Complying with the Edwards Aquifer Rules

Prepared for:
Texas Commission on Environmental Quality

Prepared by:
Michael E. Barrett, Ph.D., P.E.
and
Bradley J. Eck, Ph.D., P.E.

Center for Research in Water Resources
Bureau of Engineering Research
University of Texas at Austin

June 28, 2011
## Contents

1. **Introduction** ............................................................................................................................. 1

2. **General Guidelines** .................................................................................................................. 2

   2.1 Separation from Groundwater on the Recharge Zone .......................................................... 2

   2.2 Sensitive Features .................................................................................................................... 3

       2.2.1 Introduction .................................................................................................................. 3

       2.2.2 Setbacks/Buffs for Sensitive Features ........................................................................... 4

       2.2.3 Sensitive Features Identified in the Geological Assessment ......................................... 5

       2.2.4 Sensitive Features Discovered During Quarry Operation ............................................ 6

       2.2.5 Inspection and Maintenance of Sensitive Features ....................................................... 6

   2.3 Perimeter Berms ..................................................................................................................... 6

   2.4 Haul Roads, Parking Lots, & Tire Washes ............................................................................ 7

   2.5 Stream Crossings/Buffers ..................................................................................................... 7

   2.6 Dust Control ........................................................................................................................ 8

   2.7 Mineral Exploration Test Holes & Water Wells ................................................................... 9

   2.8 Vehicle and Equipment Maintenance .................................................................................. 10

   2.9 Petroleum/Fuel Storage and Movement .............................................................................. 11

       2.9.1 AST Facility Plan ........................................................................................................... 11

       2.9.2 Fueling Outside the Pit ................................................................................................. 12

       2.9.3 Fueling of Equipment in the Pit .................................................................................... 12

   2.10 Industrial Facilities on Site ................................................................................................ 13

   2.11 Sanitary Wastewater Disposal ........................................................................................... 13

       2.11.1 Portable Toilet BMPs ................................................................................................ 13

   2.12 Spill Prevention and Control ............................................................................................... 14

3. **BMP Requirements for Areas Discharging to Surface Waters** ............................................. 17
3.1 Introduction .................................................................................................................... 17
3.2 Temporary Erosion and Sediment Control Best Management Practices .................. 17
3.3 Permanent Structural BMPs ........................................................................................... 17
   3.3.1 General Requirements ............................................................................................. 17
   3.3.2 Required Calculations ............................................................................................. 18
4 BMP Requirements for Areas Within Quarry Pits ............................................................... 19
   4.1 Introduction .................................................................................................................... 19
   4.2 Permanent Structural BMPs ........................................................................................... 19
5 Process Water Management .................................................................................................. 20
   5.1.1 Dimension Stone Facilities (and other sites with “minor” water use) .................... 20
   5.1.2 Innovative Technology for Aggregate Production Facilities .................................. 21
6 Hydrologic Design Summary ............................................................................................... 25
7 References ............................................................................................................................. 25
LIST OF FIGURES

Figure 1 Concrete lined Sedimentation Basins ............................................................................. 21
Figure 2 Large scale Sedimentation Basin at Aggregate Quarry .................................................. 22

LIST OF TABLES

Table 1 Reference Well Water Levels ............................................................................................ 2
Table 2 Precipitation Intensity (in/hr) for various Times of Concentration for the 2-Year Storm (from Asquith and Roussel 2004) ................................................................................................... 8
Table 3: Sample material inventory .............................................................................................. 15
Table 4: Example water balance for unlined sedimentation basins.............................................. 24
1 Introduction

Quarry development is considered a regulated activity under the Edwards Aquifer rules (30 TAC Chapter 213) and owners must submit an application to the TCEQ to create or expand a quarry located on the recharge and contributing zones. An application for development in the recharge zone is generically referred to as an Edwards Aquifer Protection Plan and consists of several plan types including a Water Pollution Abatement Plan. An application for development on the contributing zone is referred to as a Contributing Zone Plan. This guidance uses the term “application” to refer to all of these documents.

A quarry operation in the areas subject to the Edwards Aquifer rules presents a special risk to groundwater quality and water supplies. This is because quarrying requires substantial amounts of heavy equipment, equipment maintenance areas, refueling operations, and often includes associated activities such as concrete or asphalt batch plants. The act of removing rock reduces the separation between these activities and the water table, making the groundwater system much more vulnerable in the process.

Since 1999, quarry operators have attempted to develop applications following the guidelines in the Complying with the Edwards Aquifer Rules Technical Guidance on Best Management Practices (TCEQ RG-348). This manual was developed primarily to address pollutant reduction requirements for residential and commercial projects. Consequently, many of the recommended measures are not appropriate for quarry activities. This has led to considerable confusion on the part of both quarry owners and their consultants. This guidance document is intended to provide guidance specifically for quarry operations, which should reduce confusion among all parties and provide for more rapid review and approval of applications.

Quarries on the Edwards Aquifer include operations that produce dimension stone, aggregate, and sand and gravel. These quarries also come in a wide range of sizes. Dimension stone and aggregate operations differ in the type of equipment employed, and water use and storage requirements. In addition, some quarry operations are located in pit areas, where no surface discharges occur, while others have a substantial presence in areas where surface discharges do occur. The latter include office areas, material stockpiles, parking lots, and retail sales.

This manual is divided into a number of sections. Chapter 2 covers general guidelines that apply to all quarries and address elements such as perimeter berms, sensitive features, dust control, stream crossings, maintenance and fueling facilities, spill response, and operation of associated industrial facilities, such as batch plants. Chapter 3 provides recommended measures for implementation in portions of the quarry that discharge to surface waters, while Chapter 4 provides guidance for operations within the pit area. The manual concludes with Chapter 5, which addresses the management of process water on-site.
2 General Guidelines

2.1 Separation from Groundwater on the Recharge Zone

In order to prevent pollution of groundwater in the Edwards Aquifer, it is recommended that a minimum separation of 25 feet between the quarry pit floor and the groundwater level be maintained for quarries located on the recharge zone. The water level in the Edwards varies substantially across the area and with changes in rainfall. Consequently, the 25 foot separation should be maintained during even relatively wet years. Analysis of historical rainfall records indicates that 90% of years have rainfall depths of less than 45 inches, and this has been selected as the critical rainfall depth.

The determination of allowable quarry depth generally requires an initial estimate of the high water level at the site. The best way to do this is to use the water level measured in a water supply well or boring on-site and to compare that to the level in a reference well. Reference wells and their high level water measurements are shown in Table 1.

