Drainage Wells—A Dual Purpose

C.W. Sheffield, Carlos Rivero-deAguilar, and Kevin McCann

Disposal of stormwater by injection wells to the underground aquifer has been practiced in Florida for years. Regulatory agency rules are wide and varied on the subject. The adaption of existing wells to the dual purposes of removal of excess stormwaters and aquifer recharge seems feasible in many cases.

In central Florida, it is estimated that up to 40 percent of the aquifer recharge is through drainage wells. The emphasis of this article is to summarize the existing available wells; discuss water quality of stormwaters as is presently known; review DEP requirements for drainage wells; and stormwater treatment methods to achieve the required water quality.

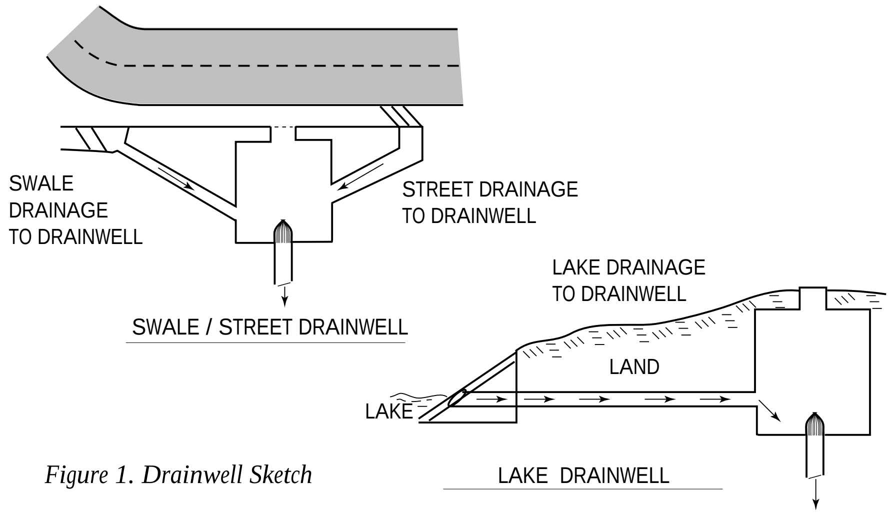

Figure 1. Drainwell Sketch

As forecast by the USGS Report of Investigations No. 50, published in 1968, aquifer withdrawals now exceed recharge in Orange County. In the past the priority of injection wells has been to reduce flood damage by disposal of excess stormwater. A higher priority is becoming the renewal of drinking water resources, as evidenced by the estimate that up to 40 percent of aquifer recharge is contributed by injection wells.

Since intermingling of surface and groundwater occurs, and since recharge by natural percolation is steadily being diminished by increased population growth and its corresponding demand, it is essential that use of injection wells for the dual purpose of water supply and flood control be enhanced. Engineering studies are needed in the several elements dual use, such as minimum pretreatment requirements; quantities available for storage; unit costs for construction, maintenance, and operation; and long term impacts of the practice.

There are about 1,200 injection wells in Florida. There are more than 400 in Orange County. It is thought that many of the wells can be economically adapted to be dual purpose units. Figure 1 shows how some of the existing drainage wells function, while other figures show some suggested methods that may be appropriate for pretreatment measures.

Water quality of Stormwater Run-off

In the city of Orlando, there are 83 named lakes and 154 known active drainage wells. Twenty-four of the city lakes discharge lake waters to drainage wells.

Water, prior to entering certain drainwells, was sampled and analyzed for BOD, COD, nutrients, metals, bacteria, inorganics, volitiles, total phenols, cyanide, oil and grease, pH, pesticides, acid extractables organics and base/neutral organics. The results of the analyses are shown in Tables 1 and 2. BOD ranged from 6.5 to 20.3 mg/l. Mean COD concentrations ranged form 44 to 93 mg/l. Industrial and single family land use sites had the highest mean BOD and COD concentrations.

Total phosphorus ranged from 0.19 to 0.56 mg/l. Mean total phosphorus concentrations were approximately twice as high at the industrial and single family land use sites when compared to the other land sites in the study.

Total nitrogen concentrations ranged from 0.93 to 2.86 mg/l and were highest at industrial and single family sites. Nitrate-nitrite concentrations ranged from 0.15 to 0.46 mg/l.

Total suspended solid concentrations were highly variable, ranging from 19 mg/l at the heavy commercial site to 103 mg/l at the industrial site.

