SALTWATER INJECTION WELL

This is a well constructed and used for the sole purpose of disposing of saltwater, a by product of oil and natural gas production. A saltwater injection well is constructed to isolate the injected fluid in a specific formation and prevent contamination of freshwater. The following is a description of the construction and monitoring system used on saltwater injection wells. Please refer to diagram #1 for a graphic illustration.

(A) Surface Casing - steel casing must be set below the depth of freshwater and sealed to the surface with cement. This prevents saltwater from getting into the freshwater aquifers from the well bore as the well is drilled deeper through saltwater bearing formations.

(B) Longstring Casing - steel casing which must be set to the total depth and cemented to a minimum of 300 feet above the top of the injection zone. This confines all injected water to the injection formation.

(C) Confining Strata - layers of impervious rock that prevent fluid from migrating upward.

(D) Monitoring System - steel tubing is set on a packer (a device used to seal the tubing to the casing) no more than 100 feet above the injection zone. The space between the tubing and casing is filled with freshwater with a corrosion inhibitor. Pressure is applied to this fluid to indicate if a leak exists in the tubing, casing, or packer. This monitoring must be performed prior to injection under the supervision of Division personnel and at least once a month to ensure that there are no leaks.

(E) The Division regulates injection by limiting the injection pressure. This prevents extending fractures in the injection formation and prevents fracturing the confining strata.

In addition to construction of the injection well itself, the Division has specific requirements for the unloading and surface storage facilities at injection wells. Diagram #2 shows an example of saltwater injection well surface facilities. The designation "A" refers to a cement unloading pad which is used to catch any spillage from unloading trucks. The symbol "B" refers to the dike, which is constructed to contain saltwater should there be a spill from one of the tanks. Because surface storage needs vary a great deal from facility to facility, the Division evaluates each on a site specific basis.