Table 1 Reference Well Water Levels

<table>
<thead>
<tr>
<th>Reference Well</th>
<th>Wet Weather High Water Elevation (ft-msl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hays (LR-67-02-104 (Kyle No. 2))</td>
<td>576</td>
</tr>
<tr>
<td>Bexar (J-17)</td>
<td>691.4</td>
</tr>
<tr>
<td>Medina</td>
<td>762.9</td>
</tr>
<tr>
<td>Uvalde</td>
<td>882.5</td>
</tr>
<tr>
<td>Williamson (State Well #5827305)</td>
<td>690</td>
</tr>
</tbody>
</table>

Applicants should select the well located in the county of the proposed project or nearest well if located in Travis or Comal Counties. A measurement of the water level in a well within the project boundary should be made prior to submitting the application to TCEQ for review. This level should be compared to the level in the reference well made at approximately the same date. The difference between the reference well water level at that date and the high water level shown in Table 1 should be used to make an estimate of the difference between the on-site water level at the date of measurement and the anticipated water level in a wet year. Daily water levels of the Bexar, Median, and Uvalde wells are available at http://www.saws.org/our_water/aquifer/.

Data from the well in Hays County is available from USGS. From the USGS groundwater data website (http://waterdata.usgs.gov/nwis/gw), navigate to Daily Data and search for site number 295858097521801. Or, access the data directly at: http://nwis.waterdata.usgs.gov/tx/nwis/gwlevels?site_no=295858097521801&agency_cd=USGS&format=html.
Data from the well in Williamson County is available from the Texas Water Development Board. From the board’s data website (www.twdb.state.tx.us/data/data.asp), navigate to the Groundwater and Well Water section, and then to Williamson County and Water Level Table. Or, visit: http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWDatabaserpt.asp

As an example, assume that an exploratory well on a proposed quarry location in Bexar County encounters groundwater at an elevation 580 feet above sea level. On approximately the same date the elevation in the reference well (J-17) is found from the SAWS website to be 670 feet. The difference between the current elevation and the wet weather level is 21.4 feet. Consequently, the initial estimate for the high water level at the proposed quarry location would be 21.4 + 580, or 601.4 feet. The quarry floor should be located a minimum of 25 feet above that, which means that the application should indicate a minimum pit floor elevation of 626.4 feet.

Quarries are typically in operation for many years and it is expected that the critical wet year rainfall depth will occur sometime during the period of quarry operation. The quarry operator may make a measurement of the groundwater surface elevation after a period of 12 consecutive months with a rainfall total of at least 45 inches. This onsite water elevation can then be used to revise the minimum pit floor elevation in a modification of the application submitted to TCEQ.

2.2 Sensitive Features

2.2.1 Introduction
Sensitive features are defined in the Edwards Aquifer rules as permeable geologic or manmade features located on the recharge zone or transition zone where:

- a potential for hydraulic interconnectedness between the surface and the Edwards Aquifer exists, and
- rapid infiltration to the subsurface may occur

Sensitive features comprise a large variety of types including caves, solution cavities, solution enlarged fractures, sinkholes or other karst surface expressions that meet the definition for sensitive in the “Instructions to Geologists for Geological Assessments” (TCEQ-0585 Instructions).

Sensitive features may be identified during the geological assessment or may be encountered during quarrying activities. Sensitive features identified in the geological assessment drive the site planning process and may need special protection if located near areas with significant pollutant sources such as where vehicle maintenance or fueling occurs or onsite industrial facilities are located.
The rules require that Best Management Practices (BMPs) be implemented to “prevent pollutants from entering...sensitive features...” and “maintain flow to naturally occurring sensitive features.” [TAC 213.5(b)(4)(B) and TAC 213.5(b)(4)(C)]. The recommended practice for protecting sensitive features is natural buffer areas as described in Section 2.2.2. Features identified in the geological assessment and their buffers should be addressed in the application’s site plan as described in Section 2.2.3. Even with a very thorough assessment, some sensitive features may be discovered during while the quarry is operating. These features may be addressed as described in Section 2.2.4. Finally, Section 2.2.5 describes recommended inspection and maintenance procedures.

2.2.2 Setbacks/Buffers for Sensitive Features
Sensitive features are analogous to icebergs in that the surface expression often represents only a fraction of the spatial extent of the feature that exists just below the soil profile. Because these features can accept recharge over a substantial area providing treatment of runoff only within the depression may lead to degradation of water quality in the aquifer. Consequently, the best protection of these features is provided by a natural buffer area.

In some cases where several sensitive features occur in close proximity with each other, setback provisions may be applied collectively or setbacks may overlap, provided that the minimum standard setback for each feature is retained. No stormwater conveyance systems (storm drains, roadside swales, etc.) that would bring runoff from outside the existing drainage area should have outfalls where the runoff would be directed to a sensitive feature by the natural topography.

The "natural state" of a buffer will typically be a combination of dense native grasses and forbs in a mosaic of shrubs and trees. Native vegetation, particularly live oak trees, should be preserved within the catchment area of caves or sinkholes. Stemflow occurring along the branches and trunks of large trees may enhance infiltration by channeling rainfall to the root zone (Thurow et al., 1987). The existing soil structure and vegetation are compatible with pre-existing recharge conditions and should require little maintenance.

It is recommended that the buffers around a sensitive feature or group of features be maintained in a natural state to the maximum practical extent. This implies a construction-free zone.

Temporary runoff protection measures should be installed according to existing recommendations (TCEQ RG-348) during any construction activities within drainage area of the feature. Temporary erosion control measures should be placed as near the construction as possible to minimize disturbance within the buffer zones and drainage areas.

2.2.2.1 Sinkholes
For a sinkhole, the buffer is based on the drainage area, which frequently will include a well-defined bowl-shaped depression of a few feet to many yards across and which represents the local collapse zone over a subterranean cavity. The top of the sharp slope break present at the perimeter of such a collapse zone should constitute the edge of the feature for the purposes of
calculating setbacks, since the steep slopes within such a bowl usually provide little or no water quality filtration.

The natural buffer around a feature should extend a minimum of 50 feet in all directions. Where the boundary of the drainage area to the feature lies more than 50 feet from the feature, the buffer should extend to the boundary of the drainage area or 200 feet, whichever is less. Buffer areas that extend into areas where people or equipment may be present should be fenced with materials that allow drainage but deter access.

