after initiation of operations).

Individual loading cycle application rates (as opposed to annual rates) are usually set at less than 50% of the observed infiltration rate to allow for reduced infiltration caused by organic matter and solids in the wastewater (10). This should also be addressed in the O & M Plan.

VII. Ground Water Mounding

Accurate soils and hydrogeologic information is needed to estimate the RIB system's performance. To reduce mounding and to provide maximum treatment the long axes of the RIBs should be aligned perpendicular to ground water flow direction. Therefore the direction of ground water flow should be determined in the areas proposed for the basins, prior to them being built.

Hydraulic acceptance rates are not mounding calculations. Mounding calculations need to be determined based on hydraulic loading rates, aquifer thickness, K_h and K_v , and depth to the seasonal high water table to ensure that an adequate aerated treatment zone is maintained. As per the EPA "The capillary fringe above ground water mounds should never be closer than 2 feet to the bottom of the infiltration basin. This corresponds to a water table depth of about 3 to 7 feet, depending on soil texture" (11).

Under certain circumstances such as systems located in coarse soils with a deep water table a more formal mounding analyses may not be necessary. However the closer the water table is to

the base of the RIBs, the more variable the soils, the higher the proposed loading rates and the lower the K_h , the more important mounding calculations become and corresponding, the more conservative the assumptions used should be when making the calculations. The EPA estimation (12) and the Finnemore and Hantzsche method (13) are acceptable methods for estimating mounding (see bottom of Appendix II).

Mounding calculations are estimates. Depending on the potential for mounding estimated from the mounding analyses piezometers will need to be installed between or immediately adjacent to the RIBs. An enforceable part of the MPCA permit will state that even with mounding, the ground water surface as measured in the piezometers will need to be kept 3 feet or lower than the bottom of the RIBs. Therefore the surveyed elevation(s) of the bottom of the RIBs need to be obtained for operational and comparative use later.

During construction, marginal overlying soils may be carefully removed from the proposed RIB site(s) to expose less hydraulically restrictive horizons. Unfortunately by doing so, it may bring the base of the RIB closer to the acceptable three feet separation distance of the (mounded) water table. When constructing RIBs the equipment that is used must minimize soil compaction.

VIII. Operational Criteria

Depending on site conditions and effluent strength loading and resting cycles may be selected to either maximize infiltration, or to maximize nitrogen removal. A regular drying period is necessary for system performance. To maximize infiltration the drying periods should be long enough to re-aerate the soil, to dry and oxidize the filtered solids. To maximize nitrogen removal the entire basin needs to be flooded, and the application period must be long enough for the soil bacteria to deplete soil oxygen, resulting in anaerobic/denitrifying conditions. Table 1 summarizes EPA suggested loading and resting cycles.

Table 1			
Suggested Loading and Resting Cycles			
Objective	Pond Discharge	Application Period (days)	Drying Period
Maximize Infiltration Rates	Primary	1-2	5-7
	Secondary	1-3	4-5
Maximize Nitrogen Removal	Primary	1-2	10-14
	Secondary	7-9	10-15

These wet/dry cycles are usually expressed as ratios. For example a load/rest cycle of load for one day and rest for five days would have a load/rest ratio of 0.2. For maximizing nitrogen removal from a secondary pond a load/rest ratio of 0.5 to 1 may be suggested. Loading and resting cycles are adjusted based on site-specific factors that include soil conditions and influent constituent of concern concentrations. The EPA six-step method may be used to estimate nitrogen removal based on wastewater strength, and various load/rest cycles (15).

From the MPCA’s perspective the most important operational criteria may be summarized as follows:

- A. Unless otherwise specified RIBs will not be operated in the winter (between 120-150 days);
- B. A minimum of three feet must be maintained between the top of the ground water mound and the bottom of the RIBs. If piezometers are required then the prescribed separation distance between the ground water and the bottom of the RIB system must be routinely observed and noted in the on-going operator’s reports;
- C. To the greatest extent possible flooded conditions should be maintained for the entire loading period to provide the anaerobic conditions necessary for denitrification;
- D. For each RIB all standing water at the end of the flooding period must infiltrate within the first one third of the drying period;
- E. The entire basin cross-sectional area must be uniformly loaded;
- F. Effluent limits and/or ground water limits in monitoring wells need to be met; and
- G. No springs, seeps or overland flow will be allowed hydraulically downgradient of the RIBs.

Depending on soil conditions (no soil horizons that restrict vertical root growth) and the depth to ground water (less than ten feet) a dense stand of hybrid poplar trees planted hydraulically down-gradient of the RIBs may evapotranspire much of the effluent from the system. The local Soil and Water Conservation District may be able to assist with the cost of planting and maintaining the trees. Due primarily to problems observed with reduced infiltration Reed Canary grass should not be grown in the RIBs to add a transpirational component.

IX. Engineering Design Report Submittal Requirements

The purpose of the Engineering Design Report is to ensure that the system will meet or exceed MPCA and accepted engineering standards for design, construction, operation, and maintenance. The requirements for the Engineering Design Report are found in Appendix VI.

With the Engineering Design Report a detailed draft O & M Plan needs to be submitted with the permit application. The O & M Plan (a manual) must include the following:

- system maintenance (basin maintenance performed when the basins are dry);
- proposed system yearly loading rate;
- specify the number and duration of individual loading and resting cycles;
- specify the order in which the RIBs will be loaded;
- describe how uniform distribution of the effluent over the entire basin floors will be undertaken and documented for each event;
- a Mitigation Plan; and
- a Sampling and Analysis Plan (for sampling the system, piezometers, and monitoring wells as required).

