Elizabeth Creek Phase II Implementation Strategies

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Acronym List

ACEPD	Alachua County Environmental Protection Department
ACHD	Alachua County Health Department
ARV	Air Release Valve
BMAP	Basin Management Action Plan
BMP	Best Management Practice
CCTV	Closed Circuit Television
CFU	Colony-forming Unit
COG PWD	City of Gainesville Public Works Department
CSO	Combined Sewer Overflows
ERP	Environmental Resource Permit
FDOT	Florida Department of Transportation
FOG	Fat, Oil and Grease
FOWA	Florida Onsite Wastewater Association
GIS	Geographic Information System
GRU	Gainesville Regional Utilities
IDDE	Illicit Discharge Detection and Elimination
MCTT	Multi Chambered Treatment Train
MST	Microbial Source Tracking
OSTDS	On-site Sewage Treatment and Disposal System
SCADA	Supervisory Control and Data Acquisition
SR	State Road
SSE	Sanitary Sewer Events
SSO	Sanitary Sewer Overflow
TSS	Total Suspended Solids
UF	University of Florida
UV	Ultraviolet
WAV	Watershed Action Volunteers
WWTF	Waste Water Treatment Facility

1.0 Elizabeth Creek Phase II Implementation Strategies Introduction

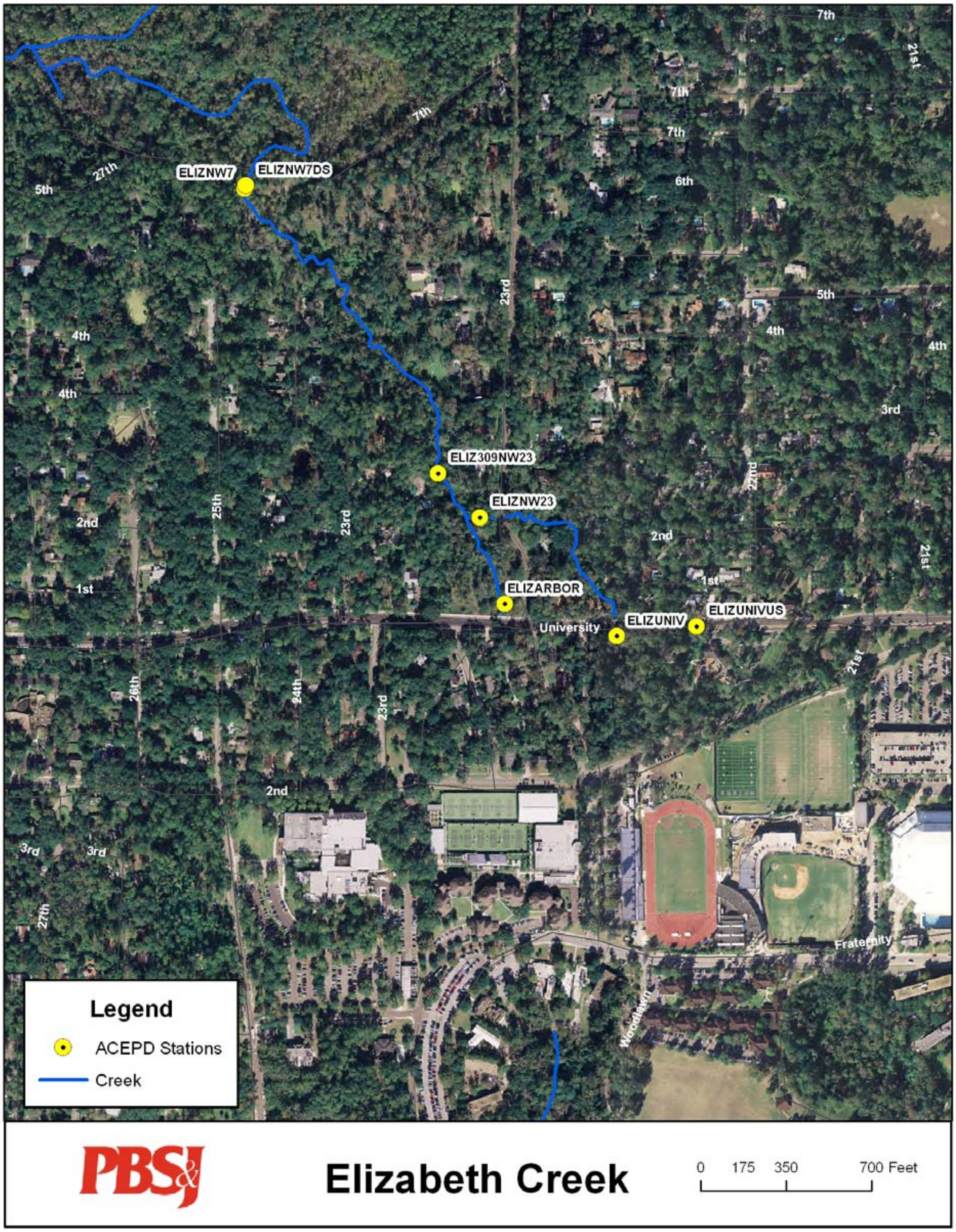
Data provided by local stakeholders (e.g., Geographic Information System [GIS] data and water quality data), as described in the Orange Creek Report, have been utilized to develop an Implementation Strategy for Elizabeth Creek. This Implementation Strategy follows management actions listed in the Decision Tools (Appendix A) and includes detailed recommendations for conducting additional diagnostic measures such as: 1) an evaluation of the area's current infrastructure; 2) additional field evaluations; and 3) supplemental indicator organism and/or Microbial Source Tracking (MST) sampling. The information presented in the Elizabeth Creek Implementation Strategy will be used to execute the Elizabeth Creek Pilot Study to help further identify potential sources of fecal contamination contributing to Elizabeth Creek surface waters.

1.1 Elizabeth Creek Watershed Description

Elizabeth Creek is located within the Hogtown Creek Basin. There are two "headwaters" that appear to originate just south of West University Avenue, approximately 40 meters west of NW 23rd Street, and form the "west fork" and "east fork". The west fork extends approximately 130 meters north from West University Avenue before connecting with the east fork at the main channel. The east fork meanders in a semi-circle near the University of Florida (UF) President's House at West University Avenue before extending nearly 130 meters to the northwest and bending west for another 125 meters before reaching the main channel. With the exception of these branches, the waters of Elizabeth Creek generally flow northwest in a single channel. It is worth noting that the creek primarily flows through residential areas and that the headwaters are in close proximity to the UF Main Campus. Elizabeth Creek eventually merges with Hogtown Creek approximately 180 meters north of NW 27th Way (Map 1).

