Rapid Infiltration Basin (RIB) Design Considerations

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Overview

- Sites are limited
- Design must be efficient to preserve land
  - Minimize number of basins
  - Narrow dikes
  - Maximize slopes
  - Minimize access ramp area

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Overview

- Integrate RIB design with pretreatment system
  - Facultative lagoon
  - Aerated lagoon
  - Conventional activated sludge or advanced treatment

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Facultative Lagoons

- Use in-basin volume to store up to 3 days of average flow
- Average daily flow applied in 8 to 12 hours

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Aerated Lagoons

- Normally equipped with quiescent lagoon
- Detention time 1 to 3 days

Activated Sludge/Advanced Treatment

- In plant storage usually inadequate
- Must account for storage provisions

Hydraulics of Dosing

- Average daily flow applied 8 to 12 hours – *all systems*
- Discharge into the basin should not exceed 1,000 gpm per point
- Discharge points in the basins need to be protected from erosion

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Dosing Structures

- Likely it will be necessary to pump to the basins

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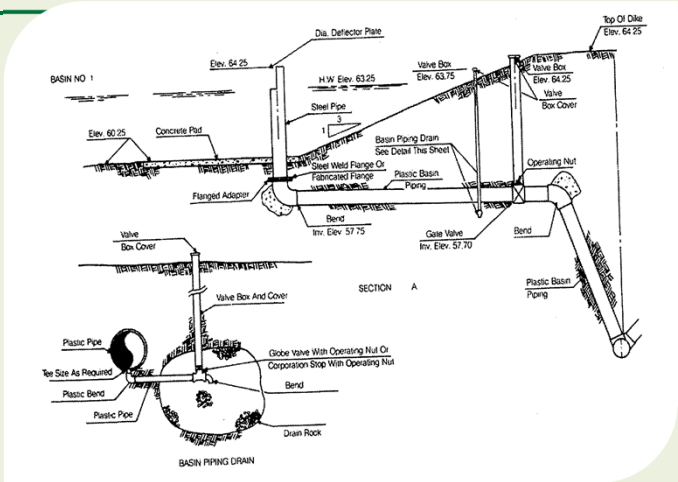
Dosing Structures

Typical dosing structure and piping



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Dosing Structures

- Accomplished by gravity
  - Pipe invert must be above high water levels in basin
  - Pipe must be free draining

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Basin Layout

- Unlikely to find a perfect site
- Utilize land in optimal manner
- Look at a number of iterations using earthwork software
- Storage and flow equalization is a necessary component

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Basin Layout

Rules:

- If groundwater mounding is an issue, the long axis of the basin should be perpendicular to direction of groundwater flow
- Layout should minimize earthwork, dikes, and fill

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Basin Layout

Rules:

- Final grades set by cut
- Dike slopes must be protected from erosion
- If soil has significant fines, surface must be vegetated

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Basin Layout

Rules:

- If vegetation does establish naturally, it may have to be managed, but should not be eliminated

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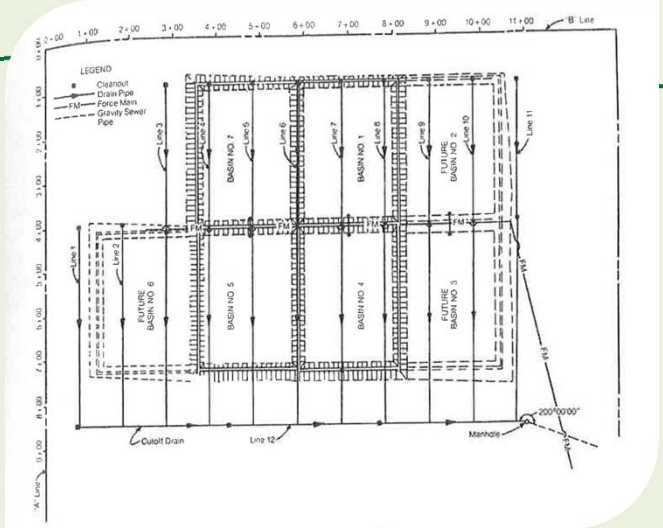
Typical underdrain layout for rapid infiltration