A Final O & M Plan must be submitted to the MPCA for review and approval at least 60 days prior to initiation of operation of the system. A *revised* Final O & M Plan that includes revised basin-by-basin loading rates must be submitted for review and approval at the end of the performance certification period (twelve months after initiation of operation). The revised Final O & M Plan must be complete enough to be used as a textbook for start-up training and plant start-up, including suggested operational criteria to be used as a guideline in attaining optimum treatment efficiency as soon as possible. More guidance on O & M Plans may be found at the following Internet address:

<http://www.pca.state.mn.us/water/wastewater.html#operation>

X. Example Problem

The following are examples of two soil profiles within a prospective site, and the associated analyses in terms of providing a preliminary estimate on hydraulic acceptance rates. The most hydraulically limiting (MHL) horizon in the profile is determined, and the vertical hydraulic conductivity (K_v) of that horizon is used for estimating hydraulic acceptance rates:

Profile A

0'-1'	silty sand topsoil (SM/OL)	
1'-2'	clayey sand (SC), $K_v = 4 \times 10^{-6}$ cm/s	---MHL---
2'-7.5'	poorly graded sand with gravel (SP), saturated/mottles at 7.0'	
7.5'-14'	lean clay, lean clay with sand (CL)	--base of the water table aquifer---
14'-16'	silt (ML)	

As per the EPA RIB guidance “Fine-textured soils, and even sandy soils with a significant silt or clay content (>10%) are not desirable” (16). This is because of their low *in-situ* permeabilities, and possibly the re-suspension and clogging of soil pores by fines. Therefore the SC soils as described in the boring log are “not desirable” for RIBs.

If the clayey sand is removed (excavated) from this location then only about 5' of unsaturated sand would be available to transmit the relatively large volume of water away from the RIB, without causing unacceptable mounding, or seeps or springs to emerge (daylight) downgradient of the proposed RIBs.

If the site is still being considered then mounding calculations need to be run with the SP hydraulic conductivity using 5' of sand over clay (assuming that the SM is excavated). Alternatively the RIB should be constructed elsewhere. Ground water depth and aquifer thickness must be accounted for when running mounding calculations.

Profile B

- 0'-2.5' medium sand (SP)
- 2.5'-4.5' sand, some silt (SP/SM)
- 4.5'-7.5' fine silty sand (SM), $K_v = 1.9 \times 10^{-3}$ cm/sec ---MHL---
- 7.5'-25'+ fine to medium grained sand (SP), saturated/mottles 10 feet below grade

Based on the boring log the hydraulic conductivity from 4.5'-7.5' needs to be used for estimating hydraulic loading rates. Alternatively removing the top 7.5' of soils would expose the underlying, much more permeable sands, but this may bring the top of the basin too close to the (mounded) water table.

What may be inferred from analyzing the two borings (if taken together) is a high degree of soil variability, possibly even within an individual RIB. Depending on the degree of variability more borings or test pits may be needed in the proposed RIB area(s), possibly with the less favorable areas being excluded from consideration.

The following is a worked example for estimating annual hydraulic loading rates. The most restrictive K_v within the proposed basin needs to be used for estimating hydraulic loading rates. The EPA only allows averaging of K_v s if there is no obvious restrictive layer (17).

Example Calculations Using Profile B

$$K_v = 1.9 \times 10^{-3} \text{ cm/sec; MPCA: use 10\% of } K_v ; (1.9 \times 10^{-3})(0.10) = 1.9 \times 10^{-4} \text{ cm/sec;}$$

$$(1.9 \times 10^{-4} \text{ cm/sec}) / (2.54 \text{ cm/inch}) = 1 \times 10^{-4} \text{ inch/sec.};$$

$$(1.0 \times 10^{-4} \text{ inch/sec}) / (12 \text{ in/ft.}) = 6.23 \times 10^{-6} \text{ ft/sec.};$$

$$(6.23 \times 10^{-6} \text{ ft/sec.})(60 \text{ sec/min})(60 \text{ min/hr})(24 \text{ hr/day}) = 0.54 \text{ ft/day};$$

The system is not operated between November 15 and April 15: 365 days – 150 days = 215 days;

Assume loading cycle is 1/3 of loading/resting cycle: 215/3 = 71 days;

$$(0.54 \text{ ft/day})(71 \text{ days}) = \underline{\underline{38 \text{ ft/year/basin @ 10\%}}}$$

$$\text{If each basin was } 200' \times 100' = 20,000 \text{ ft}^2 ;$$

$$(20,000 \text{ ft}^2)(38 \text{ ft/yr}) = 764,787 \text{ ft}^3/\text{yr};$$

$(764,787 \text{ ft}^3/\text{yr})(7.48052 \text{ gal}/\text{ft}^3) = 5,721,000 \text{ gal}/\text{yr} @ 10\%$; 3 basins = 17,163,000 gal/yr

In summary (as a preliminary estimate) if ten percent of the most restrictive vertical hydraulic conductivity is used then 38 feet/ year would be allowed in each of the three RIBs, for a total of 17,163,000 gallons per year.

Calculated loading rates are needed to provide an estimate of the hydraulic performance (and potential viability) of the system. Interim permit limits in the permit will be based on ten percent of *insitu* hydraulic conductivity tests. Final permit limits will be based on basin-by-basin loading tests run after construction of the basins, as specified in the revised Final O & M Plan that is submitted to the MPCA for review and approval at the completion of the performance certification period (twelve months after initiation of operation). The results of the post-construction basin flooding tests are multiplied by 0.1 (ten percent) to provide annual limits that includes the safety factor set by the EPA (18) and the MPCA.