1.2 Elizabeth Creek Water Quality Data

Seven stations sampled by Alachua County Environmental Protection Department (ACEPD) provided fecal coliform data in Elizabeth Creek (ELIZARBOR, ELIZNW23, ELIZ309NW23, ELIZNW7, ELIZNW7DS, ELIZUNIV, and ELIZUNIVUS (Map 1). Station location descriptions and water quality data are listed in Table 1 and Table 2, respectively. Water quality data indicate that multiple locations of Elizabeth Creek are impacted by fecal pollution. All samples collected by ACEPD between July 2005 and July 2007 exceeded the fecal coliform criterion (400 Colony Forming-Units [CFU]/100ml in >10% of samples) at each of the Elizabeth Creek stations (Table 2). In addition, MST, including the use of multiple human-specific markers, indicates that human contamination has contributed and may continue to contribute to Elizabeth Creek surface waters (Table 3).



Map 1. Elizabeth Creek ACEPD sampling stations

Table 1. Elizabeth Creek ACEPD station locations as described by ACEPD (2008)

Station ID	Station Description	Latitude	Longitude	Lat/Long Measurement Date	Datum	Travel Directions
ELIZUNIVUS	Vegetated banks. Stream bottom sand, silt, and organics.	29.65207	-82.35430	9/29/2005	NAD83	From University Avenue (State Road [SR] 26) and Main Street (SR 329), head West on University Avenue (SR 26) to just past NW 22nd St. This is the first stream crossing west of NW22nd St. Sample on the south side of University Avenue, near UF President's house.
ELIZUNIV	Concrete. Can't sample in natural streambed due to fence along president's property.	29.65196	-82.35533	7/15/05	WGS84	From University Avenue (SR 26) and Main Street (SR 329), head West on University Avenue (SR 26) to just past NW 22nd St (and before SW 23rd Street. This is the 2nd stream crossing west of NW 22nd St. Sample on the south side of University Avenue, near UF President's house; sample between culvert and fence.
ELIZARBOR	Overgrown with vines, lots of trash.	29.65235	-82.35682	9/29/2005	NAD83	From University Avenue (SR 26) and Main Street (SR 329), head West on University Avenue (SR 26). Go north (right) on NW 23rd St. The Arboretum is on the west side of the road. Sample downstream of culvert at University Ave.
ELIZNW23	This site is approximately 10 meters upstream of the culvert at NW23rd St. The stream bank is eroded and has a narrow forested riparian buffer. The stream bottom is rocky, silt, with clay outcrops.	29.65331	-82.35664	4/26/06	WGS84	From University Avenue (SR 26) and Main Street (SR 329), head West on University Avenue (SR 26). Go north (right) on NW 23rd St. The creek crosses NW 23rd St about 1/4 of a mile North of University Ave. Sample upstream of the crossing.

Station ID	Station Description	Latitude	Longitude	Lat/Long Measurement Date	Datum	Travel Directions
ELIZ309NW23	Elizabeth Creek behind the residence at NW23rd Dr. The bank is eroded but vegetated with an overstory and an understory. There are some bank reinforcement structures. The stream bottom is sand with rock rubble, leaf letter, and silt.	29.05458	-82.35759	4/26/06	WGS84	From University Avenue (SR 26) and Main Street (SR 329), head West on University Avenue (SR 26). Go north (right) on NW 23rd Drive. Take a left into the driveway at 309 NW 23rd Drive. The creek is behind the house. Ask permission to access.
ELIZNW7	Herbaceous and forested riparian; driveway and lawn ~10 ft on west bank; banks are not steep; shifting sand bottom; outfall pipe just upstream of sample point. Site is located at: 2401 NW 7th Road; sample upstream of culvert.	29.65708	-82.36002	7/15/05	WGS84	From University Avenue (SR 26) at Main Street (SR 329), head West on University Avenue (SR 26). Then, turn North (right) onto NW 22nd Street and then turn west (left) on NW 7th Road. Site is located at: 2401 NW 7th Road. Sample upstream of culvert.
ELIZNW7DS	Site is located downstream of the culvert at NW 7th Road. Creek is braided through a wetland. There is a developed overstory and an understory. The stream bottom is sandy with lots of silt.	29.65708	-82.36002	6/8/05	WGS84	From University Avenue (SR 26) at Main Street (SR 329), head West on University Avenue (SR 26). Then, turn North (right) onto NW 22nd Street and then turn west (left) on NW 7th Road. Site is located at: 2401 NW 7th Road. Sample approximately 100-200 meters downstream of culvert.

Table 2 Summary of fecal coliform concentrations recorded at Elizabeth Creek stations. Concentrations expressed as CFU/100mL. *Data for station ELIZ309NW23 were obtained from the ACEPD Mico Report (ACEPD 2008)

Station	Basin	Mean	Geometric Mean	N	Minimum Obs.	Maximum Obs.	Start Date	End Date	# Exceedance	% Exceedence
ELIZUNIVUS	Hogtown Creek	2010.00	1749.29	2	1020	3000	9/12/2005	5/16/2007	2	100.00
ELIZUNIV	Hogtown Creek	9000.00	6409.38	7	1700	19750	7/15/2005	7/26/2007	7	100.00
ELIZARBOR	Hogtown Creek	5821.25	4335.31	8	790	12300	5/10/2006	7/26/2007	8	100.00
ELIZNW23	Hogtown Creek	2752.50	2545.00	4	1250	3800	5/10/2006	4/26/2007	4	100.00
*ELIZ309NW23	Hogtown Creek	3433.33	3368.45	3	2,600	4,200	4/26/2006	5/10/2006	3	100.00
ELIZNW7	Hogtown Creek	3233.33	2309.60	3	1100	7000	7/15/2005	9/12/2005	3	100.00
ELIZNW7DS	Hogtown Creek	3437.50	2813.59	4	1230	7100	5/10/2006	4/26/2007	4	100.00

Table 3 Elizabeth Creek MST data for human-specific markers 2005-2007 (CH2M HILL & Biological Consulting Services of North Florida 2007, ACEPD 2008)