2.2.2.2 Caves
For a cave, the buffer is based on the cave footprint, defined by TCEQ-0585 Instructions as the horizontal or plan view map of the cave, projected up to the surface to show the area of the site underlain by cave passage. The projected surface, cave footprint, should be delineated on the site geologic map and proposed site plan. If caves are identified during the geologic site assessment, a map showing scale or dimensions should be made of its extent, including any associated cave openings, sinkholes, and subsurface extent.

The natural buffer around the cave should extend a minimum of 50 feet in all directions around the delineated cave footprint as well as any associated openings and sinkholes. Where the boundary of the drainage area to the cave lies more than 50 feet from the footprint, the buffer should extend to the boundary of the drainage area or 200 feet, whichever is less.

2.2.3 Sensitive Features Identified in the Geological Assessment
There are several outcomes for sensitive features identified in the geological assessment, including:

(1) A natural buffer, as described above, is established around the feature. Recharge to the aquifer is preserved and its water quality is protected.

(2) The feature is removed as part of the quarrying process.

(3) In certain cases it may be appropriate to permanently seal a feature in order to protect water quality.

A key part of the quarry planning and permitting process is developing the site plan for inclusion in the application. Since the application’s site plan must show ‘areas of soil disturbance’ and ‘existing and finished contours’ [30 TAC 213.5(b)(2)(B)], an approved application effectively serves as the approved boundary of the quarry pit.

An effort should be made to avoid sensitive features when locating items outside the quarry pit. Where extenuating circumstances exist and development over a sensitive recharge feature or its catchment is proposed, the project owner can consider demonstrating that no feasible alternatives exist. Feasibility of alternatives should be based primarily on technical, engineering and environmental criteria. Feasibility should not be based predominantly on marketing or economic
considerations or special or unique conditions which are created as a result of the method by which a person voluntarily develops a site plan.

Sensitive features not actively being mined should either be protected either by a natural buffer or sealed to prevent infiltration. Natural buffers are recommended when proposed development such as haul roads or other facilities are located outside the buffer areas for such features. Features should be sealed when a significant incursion on the buffer area by a road or other facility is unavoidable.

Where extenuating circumstances are approved by the TCEQ, the owner should provide alternatives to make up for the loss of recharge to the aquifer. Measures shall be taken to assure that the quality of enhanced or induced recharge is adequate to protect groundwater quality, and is consistent with the requirements to protect “improved sinkholes” as directed in 30 TAC 331 (Underground Injection Control).

2.2.4 Sensitive Features Discovered During Quarry Operation
Some sensitive features are discovered during quarry operation. When a new sensitive feature is discovered, work stops and the discovery should be reported to TCEQ. Wall voids with no surface expression and no drainage area are not considered “sensitive.” Thus, discovering a wall void during the quarrying process should not increase the risk of contamination and does not require notification of TCEQ or a work stoppage.

2.2.5 Inspection and Maintenance of Sensitive Features
Sensitive features with buffer areas that extend into areas where people or equipment may be present should be inspected at least twice yearly. The inspection should verify that fencing or other barriers to deter access are in place and functional. The buffer itself should be inspected to verify that no disturbance of the natural vegetation or soil has occurred as a result of human or vehicle activity.

If disturbance of the area has occurred, the perimeter fencing should be repaired and stabilization and re-vegetation of the area should be accomplished as soon as feasible. Use of fertilizers and pesticides should be minimized during buffer repair and only native vegetation used for stabilization.

2.3 Perimeter Berms
Perimeter berms should be used to prevent run-on of surface drainage into the quarry pit by routing flow around the pit. Berms are also useful for creating a visual and physical buffer between the quarry pit and adjacent property. Consistent with guidance for online facilities (TCEQ RG-348), berms should be sized based on the 10-year, 24-hour storm event and should be vegetated. The berms should prevent the design event from entering the quarry pit, but have spillways to safely pass the 100-year 24-hour event into the quarry pit. In sizing the berms, the contributing drainage area and land cover, should be considered. Detailed design of the berms
including required height, side slope, construction material, and compaction requirements should be performed by a licensed engineer.

The top of earthen berms should be at least 2 feet wide. The minimum height for earth berms should be 2 feet, with side slopes no steeper than 2:1. If vehicle crossings of the berm are necessary, the crossings should have a slope of 3:1 or flatter and be armored with gravel. This design makes the berm last longer and strengthens the point of vehicle crossing.

If a channel is excavated along the berm, its shape can be parabolic, trapezoidal, or V-shaped. The maximum design flow velocity should range from 1.5 to 5.0 feet per second, depending on the vegetative cover and soil texture.

Inspect earthen diversion berms quarterly to ensure continued effectiveness. Berms should be maintained to their original height with any decrease in height due to settling or erosion repaired immediately.

### 2.4 Haul Roads, Parking Lots, & Tire Washes

Roads and parking areas for vehicles that will leave the site should be paved to prevent tracking of sediment onto adjacent highways and to reduce the generation of dust. Roads outside of the quarry pit should have BMPs as described in Chapter 3. Areas used for material stockpiles do not need to be paved, but a tire wash system should be provided to wash mud and dirt from wheels of vehicles that have traveled on unpaved sections of the quarry.

The tire wash system should be (1) located in front of some type of traffic restriction such as the quarry scale or a stop sign to encourage proper use of the system; and (2) set back a distance of at least 100 ft from the public road. The system should use a recycle system to minimize water use and prevent discharge of the process water. Note that water from these systems cannot be discharged to surface water or infiltrated through the quarry floor. The design of the wash system should be performed by a professional engineer. Automatic wash systems are available from a variety of manufacturers.

### 2.5 Stream Crossings/Buffers

Natural buffer areas adjacent to streams and natural drainage ways play an important role in maintaining predevelopment water quality. The riparian vegetation stabilizes stream channels and floodplain areas, reducing erosion. In addition, they provide an area to filter overland flow from adjacent development. Consequently, all streams and drainage ways should have an undisturbed native vegetation buffer on each side. The buffer should extend 25 feet on either side from the 100 year floodplain or drainage centerline if no floodplain exists.