Measurements of pH indicate that stormwater runoff is typically slightly alkaline with values ranging from 7.5 to 7.9.

Phenol concentrations of 0.06 mg/l were reported at the heavy commercial site, while the highest phenol concentration was 0.08 mg/l at the industrial site.

Total cyanide was below detectable limits in all samples.

Metals which were consistently present above the detectable level were cadmium, copper, lead, and zinc. Mean cadmium concentrations ranged from 0.0003 to 0.00019 mg/l.

Copper concentrations ranging from 0.008 mg/l at the heavy commercial site to 0.036 mg/l at the industrial site. Mean lead concentrations ranged from 0.008 to 0.088 mg/l, with the highest at industrial land use sites. Zinc mean concentrations ranged from 0.060 mg/l at the single family residential site to 0.320 mg/l at the industrial site.

Barium was detected at a concentration of 0.20 mg/l at an industrial and transportation drainwell site. Chromium was detected in the two samples run at the 0.001 mg/l detection limit with concentrations of 0.028 mg/l at the industrial site and 0.005 mg/l at the light commercial site.

These results should provide valuable data on stormwater entering drainwells in central Florida.

Regulations Governing Drainage Wells

In Florida, injection wells are covered under Chapter 17-28 F.A.C., "Underground Injection Control Rule." DEP obtained delegation of the Underground Injection Control (UIC) program from EPA on March 9, 1983.

The state adopted the Federal UIC regulations and developed rules tailored to the hydrogeology and injection practices in Florida. On April 1, 1982, Chapter 17-28, F.A.C. was officially promulgated. The intent of the program is to allow underground injection, provided that designated uses of ground water are not interfered with, no violations of water quality standards occur, and public health is protected.

According to Chapter 17-28, F.A.C., there are five classes of injection wells. Stormwater/lake level drainage wells are considered Class V and are further defined as Group 5 within that class. Class V wells are grouped together depending on the expected quality of the injected fluid (injectate), well type and activity generating the fluid.

All existing wells must operate in a way that does not present a hazard to existing or future use of an underground water source. Similarly, DEP will not permit new wells unless groundwater protection can be guaranteed. The fact that many Class V wells existed prior to the promulgation of state and federal UIC rules was recognized when Chapter 17-28 was developed. To accommodate them, wells operating prior to April 1, 1982 were "grandfathered" and authorized by rule.

When is a department UIC permit required? Existing wells (those in operation prior to April 1, 1982), may continue to operate without a permit as long as they work as intended. However, if an existing well is no longer used for its intended purposes, the department may require that the well be plugged and abandoned. A permit will be needed. Likewise, a permit may be required if the department finds a well is causing violations of primary drinking water standards or affecting public health and would also be required to alter an existing well for other than regular routine maintenance, or repair work to restore a well to its original condition. Casing modifications, deepening of the well, and changes to inlet elevation would be among the types of modification needing a permit.

New Class V wells (those after April 1, 1982) cannot be constructed, operated, modified, or plugged and abandoned without a permit.

For permitting of stormwater/lake level drainage wells, the following construction permit criteria apply to new wells as well as to modifications of existing ones.

In all underground drinking water sources, the federal primary drinking water standards (USDW) must be met, as well as the non-federal (state) primary and secondary drinking water standards, or ambient water quality for the constituents contained in the non-federal primary water quality standards (whichever is of lower quality) while meeting the minimum criteria of "free froms."

Table 1. Mean concentration for pollutants in stormwater runoff samples collected in the City of Orlando at seven sites. All concentrations are mg/l except for bacteria and pH data which is #/100 ml and standard units, respectively.