Source	Human Marker	ELIZUNIV	ELIZARBOR	ELIZNW23	ELIZNW7DS
GRU 2005	**Enteric Virus**	NA	0/2	NA	NA
	polyomavirus	NA	2/2	NA	NA
	***esp* gene**	0/1	2/2	NA	NA
	***Bacteroides* spp.**	1/1	2/2	NA	NA
ACEPD 2006	**polyomavirus**	1/2	0/1	NA	NA
	***Bacteroides* spp.**	1/2	0/1	NA	NA
	***esp* gene**	2/2	0/1	NA	NA
ACEPD 2007	**polyomavirus**	NA	0/1	0/1	0/1
	***Bacteroides* spp.**	NA	0/1	0/1	0/1
	***esp* gene**	NA	0/1	1/1	0/1
Total Positive MST Results		5 out of 8 (63%)	6 out of 14 (43%)	1 out of 3 (33%)	0 out of 3 (0%)

1.3 Potential Human Sources in the Elizabeth Creek Watershed

It is apparent that human sources have contributed and may continue to contribute to Elizabeth Creek surface waters as indicated by human-specific markers detected during ACEPD and Gainesville Regional Utilities (GRU) MST studies at Elizabeth Creek stations ELIZUNIV, ELIZARBOR, and ELIZNW23 (Table 3; ACEPD 2008, (CH2M HILL & Biological Consulting Services of North Florida 2007). Possible human sources that may contribute to the fecal contamination of Elizabeth Creek include public and private sanitary sewer infrastructure and septic systems. It is important to note that although septic systems are located within this watershed, those parcels located adjacent to surface waters were determined to meet the On-site Sewage Treatment and Disposal

System (OSTDS) code (e.g., 24-inch separation between the seasonal high water table and the drainfield, and a minimum distance of 75 feet from surface waters) by the Alachua County Health Department (ACHD) (ACHD 2006). In addition, no homeless populations have been reported in the vicinity of Elizabeth Creek.

1.3.1 Public and Private Sanitary Sewer

Public and private sanitary sewer infrastructure (e.g., manholes, gravity and slipped-gravity sewer lines) parallels and is in close proximity to Elizabeth Creek surface waters. The Public and Private Sewer Decision Tool (Appendix A) lists several recommended management actions that should be implemented in specific areas, and in some cases, to the entire basin. Basin-wide management actions for public sanitary sewer infrastructure include the implementation of a Sanitary Sewer Overflow (SSO) Root Cause Program (Appendix A) and the improvement of the effectiveness of the FOG program. Also, as manholes are in close proximity to Elizabeth Creek surface waters it is recommend that a Pop-Top Program be executed within the basin (Appendix A). Those manholes with cited deficiencies should be repaired (e.g., fiberglass lining) and be included in the Manhole Monitoring Program (Appendix A). Detailed field investigations should also be initiated throughout the basin to identify potential illicit discharges, especially in the upstream areas of the basin where high fecal coliform levels and human-specific markers were detected. GRU has provided GIS data that includes the locations of sewer lines, lift stations, unverified OSTDS, and SSOs within the basin. Further information, including cave-ins, blockages, and repair and assessment results could be beneficial in identifying problematic areas. UF has provided sewer infrastructure that includes locations of sewer lines; however, more detailed GIS data should be provided (e.g., age of sewer lines, type of sewer lines, lift stations, package plants, manholes) before specific management actions are implemented.

According to the ACEPD, several neighborhoods in the Elizabeth Creek watershed have been converted to student housing which may increase the possibility that sewer lines from housing retrofits cross-connect with the stormwater collection system (ACEPD 2008). More specific management actions should be implemented in these areas and in other locations of the basin where sewer lines are in close proximity to surface waters and/or cross the stormwater collection system. Table 4 describes each of these areas and lists the recommended management actions following the Public and Private Sewer Decision Tool under the “Main & Secondary Lines (Force Mains & Gravity Lines)” box (Appendix A). The suggested management actions are grouped by source-type and are listed from top to bottom in priority order (Table 4). In instances where discrete tasks are intended to build directly upon prior efforts, the order of events to address that source is listed from left to right (Table 4). The agency responsible for completing each task is indicated in parentheses. As extreme levels of fecal coliforms (>10,000 CFU/100mL) and the detection of human-specific markers have been observed in the upstream segments of Elizabeth Creek, management actions have been prioritized from upstream to downstream. The suggested action items listed in Table 6-1 of the Orange Creek Summary Report for hot spot ELIZUNIV have also been included in Table 4 (PBS&J 2009 Draft). Appendix B includes infrastructure maps associated with some of the management actions that identify sampling locations and areas for further investigation.

It is worth mentioning that at station ELIZARBOR six human markers were detected in the 2005 GRU study (CH2M HILL & Biological Consulting Services of North Florida 2007) while no markers were detected in the studies conducted by ACEPD in 2006 and 2007 (ACEPD 2008). Although this may indicate that the potential human source(s) contributing to this station has been removed; use of the markers was limited and high levels of fecal coliforms were still detected in water samples during the last four sampling events (4,250-12,300 CFU/100mL) after the ACEPD 2007 MST study. It is recommended that genomic profiling be performed at this site to determine if the pattern of bacterial profiles in the sediments differs from those in the water column. This would assist in determining if the fecal contamination at this site is originating from the sediments or is resulting from more recent contamination. Lastly, there are no lift stations located within a mile of Elizabeth Creek surface waters and there are no force mains in the surrounding areas.

1.3.2 OSTDS

As mentioned previously, in 2006 ACHD investigated septic systems at parcels adjacent to Elizabeth Creek surface waters and determined that these parcels were within code (e.g., 24-inch separation between the seasonal high water table and bottom of the drainfield) (ACHD 2006). Currently, there are no GIS data, however, to determine the locations of all septic systems within the Elizabeth Creek watershed. As listed in the OSTDS Decision Tool, it is important for ACHD to identify and maintain a detailed, county-wide GIS infrastructure database (e.g., records of OSTDS locations, failures and repairs). These data could be helpful in determining areas within the watershed where septic systems are potential sources. GIS data provided by GRU show parcels with unverified OSTDS within close proximity to Elizabeth Creek surface waters in several areas of the basin (Table 4). It is suggested that these unverified OSTDS be compared to those parcels already inspected by ACHD. Those parcels that have not already been inspected by ACHD (e.g., 2239 NW 2nd Avenue) should be investigated to determine if they utilize OSTDS and to ensure that they are operating properly and meet the current OSTDS code. In March 2009 the ACHD conducted preliminary investigations on three of the parcels identified by GRU (7 SW 23rd Street, 20 SW 23rd Street, and 2291 West University Avenue) and determined that no OSTDS records were available for these parcels.