Individual loading cycle application rates (as opposed to annual rates) are usually set at less than 50% of the K_v to allow for reduced infiltration by organic matter and solids in the wastewater. Note that depending on soil variability each basin may have its own hydraulic conductivity, and associated acceptance rate.

XI. Summary and Conclusions

RIBs may provide a cost-effective means of treating and dispersing municipal wastewater. A thorough site characterization is needed to determine system viability, and to estimate the hydraulic performance of the system. Empirically derived basin-by-basin loading tests conducted after the basins are constructed are used in conjunction with a “safety factor” to set final basin loading rates.

Depending on nitrogen concentrations in the effluent, ground water monitoring may be required. The separation distance between the ground water mound height and the base of the RIBs must be greater than three feet, and this separation distance may need to be verified with piezometers.

References

1. EPA. Process Design Manual for Land Treatment of Municipal Wastewater Supplement on Rapid Infiltration and Overland Flow. EPA 625/1-81-013a. 1984. p. 1
2. EPA. Process Design Manual for Land Treatment of Municipal Wastewater. p. 5-3.
3. EPA. Process Design Manual Land Treatment of Municipal Wastewater. EPA 625/1-81-013. 1981. p. 5-25
4. EPA. Process Design Manual Land Treatment of Municipal Wastewater. EPA 625/1-81-013. 1981. p. 5-26
5. EPA. Process Design Manual for Land Treatment of Municipal Wastewater Supplement on Rapid Infiltration and Overland Flow. EPA 625/1-81-013a. 1984. p. 47
6. Amoozegar, A. 1992. Compact Constant Head Permeameter: A Convenient Device for Measuring Hydraulic Conductivity. *Advances in Measurement of Soil Physical Properties*
7. EPA. Process Design Manual for Land Treatment of Municipal Wastewater Supplement on Rapid Infiltration and Overland Flow. EPA 625/1-81-013a. 1984. p. 23
8. EPA. Process Design Manual for Land Treatment of Municipal Wastewater Supplement on Rapid Infiltration and Overland Flow. EPA 625/1-81-013a. 1984. p. 28
9. EPA. Process Design Manual for Land Treatment of Municipal Wastewater Supplement on Rapid Infiltration and Overland Flow. EPA 625/1-81-013a. 1984. p. 29
10. EPA. Process Design Manual for Land Treatment of Municipal Wastewater Supplement on Rapid Infiltration and Overland Flow. EPA 625/1-81-013a. 1984. p. 33
11. EPA. Process Design Manual Land Treatment of Municipal Wastewater. EPA 625/1-81-013. 1981. p. 5-30
12. EPA. Process Design Manual for Land Treatment of Municipal Wastewater Supplement on Rapid Infiltration and Overland Flow. EPA 625/1-81-013a. 1984. p. 38
13. Finnemore, E.J and N. N. Hantzsche. June 1983. Ground-Water Mounding Due to On-Site Sewage Disposal. *Journal of Irrigation Drainage Engineering*. Vol. 109, No. 2.
14. EPA. Process Design Manual Land Treatment of Municipal Wastewater. EPA 625/1-81-013. 1981. p. 5-17
15. EPA. Process Design Manual for Land Treatment of Municipal Wastewater Supplement on Rapid Infiltration and Overland Flow. EPA 625/1-81-013a. 1984. p. 51
16. EPA. Process Design Manual for Land Treatment of Municipal Wastewater Supplement on Rapid Infiltration and Overland Flow. EPA 625/1-81-013a. 1984. p. 7
17. EPA. Process Design Manual Land Treatment of Municipal Wastewater Supplement on Rapid Infiltration and Overland Flow. EPA 625/1-81-013a 10/1984. EPA p. 28

18. EPA. Process Design Manual Land Treatment of Municipal Wastewater Supplement on Rapid Infiltration and Overland Flow. EPA 625/1-81-013a 10/1984. EPA p. 29

Appendix I

The RIB Permitting Process

Minnesota Pollution Control Agency staff is not required to begin review of a proposed project until it receives a complete application, including all of the necessary supporting documents. Failure to complete the application or submit the supporting documents will likely result in a delay in the issuance of the permit. The following is a description of the permitting process for a RIB system:

1. Meet, discuss proposed project with MPCA staff;
2. Submit Preliminary Proposal/Facilities Plan;
3. Submit site, soils, hydrogeologic workplans;
4. Site, soils, hydrogeologic reports approved by the MPCA;
5. MPCA approval of Preliminary Proposal/Facilities Plan;
6. Submit complete permit application, Plans and Specifications, supporting documents;
7. MPCA approval of Plans and Specifications;
8. Permit issued;
9. System constructed;
10. Conduct basin-by-basin flooding tests;
11. Final O & M Plan submitted to the MPCA 60 days prior to initiation of system operations;
12. Commence operations, 1 year certification period elapses;
13. 1 Year Certification Report and revised Final O&M Plan submitted to the MPCA; and
14. Permit modified as needed based on flooding tests.

The following information is required to initiate processing the RIB permit application:

1. SDS Permit application forms found at the MPCA's Web site.
<http://www.pca.state.mn.us/water/permits/index.html#>
Including:
 - Water Quality Transmittal Form
 - Attachment for Municipal Facilities
 - Stabilization Pond Information Sheet
 - Attachment for Municipal Land Application
2. RIB Guidance Document attachments that include the following:
 - Site Evaluation (Appendix II)
 - Soils Report (Appendix III)
 - Hydrogeologic Report and checklist (Appendix IV)
3. Engineering Report (Appendix V)
4. Additional information as appropriate.