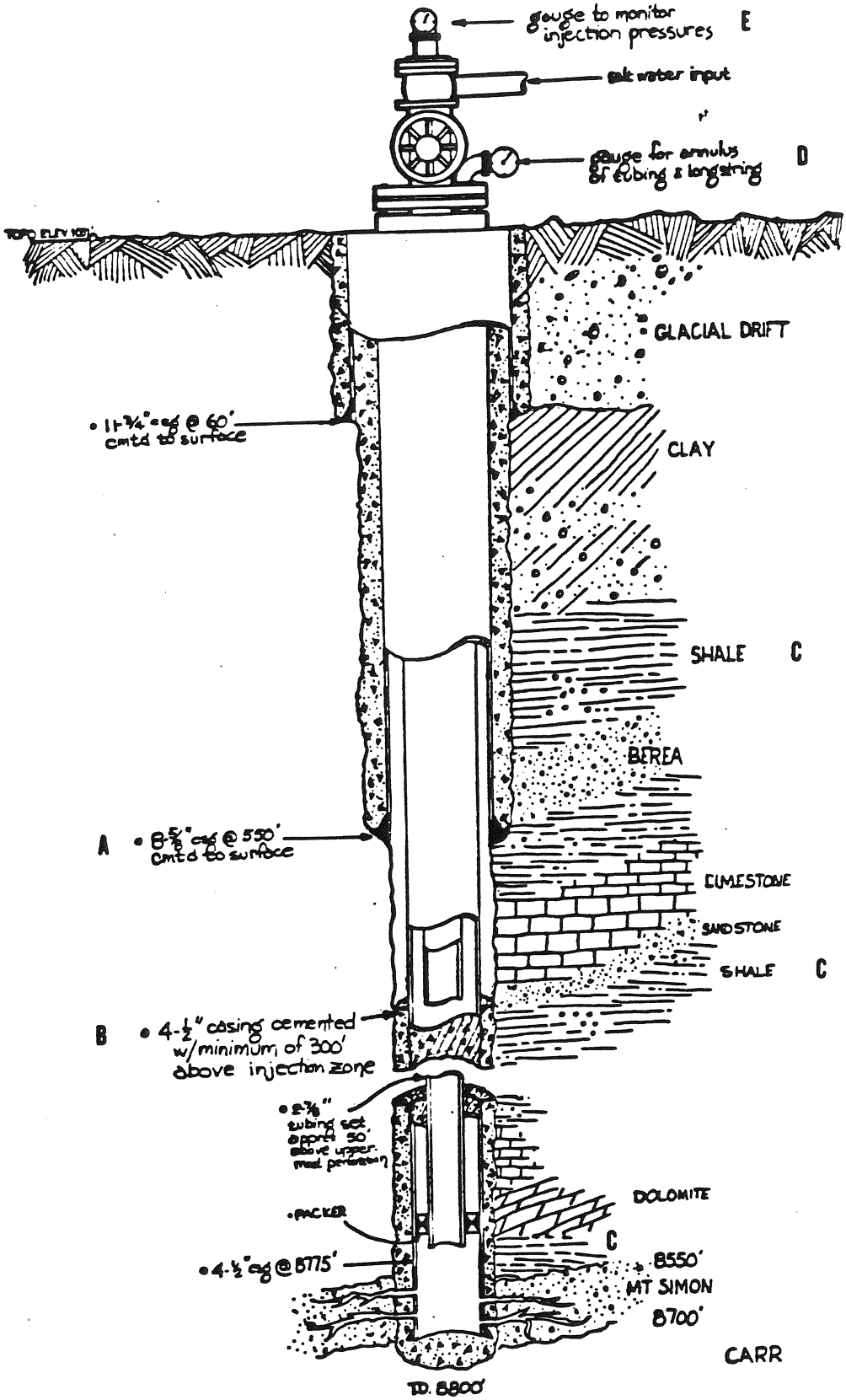
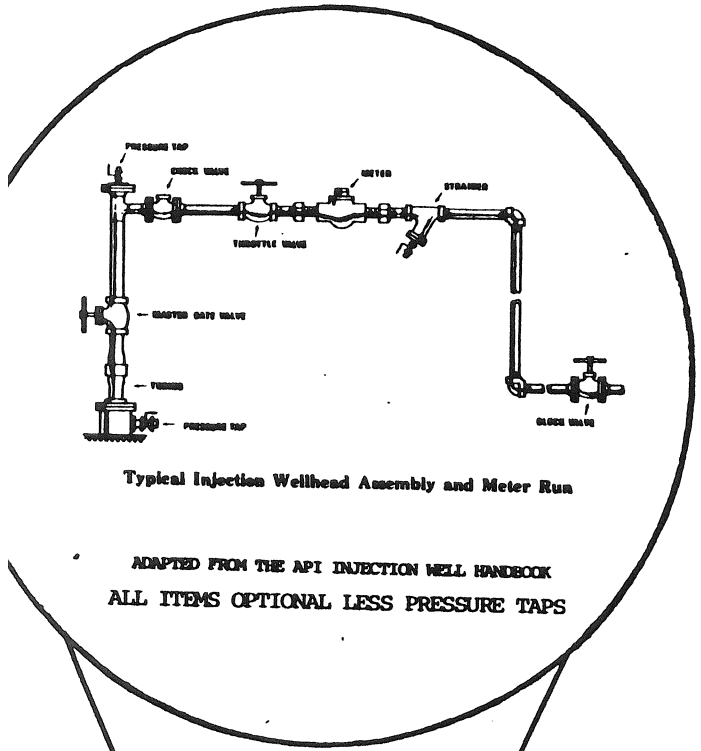

gauge to monitor injection pressures
E
salt water input
gauge for annulus or tubing & longstring
D
TOPO ELEV 1081'
GLACIAL DRIFT
• 11-¾" csg @ 60' cmtd to surface
CLAY
SHALE
C
BEREA
A • 8-⅝" csg @ 550' cmtd to surface
LIMESTONE
SANDSTONE
SHALE
C
B • 4-½" casing cemented w/minimum of 300' above injection zone
• 2-⅜" tubing set approx 50' above upper most perforation
DOLOMITE
• PACKER
C
• 4-½" csg @ 8775'
8550'
MT SIMON
8700'
CARR
TD. 8800'

DIAGRAM 2



Typical Injection Wellhead Assembly and Meter Run

ADAPTED FROM THE API INJECTION WELL HANDBOOK

ALL ITEMS OPTIONAL LESS PRESSURE TAPS

SURFACE CONSTRUCTION AT SALTWATER INJECTION WELL SITES

A - Concrete unloading pad with concrete vault.