1.3.3 Homeless Camps

Homeless populations have not been reported through efforts such as wildlife surveys that have been conducted by ACEPD in areas surrounding Elizabeth Creek. However, as homeless populations are often transient, there is a need to perform periodic field investigations. These investigations should include field surveys of areas potentially used by homeless to identify indications (e.g., the presence of toilet paper, human feces, discarded clothing) that transient populations are contributing to the fecal contamination of Elizabeth Creek surface waters.

1.4 Non-point Sources

GIS data provided by local stakeholders show that stormwater collection systems, including both open ditches and closed conveyances, outfall or flow into Elizabeth Creek surface waters. FDOT has done limited CCTV inspection of their storm sewers along University Avenue (SR 26), but the inspection appears to stop before the area of interest. Currently, there are no GIS data indicating where dye/smoke testing or CCTV of the stormwater system has been performed by local governments or UF or the results (e.g., areas with cross-connections, pipes with sediment frequent accumulation) of such efforts. It is especially important to note that UF stormwater infrastructure appears to connect or outfall into areas in close proximity to the headwaters of Elizabeth Creek, which may directly impact surface waters. As listed in the Stormwater Decision Tool, GIS data should be maintained by UF and City of Gainesville Public Works Department (COG PWD) and reported as needed to the Orange Creek Basin Working Group and city and county commissions (as appropriate) to assess problematic areas that may contribute to the fecal pollution of Elizabeth Creek. GIS data that shows the boundary of the drainage system that discharges into Elizabeth Creek should be maintained and crucial flow patterns from upstream basins identified. A visual inspection of the stormwater collection system where it outfalls to Elizabeth Creek, including areas just south of University Avenue at the UF Main Campus, should be conducted to ensure that systems are maintained and that there are no urban wildlife inhabiting stormwater infrastructure. There were insufficient data available as of July 27, 2007 to conduct robust statistical analysis to determine the relationship between rainfall and fecal coliforms in the Elizabeth Creek watershed. It is therefore suggested that more current data be obtained to augment the data utilized in this report to perform this analysis. The collection of additional samples is recommended to supplement the current data, as necessary. The ACEPD has performed a preliminary study that included limited storm flow and baseflow sampling at Elizabeth Creek stations ELIZUNIV and ELIZARBOR (ACEPD 2008). Two replicate samples were collected from station ELIZUNIV and ELIZARBOR following a storm event on July 24, 2007, which showed fecal coliform means of 19,750 CFU/100mL and 12,300 CFU/100mL, respectively. One day following the rain event during baseflow conditions, fecal coliform levels decreased slightly, but remained elevated as shown by means of 17,950 CFU/100mL at station ELIZUNIV and 4,250 CFU/100mL at station ELIZARBOR. There was variable rainfall in the watershed following the July 25, 2007 sampling event. Results showed decreasing mean fecal coliform concentrations at ELIZUNIV (6,400 CFU/100mL) and an increase in mean concentrations at ELIZARBOR (8,550 CFU/100mL). Although these data may indicate stormwater potentially contributes to the fecal coliform contamination at these locations, more data are needed during baseflow/dry conditions to determine the impacts of stormwater at these sites.

The persistence and likelihood for re-growth of indicator bacteria in sediments allows stormwater conveyance systems, especially those underground or in heavily shaded areas, to act as reservoirs for contamination that periodically result in the influx of high levels of bacteria to receiving waters (Anderson et al. 2005, Brownell et al. 2007). Therefore, sediments in the stormwater collection system should be considered as a possible contributing source. It is important to note that efforts should first be made to identify primary sources (e.g., human and animal sources) that contribute to the bacterial contamination/re-growth in the sediments. MST sampling to detect potential human sources has already been conducted by GRU and ACEPD within the Elizabeth Creek watershed. Results indicate that a human source has contributed to the upstream areas of the basin and potentially continue to impact this segment of the creek (Table 3). Following the Stormwater Decision Tool, several management actions should be initiated to determine possible sources of human contribution in the vicinity of those stations impacted by human contamination:

(1) **Closed conveyance inspection using CCTV to identify cross-connections with sewer lines**. Several areas of Elizabeth Creek have been identified where stormwater infrastructure crosses or is in close proximity to sewer infrastructure (Table 4). If high levels of fecal coliforms are detected following ACEPD sampling, COG PWD could coordinate with GRU or UF and perform visual inspections using CCTV of the underground stormwater conveyance system in these areas to verify that there are no cross-connections. If there are cross-connections associated with sewage contamination, the sediments could be removed from the stormwater conveyance system and repairs made to the stormwater and wastewater infrastructure as necessary, but only after careful assessment of the environmental consequences.

(2) **Implementation of an Illicit Discharge Detection and Elimination (IDDE) Program**. Since there are ditches that meander through residential areas where sewer lines and OSTDS are located, there is a possibility of cross-connections and illicit discharges to the stormwater system. A detailed field investigation to identify possible illicit discharges to ditches should be coordinated and conducted throughout the basin. Please refer to the manual, "Illicit Discharge Detection and Elimination *A Guidance Manual for Program Development and Technical Assessments* (2004a) (http://www.cwp.org/Resource_Library/Center_Docs/IDDE/IDDE_Manual_06_release.pdf) and associated technical appendices (USEPA 2004b)(http://www.cwp.org/Resource_Library/Center_Docs/IDDE/IDDE appendices1-05.pdf) for information on developing an IDDE Program for local stakeholders within the Elizabeth Creek watershed.

(3) **Visual inspection for homeless populations**. As mentioned previously, no homeless populations have been reported in the Elizabeth Creek watershed; however, as these are oftentimes transient communities, there is a need to perform semi-annual inspections of stormwater infrastructure for signs of homeless (e.g., mattresses or clothing in or near stormwater culverts). Indications of homeless populations should also be recorded if identified during routine sampling and related field investigations.