The completed permit application forms, attachments and check must be sent to:

Minnesota Pollution Control Agency
Attn: Beckie Olson, Permit Document Coordinator
520 Lafayette Road North
St. Paul, Minnesota 55155-4194

To complete the permitting process the following must be submitted to and be approved by the MPCA **prior to permit issuance**:

- The MPCA-approved site investigation, soils, and hydrogeologic reports of the proposed site;
- the MPCA-approved Engineering Report. Please provide in the estimations the number and sizes of the basins, and any buffer areas. Projections of future wastewater needs should also be incorporated into these calculations;
- as needed, a workplan and report for installing piezometers and monitoring wells;
- as needed, a sampling and analysis plan for monitoring wells; and
- a draft O & M Plan. The O&M Plan will need to specify individual and annual loading rates, maintenance of the system, monitoring, etc. Interim limits in the will be based on ten percent of *insitu* hydraulic conductivity tests. Final limits will be based on basin-by-basin loading tests run after construction of the basins, as specified in the revised Final O & M Plan.

Appendix II
RIB Site Suitability Evaluation Methodology
Step-by-Step Procedure

Name of Project:
Legal Location:
County:
Name, address, and phone of project proposer:
General Description of the Project:
Proposed RIB Dimensions and Site Size:

Preliminary evaluation

A.	The average daily flow for the design to the RIB will be: _____ Gallons per day.
B.	Cultural and Other Conditions. Please prepare a preliminary map of the proposed site including the following information:
	Floodplain designation and flooding elevation from published data or data that is acceptable to and approved by the permitting authority, within 50 feet of the proposed system;
	<input type="checkbox"/> no floodplain within 50' <input type="checkbox"/> flood elev. drawn on map
	Wetland designations within 50 feet of the proposed system;
	<input type="checkbox"/> no wetland within 50' <input type="checkbox"/> wetland drawn on map
	Property lines of the proposed site;
	<input type="checkbox"/> Yes <input type="checkbox"/> No property lines drawn on map
	Current land use of the site and surrounding areas.
	<input type="checkbox"/> Yes <input type="checkbox"/> No Current land use drawn on map

Soil Survey Information

Please list all the soil map units for the proposed site along with the following soil characteristics.

Soil Feature	Soil Map Unit	Soil Map Unit	Soil Map Unit
	_____	_____	_____
Landscape position			
Flooding potential			
Slope range			
Seasonally saturated soil level			
Depth to bedrock			
Texture of all soil horizons			
Permeability of all soil horizons			
<input type="checkbox"/> Yes <input type="checkbox"/> No Soil survey map submitted with the location of the proposed site			
Note: For availability on Soil Survey maps, please refer to the local Natural Resource Conservation Service Office located in all counties in Minnesota.			

Surface Information

<input type="checkbox"/> Yes <input type="checkbox"/> No USGS quadrangle map submitted of proposed site and surrounding area.
Maps depicting:
<input type="checkbox"/> Yes <input type="checkbox"/> No property lines;
<input type="checkbox"/> Yes <input type="checkbox"/> No any municipal, industrial or domestic wells within a half-mile radius of the site;
<input type="checkbox"/> Yes <input type="checkbox"/> No actual boring and trench locations;
<input type="checkbox"/> Yes <input type="checkbox"/> No the proposed RIB configuration;
<input type="checkbox"/> Yes <input type="checkbox"/> No proposed monitoring points; and
<input type="checkbox"/> Yes <input type="checkbox"/> No any existing drain tile, and any surface water drainage features.
Note: For information on quadrangle maps, please refer to: http://mapping.usgs.gov/mac/findmaps.html

Field evaluation.

General:	
<input type="checkbox"/> Yes <input type="checkbox"/> No Meet with permitting authority and determine if any additional fieldwork needs to be conducted than what is outlined in this section	
List any additions here:	
<input type="checkbox"/> Yes <input type="checkbox"/> No Field work plan reviewed and approved by permitting authority.	
<input type="checkbox"/> Yes <input type="checkbox"/> No Site boundaries, setbacks, easements identified, located, and marked on-site and on maps.	
Note: Minnesota Statute 216D requires that anyone excavating must call the statewide notification center prior to the start of digging. For more complete information please refer to: http://www.dps.state.mn.us/pipeline/gsoc.html/	

Surface features. Identify, locate, and describe:

Provide a general description and classification of any wetland vegetation as per the US Army Corps of Engineers Wetlands Delineation Manual.
Note: Wetlands manual may be found at: http://www.wetlands.com/regs/tlpge02e.htm .
<input type="checkbox"/> Yes <input type="checkbox"/> No surface evidence of disturbance or compaction If yes, describe and locate on map any surface evidence of disturbed or compacted soil.
<input type="checkbox"/> Yes <input type="checkbox"/> No surface evidence of disturbance located on map
<input type="checkbox"/> Yes <input type="checkbox"/> No evidence of flooding or run-on potential
Describe and locate on map any flooding or run-on potential.
<input type="checkbox"/> flooding or run-on potential located on map
Landscape position, landform, micro-features, slope gradient and surface morphometry in accordance with the Field Book for Describing and Sampling Soils, USDA – NRCS.
Description of geomorphic surface features:

Describe number, locations, descriptions of any hand borings:
Note: The field book can be obtained from: (http://www.statlab.iastate.edu/soils/nssc/field_gd/field_gd.pdf)

Describe any discrepancies between the onsite soil information with the soil survey information.
Please resolve any discrepancies, and identify the soil information to be used for design.
Please list the elevation to bedrock, if encountered, and the determination of how that elevation was derived (please refer to Minnesota Rules 7080)
Please list the elevation to the seasonally/periodically saturated soil, if encountered, and the determination of how that elevation was derived* (please refer to MR 7080):
<i>*If redoximorphic features are deemed not to be reflective of current day seasonally saturated levels, please submit other information to determine the depth of the seasonally saturated soil (see footnote on redoximorphic features below).</i>
Determine the elevation of the bottom of the RIB system:
Please provide an assessment if the soil has been disturbed, compacted, cut filled or other unnatural condition:
Please provide a description of the uniformity of the soil over the site.
<input type="checkbox"/> Yes <input type="checkbox"/> No Proposed site is or will be protected from disturbance, compaction or other damage by staking, fencing, posting or other effective method.