B - Impermeable dike of sufficient capacity to contain volume of largest tank on site.

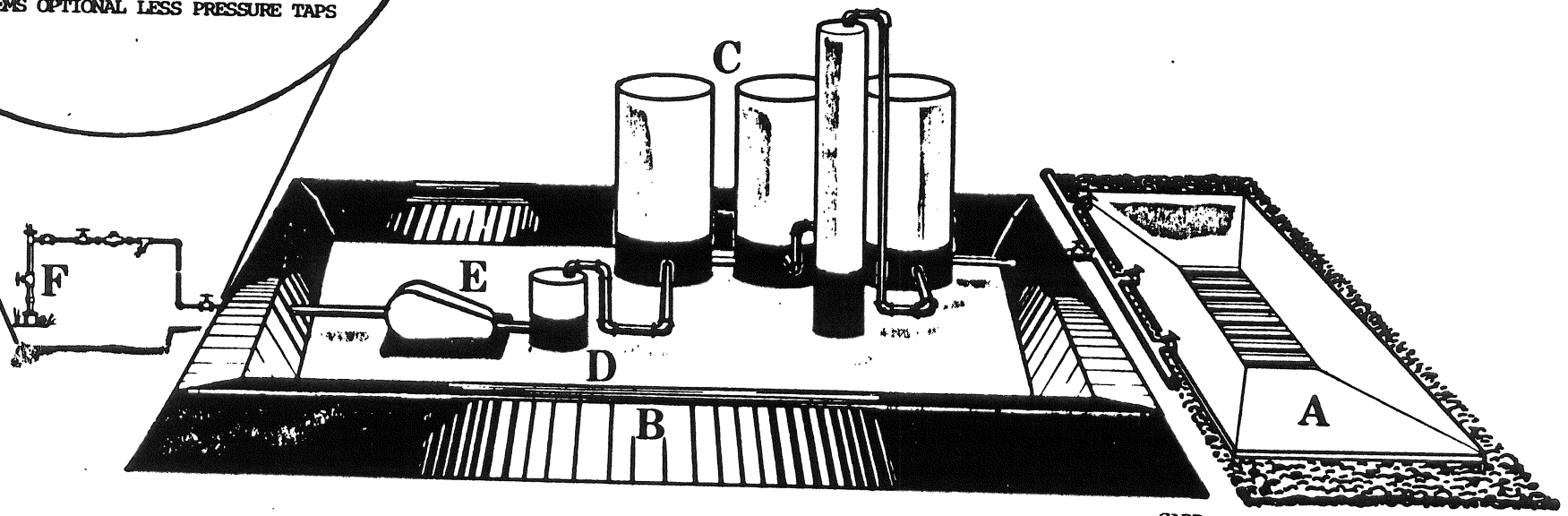
C - Containment vessels

D - In-line filter system

E - Pump

F - Injection well

Note: All facilities must contain as a minimum items A,B,C and F.



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CONSTRUCTION REQUIREMENTS FOR CONTAINMENT FACILITIES[1] AT ALL SWIW SITES

All surface containment facilities shall be constructed so as to prevent migration of fluids into the soils and waters of the surface and subsurface. In addition to the requirements established in Rule 1501:9-3-05 (A)(6) and (B)(7) of the Ohio Administrative Code, the following requirements shall be met:

1. Each surface containment facility shall be reviewed on an individual basis. All containment facilities shall be of sufficient capacity to contain the volume of the largest tank or vessel on site (allowance for rainfall should be made).

2. All containment facilities shall be of impervious construction so as to prevent leachate of spilled fluids within diked area into surrounding surface and subsurface soils and waters. This requirement shall be met by utilizing one of the following construction schemes or its equivalent:

   - containment facility shall be constructed of sufficient amounts of clay prepared by adequate compaction methods to prevent any leachate of fluids. This clay can be overlain with other materials if so desired, or

   - utilization of polyethylene (or equivalent material) liners in containment facility overlying properly prepared soil to prevent liner rupture (minimum thickness of 30 mil), or

   - in lieu of the above methods utilize steel-reinforced concrete surface area to encompass entire containment facility.

