Utah Guidance for Constructing Rapid Infiltration Basins (RIBs)

Utah Department of Environmental Quality
Division of Water Quality

Photo of a RIB system (Neal Wilson, Minnesota Pollution Control Agency, 2005).

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INTRODUCTION

The purpose of this document is to provide technical and regulatory guidance for constructing rapid infiltration basins for the disposal of treated wastewater effluent. Much of the information in this guidance was adopted from a similar guidance written by Neal Wilson, Senior Hydrogeologist with the Minnesota Pollution Control Agency. Another important reference is the National Ground Water Association Short Course "Artificial Recharge of Ground Water" (Daniel B. Stephens & Associates, Inc., 2008).

What is a Rapid Infiltration Basin?

As the name implies, a rapid infiltration basin (RIB) is an earthen basin designed to promote rapid infiltration and dispersal of treated effluent into the subsurface. Because they are designed for rapid infiltration, RIBs should only receive treated effluent that complies with the Utah Ground Water Quality Protection Rules (UAC R317-6). In particular, total inorganic nitrogen must be less than 10 milligrams per liter (mg/l) for Class IA Pristine and Class II Drinking Water Quality ground water, and under 20 mg/l for Class III Limited Use and Class IV Saline ground water. In addition, total dissolved solids (TDS) can not exceed the upper TDS limit of the underlying ground water class.

Table 1: Utah Ground Water Classes

Ground Water Class	Beneficial Use	TDS Range (mg/l)	TDS Upper Limit (mg/l)
IA	Pristine	<500	500
II	Drinking Water Quality	501-3,000	3,000
III	Limited Use	3,001-10,000	10,000
IV	Saline	>10,000	none

For example, Class II ground water has a TDS range between 501 and 3,000 mg/l. Therefore, the treated effluent entering the RIB can not exceed a TDS of 3,000 mg/l. Because the treated effluent discharge must meet Ground Water Quality Standards, RIBs qualify for ground water discharge permit-by-rule and are not required to obtain a ground water discharge permit. However, an Operating Permit is required to verify that the effluent quality standards are being met and the RIB is operating effectively as designed.

How Does a RIB System Operate?

A RIB system is managed by repetitive cycles of hydraulic loading, infiltration, and drying. Rapid infiltration of treated wastewater is based on a relatively high rate of wastewater infiltration into the soil followed by rapid percolation vertically and/or laterally. The best soils for rapid infiltration are coarse textured with high permeability (EPA, 1984). Particulates, trace metals, and suspended solids are removed in part at or near the soil surface. A RIB drying cycle is typically five to 10 times longer than the hydraulic loading cycle and in areas with long-term freezing temperatures in winter, shallow RIB systems are usually not operated during winter months (90-150 days). These criteria need to be considered when proposing RIB hydraulic loading rates.

PRELIMINARY DESIGN

The goals of RIB design are to:

1. Maximize infiltration;
2. Minimize land area;
3. Minimize construction costs, such as earth moving; and
4. Minimize maintenance costs.

Favorable Site Characteristics

The following site characteristics are favorable for constructing a successful high performing RIB system and reducing environmental impacts.

- Relatively level elevation;
- Thick section of uniform, highly permeable unsaturated soils;
- Deep water table; and
- Adjacent to a ground water discharge area.

Soils
To avoid fine-grained soils, RIBs should not be constructed on backfilled materials, and soil compaction must be minimized during construction. To compensate for low infiltration rates due to fine-grained soils, more and larger RIBs with lower hydraulic loading rates may be required.

Depth to Ground Water
Shallow water tables reduce the vertical gradient, which requires a larger basin area. Without a clogging layer, infiltration becomes independent of water table depth as depth to water increases. If depth to water is twice the basin width, the shallow water table limitation can be ignored.

Unfavorable Site Conditions

Sites with steep slopes, shallow water tables, and adjacent to wetlands may compromise the performance of the RIB system. In addition, the following site characteristics are not favorable for a proposed RIB system:

- Within wellhead protection areas;
- Areas underlain by hardpan or with shallow bedrock;
- Located above a sole-source aquifer; and
- Located in a flood plain.