Appendix III

RIB Site Soils Evaluation

The permittee must undertake a Site Soils Evaluation irrespective of the nitrogen management option that is selected. The purpose of the Soils Evaluation is to adequately characterize the site soils for design purposes.

Soils are critical for the treatment process. The person who prepares the soils report must certify by signature that they have expertise in Soil Science as defined by education and experience (especially soil morphology) which includes having taken the Onsite Sewage Treatment Workshop Soils class or equivalent. Under some circumstances the person who designates where the soil pits are to be located may differ from the individual who actually logs the soil pits. If this occurs, then it must be noted in the Soils Report.

The general procedure for characterizing site soils is as follows:

- Obtain the Natural Resources Conservation Service (NRCS) soil survey maps of the proposed RIB site and evaluate soil variability.
- For uniform soils at least one test pit per basin, or one per 10,000 square feet is suggested. If soils are more variable then more pits may be needed.

Test pits should be located immediately adjacent to the proposed RIBs, to reduce soil disturbances within the basins. Test pits are generally less than 10' deep. As such soil borings must be used to provide information below and around the test pits as necessary.

A minimum of four deeper borings are also required to determine the depth to the seasonal high water table. For mounding calculations at least two borings should extend all the way through the saturated zone.

Continuous vertical observations and/or sampling of the entire vertical extent of the pit wall or boring using the ASTM D 2487 or the USDA field taxonomy must be used. The test pit and soil boring logs must contain the soil horizon, field texture, structure (grade and shape), consistence, moisture content, elevation of ground water (perched or otherwise), Munsell colors, and redoximorphic features such as gleying and mottling. A determination of seasonal high ground water table must be made, and the elevations of the pits must also be submitted.

Laboratory derived or preferably *in-situ* permeability measurements and grain size analyses of the most transmissive and most hydraulically limiting soil horizons should be obtained and be compared with other site information.

The *estimated* hydraulic loading rates are determined primarily from soil texture, consistency, and structure. Loading rates are also determined from saturated hydraulic conductivity, (K_{sat}) measurements made of the most *and* least transmissive horizon within five feet of the bottom of the proposed system, above the seasonal high water table.

Combinations of these soil properties assist in determining the most limiting horizon, and provide estimates of individual and annual loading rates.

In-situ measurements of K_{sat} using a double ring infiltrometer (or equivalent method) in most cases should be undertaken, especially on less favorable sites. It should be noted that the measured K_{sat} typically represents the fastest rate that clean water will move through the soil, and that waste water infiltration rates are usually lower than the K_{sat} .

Perhaps the best method to estimate hydraulic acceptance rates is to use test infiltration basins. If test infiltration basins (test areas at least 75 ft²) are used then *in-situ* saturated hydraulic conductivity measurements typically then would not be required.

Checklists and worksheets to be included with the Site Soils Evaluation Report

I. Soil Descriptions

<input type="checkbox"/> Yes <input type="checkbox"/> No A minimum of one soil pit per basin or one per 10,000 square feet (whichever is more) of proposed site examined, with the pits located within or on the borders of the proposed system. If possible the test pits should be located outside of the proposed basins to reduce soil disturbances.
<input type="checkbox"/> Yes <input type="checkbox"/> No Soil profiles in pits described to a depth of 5 feet below the proposed depth of the system.
<input type="checkbox"/> Submitted rationale for the final number of soil pits excavated and described <input type="checkbox"/> Submitted the number, location, and depth of the test pits <input type="checkbox"/> Submitted the number, location, and depth of deeper borings <input type="checkbox"/> Submitted in-depth discussion of site soils
<input type="checkbox"/> Submitted Soil Description sheets (<i>located on page 27</i>) for all soil pits/borings.
Note: Occupational safety and health administration regulations (29 CFR 1926 Subpart P) apply to entering certain types of excavations. For more information, please refer to: http://www.osha.gov/SLTC/confinedspaces/

II. Soil Hydraulic Conductivity Testing Checklist

Hydraulic conductivity testing should be undertaken for the most transmissive horizon within five feet of the bottom of the proposed system. If the least transmissive horizon observed within the test pit(s) has an anticipated conductivity that is appreciably slower than the horizon receiving the effluent then the hydraulic conductivity of the least transmissive horizon should also be determined.
Which method of hydraulic conductivity testing was conducted?
<input type="checkbox"/> Permeameter
<input type="checkbox"/> Infiltrometer
<input type="checkbox"/> Test basins
<input type="checkbox"/> Other method _____
<input type="checkbox"/> Submitted the method used to conduct the test
<input type="checkbox"/> Submitted the readings and calculations
<input type="checkbox"/> Submitted the number location and depth of the tests (min of 3 tests on the most and least transmissive horizons)
<input type="checkbox"/> Submitted the number location and depth of any deep tests

