Soakage Trenches

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Soakage trenches (also known as infiltration trenches or recharge beds) are excavated trenches, wrapped in geotextile and filled with coarse stone, that receive runoff via pipes and store it in the rock voids until it is able to infiltrate into surrounding soils. The EPA defines soakage trenches as assemblages of perforated pipes, drain tiles, or other similar mechanisms designed to emplace or distribute fluids below the ground surface.

By their design, soakage trenches are underground injection-control devices (UIC); thus, they will trigger state UIC permitting requirements (*see Permits section below*). For aesthetic purposes, the fill placed in the trench can be covered in grass or plantings, and the trench can be located beneath impervious or pervious pavements, or designed with rock at the surface for a dry creek-bed look. Soakage trenches often accept water from several inlets (Field et al. 2007). Infiltration trenches in Oregon always work in conjunction with other pretreatment facilities.

LCREP 2008

Soakage trench, Portland, Oregon.

Design

Soakage trenches are typically designed to capture the stormwater runoff during 100 percent of annual storm events, on average. In some cases, cities may allow soakage trenches that infiltrate smaller storm events, especially where local soils don't drain well. *Check with your local planning department for specific design requirements for your area.*

VARIATIONS

Several variations of soakage trenches exist and are described briefly below. For more detail, please refer to referenced sources.

Underground soakage trench. These facilities have a cover medium of soil and vegetation. Because they are not visible, they are often desired for aesthetic value. Pretreatment and distribution of the runoff prior to entering the trench is required, and due to accessibility difficulties, they are more costly to maintain (Field et al. 2007).

Full exfiltration system. This type of facility is designed to capture a predetermined volume of runoff from a design storm and fully infiltrate into

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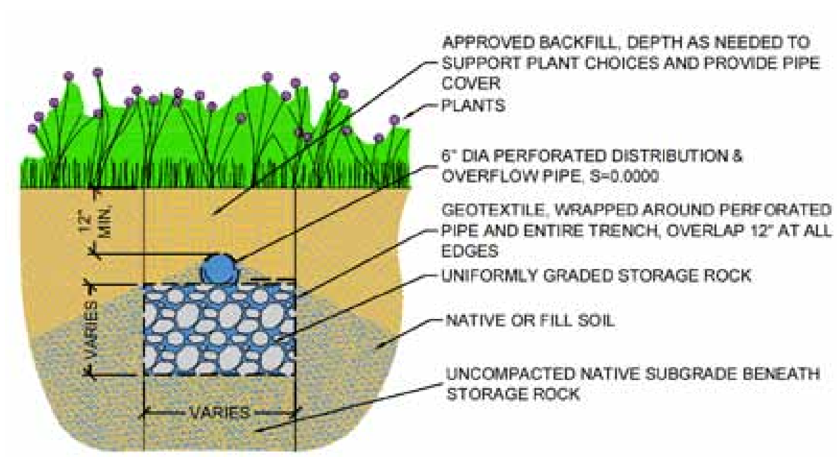
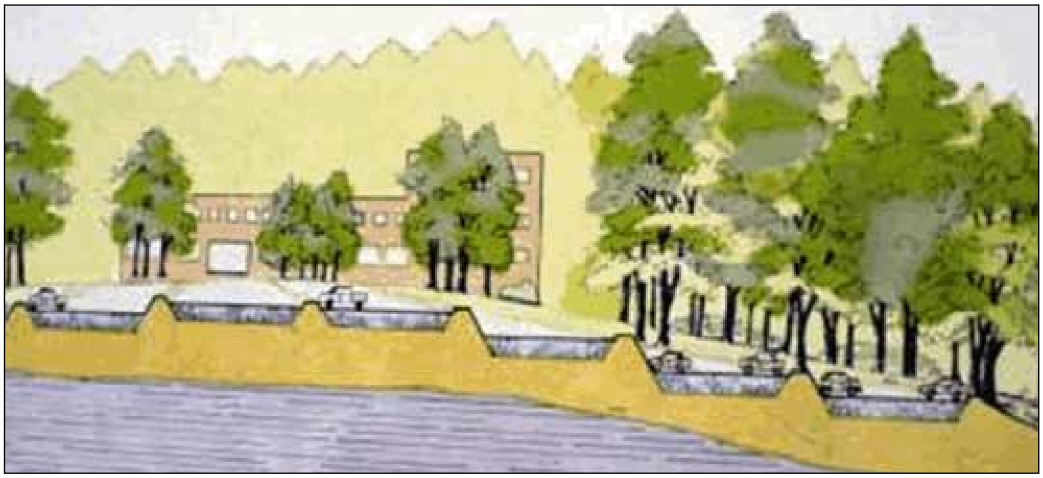


Soakage trench in landscape area.