To protect drinking water sources, RIBs are prohibited in Zones I and II of Source Water Protection Areas and may be allowed in Zone III for a confined aquifer.

Minimum Number of RIBs

The minimum number of basins for a successful RIB system is three, but the number of basins can vary from three to 17 depending on the need for continuous discharge. Individual basin size can range from one-half acre to five acres for small to medium-sized systems and from five to 20 acres for larger systems. The EPA has provided guidance on the number of basins needed for an effective RIB system based on the projected number and duration of hydraulic loading and drying cycles (EPA, 1981).

Basin Dimensions

To maximize land use, multiple infiltration basins should adjoin one another and be rectangular in shape. Rectangular basins are preferred because larger side areas allow higher infiltration rates than square or circular basins of the same area. In addition, long, narrow basins with their length perpendicular to the ground water flow direction may reduce ground water mounding. The potential for unacceptable mounding in adjacent basins needs to be evaluated during system design (EPA, 1981). Deeper basins may be preferable to allow for greater head and higher infiltration, and the reduced sunlight penetration may inhibit algae growth on the bottoms of RIBs.

Dikes

Each basin should be constructed at least 12 inches deeper than the maximum design wastewater depth (EPA, 1981). 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 (EPA, 1984). Dikes must be protected from erosion both during and after construction to keep fines from washing in and reducing basin infiltration by clogging.

REQUIREMENTS FOR A SITE SUITABILITY EVALUATION

A Site Suitability Evaluation should be conducted to characterize the proposed RIB location. This includes estimating hydraulic loading rates and ground water mounding. A minimum of four feet of unsaturated soil must exist between the bottom of each basin and the expected height of the ground water mound, including the capillary fringe. For RIB systems where mounding analyses indicate a potential mounding problem, piezometers must be installed and on-going measurements must be made as part of an Operating Permit to ensure that a minimum four-foot separation is maintained during operation.

Hydraulic Loading Rates

Annual and individual hydraulic loading rates for a proposed RIB system must be determined by: 1) adequately characterizing site soils; 2) estimating annual and daily hydraulic loading rates; and 3) verifying the estimates with empirically-derived (actual) basin-by-basin hydraulic loading tests after the basins have been constructed.

Hydraulic loading rates are estimated primarily on texture, consistency, 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 corresponding infiltration rates below the system.

To estimate hydraulic loading rates, hydraulic conductivity values must be determined for the most transmissive and the most hydraulically limiting horizons (Amoozegar, 1992). In-situ measurements using a double ring infiltrometer or equivalent method are preferred, but laboratory sieve and permeability measurements are acceptable. An example problem is provided at the end of this section.

When working with RIBs, the terms vertical hydraulic conductivity (Kv), horizontal hydraulic conductivity (Kh) and saturated hydraulic conductivity (Ksat) are used. Vertical hydraulic conductivity is used to estimate the flow rate downward through the soil, and can be considered as a "soil acceptance rate". Horizontal hydraulic conductivity is used for mounding analysis. Mounding occurs when infiltrating wastewater 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 Kv and Kh are used for a mounding analysis and the further away from the mound center, the more the ground water is controlled by Kh. Saturated hydraulic conductivity (Ksat) is a field-derived Kv. Ksat typically represents the fastest rate that clean water will move through the soil, and wastewater infiltration rates are usually lower than the Ksat.

Field-scale basin hydraulic loading tests should also be considered for design purposes. This is because field-scale flooding measurements are typically more accurate than laboratory-derived permeability or double-ring infiltrometer measurements for estimating hydraulic acceptance rates and ultimately system performance. The primary purpose of a basin hydraulic loading test is to define Kv. Hydraulic loading 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 basin hydraulic loading tests (EPA, 1984, p. 23).

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 (EPA, 1984, p. 28).