Land Use		Industrial		Light Commercial		Heavy Commercial	Single Family Residential	Multi Family Residential
Site Location		Central Av.	Atlantic Av.	Lawton Av.	Curry Ford Rd.	Concord Av.	Marabon Av.	Woodlake Villas
	n	4	4	4	5	4	4	4
Parameter	*Detection Limit*							
B.O.D.	0.5	20.3	No Data	6.5	No Data	7.5	15.8	9.7
C.O.D.	1.0	91	No Data	72	No Data	44	93	75
Diss. Phosphorus	0.005	0.109	No Data	0.050	No Data	0.076	0.179	0.059
Fecal Coliform	2	TNTC*	No Data	TNTC*	No Data	TNTC*	TNTC*	7125
Fecal Strep.	2	TNTC*	No Data	TNTC*	No Data	55550	TNTC*	17950
Florida	0.01	No Data	0.42	No Data	*	No Data	No Data	No Data
Nitrate	0.02	0.21	1.56	0.22	0.37	0.25	No Data	0.23
Nitrate-Nitrite	0.02	0.27	No Data	0.23	No Data	0.37	0.46	0.15
Oil & Grease	1.0	10.8	No Data	BDL	No Data	103	307	10.6
pH		7.9	No Data	7.9	No Data	7.5	7.6	7.6
Sodium	0.01	No Data	9.20	No Data	2.09	No Data	No Data	No Data
T. Phosphorus	0.05	0.56	No Data	0.20	No Data	0.19	0.40	0.196
T.D.S.	5.0	121	No Data	78	No Data	100	56	56
T.S.S.	1.0	103	No Data	61	No Data	19	64	55
T.K.N.	0.04	2.57	No Data	1.19	No Data	1010	1.97	0.80
Total Cyanide	0.02	<0.02**	No Data	<0.02**	No Data	<0.02**	<0.02**	<0.02**
Total Nitrogen	0.06	2.86	No Data	1.40	No Data	1.46	2.42	0.93
Total Phenols	0.05	<0.05**	No Data	<0.05**	No Data	<0.05**	<0.05**	<0.05**
Metals								
Total Antimony	0.005	<0.005**	No Data	<0.005**	No Data	<0.005**	<0.005**	<0.005**
Total Arsenic	0.001-0.005	<0.005**	0.004	<0.005**	<0.001**	<0.005**	<0.005**	<0.005**
Total Barium	0.005	No Data	<0.005**	No Data	<0.005**	No Data	No Data	No Data
Total Beryllium	0.004	<0.004**	No Data	<0.004**	No Data	<0.004**	<0.004**	<0.004**
Total Cadmium	0.0005	0.0019	0.0018	0.0009	*	0.0003	0.0005	0.0005
Total Chromium	0.005	<0.005**	<0.005**	<0.005**	<0.005**	<0.005**	<0.005**	<0.005**
Total Copper	0.010	0.36	No Data	•	No Data	0.008	0.012	0.013
Total Lead	0.005	0.088	0.039	0.023	0.013	0.008	0.012	0.010
Total Mercury	0.0002	<0.0002**	<0.0002**	<0.0002**	<0.0002**	<0.0002**	<0.0002**	<0.0002**
Total Nickel	0.030	0.030**	No Data	0.030**	No Data	0.030**	0.030**	0.030**
Total Selenium	0.005	<0.005**	<0.005**	<0.005**	<0.005**	<0.005**	<0.005**	<0.005**
Total Silver	0.01	<0.01**	<0.01**	<0.01**	<0.01**	<0.01**	<0.01**	<0.01**
Total Thallium	0.002	<0.002**	No Data	<0.002**	No Data	<0.002**	<0.002**	<0.002**
Total Zinc	0.030	0.320	No Data	0.086	No Data	0.058	0.060	0.101

*majority of results were reported at TNTC (Indicates >20,000/100m)

**majority of results were below detectable limits otherwise means were calculated using 1/2 detection limit.

Injection wells do not qualify for a zone of discharge (ZOD) permit if discharging into a Class II groundwater having total dissolved solids of 10,000 mg/l or less.

For discharges into Class III and Class IV groundwaters in unconfined zones having TDS of 10,000 mg/l or greater, the injected water must meet the criteria for "free froms" and be non-hazardous.

Finally, the department may impose monitoring and reporting requirements on new and modified drainage wells and the construction permit should reflect that. However, according to Rule 17-28, F.A.C. no operation permit will be needed.

Suggested Stormwater Treatment Methods

The problem of untreated drainage water into the lakes, streams and injection wells is basically, the nutrients (nitrogen and phosphorus), solids, bacteria and viruses. Stormwater water quality results, presented above, along with the rules and regulations by the state agency document the fact that the majority of the pollution load within stormwater is the first flush. From this it can be concluded that some means of treatment should be enacted to treat the first half to one inch of runoff, which is basically the requirement at the present time.

Prior to establishing design criteria for stormwater before it enters any drainage well, various physical and climatic constraints should be reviewed. Stormwater quality in this area is very dependent on the climatic and topographic features such as storm intensity and duration; distribution over the basin; land use; and topographic features (such as hills, swamps and soil types).