Oregon Sea Grant
Corvallis, Oregon

ORESU-G-11-009

Credit?



Soakage trenches (aka recharge beds) stepping down a hill reduce excavation and increase storage and infiltration capacity.

underlying soils. Excess runoff in large storms is diverted to an overflow facility (Field et al. 2007).

Partial exfiltration system. This facility does not fully infiltrate all runoff. Instead, regularly spaced perforated pipes, located either at the bottom of the facility or higher in the medium, collect runoff that does not infiltrate into underlying soils if they have a lower infiltration rate. The pipes route the excess runoff to a central, approved discharge point.

Recharge (or infiltration) beds underneath pavement. This variation adds more rock underneath either porous or impervious pavements. It directs concentrated runoff from other areas to the bottom of the rock, with perforated pipes laid out along the bottom. In this type of facility, the geotextile would be installed on the sides and bottom only. If these facilities are installed beneath impervious pavement, the pavement section in that area must be designed and installed in a fashion similar to that of porous pavements *(see the* Porous Pavement *fact sheet in this series).* There can be no compaction of the native subgrade, either intentional or unintentional, and the depth of rock will have to be increased to ensure adequate structural stability, due to this lack of compaction. The rock itself should be lightly compacted, as discussed in the porous pavement fact sheet.

SIZING

As a general guideline, soakage trenches should not manage runoff from drainage areas greater than 5 acres (Arnold 1993, NCDWQ 2007), and less than 2 acres is preferred (Barr 2001, SEMCOG 2008). They are designed to drain within 24 to 30 hours to be available for the next storm.

Facility area will vary with site conditions and is dependent on factors such as soil types, the volume of water to be treated, the depth to groundwater, and the void ratio of the washed storage rock. The amount of runoff routed to the infiltration trench depends on local rainfall patterns, area of surfaces draining to the garden, and how much of the water runs off these surfaces. Impervious surfaces will generate the most runoff; simple landscapes (like lawns) will generate a moderate amount of runoff; and complex garden areas with trees, shrubs, and mulch will generate the least, if any, runoff.

Soakage trenches should be designed wide and shallow rather than deep and narrow. For independent trenches (not designed to be built underneath pavement), a side-to-bottom ratio of 1:4 is recommended (Arnold 1993), with a rectangular cross-section (Field et al. 2007). A width of 2 to 25 feet, constructed perpendicular to flow direction, is suggested (NCDWQ 2007, NRCS 2008), along with a depth of 3 to 10 feet (Field et al. 2007). Calculating the dimensions of a soakage trench can be an iterative process (NCDWQ 2007).

For the common variation of soakage trenches that are designed underneath either porous or impervious pavements (or recharge beds), the width might exceed 25 feet, and the area is often equal to a convenient area of pavement based on existing contours. Designing the trenches into the existing contours will reduce excavation and allow for the maximum effective storage volume as water infiltrates. Soakage trenches running perpendicular to contours must be designed to not function as conveyance conduits that transport water to undesirable locations. To avoid this, it is common to step them down the hill by creating underground berms between beds. Excess runoff cascades over berm after berm and is captured by an overflow pipe with a control structure to be conveyed downstream. As with all infiltration facilities, a larger footprint will result in more effective infiltration capacity, and less storage (in this case, depth of rock) will be needed to infiltrate runoff. More information about this approach can be found on the Web in the publication, *Porous Asphalt Pavement With Recharge Beds, 20 Years and Still Working* (Adams 2003).

Several design and sizing equations are available in both Barr (2001) and NCDWQ (2007). The City of Portland's *Stormwater Management Manual* (BES 2008) provides sizing mechanisms such as the Presumptive Approach. Durability and longevity of a soakage trench is highly influenced by proper design, and it is necessary to perform field tests of soil infiltration rates and investigate for impermeable layers, rather than determine construction location from preexisting data (Field et al. 2007).