To expedite issuance of an Operating Permit, annual basin hydraulic loading limits will be set at 10% of the measured in-situ infiltration rates (EPA, 1984, p. 29). Laboratory and in-situ measurements are estimates of hydraulic performance. The final annual hydraulic loading rates will be obtained by taking 10% of the effective infiltration rate(s) obtained by basin-by-basin hydraulic loading tests, conducted after the permit is issued and the RIBs are built. These final loading rates will be included in the Operating Permit that must be obtained from DWQ at the completion of the performance certification period (twelve months after initiation of operations).

Individual loading cycle 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 (EPA, 1984, p. 33). This should also be addressed in the Operating Plan and Operating Permit.

Example Problem

Below are examples of two soil profiles within a prospective site, and the analyses for providing a preliminary estimate on hydraulic acceptance rates. The most hydraulically limiting horizon (MHL) 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; this represents the MHL layer.
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)

According to the EPA RIB guidance “Fine-textured soils, and even sandy soils with a significant silt or clay content (>10%) are not desirable” (EPA, 1984, p. 7). This is because of their low in-situ permeabilites, 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 from this location then only about five feet 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 estimates must be calculated with the SP hydraulic conductivity using five feet of sand over clay (assuming that the SM is removed). Alternatively, the RIB should be located elsewhere. Depth to ground water and aquifer thickness must be accounted for when estimating ground water mounding.

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), $Kv = 1.9 \times 10^{-3}$ cm/sec; this represents the MHL layer.
7.5-25’+	fine to medium grained sand (SP), saturated/mottles 10 feet below grade.

Based on the boring log, the lithology from 4.5-7.5’ is the most hydraulically limiting horizon (MHL) and must 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 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 areas, possibly with the less favorable areas being excluded from consideration.

Below is an example for estimating annual hydraulic loading rates. The most restrictive Kv within the proposed basin must be used to estimate hydraulic loading rates. EPA only allows averaging Kv values if there is no obvious restrictive layer (EPA, 1984, p. 28).

Example Calculations Using Profile B
Kv= 1.9 x 10^{-3} cm/sec; use 10% of Kv; (1.9 x 10^{-3})(0.10) = 1.9 x 10^{-4} cm/sec.
(1.9 x 10^{-4} cm/sec)/(2.54 cm/inch) = 1 x 10^{-4} inch/sec.
(1.0 x 10^{-4} inch/sec)/(12 in/ft.) = 6.23 x 10^{-6} ft/sec.
(6.23 x 10^{-6} ft/sec.)(60 sec/min)(60 min/hr)(24 hr/day) = 0.54 ft/day.

The system is not operated during the winter months 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 ft/day)(71 days) = 38 ft/year/basin @ 10%.

Given a basin size 200' x 100' = 20,000 ft^2: (20,000 ft)(38 ft/yr) = 764,787 ft^3/yr.
(764,787 ft^3/yr)(7.48052 gal/ ft^3) = 5,721,000 gal/yr @ 10%; 3 basins =17,163,000 gal/yr

Therefore, if 10% 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 gal/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 Operating Permit will be based on 10% of in-situ 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 Operating Permit issued by DWQ after completion of the performance certification period. The results of the post-construction basin flooding tests are multiplied by 0.1 to provide annual limits that includes the safety factor set by EPA (EPA, 1984, p. 29).

Individual loading cycle application rates (as opposed to annual rates) are usually set at less than 50% of the Kv 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 soil acceptance rate.

Ground Water Mounding

Mounding calculations must be determined based on hydraulic loading rates, aquifer thickness, Kh, Kv, and the depth to the seasonal high water table. According to EPA, "The capillary fringe above the ground water mound should never be closer than two feet to the bottom of the RIB. This corresponds to a water table depth of about three to seven feet below ground surface depending on soil texture" (EPA, 1981, pp. 5-30). To be consistent with DWQ separation distances required for onsite systems, a minimum four-foot separation distance is required between the basin bottom and the top of the ground water mound.

Under certain circumstances, such as coarse soils with a deep water table, a more formal mounding analysis may not be necessary. However the closer the water table is to the base of the RIB, the more variable the soils, the higher the proposed loading rates, and the lower the Kh, the more important mounding calculations become and the more conservative the assumptions need to be when calculating estimates. The EPA estimation (EPA, 1984, p. 38) and the Finnemore and Hantzsche method (1983) are acceptable methods for estimating mounding. A hydrogeologic analysis using the analytical model of Hantush (1967) and the software program AQTESOLV is an option for evaluating ground water modeling. However, the Hantush analytical solution is based on Darcian assumptions and is dependent on a number of parameters that should be validated with site-specific information (e.g., Ksat, specific yield, saturated thickness, recharge area, and recharge rate).