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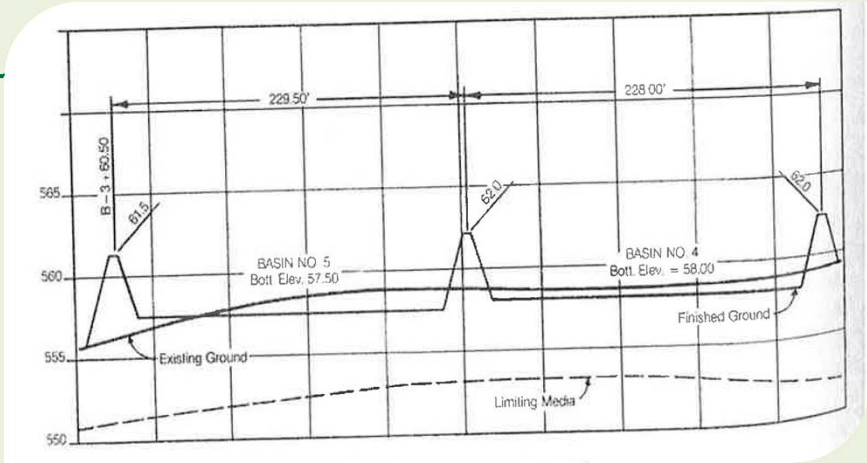

Typical rapid infiltration basin cross section

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Construction Considerations

- Soils with fines should not be used for fill
  - If fill is absolutely necessary, it should be accomplished by end dumping from a truck
  - Minimize working of the surface
- Grading for final surface accomplished by cutting

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Construction Considerations

- Suspend construction during ***ANY*** rainfall
- Use low pressure tire equipment
- If compaction is a concern, rip basin with 18-inch shanks 12 inches on center

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Construction Considerations

- Contract specification criteria should specify a minimum acceptable double-ring infiltrometer infiltration rate

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Drainage

- Underdrains or recovery wells may be necessary to prevent groundwater mounding
- Minimum unsaturated vertical travel distance should be greater than 3 foot

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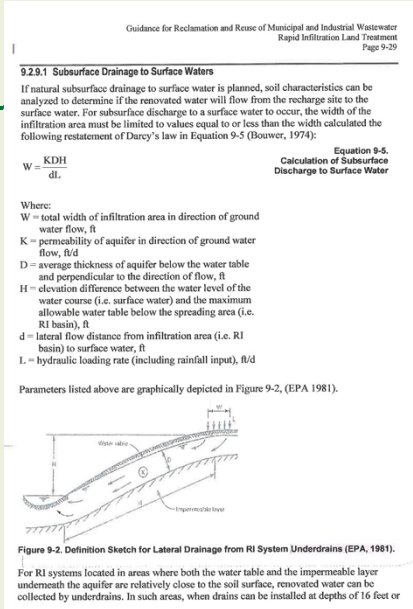
Drainage



Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater
Rapid Infiltration Land Treatment
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9.2.9.1 Subsurface Drainage to Surface Waters

If natural subsurface drainage to surface water is planned, soil characteristics can be analyzed to determine if the renovated water will flow from the recharge site to the surface water. For subsurface discharge to a surface water to occur, the width of the infiltration area must be limited to values equal to or less than the width calculated the following restatement of Darcy's law in Equation 9-5 (Bouwer, 1974):

$$W = \frac{KDH}{dL}$$

Equation 9-5. Calculation of Subsurface Discharge to Surface Water

Where:
W = total width of infiltration area in direction of ground water flow, ft
K = permeability of aquifer in direction of ground water flow, ft/d
D = average thickness of aquifer below the water table and perpendicular to the direction of flow, ft
H = elevation difference between the water level of the water course (i.e. surface water) and the maximum allowable water table below the spreading area (i.e. RI basin), ft
d = lateral flow distance from infiltration area (i.e. RI basin) to surface water, ft
L = hydraulic loading rate (including rainfall input), ft/d

Parameters listed above are graphically depicted in Figure 9-2, (EPA 1981).

Figure 9-2. Definition Sketch for Lateral Drainage from RI System Underdrains (EPA, 1981).

For RI systems located in areas where both the water table and the impermeable layer underneath the aquifer are relatively close to the soil surface, renovated water can be collected by underdrains. In such areas, when drains can be installed at depths of 16 feet or

Use Equation 9.5 from DEQ guidelines to determine if mounding will be an issue.