SLOPE

A grade at the bottom of the facility between 0.0% and 0.5% is appropriate (NCDWQ 2007). Slopes at the ground surface may exceed 0.5% without impacting the functionality of the facility, because runoff is conveyed to the soakage trench via an underground pipe. If slopes exceed 0.5%, a soakage trench on its own can be stepped down the hill in the same fashion proposed for the recharge bed variation.

SOILS AND MEDIUM

Like all infiltration facilities, soakage trenches should be installed in native soils (LCREP 2006). Often NRCS type A and B are ideal, while C soils require partial infiltration and D soils are generally unacceptable (NCDWQ 2007, Field et al. 2007). However, field infiltration tests can yield very different results than mapped soils and should be performed to ensure adequate infiltration (Barr 2001). In addition, multiple soil horizons may have different infiltration rates, so testing should be done at different depths to optimize the size of the facility. In facilities that rely on retention time in the soil for water quality treatment (such as rain gardens), a maximum infiltration rate is often recommended. All runoff directed to these systems must be pretreated, however, so there is no recommended maximum infiltration rate.

The storage rock medium is a uniformly graded aggregate with about 40% pore space (Arnold 1993, Barr 2001, Field et al. 2007). It should be washed, uniform, and durable, and containing no fine material such as slate, shale, clay, silt, or organic matter (NCDWQ 2007). In place of the uniformly graded aggregate, concrete vaults with open bottoms can be used (NCDWQ 2007). These chambers are optimal in areas with high water tables or impermeable layers where the facility needs to be shallower in order to be installed high enough above these barriers (BES 2008).

VEGETATION

Since runoff does not pass through a ground surface but instead is delivered directly underground via a pipe, vegetation does not play a direct role in providing water quality. Vegetation should be hardy, and can consist of small plants, shrubs, or grasses that can be planted over trenches. A rule of thumb for grass is that its roots will grow as deep as the plant is allowed to grow tall. Deep rooting systems can ruin piping systems (LCREP 2006, Arnold 1993). If larger vegetation is desired and conditions will allow for the bottom of the soakage trench to be deeper, then additional soil can be added to accommodate the roots of shrubs (24 inches minimum soil depth) and trees (36 inches minimum soil depth). Be aware that larger vegetation and the greater depth of rock trench required to sustain it will make eventual replacement more costly.

GEOTEXTILE FABRIC

The sides and bottom of the facility should be lined with filter fabrics—in addition to the top of the trench, if soil will be placed over it. This design provides separation between the soil and trench rock and can prevent clogging of the facility (Field et al. 2007, Barr 2001). Filter fabric segments should overlap by 12 inches, a layering pattern referred to as the "shingle effect" (Field et al. 2007). Since geotextiles tend to clog if the rock isn't clean enough when installed, the bottom layer of filter fabric can be replaced with a 6- to 12-inch layer of clean sand as an alternative (Field et al. 2007).

Subgrade Geotextile for Separation (adapted from PSMM 2008)				
Permitivity ASTM D4491	Grab Strength ASTM D4632	Puncture Strength ASTM D4833	Mullen Burst ASTM D3786	Apparent Opening Size ASTM D4751
0.01 s^{-1} min	180 lb min	80 lb min	290 psi min	30 US Sieve max
Woven fabrics: Geotext 111F: AMOCO 1198 (GEOTEX 106F). Also refer to the Federal Highway Administration Manual, "Geosynthetic Design and Construction Guidelines," Publication No. FHWA HI-95-038, May 1995 for design guidance on geotextiles in drainage applications.				

OBSERVATION WELLS/ CLEANOUT PIPES

An observation well is vertical piping that allows the owner to confirm that the facility is infiltrating, which is especially important for facilities with overflow pipes. If a soakage trench stops infiltrating, then the observation well will always be full and subsequent runoff will simply bypass the system, with no water-quantity or -flow management at all.

Soakage trenches require at least one observation well near the center of the facility or in its lowest point, and a well every 50 feet is suggested. Piping should be a 4- to 6-inch-diameter PVC pipe. It should be properly attached to the base of the facility and the above-ground end equipped with a cap (Field et al. 2007, Barr 2001, NCDWQ 2007).

Routing

To distribute runoff across the length of the trench, a perforated pipe embedded in the trench itself is usually used, but a level spreader uphill of the trench may also be used.