Therefore, any type of stormwater treatment device should be designed to meet the needs of the particular constraint as described above. The treatment of stormwater can be basically broken down into physical, chemical, and biological. Physical treatment includes just operations as settling and screening. Chemical treatment could be injection of alum into the stormwater on a storm by storm basis. Biological treatment might be accomplished using plants, fish, or other types of treatment in retention ponds. In many instances, physical treatment (screening-percolation) is in combination with chemical treatment (alum injection) and followed by a retention pond (with plants) prior to discharging into an injection well.

There are numerous types of physical methods. Figure 2 shows the most typical—a chain link filter and silt trap. There are other methods, as shown in Figure 3, by which stormwater is treated prior to flowing into the street and /or the drainage pond using swales. There are numerous other types of physical barriers or filtering systems.

In general, chemical treatment consists of alum injection directly into the stormwater pipe, as shown in Figure 4. Various types of chemicals can be used to meet such physical conditions as velocity, pipe size, and outfall location.

Figure 4 also indicates a biological treatment, which is mainly using the littoral zone vegetation. Figure 5 indicates the slopes and where the vegetation would be planted.

Figure 6 illustrates drainage water from an 8-acre wetland

Table 2. Concentrations of organic contaminants detected in the city of Orlando at 9 stormwater runoff and 1 lake overflow sampling site. All concentrations are ug/l.

Location	Atlantic Av	Central Av	Curry Ford Rd.	Lawton Av	Concord Av	Gertrude Av	Marabon Av	Marks St	Woodlake Villas	Lk. Underhill
Land Use	Industrial	Industrial	Light Commercial	Light Commercial	Heavy Commercial	Transportation	Single Family Residential	Single Family Residential	Multi-Family Residential	Mixed Lake Overflow
Samples	n=4	n=5	n=5	n=5	n=5	n=2	n=5	n=1	n=4	n=5
Base/Neutrals Compounds										
3,4 Benzofluoranthene					13, 17					
Benzo(A)Anthracene	193									
Benzo(A)Pyrene					11					
Benzo(A)Fluoranthene			12		10, 15					
BIS(2-Tthylhexyl)Phthalate	195	90					11		7	
Chrysene					12					
Di-N-Butyl phthalate		132							60	
Di-N-Octyl phthalate	275									
Fluroanthene	192				10, 14					
Indeno (1,2,3-CD Pyrene)					12					
Pyrene					12					
Volatiles										
1,1,2 Trichloroethane		30.8			24.0					
1,2 Dichloroethane		4.2			4.2, 1.7					
Acrylonitrile			11							
Chloroform	1		4							1
Tetrachloroethylene					30.8					
Toluene							4.7			
Pesticides										
BHC Alpha Isomer										0.07
Diazinon	0.727		0.2							0.2
Ethion			0.012							
Guthion			0.072							
Malathion	2.8, 0.203		0.253, 0.312							
Parathion			0.13							
Herbicides										
2, 4-D	0.33									
2, 4, 5-TP	0.17									