MST sampling results were negative for the three human-specific markers, each tested on one occasion, at station ELIZNW7DS (Table 3). Also, ACEPD noted that the median values of *Enterococcus* spp. in water samples during a baseflow study of three separate sampling events (April 26, 2007, 5-day cumulative rainfall 0.7 inches; May 3, 2006, 5-day cumulative rainfall 0 inches; May 10, 2006, 5-day cumulative rainfall 0.13 inches) were higher (13,000 CFU/100mL) than the other indicator bacteria (fecal coliform -

5,200 CFU/100mL, *E. coli* - 3,300 CFU/100mL, and *C. perfringens* - 147 CFU/100mL) at this location (ACEPD 2008). The combination of MST marker results and indicator bacteria data may indicate that non-human sources (e.g., re-growth in sediments, wildlife) or those originating farther upstream are contributing to the fecal pollution at this station. As the potential for multiplication, especially in warm subtropical waters, may differ among indicator bacteria, performing additional sediment sampling for indicator organisms (*E. coli*, enterococci, and fecal coliforms) at ELIZNW7DS where bacterial persistence may be a factor would be helpful in determining if the contamination is originating from a more recent or residual source. It is recommended that at least two sediment samples be collected at station ELIZNW7DS using the three indicator organisms, fecal coliforms, *E. coli*, and enterococci. Considerably higher levels of enterococci compared to fecal coliforms and *E. coli* may indicate persistence in the sediments. If all three indicator organisms are relatively equal in abundance, the genomic profiles of the sediments at station ELIZNW7DS should be compared to those of the overlying water column to determine if there is a reservoir of contamination that has not been recently augmented (PBS&J 2006). As this station is located downstream and may be impacted by upstream sources, recommended management actions should first be concentrated at upstream locations as listed in Table 4.

If it is determined via sampling efforts that there is a potential for bacterial re-growth in the sediments, several management actions may be implemented to decrease their levels in the watershed. Although nutrient availability has been shown to influence the persistence of indicator bacteria in microcosm studies, predation may play a greater role than the competition for nutrients in creek systems (Marino & Gannon 1991). Nevertheless, as described in the Stormwater Decision Tool, Public Outreach Programs should be continued to decrease the amount of nutrients available in this system as limiting available nutrients may in turn help to prevent extended survival of bacteria in the sediments. Outreach education should focus on the Irrigation Ordinance, the benefits of low impact development, and how the disconnection of directly connected impervious areas could help to improve water quality. According to FDEP, St. Johns River Water Management District is currently taking the lead for educational outreach efforts for the Irrigation Ordinance (Mary Paulic, personal communication, June 10, 2009).

Although it has not yet been scientifically documented, enterococci appear to demonstrate greater persistence and growth under certain circumstances, such as within enclosures and underground stormwater storage units (personal communication, Dr. Valerie J. Harwood, October 3, 2007). Therefore, if sediment samples reveal high bacterial levels for all indicators or considerably higher concentrations of fecal coliforms and *E. coli* compared to enterococci, it may indicate that the source is recent and may be originating from animals (e.g., pets and/or wildlife) or humans. Additional MST using a combination of human and non-human markers (e.g., ruminant-specific Bacteroides) is suggested to further identify sources. Public education and enforcement of proper waste management practices could be continued and even expanded in areas where pets may contribute to fecal contamination (e.g., dog walking areas). If wildlife is suspected as a source, stormwater culverts could be screened to prevent their entry, though this could prove problematic due to clogging by debris in the Gainesville urban creek areas.

Increased maintenance of the stormwater system should be performed as necessary in areas that may experience debris accumulation due to screening.

As mentioned previously, visual inspections of the stormwater system should be continued basin-wide to determine if there are maintenance deficiencies. Inspections should also assess the potential for additional stormwater Best Management Practices (BMPs) or improvements to existing measures in areas that appear to be impacted by stormwater runoff. If maintenance deficiencies exist, maintenance improvements or repairs and/or retrofits may be necessary. There are several non-structural and structural BMP options suggested in areas where stormwater appears to impact the surface waters of Elizabeth Creek, as described in the Stormwater Decision Tool (Appendix A). Associated tables in Appendix A give details on the efficiency of pollutant removal for each BMP. Table A-6 of Appendix A provides a comparison of suggested BMPs in terms of relative cost, level of maintenance necessary for proper function, and degree of design effort necessary to implement each BMP.

Table 4. Recommended Management Actions for the Elizabeth Creek watershed. Listed by source in order of highest priority from top to bottom. In instances where discrete tasks are intended to build directly upon prior efforts, the order of events to address that source is listed from left to right.

Priority #	Source Addressed	Location Description	Management Action Task #1	Management Action Task #2	Management Action Task #3	Management Action Task #4
#1	Public and Private Sanitary Sewer OSTDS Stormwater	Basin-wide	Identify and maintain detailed county-wide GIS infrastructure database for: 1. Public sanitary sewer (e.g., records of cave-ins, blockages, SSOs, repairs, and assessment results (GRU) 2. Private sanitary sewer (e.g., age of sewer lines, type of sewer lines, lift stations, package plants, records of cave-ins, blockages, SSOs, repairs, and assessment results) (UF) 3. OSTDS (e.g., records of OSTDS locations, failures, and repair permits) (ACHD) 4. Public stormwater system (e.g., layer showing boundary of stormwater system that flows into Elizabeth Creek, records of cross-connections and illicit discharges) (COG PWD) 5. Private stormwater system (e.g., locations of outfalls, inlets, sediment traps, layer showing boundary of stormwater system that flows into Elizabeth Creek, records of cross-connections and illicit discharges) (UF)			
#2	Stormwater	Basin-wide	Supplement water quality data received for ACEPD stations as of July 2007, with more current data in order to conduct a statistical analysis between rainfall and fecal coliform concentrations (ACEPD)			
#3	Public Sanitary Sewer	Basin-wide, with particular emphasis on the upstream locations near the headwaters	Implementation of the Pop-Top Program for manholes near Elizabeth Creek surface waters (GRU)	Identify and confirm all manholes with deficiencies including those with welded lids (GRU)	Repair as necessary (e.g., fiberglass line) and include in a Manhole Monitoring Program (GRU)	
#4	Public Sanitary Sewer	Basin-wide, with particular emphasis on the upstream locations near the headwaters	Improve the effectiveness of the FOG Program (GRU) by continuing to enforce the mandatory participation of all local food-service establishments and continue or expand residential FOG program efforts	Determine problematic businesses (e.g., restaurants with previous grease trap overflows and grease blockages) and work with them to identify the necessary repair mechanisms. Also continue to distribute information on FOG control (GRU)		
#5	OSTDS	Perform field investigations on septic systems at 1. 7 SW 23rd Street 2. 20 SW 23rd Street 3. 2291 West University Avenue 4. 2239 NW 2nd Avenue	Field investigations should be performed on these parcels to determine if the residents utilize OSTDS and to verify if they meet the current code and are functioning properly			
#6	OSTDS	Specific to neighborhoods that currently utilize OSTDS	Identify neighborhoods that currently utilize OSTDS within the Elizabeth Creek basin	Perform public outreach and education on proper preventative maintenance (ACHD)		