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 Operating Permit will be to keep the mounded ground water surface at least four feet below the bottom of the RIBs. Therefore the surveyed elevations of the bottom of the RIBs need to be obtained for operational and comparative use later.

Accurate soil boring logs and hydrogeologic information are needed to estimate the RIB system performance. To reduce mounding, the long axes of the RIBs should be aligned perpendicular to the ground water flow direction. Therefore, the direction of ground water flow must be determined prior to construction at proposed RIB locations.
During construction, marginal overlying soils may be carefully removed from the proposed RIB sites to expose less hydraulically restrictive horizons. Unfortunately, by doing so may bring the base of the RIB closer to the acceptable four-foot separation distance from the mounded water table. When constructing RIBs, the equipment that is used must minimize soil compaction.

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 four feet of the bottom of the system during loading. Mounding calculations must also consider mounding influences from adjacent basins.

Soil borings must be advanced and logged 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 are recommended. Alternatively, a minimum of three laboratory hydraulic conductivity tests of the most and least transmissive horizons must be conducted.

Recommended Mounding Calculation Estimate (Finnemore and Hantzche)
zm = Mound height in center of system (ft)
zm = IC * (L/4)^n * (1/ K*h)^0.5n * (t/Sy)^1-0.5n *h*
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 Table 2 below
L = Length of system (ft)
n = from Table 2 below
K = from hydraulic testing
h = ho + zm/2
Sy = Specific Yield
ho = Aquifer thickness (ft**)**
zm (guess) = estimated mound height

Table 2: 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) are included in the Length to Width (L/W) ratio found in the "C" and "n" values of the formula.

The objective of this calculation is to estimate if the proposed system will have at least four feet of separation between the bottom of the RIB and the top of the predicted ground water mound, including the capillary fringe.

RIB Limiting Factors

Factors that can limit the effectiveness of RIBs include clogging layers, temperature, air entrapment, and wave action. The Operating Permit must address these limiting factors.

Clogging is the most common problem that decreases infiltration in RIBs. Factors that lead to the formation of clogging layers include buildup of silt and clay (TSS) and suspended biomass (e.g., algae, sludge, debris), biofilm growth on soil particles, and chemical precipitates.

Temperature affects hydraulic conductivity so if basins need to be sized accordingly for winter use. Air entrapment or encapsulation reduces infiltration. Gas solubility in water increases with decreasing water temperature, so if water warms in soil, air comes out of solution and can decrease infiltration by 50%.

Wave action on the downwind banks of basins should be limited to widths of 560 feet to prevent erosion. In addition, the velocity of the discharge input should be reduced to prevent scouring of the banks.

Operating Parameters

Hydraulic loading and basin drying cycles should be managed to maximize infiltration. A regular drying period is necessary for optimal system performance. To maximize infiltration, the drying periods should be long enough to re-aerate the soil to dry and oxidize the filtered solids. Table 3 below summarizes EPA suggested hydraulic loading and basin drying cycles.

Table 3: Suggested Hydraulic Loading and Basin Drying Cycles

Objective	Pond Discharge	Loading Period (days)	Drying Period (days)
Maximize Infiltration Rates	Primary	1-2	5-7
	Secondary	1-3	4-5

These wet/dry cycles are usually expressed as ratios. For example a wet/dry cycle of hydraulic loading for one day and basin drying for five days would have a wet/dry ratio of 0.2. Hydraulic loading and basin drying cycles are adjusted based on site-specific factors that include soil conditions.

Below are the most important operational criteria:

1. Treated effluent must meet ground water quality limits prior to discharge to RIBs.

2. A minimum of four feet of separation must be maintained between the bottom of an RIB and the top of the ground water mound. Piezometers may be required to verify that this four-foot separation distance is being met.