Buffer zones should generally remain free of construction, development, or other alterations. The number of haul road crossings through the buffer zones should be minimized and constructed only when necessary, such as when a significant portion of the site can only be reached by crossing a buffer zone. Utility crossings should also be minimized. Roadways and utilities crossings should be approximately perpendicular to the buffer zone.
Roadway crossings must be paved and include a bridge or culvert that can convey the 2-year storm without overtopping the road. The Rational Method (e.g., Maidment 1993 and many other sources) can be used to compute the peak discharge of the 2-year storm using the rainfall intensities provided in Table 2. Any roads within the stream buffer should be paved to reduce the generation of dust that can be directly deposited in the stream or drainage channel. Stream crossings whether by bridge or culvert are considered impervious cover and require 80% TSS removal. Vegetated filter strips are an obvious choice for treating roads located outside of the pit area. Additional BMPs that are approved for stormwater treatment are described in TCEQ RG-348. Where feasible, the runoff from a bridge over the stream should be conveyed to the bank for treatment, rather than discharging directly into the stream.

Table 2 Precipitation Intensity (in/hr) for various Times of Concentration for the 2-Year Storm (from Asquith and Roussel 2004)

<table>
<thead>
<tr>
<th>County</th>
<th>15 min</th>
<th>30 min</th>
<th>1 hr</th>
<th>2 hr</th>
<th>3 hr</th>
<th>6 hr</th>
<th>12 hr</th>
<th>1 day</th>
<th>2 day</th>
<th>3 day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bexar</td>
<td>4.20</td>
<td>2.90</td>
<td>1.80</td>
<td>1.10</td>
<td>0.80</td>
<td>0.467</td>
<td>0.267</td>
<td>0.150</td>
<td>0.0833</td>
<td>0.0590</td>
</tr>
<tr>
<td>Comal</td>
<td>4.00</td>
<td>2.70</td>
<td>1.80</td>
<td>1.10</td>
<td>0.80</td>
<td>0.467</td>
<td>0.258</td>
<td>0.150</td>
<td>0.0833</td>
<td>0.0625</td>
</tr>
<tr>
<td>Hays</td>
<td>4.00</td>
<td>2.60</td>
<td>1.75</td>
<td>1.10</td>
<td>0.80</td>
<td>0.450</td>
<td>0.258</td>
<td>0.142</td>
<td>0.0833</td>
<td>0.0625</td>
</tr>
<tr>
<td>Kinney</td>
<td>4.00</td>
<td>2.70</td>
<td>1.70</td>
<td>1.03</td>
<td>0.70</td>
<td>0.417</td>
<td>0.233</td>
<td>0.133</td>
<td>0.0729</td>
<td>0.0521</td>
</tr>
<tr>
<td>Medina</td>
<td>4.20</td>
<td>2.90</td>
<td>1.80</td>
<td>1.10</td>
<td>0.80</td>
<td>0.467</td>
<td>0.267</td>
<td>0.150</td>
<td>0.0833</td>
<td>0.0590</td>
</tr>
<tr>
<td>Travis</td>
<td>3.80</td>
<td>2.60</td>
<td>1.70</td>
<td>1.05</td>
<td>0.767</td>
<td>0.450</td>
<td>0.250</td>
<td>0.142</td>
<td>0.0833</td>
<td>0.0556</td>
</tr>
<tr>
<td>Uvalde</td>
<td>4.20</td>
<td>2.80</td>
<td>1.80</td>
<td>1.05</td>
<td>0.767</td>
<td>0.450</td>
<td>0.250</td>
<td>0.142</td>
<td>0.0833</td>
<td>0.0556</td>
</tr>
<tr>
<td>Williamson</td>
<td>3.60</td>
<td>2.60</td>
<td>1.70</td>
<td>1.05</td>
<td>0.733</td>
<td>0.433</td>
<td>0.250</td>
<td>0.142</td>
<td>0.0781</td>
<td>0.0556</td>
</tr>
</tbody>
</table>

2.6 Dust Control

Dust generated by quarrying activities including excavation, product processing, storage, and vehicle traffic should be controlled by reasonable means such as watering, paving, or other suitable management practices. Proper management practices for dust control reduce or prevent wind erosion by protecting and roughening the soil surface, roughening the surface, and reducing the surface wind velocity. Specific BMPs for dust control include the following list adapted from the US EPA (2006) and Edwards Aquifer Technical Guidance Manual (TCEQ Guidance RG-348):

- **Vegetative Cover.** In areas that are outside the active quarry and not expected to handle vehicle traffic, vegetative stabilization of disturbed soil is often desirable. Vegetative cover provides coverage to surface soils and slows wind velocity at the ground surface, thus reducing the potential for dust to become airborne. Refer RG-348 section 1.3.8 for additional information about establishing vegetation.
- **Mulch.** Mulching can be a quick and effective means of dust control for a recently disturbed area.

- Commercially available dust suppressors if applied in accordance with the manufacturer’s recommendations. Examples of chemical adhesives include anionic asphalt emulsion, latex emulsion, resin-water emulsions, calcium chloride, and polyacrylimide. Polyacrylimide should conform to ANSI/NSF Standard 60 the criteria in RG-348, Section 1.3.4. Cationic chemicals should not be used. Chemical palliatives should be used only on mineral soils. When considering chemical application to suppress dust, determine whether the chemical is biodegradable or water-soluble and what effect its application could have on the surrounding environment, including water bodies and wildlife.

- **Sprinkling/Irrigation.** Sprinkling the ground surface with water until it is moist is an effective dust control method for unpaved haul roads and other traffic routes.

- **Wind Breaks.** Wind breaks are barriers (either natural or constructed) that reduce wind velocity through a site and, therefore, reduce the possibility of suspended particles. Wind breaks can be trees or shrubs left in place during site clearing or constructed barriers such as a wind fence, tarp curtain, hay bale, crate wall, or sediment wall (USEPA, 1992). Barriers placed at right angles to prevailing currents at intervals of about 15 times their height are effective in controlling soil blowing.

- **Stone.** Stone can be an effective dust deterrent for unpaved haul roads or as a mulch in areas where vegetation cannot be established.

- **Tarping.** Trucks exiting the site should be tarped to minimize dust.

- **Speed Limit.** Posted speeds of 10-15mph for unpaved haul roads to minimize dust.

### 2.7 Mineral Exploration Test Holes & Water Wells

Drilling of test holes during quarry operation or while exploring sites for new quarries may be necessary to determine the size of the deposit. These test holes or borings are regulated by the TCEQ. Borings can provide a path for pollutants to enter the groundwater, so it is important that they be properly sited, drilled and plugged.

Test holes should be located where there is good surface drainage and, if possible, at higher elevation than potential sources of pollution. The location should allow the well and surrounding area to be kept in a sanitary condition. Proper drainage should be provided so no ponding or accumulation takes place within 20 feet of the well. If possible, holes should be located in areas
that do not flood. Water wells should have a minimum separation distance of 20 feet from vehicle maintenance or storage areas.