To reduce the volume of suspended solids entering the trench, pretreatment facilities such as filter strips, grit chambers, grassed swales, silt basins, or forebays are required (NCDWQ 2007, Field et al. 2007). Some enhanced pretreatment facilities, such as rain gardens or proprietary filters, are also able to remove sediments and soils (Field et al. 2007)—and may be required, depending on the permitting requirements placed on your individual project by the Oregon Department of Environmental Quality (ODEQ) UIC program. Since soakage trenches are prone to clogging, difficult to maintain, and expensive to replace, a facility with higher potential pollutant loading requires greater care in the design and function of the pretreatment device (Field et al. 2007). While no pretreatment of roof runoff is required by the ODEQ, a silt basin that reduces sediment to protect the system against long-term clogging is recommended for roofs, since fine sediments and other pollutants can be deposited by air. In addition, roofs may have a number of soluble pollutants (such as biological contaminants or hydrocarbons from asphalt shingles) that may warrant additional treatment in sensitive areas. Runoff from vehicular traffic must be treated more robustly.

Overflow systems are needed to ensure that very large storms don't back up and flow out from the system too close to buildings. Even when the system is designed to infiltrate "all" of the stormwater, there will always be a larger storm than the maximum design storm that will overwhelm the system. Perforated pipes can be placed at the bottom of the facility, where they will collect runoff. These may decrease infiltration rates by piping water off the site before it is able to soak into soils. Alternatively, the spreader pipe at the top of the facility can double as the underdrain and overflow pipe and will capture runoff only when it reaches this higher elevation (ASCE 2001, Field et al. 2007). *Check with local plumbing and piping codes and regulations for sizing and discrepancies between public and private facilities (BES 2008).*

Setbacks

Soakage trenches should be set back a minimum of

- 5 feet from property lines (although they are allowed to be situated on the right-of-way line);
- 10 feet from building foundations;
- 20 feet, if a structure is located downslope;
- 100 feet, if located upslope of steep slopes (BES 2008);
- 30 feet from surface waters (although buffer requirements may not allow excavation work or other disturbance this close to surface water);

- 500 feet from water supply wells and drinking water springs (ODEQ 1998);
- 100 feet from septic tanks or drain fields;
- 20 feet from Growth Protection easements; and
- 50 feet from the top of slopes greater than 15% (Barr 2001, LCREP 2006, Field 2007, BES 2008, NCDWQ 2007).

Check with your local jurisdiction for proper siting.

Physical Setting

Soakage trenches occupy less space than many best management practices (Field et al. 2007), and the space they do occupy is often available for another use at finish grade. Potential locations for them include front, side, and back yards, as well as underneath porous and impervious pavements. They are suitable for both public and private property, and in rights-of-way. Soakage trenches may be built in new and existing developments. Although they are generally designed for smaller areas, trenches can be constructed to help manage the appropriate volume of runoff *(see the Design section for sizing criteria).* Some siting criteria for soils have been mentioned already in this document; additional criteria follow.

City of Portland BES

Soakage trench with silt-basin pretreatment. Pretreatment is not required by the DEQ for single-family residences but is highly recommended.

Soakage trenches can be installed effectively where

- soils infiltrate at a rate equal to or greater than the design infiltration rate for a depth of 3 feet below the facility (NRCS 2008)[1];
- bedrock is lower than 24 inches from the bottom of the soakage trench;
- the seasonal high groundwater table is lower than 5 feet from the bottom of the soakage trench for roofs, and lower than 10 feet for non-roof runoff; and
- the infiltration rate of the native soil and the size of the system can be balanced to infiltrate, at a minimum, the water-quality storm.

Soakage trenches should not be installed

- where the seasonal high groundwater table is higher than 5 feet from the bottom of soakage trench for roofs, and higher than 10 feet for non-roof runoff;
- where the bedrock is higher than 24 inches from the bottom of the soakage trench;

1 "A soils report and test boring should be required. The basic requirement is a minimum of 3 or 4 feet of permeable soil below the bottom of the infiltration facility (pond/tank/trench, etc.) and at least 3 feet between the bottom of the facility and the maximum wet season water table" (ODEQ 1998).

Lower Columbia River Estuary Partnership

Residential soakage trench, Portland, Oregon.