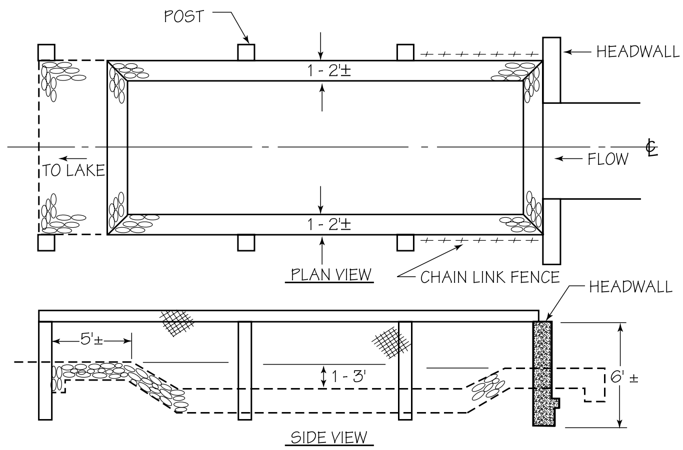

Figure 2. Chain Link Fence Filter and Silt Trap

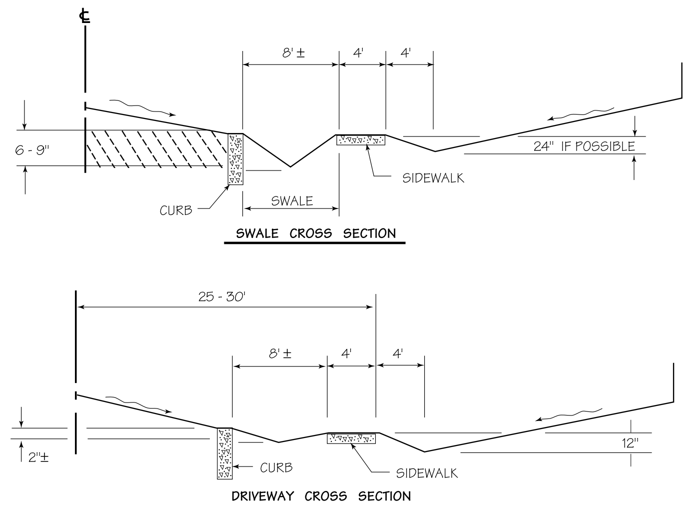

Figure 3. Typical Curb Swale, Percolation Method

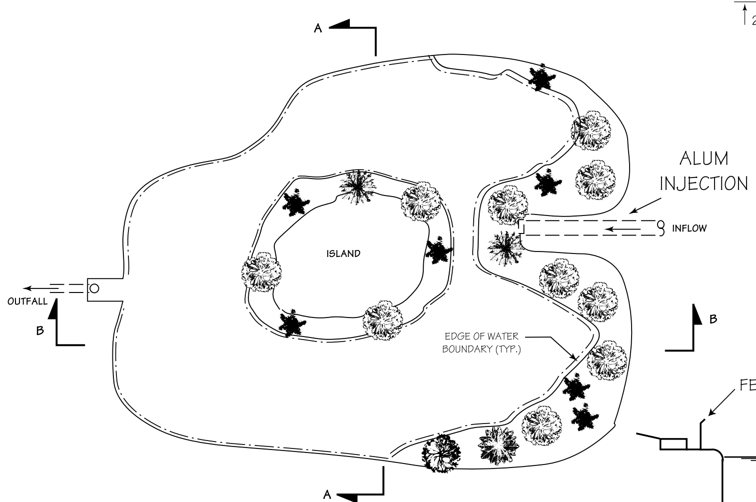

Figure 4. Suggested Stormwater Pond, Plan View

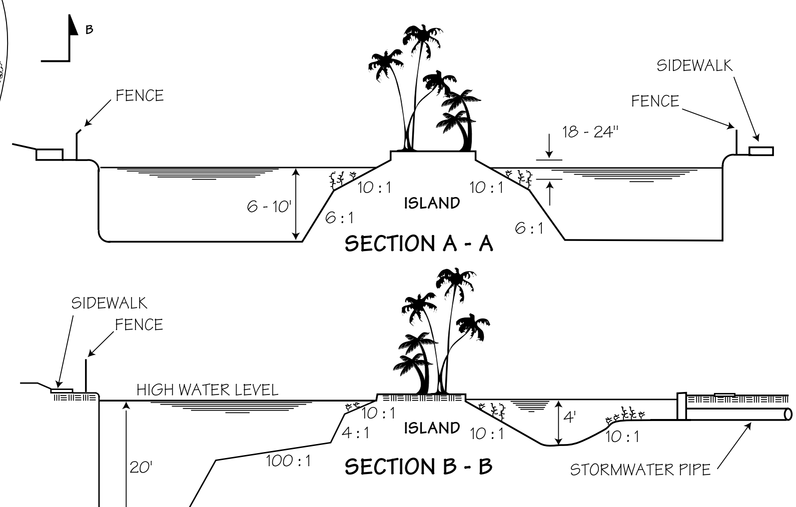

Figure 5. Suggested Stormwater Pond, Profiles

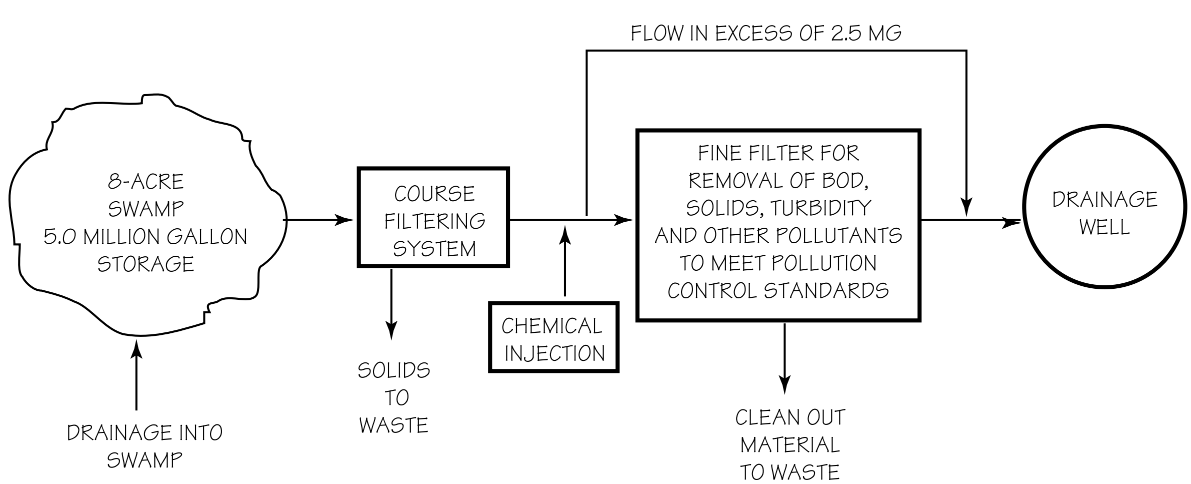

Figure 6. Eight-Acre Swamp Recharge Well Treatment System

entering a filtering system, consisting of a coarse and a fine filter, prior to entering a drainage well. The filters treat the first inch of runoff from the wetland or the initial 2.5 MG of water. This system can be in conjunction with some type of chemical injection, if deemed necessary for the removal of phosphorus material.

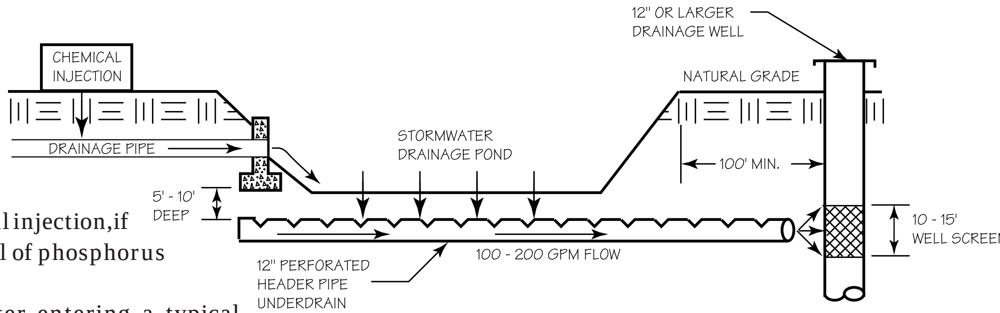

Figure 7. Recharge System, Side View

Figure 7 illustrates stormwater entering a typical retention-detention pond and then being filtered through sand to a perforated header pipe, which in turn drains into a well. The perforated header pipe is similar to french drains, which have been used for years in central Florida.