In accordance with 30 TAC 213.7, all borings with depths greater than or equal to 20 feet must be plugged with a non-shrink grout from the bottom of the hole to within three feet of the surface. The remainder of the hole must be backfilled with cuttings from the boring or gravel. All borings less than 20 feet must be backfilled with cuttings from the boring or gravel. All borings must be backfilled or plugged within four days of completion of the drilling operation. Voids may be filled with gravel.

2.8 Vehicle and Equipment Maintenance

Vehicle and equipment maintenance including washing should occur in designated areas specifically designed for the purpose and located outside of the natural buffer area of sensitive features and outside of the quarry pit. Vehicles and equipment that are scheduled for maintenance or that have potential fluid leaks should be confined to the repair area described below.

Areas for vehicle repair should be covered and paved. Curbs or berms should be used to prevent runoff from entering or leaving the repair area. Pavement should be sloped to a contained drainage point. These repair areas are considered permanent developments outside of the quarry pit and should therefore have permanent BMPs as outlined in Chapter 3.

Washing areas should also be paved so that the bottom is sealed because the wash water cannot be discharged to surface or ground water. Direct wash water to sanitary sewer systems or, ensure that vehicle washing areas are impervious and are bermed. If the quarry has no access to wastewater disposal, the wash water should be collected and disposed of properly or washing should be performed off site at an appropriate facility. Because water alone can remove most dirt adequately, use high-pressure water spray without detergents at vehicle washing areas. If you must use detergents, avoid phosphate- or organic-based cleansers to reduce nutrient enrichment and biological oxygen demand in wastewater. Use only biodegradable products that are free of halogenated solvents. Use signage to clearly mark all washing areas and inform workers that all washing must occur in this area. Do not perform other activities, such as vehicle repairs, in the wash area.

Inspect mining vehicles daily, and repair any leaks immediately. Check incoming vehicles and equipment (including delivery trucks, and employee and subcontractor vehicles) for leaking oil and fluids. Do not allow leaking vehicles or equipment onsite. Dispose of all used oil, antifreeze, solvents and other automotive-related chemicals according to manufacturer instructions. These wastes require special handling and disposal. Used oil, antifreeze, and some solvents can be recycled at designated facilities, but other chemicals must be disposed of at a hazardous waste disposal site.

Operational BMPs:
• Inspect for leaks all incoming vehicles, parts, and equipment stored temporarily outside.

• Use drip pans or containers under parts or vehicles that drip or that are likely to drip liquids, such as during dismantling of liquid containing parts or removal or transfer of liquids.

• Remove batteries and liquids from vehicles and equipment in designated areas designed to prevent stormwater contamination. Store cracked batteries in a covered non-leaking secondary containment system.

• Empty oil and fuel filters before disposal. Provide for proper disposal of waste oil and fuel.

• Do not pour/convey washwater, liquid waste, or other pollutant into storm drains or to surface water.

• Do not connect maintenance and repair shop floor drains to storm drains or to surface water.

• Conduct all maintenance and repair of vehicles and equipment in a building, or other covered impervious containment area that is sloped or bermed to prevent run-on of uncontaminated stormwater and runoff of contaminated stormwater.

• Park large mobile equipment, such as front end loaders, in an area protected from run on of stormwater and sealed with a clay liner or permeable pavement to prevent infiltration. Clay liners should conform to the specifications in RG-348 for clay liners of basins.

• Post signs reminding operators to chock wheels, secure connections, check drain outlets, and report spills to the office.

2.9 Petroleum/Fuel Storage and Movement
Fuel storage poses a unique risk to the Edwards Aquifer and is specially regulated by the TCEQ. In addition, federal law requires a spill prevention control and countermeasure, or SPCC, plan if an oil, used oil or petroleum storage tank is located where it could contaminate water due to a spill, for example on or near a stream, lake or river. An SPCC plan is needed if there is either: (1) total aboveground storage capacity (of containers 55 gallons or greater) over 1,320 gallons; or (2) total underground storage capacity over 42,000 gallons that is not regulated by UST standards. Underground storage is not recommended for quarries.

2.9.1 AST Facility Plan
An aboveground storage tank (AST) facility plan is required for the installation of permanent aboveground storage tanks at a facility that will have a total capacity of 500 gallons or more on either the recharge, transition, or contributing zones of the Edwards Aquifer [30 TAC
In particular, ASTs that will store static hydrocarbons or hazardous substances are regulated.

The forms for a complete AST facility plan specify additional information that must be attached, such as maps, site plans, drawings for the containment area, and a description of spill controls and response actions. A containment area is a required element of the plan. Containment areas should be covered to prevent the accumulation of rain water. Double-walled tanks are acceptable in place of the tank containment requirement. An AST facility plan must be submitted for review and approved prior to installation.

Further information about an AST facility plan is available on the TCEQ website: http://www.tceq.texas.gov/compliance/field_ops/eapp/ast.html

2.9.2 Fueling Outside the Pit

Fueling of vehicles and equipment, whether at a central location or within the quarry pit, should occur in designated areas equipped with spill kits. Designated fueling areas should be designed to prevent stormwater runoff and spills. Fuel-dispensing areas should be paved with cement, concrete, or an equivalent impervious surface but not asphalt, and have a two to four percent slope to prevent ponding. The fueling area should be separated from the rest of the site by a grade break or curb that prevents run-on of stormwater.

Fuel dispensing areas should be covered, and the cover’s minimum dimensions must be equal to or greater than the area within the grade break or the fuel dispensing area. The cover should not drain onto the fuel dispensing area. Use a perimeter drain or slope the pavement inward so that runoff drains to a blind sump sized to hold 55 gallons. It might be necessary to install and maintain an oil control device in catch basins that might receive runoff from the fueling area.

For facilities where equipment is being fueled with a mobile fuel truck, establish a designated fueling area. Discourage “topping off” fuel tanks. Secondary containment such as a drain pan should be used when transferring fuel from the tank truck to the fuel tank.

2.9.3 Fueling of Equipment in the Pit

Fuel transfers within the quarry pit pose a higher contamination threat because the pit is closer to the water table. Place drip pans, or other appropriate temporary containment device, at locations where leaks or spills may occur such as hose connections, hose reels and filler nozzles. Drip pans should always be used when making and breaking connections. Check loading/unloading equipment such as valves, pumps, flanges, and connections regularly for leaks and repair as needed. Equipment and vehicles that can easily be driven out of the quarry pit such as personnel trucks and front end loaders should be fueled outside the pit.