- in contaminated soils;
- on slopes exceeding 10%;
- where adequate setbacks discussed previously cannot be met;
- where soils are unstable (NCDWQ 2007, Field et al. 2007);
- over karst bedrock (landscape underlain by eroded limestone) (NCDWQ 2007, Field et al. 2007);
- where hazardous or toxic materials are stored, transported, or otherwise handled; or
- where an accidental spill of a hazardous or toxic liquid would drain into the facility.

Pollutant Removal

While a literature search for information on the pollutant removal capacity of soakage trenches will yield results, the Oregon Department of Environmental Quality strictly regulates all underground injection controls and requires adequate pretreatment before disposal is permitted. In Oregon, for all practical purposes, pollutant removal of these systems should be assumed to be none.

Construction

Like all stormwater management facilities, care must be taken to properly construct a soakage trench. The proposed trench location should be fenced off to prevent vehicular and foot traffic that will compact soils and reduce the infiltration rate of the native soils. Low-compaction construction techniques, such as using track equipment or excavating from the sides of the infiltration area, should be used to protect the soils during excavation (Barr 2001, NCDWQ 2007, BES 2008). If the soils are exposed to rain, fine soil particles will be picked up and moved around and may clog the native subgrade soils. Rake the surface to loosen soil before proceeding. Raking will also be needed if the soakage trench is dug by hand, because foot traffic in the facility area might be unavoidable.

Maintenance

Durability and longevity of a soakage trench is highly influenced by proper design. Ultimately, however, careful maintenance to prevent clogging will have the greatest impact on the longevity of a properly designed and installed soakage trench. Maintenance demands range from medium to high, and, in some cases these demands are considered to be a limitation (Arnold 1993, Barr 2001, NCDWQ 2007). Inspection of the facility should be performed every 3 months and after large storms for the first year, and then once per year and after major storms (Barr 2001, NCDWQ 2007). Maintenance schedules for pretreatment will vary depending on the approach. *See the fact sheets on* Rain Gardens, Vegetated Filter Strips, *and* Planters *in this series. For structures like silt basins and water-quality manholes, follow the manufacturer's operations-and-maintenance guidelines.*

Tasks include examining for erosion and sediment buildup, observation of infiltration rates, maintaining the health and growth of vegetation, and removal of sediment and debris (Arnold 1993, Barr 2001, LCREP 2006, NCDWQ 2007). See North Carolina's *Stormwater Best Management Practices Manual* (NCDWQ 2007) for an extensive table of potential problems and solutions regarding the maintenance of soakage trenches. Properly maintained, these facilities can last up to 30 years (LCREP 2006) although the Oregon Department of Environmental Quality's UIC program stormwater management guidelines indicate that they often fail within 5 years.

Permits

Consult your local planning and building department. Ask about applicable permits, plumbing codes, and piping requirements. Find out if there are any maps, as-built drawings, or site-specific constraints. In many cases, a commercial building permit is required to build a planter on a nonresidential site, and a clearing, grading, and erosion-control permit may be required if the ground disturbance area is large enough.

UIC REGULATORY APPROVAL

A Class V Underground Injection Control (UIC) is a system designed for the subsurface placement of fluids and is regulated through the Oregon Department of Environmental Quality's UIC program. This program protects groundwater resources from injection of pollutants directly underground and may be rule-authorized or require a more formal permitting process, depending on the potential for various pollutants to be on site. According to the U.S. Environmental Protection Agency, a Class V UIC well is also, by definition, "any bored, drilled, or driven shaft, or dug hole that is deeper than its widest surface dimension" (http://water.epa.gov/type/groundwater/uic/class5/types_stormwater.cfm). Soakage trenches are considered a Class V Injection Well and must be approved by the Oregon Department of Environmental Quality (ODEQ). These systems are regulated throughout the state because, unlike rain gardens and swales, they don't inherently remove pollutants, and because they are much more likely to pollute groundwater.

In addition to the application paperwork, a long-term stormwater management plan must be developed, including a description of the best management practices for the entire site, spill prevention and response, a maintenance plan and schedule, and an employee training record. The plan must be revisited every 5 years or immediately after a spill, and the facility itself must then be repermitted. The ODEQ has very specific guidelines for pretreatment and other permitting requirements that you can find on its Web site (ODEQ 2005b).