Priority #	Source Addressed	Location Description	Management Action Task #1	Management Action Task #2	Management Action Task #3	Management Action Task #4
#7	OSTDS	Basin-wide	It is recommended that ACHD implement a DOH-Sponsored Certification Program for Haulers			
#8	OSTDS	Basin-wide	It is recommended that the County and City implement a county-wide OSTDS Ordinances (Alachua County/City of Gainesville): 1. Mandatory (not complaint-driven) OSTDS Inspection/Tracking Program 2. Require OSTDS inspection at change of property ownership 3. Require OSTDS repairs to comply to current standards 4. Periodically obtain an OSTDs inventory from ACHD			
#9	Stormwater and Illicit Discharges	At the UF Main Campus in areas between Stadium Road and University Avenue from Fraternity Road west to Fletcher Drive (Appendix B, Map A)	1. Visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations) (UF) 2. Detailed field reconnaissance as part of an IDDE Program to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS) to the stormwater system. UF to coordinate with ACEPD and ACHD if illicit discharges are identified (UF)	1. Perform maintenance of system deficiencies as necessary (e.g., screen inlets and outlets, remove garbage, debris and sediment build-up, repair manholes) (UF) 2. Implement necessary corrective actions for the removal of illicit connections (ACEPD, ACHD, and UF)	Retrofit stormwater infrastructure and provide additional BMPs (Appendix A) as necessary (e.g., disconnect directly connected impervious areas, implement treatment train) (UF)	If homeless are present within the watershed, implement and enforce homeless ordinance (Alachua County or City of Gainesville)
#10	Stormwater and Illicit discharges	Along University Avenue between SW 26th Street and NW 20th Terrace) (Appendix B, Map B)	1. Visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations) (COG PWD) 2. Detailed field reconnaissance as part of an IDDE Program to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS) (ACEPD, GRU, COG PWD, ACHD, and UF)	1. Perform maintenance of system deficiencies as necessary (e.g., screen inlets and outlets, remove garbage, debris and sediment build-up, repair manholes) (COG PWD) 2. Implement necessary corrective actions for the removal of illicit connections (ACEPD, GRU, COG PWD, ACHD, and UF)	Retrofit and provide additional BMPs (Appendix A) as necessary (e.g., disconnect directly connected impervious areas, implement treatment train) (COG PWD)	If homeless are present within the watershed, implement and enforce homeless ordinance (Alachua County or City of Gainesville)
#11	Private Sanitary Sewer	Crossing of private sanitary sewer lines with the stormwater collection system just north of SW 2nd Avenue (Appendix B, Map C)	Sample for fecal coliforms at stormwater outfall #1, located approximately 50 meters south of West University Avenue, during baseflow and following storm events (two times under each condition). If high levels of fecal coliforms are detected cease sampling (ACEPD)	If fecal coliform numbers are high from the ACEPD stormwater outfall samples, perform smoke/dye testing or closed circuit television (CCTV) of lines in the vicinity of SW 2nd Avenue and SW 23rd Street intersection (UF to coordinate with GRU) COG PWD to coordinate with UF and GRU in smoke/dye testing or CCTV of the stormwater collection system in areas listed above (COG PWD)	If fecal coliform levels are low, progressively choose sampling locations farther downstream between outfall #1 and station ELIZUNIV until contributing source is detected	

Priority #	Source Addressed	Location Description	Management Action Task #1	Management Action Task #2	Management Action Task #3	Management Action Task #4
#12	Private Sanitary Sewer	Crossing of private sanitary sewer with the stormwater collection system just north of SW 2nd Avenue (Appendix B, Map C)	Sample for fecal coliforms at stormwater outfall #2, located approximately 100 meters south of West University Avenue. A water sample should be collected during a rainfall event and for five consecutive days following the event.	If fecal coliform numbers are high from the ACEPD stormwater outfall samples, perform smoke/dye testing or CCTV of lines along SW 2nd Avenue, approximately 100 meters east of SW 23rd Street intersection (UF to coordinate with GRU) UF to coordinate with COG PWD and GRU in smoke/dye testing or CCTV of the stormwater collection system in areas listed above (UF)	If fecal coliform levels are low, sample progressively farther downstream between outfall #1 and station ELIZUNIV to detect contributing sources	
#13	Private Sanitary Sewer	Upstream of ACEPD stations ELIZUNIV, ELIZUNIVUS, and ELIZARBOR, located near University Avenue	Perform study that includes: 1. The collection of water samples at station ELIZUNIV, ELIZUNIVUS, and ELIZARBOR immediately following and for the six consecutive, tenth and fourteenth days after a major UF sporting event (e.g., football game) and; 2. The collection of a total of six water samples (three at station ELIZUNIV and three at ELIZARBOR) during periods of lowest predictable UF sanitary sewer usage (e.g., during UF winter vacation, spring vacation)	If fecal coliform levels show a decreasing trend after a major UF event and/or if water samples collected during low sanitary sewer usage show lower levels of fecal coliforms, UF is to perform an assessment of sewer lines responsible for transporting sewage from the stadium. This assessment should include lift station and/or Waste Water Treatment Facility (WWTF) hours of operation (run times) and smoke/dye testing or CCTV of lines. Non-UF infrastructure could also be the cause of the problem and should be considered for investigation.		
#14	Sediments	Station ELIZARBOR just north of University Avenue	Compare patterns of genomic profiling in sediments and water, to determine if there is a reservoir of contamination that has not been recently augmented. Work with local laboratory to identify exact methodology.	If the sediment and water samples result in similar patterns of genomic profiles this suggests the presence of a residual source. Implement stormwater BMPs to reduce sedimentation and sediment contamination		
#15	Stormwater Public Sanitary Sewer	Public sanitary sewer gravity mains parallel and cross the stormwater collection system along University Avenue West, between SW 23rd Terrace and NW 22nd Street (Appendix B, Map D)	Provide details of results (e.g., specific location televised, areas with cross-connections and excessive sediments) of the stormwater lines already televised along West University Avenue to the BMAP working group. Perform CCTV in remaining segments between SW 23rd Terrace and NW 22nd Street (Florida Department of Transportation [FDOT])	Visually inspect drop inlets for cross connection/sewage odors in areas along University Avenue West, between SW 23rd Terrace and NW 22nd Street (COG PWD)	Identify cross-connections, leaks, and blockages using smoke/dye testing and CCTV along gravity mains at University Avenue West, between SW 23rd Terrace and NW 22nd Street (GRU)	
#16	Stormwater and Illicit discharges	In areas between NW 6th Avenue and NW 1st Avenue from NW 20th Street West to NW 17th Street (Appendix B, Map E)	1. Visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations) (COG PWD) 2. Detailed field reconnaissance as part of an IDDE Program to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS) (ACEPD, ACHD, GRU, and COG PWD)	1. Perform maintenance of system deficiencies as necessary (e.g., screen inlets and outlets, remove garbage, debris and sediment build-up, repair manholes) (COG PWD) 2. Implement necessary corrective actions for the removal of illicit connections (ACEPD, ACHD, GRU, and, COG PWD)	Retrofit and provide additional BMPs (Appendix A) as necessary (e.g., disconnect directly connected impervious areas, implement treatment train) (COG PWD)	If homeless are present within the watershed, implement and enforce homeless ordinance (Alachua County)