Some equipment within the quarry pit, such as diesel powered crushers, may have very large fuel tanks. In order to limit the pollution potential from a tank leak, the size of the tanks located in
the pit should be limited to 499 gallons. Where larger tanks are used, the following minimum practices are recommended:

- A containment area sized for 150% of the tank volume should be provided;
- The containment area should be impervious to the material being stored and should be covered;
- A spill kit should be located near the tank.

2.10 Industrial Facilities on Site
Industrial facilities on the quarry site may include batch plants for concrete and asphalt and other types of operations. A perimeter of the facility should be established and shown on the site plan submitted with the application. Berms and curbs should be used to prevent run-on of drainage from outside of the facility perimeter. Drainage originating within the facility should be handled according to the requirements of an industrial stormwater permit, which may require permanent BMPs. Wastewater from industrial facilities must not be discharged into the quarry pit, permanent BMPs or surface streams.

2.11 Sanitary Wastewater Disposal
Sanitary wastewater should be discharged to a municipal wastewater system or an approved septic system located outside of the quarry pit. The use of portable toilets should be minimized and used only when the site is so large that access to permanent facilities is not feasible. Portable toilets are discouraged because of the potential for spills associated with toilet cleaning or overturning. If the use of portable toilets is unavoidable, the following BMPs are recommended

2.11.1 Portable Toilet BMPs
The following BMPs for portable toilets were adapted from the Portable Toilet Oversight Program (Orange County Stormwater Program, 2002).

Transport of portable toilets (Industrial Activity)

- Portable toilets should be emptied prior to transport.
- Portable toilets should be securely fastened to the transport truck.
- Use hand trucks, dollies, and power tail gates whenever possible.

Placement of portable toilets (Construction Site Activity)
• Portable toilets are to be placed 20 feet away from the nearest storm drain inlet or sensitive feature buffer area

• An earthen berm or sand bag containment should be constructed around the portable toilet unit for spill containment and protection from leaks.

• Prepare a level ground surface with clear access to the units.

• Secure all portable toilets with a stake driven into the ground to prevent tipping of the unit by accident, weather or vandalism.

Maintenance of portable toilets (Site Activity – Industrial and Construction)

• Inspect portable toilets frequently (daily during work week) for leaks and have the units serviced and sanitized at time intervals that will maintain sanitary conditions of each toilet (typically weekly).

• A licensed waste collector should service all portable toilets;

• Suppliers should carry bleach for disinfection in the event of a spill or leak.

• Properly store (cover) and handle chemical materials.

• Train employees on these BMPs, storm water discharge prohibitions, and wastewater discharge requirements.

2.12 Spill Prevention and Control
Quarry facilities should implement measures to prevent and control spills. In addition to the criteria of section 1.4.16 in the Edwards Aquifer Technical Guidance Manual (TCEQ Guidance RG-348), which are included here by reference, quarry facilities should implement the following measures.

Education

• Post a summary of the spill prevention procedures in appropriate locations (i.e., meeting rooms, cafeteria, and areas with a high spill potential). The summary should identify the spill cleanup coordinators, location of cleanup kits, and phone numbers of regulatory agencies to be contacted in the event of a spill.
• Develop an inventory of potentially polluting materials including estimated quantities and size and number of storage containers. The inventory is used to determine the size and type of spill kits that should be present at the site. A sample material inventory is provided below.

Table 3: Sample material inventory

<table>
<thead>
<tr>
<th>Material</th>
<th>Typical Container (including volume)</th>
<th>Number of containers kept on site</th>
<th>Reportable Quantity for Spills into Water</th>
<th>Reportable Quantity for Spills onto Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission Fluid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brake fluid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic Fluid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lubricating greases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coolant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery acid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactives, oxidizers, ammonia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detergents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portable toilet fluid/wastewater</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials classified as hazardous (specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other possible pollutants that could spill (specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• Provide spill cleanup at locations where spills are most likely to occur such as fueling and maintenance areas. Spill cleanup kits are available from several manufacturers or may be prepared by the facility owner. Each spill kit should contain sufficient adsorbent capacity to handle a spill of largest moveable container at that location.

Adsorbents used in spill cleanup kits may be targeted to specific substances such as oil based liquids, water based liquids, corrosive liquids, or may be of the ‘universal’ type for all or unknown liquids.

In general, a spill cleanup kit should have:
• Adsorbent socks or boom to contain the spill;
• Adsorbent mats or wipes to clean up the spill;
• Disposal bags for the used adsorbent;
• Personal protective equipment (PPE) such as gloves, face mask, safety goggles;
• An instruction manual describing use of the equipment; and,
• A clearly labeled container.

• Summarize the procedures and information for dealing with spills at the quarry facility in a written spill plan. At a minimum the plan should include:

  (1) a description of the facility;

  (2) an inventory of materials;

  (3) material safety datasheets (MSDS);

  (4) a site plan including drainage features, BMPs, maintenance and fueling areas, and spill kits;

  (5) spill prevention measures to be used on site, some examples of which include:

  • Using containers suitable for the material stored. For example, use a container designed for flammable liquids to store gasoline;

  • Providing overfill prevention for storage tanks such as a high-level alarm or audible vent;

  • Providing sized secondary containment for bulk storage tanks such as a berm or double-walled tank. A berm should hold 150% of the tank capacity plus possible rainfall in accordance with 30 TAC 213.5(e).

  • Providing general secondary containment to catch the most likely spill where fuel and oil transfers take place

  • Periodically inspecting and testing tanks and pipes. Tanks and pipes should be located aboveground to facilitate visual inspection. Inspections should be performed in accordance with industry standards such as API SP001, though applicable industry standards are at the discretion of the plan’s engineer.
(6) reporting requirements;

(7) cleanup procedures; and

(8) the position of the individual responsible for coordinating a spill response.

The written spill plan should be prepared by a licensed engineer (PE) in accordance with good engineering practice. Facility management should approve the plan. The plan should be reviewed (and re-sealed by a PE) at least every five years. The plan should be maintained on site for the use and benefit of the operator, but not submitted to TCEQ for review or approval.