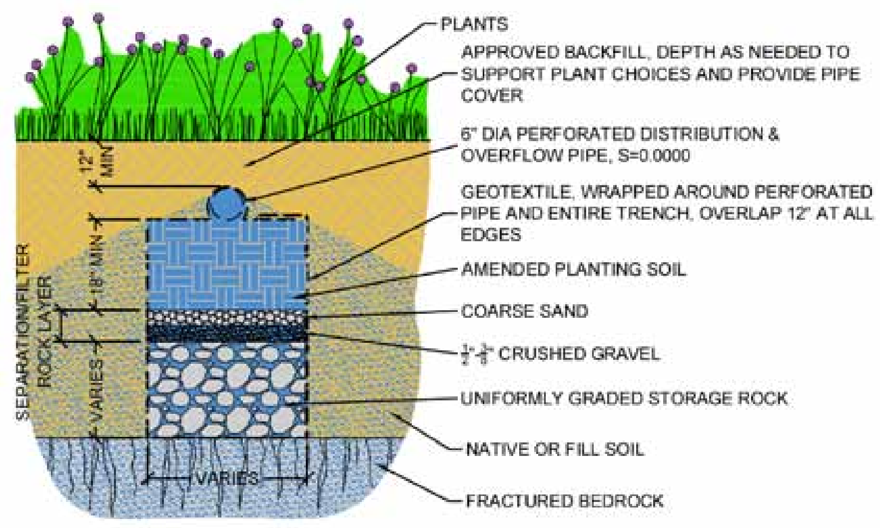
It's worth noting that "State rules prohibit the use of injection systems where better treatment or protection is available (for example, when a stormwater or municipal sewer is available), and must also meet the requirements of the state Groundwater Act (Div. 40). By policy, these services are considered available if the system is not at capacity or is within 300 feet of the site. ODEQ will confirm availability with the jurisdiction before allowing the use of injection systems" (ODEQ 2005a).

There may be other alternatives to the use of soakage trenches and other UICs to manage stormwater.

Howard's Excavating, New Buffalo, Michigan

Soakage trench under construction.

Maria Cahill



Soakage trenches may be installed on fractured bedrock when an 18-inch soil layer (minimum) is included in the design.

If site constraints allow, a designer should consider using other surface-infiltrating low impact development (LID) or green infrastructure techniques—such as rain gardens, planters, swales, vegetated filter strips, porous pavement, and green roofs—to manage runoff *(refer to the other fact sheets in this series).* Additionally, when combined with the stormwater controls noted above, other nonstructural techniques (such as better site design) will help reduce the runoff and help a designer avoid the use of soakage trenches or other UICs. Some examples of better site design include natural-area conservation, open space or cluster design, reduced street widths, reduced sidewalks, shorter driveways, and impervious surface disconnection.

Most UICs are under rule authorization, not permitting. Individual residential roof soakage trenches are not, by policy, required to register and get ODEQ approval as UICs, unless the city requests the review due to high groundwater concerns. Fourplexes, apartment houses, and commercial and industrial roof drains do need ODEQ approval though rule authorization. Usually no pretreatment is required as long as the discharge is just roof runoff. If the trench drain serves a parking area, driveway, garbage bin, or loading dock, however, it must be registered and approved by ODEQ. Trenches with a depth dimension less than their largest surface dimension are not categorized as injection wells (NCDWQ 2007).

Please note that cities and counties cannot approve UICs; only ODEQ can do this, as the agency delegated by EPA. *For more information, visit the DEQ Web site (ODEQ 2005b).*

Cost

Construction costs range from medium to high (NCDWQ 2007). Because these facilities can be easily installed in small spaces, they are often quite cost-effective (Arnold 1993). However, clogged facilities cannot be unclogged without excavating the entire system and replacing it, which could contribute to the lifecycle cost of the system (ASCE 2001).

Permitting costs for soakage trenches vary from $100[2] to $300, and the cost of preparing the required permitting documentation can be as high as $2,000. The purchase of spill response materials to be kept on site and training employees or maintenance staff in spill response measures will also add to the cost.

New state regulations went into effect in September of 2001, requiring numerous existing and previously permitted UICs around Oregon to meet the current standard. This regulation indicates that there will be no grandfathering of these systems and if new rules are believed necessary to protect Oregon's groundwater resources, there could be an unpredictable future cost associated with retrofitting.

2 Values are in 2010 dollars.

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