3. For each RIB, all standing water at the end of the hydraulic loading period must infiltrate within the first one third of the drying period.

4. Hydraulic loading must be uniform across the entire basin cross-sectional area.

5. No springs, seeps or overland flow will be allowed hydraulically downgradient of the RIBs.

6. Clogging layer abatement must be included to maintain RIB performance.

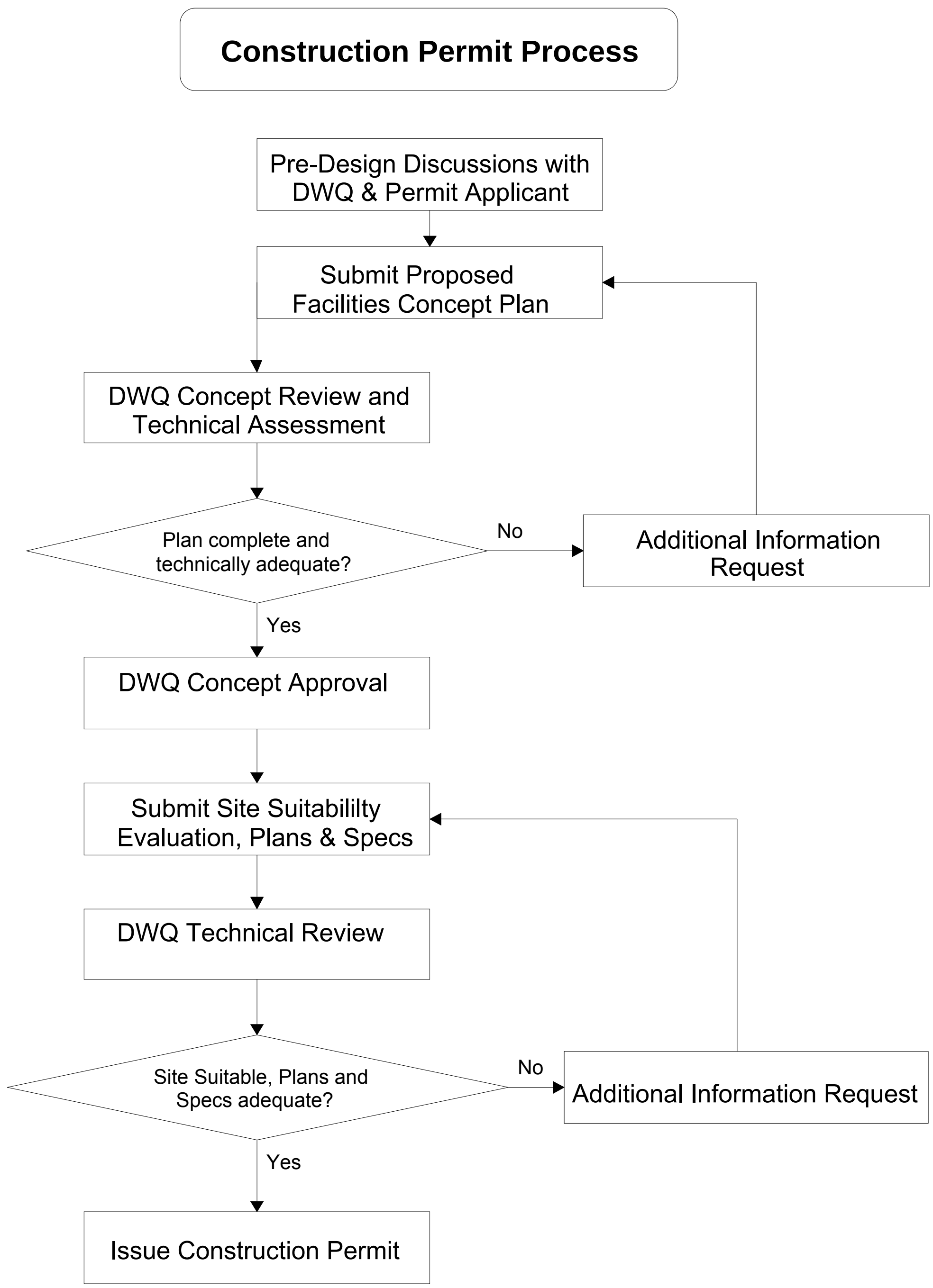
Depending on favorable soil conditions (i.e., no soil horizons that restrict vertical root growth) and depth to ground water (< 10 feet), a dense stand of hybrid poplar trees planted hydraulically down-gradient of the RIBs may evapotranspire much of the effluent from the system. Due primarily to problems observed with reduced infiltration, Reed Canary grass should not be grown in the RIBs to add a transpirational component.