3  BMPs for Areas Discharging to Surface Waters

3.1  Introduction
In this manual, quarry facilities and operations are divided into those that are located or occur in areas where stormwater runoff discharges to surface waters and those within the quarry pit that do not. Areas of the operation that discharge to surface waters typically include office buildings, vehicle storage and maintenance areas, parking lots, roads, and material stockpile areas. These areas should not discharge to the quarry pit. Even though the quarry pit is treated in this guidance as an ongoing construction activity, those improvements outside of the pit are not. This is because facilities outside the pit are typically used for decades and represent potential sources of pollutants over long periods of time. Consequently, improvements outside of the pit are considered permanent post-construction activities and an 80% reduction of the increase in TSS loadings resulting from the facilities is required.

3.2  Temporary Erosion and Sediment Control Best Management Practices
Temporary erosion and sediment control BMPs are considered appropriate for use during the construction and expansion of facilities that discharge to surface waters. Chapter 1 of TCEQ RG-348 describes a variety of strategies for minimizing the discharge of sediment during construction operations. This document is available online at:

http://www.tceq.texas.gov/compliance/field_ops/eapp/program.html

Those measures that will be implemented on a project should be described in the Water Pollution Abatement Plan or Contributing Zone Plan, and installed and maintained in accordance with the plan.

3.3  Permanent Structural BMPs

3.3.1  General Requirements
Once construction of areas outside of the quarry pit has ceased, permanent structural BMPs should be implemented and operational. Under 30 TAC Chapter 213, 80% of the increase in TSS

17
load resulting from activity (over background) must be removed. The increase is assumed to occur only on the new impervious areas, with the landscaped portions of the tract contributing the same TSS load as those areas in the undeveloped condition.

The assumption in the sizing calculations is that the TSS concentration in runoff increases from a background concentration of 80 mg/L to 170 mg/L when an area is paved. This is generally a good approximation for conventional urban development, but underestimates the potential TSS increase on heavily traffic roadways and parking areas that are not paved, especially during wet weather. Consequently, haul roads and parking lots for vehicles that travel on public roads should be paved to reduce the generation of TSS and tracking of material onto public roadways near the facility entrance. Equipment storage and material stockpile areas may be surfaced with compacted native soils or roadbase type material but are still counted as impervious cover.

The water quality volume (or equivalent rainfall intensity for flow through practices) is a function of the effectiveness of the BMP and the amount of impervious cover. Impervious cover includes but is not limited to:

- Pavement including roadways, driveways, parking lots, etc.
- rooftops if not part of a rainwater harvesting system
- Compacted road base, such as that used for parking areas
- Material stockpile areas
- Other surfaces that prevent the infiltration of water into the soil.

Roof areas connected to a rainfall harvesting system do not need to be included, but the volume of the rainfall collection system must be sufficient to retain the runoff from a 1.5 inch rainfall and the system should be managed so that it is emptied at least weekly to provide storage for subsequent storms.

3.3.2 Required Calculations

Required calculations for determining the amount of TSS that must be removed and the type and sizing of BMPs are included in the Edwards Aquifer Technical Guidance Manual (TCEQ Guidance RG-348). A spreadsheet is provided by TCEQ to facilitate these calculations at: http://www.tceq.texas.gov/compliance/field_ops/eapp/spreadsheet.html

The guidance document describes a number of approved BMPs to achieve the required TSS reduction. Filtration type BMPs (sand filters, bioretention, Aqualogic) may have very high maintenance requirements because of the large amount of sediment and dust generated by quarry operations. Vegetated filter strips often are an attractive choice where sufficient land is available and the contributing area is not too wide, such as roads, rail lines, and small parking lots.
4 BMP Requirements for Areas Within Quarry Pits

4.1 Introduction
During the operational life of the quarry, the area within the pit that does not drain to surface waters is considered to effectively be a construction site. Consequently, the primary BMPs are those associated with preventing the tracking of sediment off-site. This should be facilitated by the use of paved roads outside of the pit area and the implementation of wheel washing systems for vehicles that have traveled on unpaved areas at the quarry site.

4.2 Permanent Structural BMPs

Permanent structural BMPs must be installed to treat areas within the quarry pit only if the area will generate more TSS than it did in the original condition. Rather than installing conventional stormwater BMPs in the pit, where no surface discharges occur, the most practical solution is to return the site to its pre-construction natural condition to the extent that is feasible. This first step in this process is to provide final stabilization. As portions of the quarry are abandoned, stabilization should occur in that portion, rather than waiting until the entire quarry is abandoned. Final stabilization is considered to have occurred when any of the following conditions are met:

1. All soil disturbing activities at the site have been completed and a uniform (i.e., evenly distributed, without large bare areas) perennial vegetative cover with a density of at least 70% of the native background vegetative cover for the area has been established on all unpaved areas having slopes less than 20% (RG-348 limit for Vegetative Filter Strips) and areas not covered by permanent structures, or equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed.
2. For construction activities on land used previously for agricultural purposes, final stabilization may be accomplished by returning the disturbed land to its preconstruction agricultural use. Areas disturbed that were not previously used for agricultural activities, such as buffer strips immediately adjacent to surface water and areas that are not being returned to their preconstruction agricultural use must meet the final stabilization conditions of condition (1) above.
3. In drought-stricken areas only, all soil disturbing activities at the site have been completed and both of the following criteria have been met:
   a. Temporary erosion control measures (e.g., degradable rolled erosion control product) are selected, designed, and installed along with an appropriate seed base to provide erosion control for at least three years without active maintenance by the operator, and
   b. The temporary erosion control measures are selected, designed, and installed to achieve 70 percent vegetative coverage within three years.
5 Process Water Management

One of the most significant issues related to quarry operation is the management of water used for a variety of processes including aggregate washing and saw lubrication. This water provides a mechanism to transport sediment generated at the site to the water table, potentially resulting in increases of sediment and turbidity in the aquifer, nearby wells, and surface water.

Sedimentation basins are typically constructed at quarries to remove the fine particles and allow reuse of the water. To prevent contamination of the underlying aquifer an impermeable liner should be provided. Section 3.4.2 of TCEQ RG-348 sets a minimum standard for clay or geotextile liners; however, other materials such as gunite or concrete may provide equivalent performance. In addition, sufficient freeboard should be available to retain the 10-year, 24-hour storm event and a stabilized spillway should be provided for larger storms. The discussion of the management of the process water is divided between the two quarry types distinguished by the substantial difference in water use.

5.1.1 Dimension Stone Facilities (and other sites with "minor" water use)
Dimension stone quarries use dry cutting Vermeer saws to rough cut the stone before it is plucked from the formation and processed. The rough cut stone is transported to a wet saw where it is sliced into different thicknesses. As the name implies, wet saws require water for cooling and lubricating the cutting process. The volume of water required is relatively small.