Figure 8 shows drainage water being stored above the filter before being discharged to a drainwell. A tremendous amount of research work on chemical and filtering system would be needed prior to full scale operation.

Conclusion

There needs to be additional research studies on determining the quality of the stormwater prior to entering drainwells and various treatment systems that could include chemical, physical, and filtration prior to entering any type of drainage-injection well. It is important to keep these drainage wells in operation, but as a dual purpose system for both solving the stormwater drainage problem and as a consistent and safe recharging method.

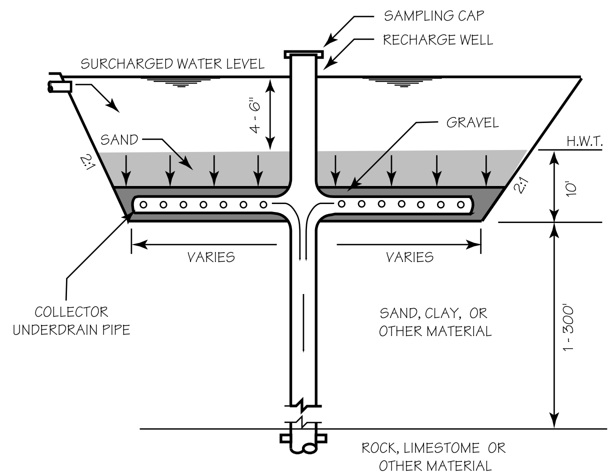

Figure 8. Drainage Well Detail

C.W. (Mickey) Sheffield,. P.E., is president of Sheffield Engineering & Associates. Orlando. Carlos Rivera di Aguilar, P.E., is with DER. Kevin McCann is with Stormwater Utilities, city of Orlando.