PERMIT REQUIREMENTS

Proposals for constructing and operating an RIB system will require a Construction Permit and an Operating Permit from the Division of Water Quality (DWQ).

Construction Permit

The process for obtaining a Construction Permit is provided below.



As indicated in the permit flow chart, the applicant should meet with DWQ staff to have pre-design discussions for the proposed project. After receiving concept approval from DWQ, the applicant must submit a Site Suitability Evaluation, engineering design plans, and construction specifications prepared by a Utah-licensed P.E. to the attention of Ed Macauley, Manager of the DWQ Engineering Section. Based on a completeness and technical review, DWQ may request additional information. After DWQ has confirmed that the site is suitable and the plans and specifications are adequate, the Executive Secretary will issue a Construction Permit which gives approval to construct the RIB system.

Operating Permit

An Operating Permit must be obtained before any RIB system can be put into service. The permit must specify individual and annual hydraulic loading rates, periodic maintenance of the system, and monitoring and reporting requirements. Interim limits of hydraulic loading will be based on 10% of in-situ hydraulic conductivity tests. Final hydraulic loading limits will be based on basin-by-basin loading tests conducted after construction of the basins, as specified in the Operating Permit.

Basin maintenance is critical to maintain efficient performance of the RIB system. This includes implementing an effective schedule of loading/drying cycles, which will vary with individual basin characteristics. Clogging layer abadement can be critical to RIB performance and must be addressed in the Operating Permit. Examples include desilting, drying, and ripping upper two to four feet of soils.

To apply for an Operating Permit, please contact Paul Krauth, P.E., Division of Water Quality Outreach Coordinator, at pkrauth@utah.gov or 801-536-4346.

REFERENCES

Amoozegar, A. 1992. Compact Constant Head Permeameter: A Convenient Device for Measuring Hydraulic Conductivity, Advances in Measurement of Soil Physical Properties.

Daniel B. Stephens & Associates, Inc., 2008. Artificial Recharge of Ground Water (#124), National Ground Water Association Short Course, December 1-2, 2008.

EPA, 1981. Process Design Manual Land Treatment of Municipal Wastewater, EPA 625/1-81-013, 1981, p. 5-26.

EPA, 1984. Process Design Manual for Land Treatment of Municipal Wastewater, Supplement on Rapid Infiltration and Overland Flow, EPA 625/1-81-013a, 1984, p. 47.

Hantush, M.S., 1967. Growth and Decay of Ground-water Mounds in Response to Uniform Percolation, Water Resources Research, 3(1): 227-235.

Wilson, Neal, 2005. Guidance and Submittal Requirements for Rapid Infiltration Basin Wastewater Treatment Systems, Minnesota Pollution Control Agency, March 2005.

Appendix A
RIB Site Suitability Evaluation Methodology

Project Name/Description:
Proposed Location:
Owner/Operator: Address: Phone Number:
Proposed RIB Dimensions and Site Size:

Preliminary Site Evaluation

A. Average daily flow rate design for the RIB: __________________ **Gallons per day.**
B. Cultural and Other Site Conditions: Please provide a map of the proposed site including the following information:
1. Floodplain designation and flooding elevation from published data that is acceptable to and approved by DWQ within 50 feet of the proposed system. ☐ Yes ☐ No No floodplain within 50 feet. ☐ Yes ☐ No Flood elevation drawn on map.
2. Wetland designations within 50 feet of the proposed RIB system. ☐ Yes ☐ No Wetland within 50 feet. ☐ Yes ☐ No Wetland drawn on map.
3. Property boundaries of the proposed site. ☐ Yes ☐ No Property lines drawn on map.
4. Current land use of the site and surrounding areas. ☐ Yes ☐ No Current land use drawn on map.
5. Ground water flow direction determined. ☐ Yes ☐ No If yes, indicate ground water flow direction with arrows on map.
6. Any water wells within one-half mile of the proposed RIB system. ☐ Yes ☐ No If yes, show wells on map.
7. Any source water protection zones within a mile of the proposed RIB system. ☐ Yes ☐ No If yes, show protection zones on map.