The most cost effective way to manage process water at this type of site is to construct concrete lined multi-chamber sedimentation basins, like the one shown in Figure 1. In this example, water is discharged to the basin on the far left then overflows sequentially into the following basins. Water is withdrawn from the last basin for reuse in the sawing process. The multiple chambers reduce short circuiting and improve fines removal compared to a single basin of equivalent volume. The concrete construction, including basin walls, facilitates the removal of accumulated sediment without damaging a clay or geomembrane liner.

The basins are constructed with side slopes of not more than 3:1 to allow access by front end loaders to remove accumulated sediment. Basins should be constructed with approximately one foot of freeboard to prevent process water from being displaced from the basin during sediment removal. The volume of the basins is a function of the amount of water use in the manufacturing process and the contributing drainage area. The basin needs to be large enough to provide sufficient sedimentation that the water can be recycled and contain the 10-year 24-hour event with 1 foot of freeboard. Thus, controlling the drainage area to the basin will help minimize the necessary size. Accumulated sediment should be removed when the recycled water sediment content increases to an unacceptable level. The sediment may then be dried and used as fill material on-site.
Aggregate production facilities generally have much higher water demands related to aggregate washing. Consequently, the sedimentation basins are typically many times larger than those used on dimension stone operations, which makes basin lining a more difficult undertaking (Figure 2). In particular, lining the vertical faces of the abandoned portions of quarries, which are commonly converted to sedimentation basins is exceptionally difficult. Consequently, an alternative is provided, which is easier to implement, but requires monitoring for a period of at least six months following the beginning of operation or the creation of a new lift to demonstrate that water is not lost from the basin to groundwater at a rate greater than would occur if a conventional liner had been implemented. The alternative pond system described below is innovative technology and is reviewable in accordance with Chapter 4 of TCEQ RG-348.
There is limited data that indicates that the permeability of dense limestone within the Edwards Formation can exceed $10^{10}$ cm/s, which is sufficiently low to prevent impact to groundwater. However, these dense beds may be interrupted by voids, fractures, or other features that would allow process water to impact groundwater quality. These features must be identified and plugged with flowable fill, which is a low strength concrete, or other impermeable material.

In layered formations, such as the Edwards, the horizontal permeability is often many times larger than the vertical. Consequently, identifying and sealing permeable layers in the quarry wall is critical to reducing water loss. Voids, fractures, and permeable beds (“cave rock”) should be permanently sealed with flowable fill or other impermeable material.

Once this sedimentation basin is operational, a water balance should be performed to demonstrate its integrity. The operator of the quarry should keep detailed records of the volume of makeup water used daily over a period of six months. Makeup water also includes the volume of rainfall that falls on the sedimentation basin; rainfall measurements should be made at the basin or at the facility office. Water losses may include:
- Evaporation (measured with the standard “class A” evaporation pan (Maidment 1993) and applied to the basin using a pan coefficient of 0.70 (TWDB 1982))

- Product loss (estimated as a percentage of the bulk volume of material washed, at 6% for course material and 12% for sand)

- Other uses on-site (dust control, tire washing, etc.)

The difference between the makeup volume and the sum of the losses is the amount of water that has infiltrated into the aquifer. A calculation must be provided to demonstrate that this is less than or equal to what would have occurred if a conventional liner had been provided. If the calculated infiltration exceeds the expected infiltration from a conventionally lined pond, the quarry operator may try application of a pond sealer, such as sodium bentonite to reduce infiltration from the sedimentation basin. Otherwise, a more conventional pond liner is recommended.

A sample calculation for a basin water balance is provided in Error! Reference source not found.. Note that in order to perform a water balance, the basin volume and surface area must be known. The leakage from a conventionally lined pond is estimated for comparative purposes. Since these settling basins often have low water levels (<6 in) the example considers only seepage through the floor of a conventionally lined pond, and not the walls. Quarry operators seeking to demonstrate the acceptability of their pond may provide a more detailed analysis for review.
Table 4: Example water balance for unlined sedimentation basins

<table>
<thead>
<tr>
<th>Date</th>
<th>Pan Evap (in)</th>
<th>Rainfall (in)</th>
<th>Washed Bulk Volume (ft³)</th>
<th>Basin Area (ft²)</th>
<th>Actual Basin Volume (ft³)</th>
<th>Rainfall into Basin (ft³)</th>
<th>Make-up Water (ft³)</th>
<th>Total Water in (ft³)</th>
<th>Est. Basin Volume (ft³)</th>
<th>Loss * (ft³)</th>
<th>Evap (using pan coef of 0.7) (ft³)</th>
<th>Other uses (ft³)</th>
<th>Total Accounted for Uses (ft³)</th>
<th>Estim. Vol &amp; Infiltration</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/31/2010</td>
<td>0.03</td>
<td>0.3</td>
<td>27000</td>
<td>10000</td>
<td>9900</td>
<td>250</td>
<td>0</td>
<td>1620</td>
<td>1637.5</td>
<td>8612.5</td>
<td>1287.5</td>
<td>28.3465</td>
<td>1287.5</td>
<td>1287.5</td>
</tr>
<tr>
<td>1/1/2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2/2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/3/2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/28/2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/29/2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/30/2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Estimated Infiltration should be less than infiltration for RG 348 liner.
6 Hydrologic Design Summary

This guidance suggests hydrologic design levels for a range of practices. The purpose of this section is to tabulate the design requirements for easy reference.

<table>
<thead>
<tr>
<th>Management Practice</th>
<th>Hydrologic Design Threshold</th>
<th>Document Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>High water level for purposes of setting</td>
<td>water level in 12 month period with rainfall total at or above</td>
<td>2.1</td>
</tr>
<tr>
<td>quarry bottom elevation</td>
<td>90th percentile</td>
<td></td>
</tr>
<tr>
<td>Perimeter Berms</td>
<td>Contain 10-year 24 hour, spillway for 100 year 24-hour</td>
<td>2.3</td>
</tr>
<tr>
<td>Culverts for stream crossings</td>
<td>2-year event with duration equal to time of concentration</td>
<td>2.5</td>
</tr>
<tr>
<td>Sedimentation ponds</td>
<td>10-year 24-hour event plus 1 ft freeboard</td>
<td>5</td>
</tr>
</tbody>
</table>

7 References


TWDB Texas Water Development Board
http://midgewater.twdb.state.tx.us/Evaporation/pancoef.txt