Priority #	Source Addressed	Location Description	Management Action Task #1	Management Action Task #2	Management Action Task #3	Management Action Task #4
#17	Stormwater and Illicit discharges	In areas along NW 21st Street between NW 8th Avenue and University Avenue W (Appendix B, Map F)	1. Visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations) (COG PWD) 2. Detailed field reconnaissance as part of an IDDE Program to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS) (ACEPD, ACHD, GRU, and COG PWD)	1. Perform maintenance of system deficiencies as necessary (e.g., screen inlets and outlets, remove garbage, debris and sediment build-up, repair manholes) (COG PWD) 2. Implement necessary corrective actions for the removal of illicit connections (ACEPD, ACHD, GRU, and, COG PWD)	Retrofit and provide additional BMPs (Appendix A) as necessary (e.g., disconnect directly connected impervious areas, implement treatment train) (COG PWD)	If homeless are present within the watershed, implement and enforce homeless ordinance (Alachua County)
#18	Public Sanitary Sewer	Public sanitary sewer gravity mains parallel and cross the stormwater collection system along NW 3rd Avenue between NW 20th Street and NW 21st Street and along NW 21st Street (Appendix B, Map G)	Sample for fecal coliforms at the drop inlet located just west of the most northern terminus of NW 21st Terrace (2 water samples during baseflow; 2 water samples following storm events). If high levels of fecal coliforms are detected cease sampling (ACEPD)	Visually inspect drop inlets for cross connection/sewage odors in areas along NW 3rd Avenue between NW 20th Street and NW 21st Street and along NW 21st Street (COG PWD)	If fecal coliform numbers are high from the ACEPD drop inlet samples perform smoke/dye testing or CCTV of gravity lines: 1. along NW 3rd Avenue between NW 20th Street and NW 21st Street (GRU) and; 2. along NW 21st Street between NW 5th Avenue and NW 3rd Avenue (GRU) COG PWD to coordinate with GRU in smoke/dye testing or CCTV of the stormwater collection system in areas listed above	If fecal coliform levels are low, sample progressively farther downstream beginning at the ditch that intersects NW 22nd Street to detect contributing sources
#19	Public Sanitary Sewer	Public sanitary sewer gravity mains parallel and cross the stormwater collection system along NW 22nd Street (Appendix B, Map H)	Sample stormwater manhole located 10 meters west of the NW 22nd Street and NW 1st Avenue intersection (2 water samples during baseflow; 2 water samples following storm events). If high levels of fecal coliforms are detected cease sampling (ACEPD) COG PWD to coordinate with ACEPD to assist in sample collection from stormwater manhole if necessary	If fecal coliform numbers are high from the ACEPD stormwater manhole, perform smoke/dye testing or CCTV of lines along NW 22nd Street between NW 1st Avenue and NW 2nd Avenue (GRU) COG PWD to coordinate with GRU in smoke/dye testing or CCTV of the stormwater collection system in the areas listed above		
#20	Stormwater and Illicit discharges	In areas just west of 3rd Place (Appendix B, Map I)	1. Visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations) (COG PWD) 2. Detailed field reconnaissance as part of an IDDE Program to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS) (ACEPD, ACHD, GRU, and COG PWD)	1. Perform maintenance of system deficiencies as necessary (e.g., screen inlets and outlets, remove garbage, debris and sediment build-up, repair manholes) (COG PWD) 2. Implement necessary corrective actions for the removal of illicit connections (ACEPD, ACHD, GRU, and, COG PWD)	Retrofit and provide additional BMPs (Appendix A) as necessary (e.g., disconnect directly connected impervious areas, implement treatment train) (COG PWD)	If homeless are present within the watershed, implement and enforce homeless ordinance (Alachua County)