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Drainage

To estimate underdrain configuration:

$$S^2 = \frac{4\,KH\,(2d + H)}{V}$$

S = Spacing between drains
K = Horizontal hydraulic conductivity
H = allowable mound height above drain
d = distance to impermeable layer from below the drains
V = average application rule of water to the basins

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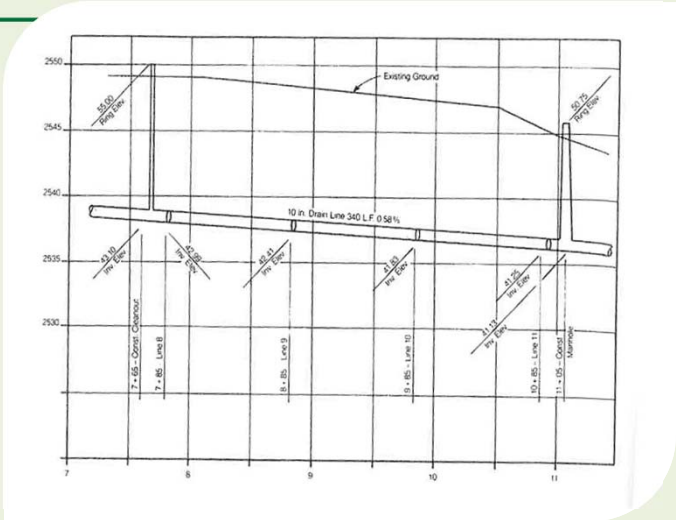
Drainage



Typical underdrain profile for rapid infiltration basin

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Drainage

- DRAINMOD dynamic modeling with weather data
- NPDES permit required for any discharged of reclaimed water
- Recovery wells
  - Mostly for unconfined deep aquifers
  - May need water right to recover and use groundwater

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Aquifer Storage

- Wastewater may be of high quality, but still unacceptable as a raw water drinking source
- Possibly the highest and best use is for agricultural irrigation
- Some water rights issues may need to be resolved

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O & M

- Basin surface may not be evenly covered during first year of operation at design loading rates
- Monitor depth of water and record all data
- Standing water should drain within 1/3 of the resting period at end of a dosing

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O & M

- If standing water remains after 1/2 resting period, maintenance should be scheduled
- Rate of infiltration will likely vary

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Cold Weather Operations

- Successful at -50°F
- Anticipate onset of cold weather
- Perform surface maintenance
- Scarification is acceptable surface preparation method

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Cold Weather Operations

- Dose so that water is 2 feet deep
- Biological activity slows

Spring Operations

- Increased biological activity
- Increase resting times
- In emergencies, select single cell for storage

Maintenance

- Maintenance equipment varies depending on the size of the basin
- Should be low impact
  - Avoid routine scarification
  - Limit surface maintenance to problem areas
  - Accomplish by raking, shoveling, and using wheelbarrows

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Maintenance

- Make sure basin surface is dry
- Pump or drain water that is not infiltrating

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Monitoring

- Operational control
- Regulatory compliance
  - NPDES permit
  - DEQ land application permit
- Monitoring may serve for compliance at property boundary

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Monitoring

- Gravity lysimeter may provide more immediate feedback

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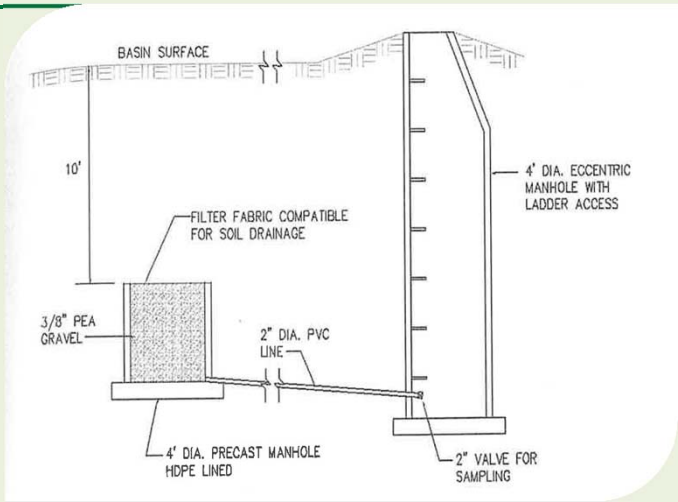
Monitoring

Schematic of gravity lysimeter



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Monitoring

- Analyze collected data with non-parametric statistics
  - Drill monitoring wells a year in advance (at minimum)
  - Take samples every two weeks
- Mann-Whitney test
- Base statistical analysis on the data collected for the year prior to becoming operational

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