III. Soil interpretation for system design (use as an attachment to the Soils Report)

Describe which surface topography and soil features will affect system siting design and performance
Localized run-on of storm water drainage:
Regional Flooding:
Constructability (slope, gradient, etc.):
Constructability (clay percentage i.e., smearing, compaction):
Determine if the system requires any setbacks:
<input type="checkbox"/> Yes <input type="checkbox"/> No buildings
<input type="checkbox"/> Yes <input type="checkbox"/> No water supply
<input type="checkbox"/> Yes <input type="checkbox"/> No water pipes
<input type="checkbox"/> Yes <input type="checkbox"/> No surface water setbacks
Describe any discrepancies between the onsite soil information with the soil survey information.
Please resolve any discrepancies, and identify the soil information to be used for design.
Please list the elevation to bedrock, if encountered, and the determination of how that elevation was derived (please refer to Minnesota Rules 7080)
Please list the elevation to the seasonally/periodically saturated soil, if encountered, and the determination of how that elevation was derived* (please refer to MR 7080):
Please describe the suggested hydraulic loading rates for the proposed system.
Overall suitability evaluation of the site, and a description of any site limitations

Soil Description Worksheet

**If redoximorphic features are deemed not to be reflective of current day seasonally saturated levels, please submit other information to determine the depth of the seasonally saturated soil (see footnote on redoximorphic features below).*

IV. Phosphorous Evaluation

A site phosphorous evaluation must also be included in the soils report. The criteria for undertaking a phosphorous evaluation are provided below.

Table 2: Phosphorous Impact Evaluation

Soil Texture	Distance to Nearest Receiving Water
Sand	2,500 feet
Loam	1,500 feet
Clay loam	300 feet

Site Phosphorous Evaluation Checklist

- Yes** **No** **Based on the above chart, the proposed RIB is within the potential impact distance.**
 If yes, then I am, therefore required to complete a Phosphorus Impact Study.

At a minimum, the Study shall include the following items:

- A detailed discussion of the Phosphorus adsorption capacity of the soil
- A detailed discussion of the expected phosphorus breakthrough to the receiving water.
- Modeled results?
- Supporting documentation including pertinent calculations?
- Treatment options? Including BMPs, source reduction options, facility treatment options?

NOTE: Designers should work with agency staff to perform this evaluation prior to application submittal.

USDA Methodology

(use one sheet per test pit or boring)

Date:	Vegetation:
Project:	Landscape:
Location:	
Soil Survey Map Unit:	Slope Form:
Disturbed Soil : <input type="checkbox"/> Yes <input type="checkbox"/> No	Slope:
Type of Observation: <input type="checkbox"/> pit <input type="checkbox"/> boring auguring	Floodplain: <input type="checkbox"/> Yes <input type="checkbox"/> No

Depth (in)	Horizon Designation	Coarse Fragments	Texture (abundance, size, contrast)	Matrix Color (abundance, size, contrast)	Redox Features (abundance, size, contrast)	Structure (Shape, Size, Grade)	Consistency	Roots (abundance and size)	Pores (Quantity and size)	Concretions Nodules	Boundary
Backhoe test pit ground surface elevation	Depth to Seasonally Saturated Soil (see footnote below)		Depth of Standing Water in Hole/Pit (if any)			Depth to Bedrock (if any)	Proposed Bottom of System Elevation			Estimated Infiltrative Loading Rate	

Weather and light conditions:

Appendix IV RIB Hydrogeologic Report and Checklist

A detailed Hydrogeologic Investigation Report and ground water monitoring report will be required for RIB systems unless the conditions described in Option 1 (see Section II) are met. The purpose of the report is to document hydrogeologic properties that include depth to ground water, ground-water flow direction, estimated ground water flow rates, ambient geochemistry, proximal receptors, the potential for unacceptable ground water mounding, and to establish a ground water monitoring network.

The person who prepares the report must certify by signature that they have expertise in Hydrogeology as defined by education and experience. The report must summarize existing (published) information, and information obtained in the field.

If ground water monitoring is required then at least one monitoring well must be installed in the approximate up-gradient location, and sampled three times **prior to permitting**. The purpose of sampling prior to permitting is to ensure that the permit reflects ambient conditions, so limits will not have to be changed once the system becomes operational.

Although not required to obtain a permit a Hydrogeologic Investigation Work Plan (Work Plan) should be submitted to the MPCA prior to initiating the field work. If the field work is performed without MPCA review and approval of a Work Plan, and it does not meet minimum requirements, then more field work will be required.

Typically for a RIB system a minimum of four deep borings are completed (in addition to the test pits required with the soils work) along with the three monitoring wells (a minimum of one up-gradient, and two down-gradient). Down-gradient monitoring wells may be located no further than the property boundary. Due to discharge flow dynamics the further from the system the monitoring wells are located, the more monitoring wells may be required to adequately monitor the site.

Under certain conditions constricted lateral movement of the effluent in the soil matrix may cause mounding of ground water. For proper soil based treatment the system must maintain a minimum of a three foot aerobic zone below the bottom of the RIBs. Mounding calculations are suggested for all RIB systems. Under certain circumstances, such as systems located in coarse soils with a deep water table, mounding analyses may not be necessary.

Alternative design approaches may be used to prevent and minimize the potential for mounding. At minimum, either mounding calculations or a rationale for why mounding calculations are not necessary for the project, must be submitted with the hydrogeologic evaluation. Additional mounding caused by adjacent basins also must be taken into account.

Unless it can be clearly demonstrated that unacceptable mounding will not occur, piezometers will be required. The purpose of the piezometers is to measure mounding during system operations, and to maintain an aerobic zone under the system during operation.

The proposed locations and rationale for the piezometers needs to be submitted to the MPCA. A MPCA-approved workplan will be needed for piezometer installation.

If ground water monitoring is required, then a ground water sampling and analysis plan (SAP) will need to be submitted to the MPCA for review and approval. Depending on the proximity of the RIBs to surface waters additional standards may need to be applied to the monitoring points. A template for a SAP is available at the following Internet address:
<http://www.pca.state.mn.us/water/pubs/gwprocwells.pdf>

Estimating Mound Height

For sites where unacceptable mounding may be an issue estimating the extent of mounding is required to ensure that ground water does not rise to within three feet of the bottom of the system during loading. Mounding calculations must also consider mounding influences from adjacent basins.