Construction of all phases of the containment facility shall be witnessed by a representative of the Division.

Construction of containment facility shall not begin prior to receiving a permit for a UIC facility. All proposals and plans for construction shall be of sound engineering design and are subject to approval and review by the Division. Any variance to the above requirements shall be approved by the UIC Section and the Chief of the Division of Oil and Gas.

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[1] Containment facility means the dike wall and area within which will accommodate storage vessels.

CONSTRUCTION REQUIREMENTS FOR EARTHEN IMPOUNDMENTS ON UIC FACILITIES

Any earthen impoundment used for the temporary storage of saltwater at a UIC facility shall be constructed so as to prevent migration of fluids into the soils and waters of the surface and subsurface. In addition to the requirements established in Rule 1501:9-3-08 of the Ohio Administrative Code, the following additional requirements shall be met.

1. Each proposed impoundment shall be reviewed on an individual basis. However, as a rule of thumb, impoundments shall not exceed a length of 200 feet, a width of 50 feet, and a depth of 10 feet.

2. An underdrain shall be constructed beneath the impoundment and drainage tile shall be laid so as to detect any leakage. The drainage tile shall protrude from the lowest part of the impoundment and periodic sampling of any fluids shall be performed. In the event that the drain tile can not be installed so that it protrudes from the embankment of the impoundment, a monitoring well shall be constructed down to the drain tile so samples may be taken periodically.

3. The impoundment must be shaped and formed using a minimum of 6 inches of clay, gelled, then approximately 6 inches of sand shall be placed on top of the clay.

4. The impoundments shall then be lined with an impervious man-made material having a minimum thickness of 40 mil.

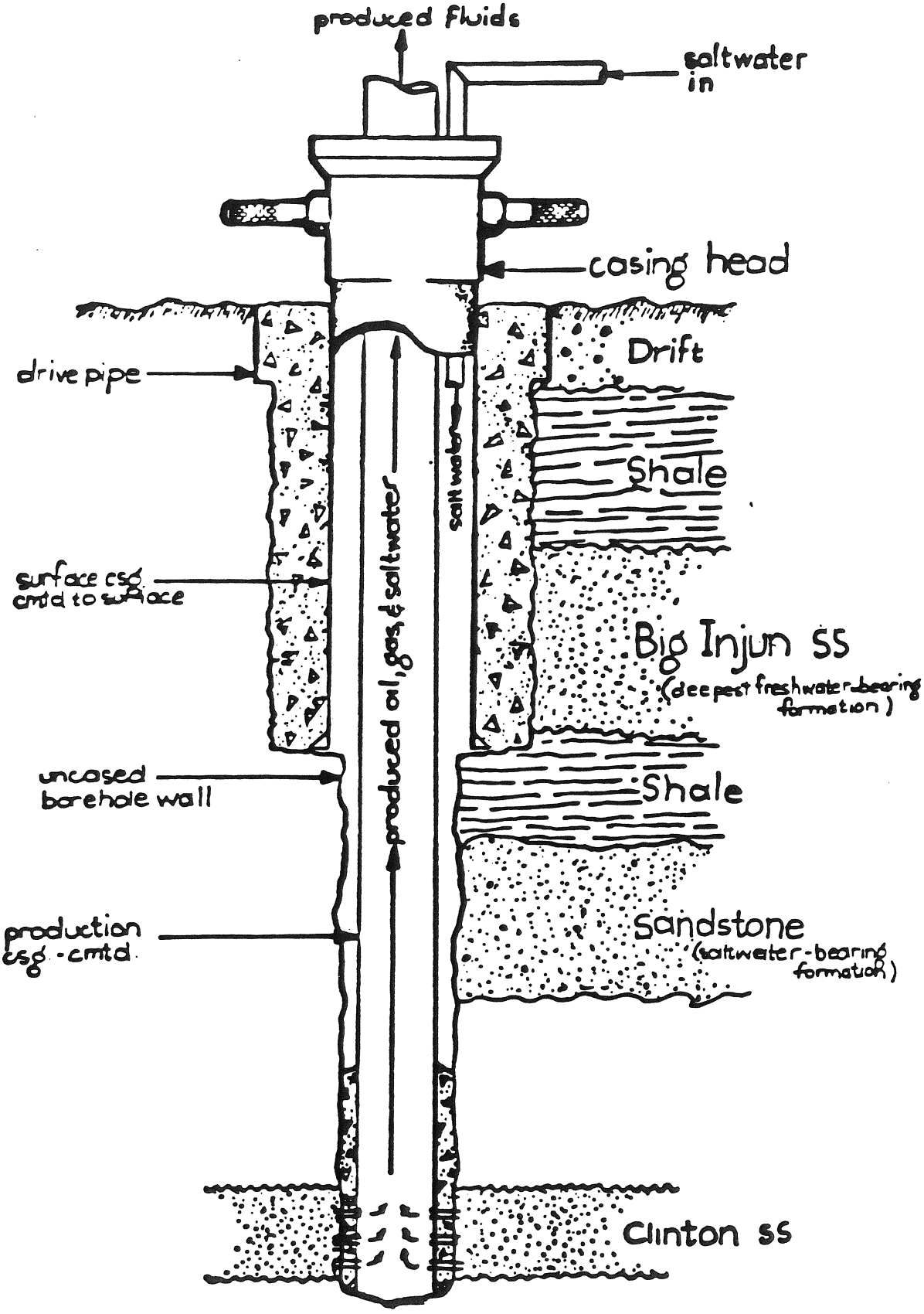
Construction of all phases of the earthen impoundment shall be witnessed by a representative of the Division, and any changes to the original process must have prior approval from the Division.