Soil Survey Information

List all 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			
Saturated soil level			
Depth to bedrock			
Texture of all horizons			
Permeability of all horizons			
☐ Yes ☐ No Soil survey map submitted with location of proposed site and area.			

Note: For availability of Soil Survey maps, please refer to the local Natural Resource Conservation Service (NRCS) office.

Surface Information

☐ Yes ☐ No USGS Quadrangle map submitted with location of proposed site and area.
Site Maps drawn to scale depicting accurate locations of:
☐ Yes ☐ No Property lines.
☐ Yes ☐ No Any water wells within a half-mile radius of the proposed site.
☐ Yes ☐ No Actual boring, test pit, and trench locations.
☐ Yes ☐ No Configuration of the proposed RIB system.
☐ Yes ☐ No Proposed monitoring points.
☐ Yes ☐ No Any existing drain tile, and any surface water drainage features.
☐ Yes ☐ No Flooding or run-on potential located on map.

Appendix B
RIB Site Soils Evaluation

The purpose of the Soils Evaluation is to adequately characterize the site soils for design purposes. 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 test pit per 10,000 square feet is required. 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. Therefore, soil borings must be used to provide information below and around the test pits as necessary.

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

Continuous vertical observations and/or sampling of the entire vertical extent of the test pit wall or soil 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. The seasonal high ground water table must be determined, and the elevations of the pits must also be surveyed.

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, (Ksat) 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 Ksat 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 Ksat typically represents the fastest rate that clean water will move through the soil, and that waste water infiltration rates are usually lower than the Ksat. Perhaps the best method to estimate hydraulic acceptance rates is to use infiltration test basins. If test basins (test areas at least 75 ft) are used then in-situ saturated hydraulic conductivity measurements typically would not be required.

Checklists for the Site Soils Evaluation

Soil Characterization

☐ Yes ☐ No A minimum of one soil test pit per basin or one per 1,000 square feet (whichever is greater) for the proposed site. If possible, the test pits should be located outside of the proposed basins to reduce soil disturbances.
☐ Yes ☐ No Submitted rationale for the final number of soil test pits.
☐ Yes ☐ No Submitted the number, location, and depth of the soil test pits.
☐ Yes ☐ No Submitted the number, location, and depth of the deeper soil borings.
☐ Yes ☐ No Submitted in-depth discussion of site soils.
☐ Yes ☐ No Submitted detailed soil test pit logs and soil boring logs.
☐ Yes ☐ No Flooding or run-on potential located on map.

Soil Hydraulic Conductivity Testing

Hydraulic conductivity testing must be conducted for the most transmissive horizon within five feet of the bottom of the proposed RIBs. If the least transmissive horizon observed within the test pits 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? ☐ Permeameter ☐ Infiltrometer ☐ Test basins ☐ Other method
☐ Yes ☐ No Submitted a description of the method used for the tests.
☐ Yes ☐ No Submitted the readings and calculations for the tests.
☐ Yes ☐ No Submitted the number, location, and depth of the tests. (Minimum of 3 tests on the most and least transmissive horizons).
☐ Yes ☐ No Submitted the number, location, and depth of any deep tests.

Soil Interpretation for RIB System Design

Describe surface and soil features that will affect system design and performance.
Localized run-on of storm water drainage
Regional Flooding
Constructability (e.g., slope; soil profile; hardpan; shallow bedrock; water table depth)
Describe suggested hydraulic loading rates for the proposed system.
Describe overall suitability evaluation of the site and any limiting factors.