Deep borings must be conducted to a minimum of 10 feet below the proposed system bottom to determine soil properties. *In-situ* hydraulic conductivity tests (slug tests, pump tests) conducted sufficiently below the water table to conduct the tests may also be suggested. If not, a minimum of three laboratory hydraulic conductivity measurements of the most and least transmissive horizons must be made.

Recommended Mounding Calculation - Finnemore and Hantzche

zm = Mound height in center of system (ft)

$$zm = IC * (L/4)^n * (1/ K_h * h)^{0.5n} * (t/Sy)^{1-0.5n}$$

- t** = Time (days): (365 days/year)-(150 days not in use) = 215 days
- I** = Average daily loading rate (ft/day) = Design loading rate/215
- C** = from chart below
- L** = Length of system (ft)
- n** = from chart below
- K** = from hydraulic testing
- h** = $h_o + z_m/2$
- Sy** = Specific Yield
- h_o** = Aquifer thickness (ft)
- zm (guess)** = estimated mound height

Table 3: Finnemore and Hantzche Length to Width Ratios

L/W Ratio	C	N
1	3.4179	1.7193
2	2.0748	1.7552
4	1.1348	1.7716
8	0.5922	1.7793

Note: The two dimensions of an RIB (length and width) is included in the Length to Width (L/W) Ratio found in the "c" and "n" values of the formula

The final result of this calculation is to estimate if the proposed system will have at least three feet of separation between the bottom of the system and the predicted mound (including a capillary fringe) height.

Hydrologic Report Requirements

The Hydrogeologic Report must include a detailed discussion of the following elements:

- Physiographic setting/topography/slopes;
- Hydrology;
- Geology and hydrogeology to include descriptions of local, intermediate and regional ground water flow regimes;
- Depth to current and seasonal ground water;
- Hydraulic gradient;
- Hydraulic conductivity;
- The directions and rates of ground water flow;
- Geologic cross-sectional analysis of the site including the presence of deeper limiting layers, perched water tables, bedrock, karst, etc.;
- Background ground water quality data;
- Potential or actual receptors; and
- Mounding analyses

The following checklist must be attached to the Hydrogeologic Report to ensure that all of the required elements described above are included in the Report.

Required Elements for a RIB Hydrogeologic Investigation Report	Completed?		SUBMITTAL PAGE No.	COMMENTS	MPCA USE
	YES	NO			
1. A USGS topographic map showing:					
• the proposed location of the system	<input type="checkbox"/>	<input type="checkbox"/>			
• the property boundary	<input type="checkbox"/>	<input type="checkbox"/>			
• the borings, test pits, piezometer and monitoring well locations	<input type="checkbox"/>	<input type="checkbox"/>			
• domestic or municipal wells within 1/2 mile radius of the proposed system	<input type="checkbox"/>	<input type="checkbox"/>			
• any wellhead protection areas within a mile radius of the proposed system	<input type="checkbox"/>	<input type="checkbox"/>			
2. Discussion, logs of deeper borings	<input type="checkbox"/>	<input type="checkbox"/>			
3. Proposed municipal or domestic well setbacks	<input type="checkbox"/>	<input type="checkbox"/>			
4. Narrative on the physiographic setting/topography/slopes	<input type="checkbox"/>	<input type="checkbox"/>			
5. Summary of the soils investigation	<input type="checkbox"/>	<input type="checkbox"/>			

Required Elements for a RIB Hydrogeologic Investigation Report	Completed?		SUBMITTAL PAGE No.	COMMENTS	MPCA USE
	YES	NO			
6. Local, intermediate and regional hydrology, Including site drainage	<input type="checkbox"/>	<input type="checkbox"/>			
7. Proximity to a flood plain	<input type="checkbox"/>	<input type="checkbox"/>			
8. Geologic narrative (local, intermediate and regional)	<input type="checkbox"/>	<input type="checkbox"/>			
9. Perpendicular geologic cross-sections including incorporating the results of the soils investigation	<input type="checkbox"/>	<input type="checkbox"/>			
10. Hydrogeologic narrative (vertical and horizontal, local, intermediate and regional ground water flow)	<input type="checkbox"/>	<input type="checkbox"/>			
11. Potentiometric surface map showing alignment (perpendicular) of system in relation to ground water flow direction	<input type="checkbox"/>	<input type="checkbox"/>			
12. Discussion, results of the phosphorous evaluation done in Soils Report	<input type="checkbox"/>	<input type="checkbox"/>			
13. Discussion, results of ground water mounding analyses	<input type="checkbox"/>	<input type="checkbox"/>			
14. Recommendations based on the report	<input type="checkbox"/>	<input type="checkbox"/>			
15. Discussion on K_v , K^h , and K^{sat}	<input type="checkbox"/>	<input type="checkbox"/>			
16. Mounding analyses	<input type="checkbox"/>	<input type="checkbox"/>			

Appendix V RIB Limited Hydrogeologic Report and Checklist

The following checklist must be used when submitting a Limited Hydrogeologic Investigation Report for a RIB system with pretreatment sufficient to reduce total nitrogen concentrations in the effluent to 10 mg/L or less (i.e. nitrogen management Option One).

On-going monitoring of total nitrogen in the effluent will be required to ensure that the total nitrogen concentrations in the effluent remain at 10 mg/L or less. If subsequent on-going monitoring demonstrates that the system cannot meet the limit of 10 mg/L or less, then a more detailed Hydrogeologic Investigation and ground water monitoring may be required.