Construction of an earthen impoundment shall not begin prior to receiving a permit for a UIC facility. No impoundment shall be used for temporary storage of saltwater until work has begun on the saltwater injection well facility. Any variance to the above requirements shall be approved by the UIC Section and the Chief of the Division of Oil and Gas.

Type of Well	Depth of Surface Casing	Surface Casing Sealing Material	Injection Pressure Monitored	Injection thru Tubing set on a packer	Monthly or Continuous Monitoring	Isolated Injection Formation
Saltwater Injection Well	50' thru deepest freshwater	Cement *	Yes	Yes	Yes	Yes
Enhanced Recovery Project Inj. Well	50' thru deepest freshwater	Cement *	Yes	Yes	Yes	Yes
Annular Disposal Well	50' thru deepest freshwater	Cement or prepared clay	Yes	No	No	No

* may be sealed with prepared clay if it is an old well being converted

MINIMUM CONSTRUCTION FOR AN ANNULAR DISPOSAL WELL



ANNULAR DISPOSAL

Annular disposal is a method of disposal in which a producing oil and gas well is also used to dispose of saltwater. The saltwater is injected between the surface casing and the production casing, as shown on diagram #3. The protection of freshwater is from the surface casing only, which must be set fifty feet below the deepest freshwater bearing formation and sealed to the surface. Mechanical integrity of the casing is tested once every five years.

Annular disposal wells are only authorized to dispose of saltwater produced on the same lease or possibly an adjacent lease. The volume of saltwater injected is limited to a maximum average volume of 5 barrels a day per year if the surface casing is sealed with prepared clay and a maximum average volume of 10 barrels a day per year if the surface casing is sealed with cement. Under no circumstances can saltwater be trucked to an annular disposal well.

Injection pressure in an annular disposal well can be only that pressure which is created by the force of gravity. Injected water is not confined to a specific formation, but may be entering any formation from the bottom of the surface casing to the top of the cement on the production casing.

ENHANCED RECOVERY PROJECTS

An enhanced recovery project is composed of both injection wells and withdrawal wells. The intent in an enhanced recovery project is to inject a substance into a producing formation in order to increase the reservoir pressure or to retard pressure decline, thereby increasing oil and/or natural gas production in the surrounding withdrawal wells. In some cases, the substance injected is produced saltwater. Enhanced recovery project injection wells are subject to the same permitting, construction, operation, and monitoring requirements as saltwater injection wells. (Refer to diagram #1 for construction requirements.)