Please note that irrespective of any Hydrogeologic Investigation Report requirements that deeper borings will be required to assess among other things ground water mounding.

Required Elements for a Limited LSTS Hydrogeologic Investigation Report	Completed?		SUBMITTAL PAGE No.	COMMENTS	MPCA USE
	YES	NO			
1. The name, title and signature of the person preparing the report	<input type="checkbox"/>	<input type="checkbox"/>			
2. Description of the system that includes:					
• legal description of the land (township section, range)	<input type="checkbox"/>	<input type="checkbox"/>			
• brief RIB description (conveyance system, ponds, basins etc.)	<input type="checkbox"/>	<input type="checkbox"/>			
• design flow of the system	<input type="checkbox"/>	<input type="checkbox"/>			
• size of the RIB (square feet of bed area)	<input type="checkbox"/>	<input type="checkbox"/>			
• projected flow rates to the RIBs (gallons/day/ft ²)	<input type="checkbox"/>	<input type="checkbox"/>			
3. A USGS topographic map showing:					
• the proposed location of the system	<input type="checkbox"/>	<input type="checkbox"/>			
• the borings, test pits, and piezometers	<input type="checkbox"/>	<input type="checkbox"/>			
• existing domestic or municipal wells within 1/4 mile radius of the proposed system	<input type="checkbox"/>	<input type="checkbox"/>			
• wellhead protection areas within a half mile radius of the proposed system	<input type="checkbox"/>	<input type="checkbox"/>			
4. Proposed municipal or domestic well locations and setbacks	<input type="checkbox"/>	<input type="checkbox"/>			
5. Narrative on the physiographic setting/topography/slopes	<input type="checkbox"/>	<input type="checkbox"/>			

	Completed?			COMMENTS	MPCA USE
	<input type="checkbox"/>	<input type="checkbox"/>			
6. Summary of the soils investigation	<input type="checkbox"/>	<input type="checkbox"/>			
7. Discussion, logs of deeper borings	<input type="checkbox"/>	<input type="checkbox"/>			
8. Local, intermediate and regional surface water hydrology Including site drainage and proximity to a flood plain using existing information	<input type="checkbox"/>	<input type="checkbox"/>			
9. Proximity to a flood plain	<input type="checkbox"/>	<input type="checkbox"/>			
10. Geologic narrative using existing information (E.G. Hydrogeologic Atlas)	<input type="checkbox"/>	<input type="checkbox"/>			
11. Separation to bedrock using results from soils investigation and information from existing (published) sources	<input type="checkbox"/>	<input type="checkbox"/>			
12. Is karst if present	<input type="checkbox"/>	<input type="checkbox"/>			
13. Discussion, results of ground water mounding analyses	<input type="checkbox"/>	<input type="checkbox"/>			
14. Discussion, results of the phosphorous evaluation	<input type="checkbox"/>	<input type="checkbox"/>			
15. Discussion, results of ground water mounding analyses	<input type="checkbox"/>	<input type="checkbox"/>			
16. Recommendations based on the report	<input type="checkbox"/>	<input type="checkbox"/>			
17. Discussion on K_v , K_h , and K_{sat}	<input type="checkbox"/>	<input type="checkbox"/>			
18. Mounding analyses	<input type="checkbox"/>	<input type="checkbox"/>			

Estimating Mound Height

Estimating the extent of mounding is required to ensure that ground water does not rise under the system during loading and reduces the designed separation and treatment distance between the saturated soil and the bottom of the system. The Finnemore and Hantzche mounding method is provided in Appendix IV.

Appendix VI

RIB Engineering Report Requirements Checklist

The design professional shall certify (by signature) to the following general conditions:

- The plans and specifications including the Engineering Report were prepared under the direct supervision of a Registered Professional Engineer licensed in the State of Minnesota.
- The design professionals preparing the Engineering Report are qualified to design wastewater systems.
- The wastewater system will not discharge directly to the surface of the ground or to surface waters.
- That a minimum distance of three feet must exist between the discharge point and the seasonal high water table and/or the estimated mound height.
- That the monitoring wells (if used) are installed according to the Minnesota Water Well Construction Code, Minnesota Rules ch 4725.

Required Elements for a RIB Engineering Report	Completed ?		SUBMITTAL PAGE No.	COMMENTS	MPCA USE
	YES	NO			
1. The name, title and signature of the person preparing the report	<input type="checkbox"/>	<input type="checkbox"/>			
2. Description of the system that includes:					
• location	<input type="checkbox"/>	<input type="checkbox"/>			
• environmental setting	<input type="checkbox"/>	<input type="checkbox"/>			
• demographics	<input type="checkbox"/>	<input type="checkbox"/>			
• wastewater characteristics	<input type="checkbox"/>	<input type="checkbox"/>			
3. Design flow	<input type="checkbox"/>	<input type="checkbox"/>			
4. Description of design loadings with appropriate design manual references	<input type="checkbox"/>	<input type="checkbox"/>			
5. A description of the proposed wastewater treatment system referencing the plans and specifications.	<input type="checkbox"/>	<input type="checkbox"/>			
• description of flow monitoring methods	<input type="checkbox"/>	<input type="checkbox"/>			
• description of treatment technology	<input type="checkbox"/>	<input type="checkbox"/>			
• describe and size all pumps and appurtenances	<input type="checkbox"/>	<input type="checkbox"/>			
• describe RIB design	<input type="checkbox"/>	<input type="checkbox"/>			
6. Plans and Specifications	<input type="checkbox"/>	<input type="checkbox"/>			
7. Operations and Maintenance Plan	<input type="checkbox"/>	<input type="checkbox"/>			