Priority #	Source Addressed	Location Description	Management Action Task #1	Management Action Task #2	Management Action Task #3	Management Action Task #4
#21	Public Sanitary Sewer	Public sanitary sewer gravity mains parallel and cross the stormwater collection system 1. approximately 62 meters northwest of the NW 2nd Avenue and NW 22nd Drive intersection, and 2. approximately 85 meters southwest of NW 3rd Place (Appendix B, Map J)	Sample for fecal coliforms at the stormwater outfall located approximately 75 meters east of where the east fork and NW 23rd Street intersect (2 water samples during baseflow; 2 water samples following storm events). If high levels of fecal coliforms are detected, cease sampling	If fecal coliform numbers are high from the ACEPD stormwater outfall sample, perform smoke/dye testing or CCTV of lines located a) approximately 62 meters northwest of the NW 2nd Avenue and NW 22nd Drive intersection b) approximately 85 meters southwest of NW 3rd Place COG PWD to coordinate with GRU in smoke/dye testing or CCTV of the stormwater collection system	If fecal coliform levels are low, sample progressively farther downstream between sampling location #1 and station ELIZNW23 to detect contributing source	
#22	Stormwater	Along the ditch that parallels NW 7th Road (Appendix B, Map K)	1. Visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations) (COG PWD) 2. Detailed field reconnaissance as part of an IDDE Program to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS) (ACEPD, ACHD, GRU, and COG PWD)	1. Perform maintenance of system deficiencies as necessary (e.g., screen inlets and outlets, remove garbage, debris and sediment build-up, repair manholes) (COG PWD) 2. Implement necessary corrective actions for the removal of illicit connections (ACEPD, ACHD, GRU, and, COG PWD)	Retrofit and provide additional BMPs (Appendix A) as necessary (e.g., disconnect directly connected impervious areas, implement treatment train) (COG PWD)	If homeless are present within the watershed, implement and enforce homeless ordinance (Alachua County)
#23	Public Sanitary Sewer	Public sanitary sewer gravity mains parallel and cross a ditch that runs east of the creek along NW 7th Road (Appendix B, Map L)	Investigate ditches for illicit discharges as listed in priority #1 and possible non-human sources (wildlife and domestic animals) (ACEPD)	Sample the outfall of the ditch at the creek (2 water samples baseflow; 2 water samples following storm events). If high levels of fecal coliforms are detected cease sampling (ACEPD)	If fecal coliform numbers are high from the ACEPD ditch outfall, perform smoke/dye testing or CCTV of lines that stretch approximately 250 meters east of sampling point, south of NW 7th Road COG PWD to coordinate with GRU in smoke/dye testing or CCTV of the stormwater collection system in the areas listed above	
#24	Public Sanitary Sewer	Public sanitary sewer gravity mains parallel and cross two ditches located south of NW 7th Road that each outfall to the west side of the creek (Appendix B, Map M)	Investigate both ditches for illicit discharges as listed in priority #1 and identify possible nonhuman sources (wildlife and domestic animals) (ACEPD)	Sample the outfall of both ditches (2 water samples baseflow; 2 water samples following storm events). If high levels of fecal coliforms are detected cease sampling (ACEPD)	If fecal coliform numbers are high from either of the ACEPD ditch outfall samples, perform smoke/dye testing or CCTV of lines that stretch approximately 250 meters west of sampling point, south of NW 7th Road COG PWD to coordinate with GRU in smoke/dye testing or CCTV of the stormwater collection system in the areas listed above	
#25	Stormwater (bacteria re-growth)	Station ELIZ7NW7DS	Collect 2 sediment samples for fecal coliforms, *E. coli*, and enterococci in conjunction with surface water samples to determine potential for re-growth in the sediments (2 samples baseflow; 2 water samples following storm events).	Compare patterns of genomic profiling in sediments and water at station ELIZNWD7, to determine if there is a reservoir of contamination that has not been recently augmented. Work with local laboratory to identify exact methodology.	If the sediment and water samples result in similar patterns of genomic profiles this suggests the presence of a residual source. Implement stormwater BMPs to reduce sedimentation and sediment contamination	

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Anderson KL, Whitlock JE, Harwood VJ (2005) Persistence and differential survival of fecal indicator bacteria in subtropical waters and sediments. Applied and Environmental Microbiology 71:3041-3048

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USEPA (2004a) Illicit discharge detection and elimination. *A Guidance Manual for program development and technical assessments*, U.S. Environmental Protection Agency, Washington, D.C.

USEPA (2004b) Technical Appendices illicit discharge detection and elimination: a Guidance Manual for program development and technical assessments, U.S. Environmental Protection Agency, Washington, D.C.

Web Resources

Illicit Discharge Detection and Elimination. *A Guidance Manual for Program Development and Technical Assessments*
http://www.cwp.org/Resource_Library/Center_Docs/IDDE/IDDE_Manual_06_release.pdf

Illicit Discharge Detection and Elimination *TECHNICAL APPENDICES*
http://www.cwp.org/Resource_Library/Center_Docs/IDDE/IDDEappendices1-05.pdf

Appendix A

A. Decision Tool of Best Management Practices (BMPs)

The following section provides a decision tree of BMPs and associated text for each potential source of fecal contamination identified in the Orange Creek watershed. The potential sources addressed include public and private sewer infrastructure, OSTDS, and stormwater and non-point sources. Both transient or homeless populations and non-human (e.g., wildlife, pets) sources are incorporated into the discussion on stormwater. Together, the decision tree and associated, more detailed text, methodically break down the various components of each potential source, including how each should be evaluated and addressed if a problem is likely or apparent. Each of the three decision trees is listed below.

A.1 Public and Private Sewer Infrastructure

As discussed in Section 1.2.1, underground sanitary sewer pipes in Florida, including forced mains and gravity sewers, can oftentimes leak. When ground water levels are high, either due to a naturally occurring high water table or due to excessive rainfall, ground water surrounding the pipes can infiltrate into the leaks in the sanitary sewer pipes. Surface water associated with flooding also can inflow into the sanitary sewer pipes when stormwater pipes are illicitly connected to the sanitary sewer pipes. In addition, surface water and/or ground water can also inflow into the sanitary sewer pipes when the caps are off the clean-out ports of sanitary sewer laterals or when there are holes or whole sections of the sanitary sewer pipe missing. The flow of surface and/or ground water into the pipes under any of these circumstances can result in a significant increase a) in the level of waste material (wet well levels) in sanitary sewer manholes, b) in the hours of operation of pump stations pumping waste into forced mains, and c) in the volume of waste material, delivered to the wastewater treatment facility (WWTF). If the wet well level rises above the elevation of the manhole, then sanitary waste can flow into the streets, stormwater drains, and adjacent surface waters and ground water. If the volume of waste flowing into the pump stations or WWTF exceeds the hydraulic capacity of either system to receive waste, then the pump stations can overflow the waste into the streets and adjacent surface waters and the WWTF can be forced to make emergency discharges of the waste to overflow ponds, tanks, or adjacent surface waters. WWTFs are forced to make emergency discharges when the biological treatment systems in the facility are compromised through reduced contact time, dilution, or as a result of toxicity from illicit stormwater or industrial connections. When ground water levels are low or the pressure in the sanitary sewer pipes is greater than the surrounding pressure of ground water, wastewater in the sanitary sewer pipes can exfiltrate out through the leaks in the pipes into the surrounding ground water and potentially migrate to adjacent surface waters. Collectively, these deficiencies in the operation of sanitary sewer systems are referred to as infiltration, exfiltration, and inflow or I/E/I.

Depending upon the antecedent hydrologic conditions and the magnitude and duration of rainfall events, increased wet well levels in sanitary sewer manholes and increased flows at pump stations and WWTFs in the first 12-24 hours of a stormwater event are indicative of an inflow problem, while increased flows that persist for 2-12 days or longer are indicative of infiltration problems. An infiltration problem can become an exfiltration problem during low ground water conditions associated with the dry season and droughts.

As discussed, I/E/I problems can contribute to the pollution of ground water and surface water and be a source of indicator bacteria contributing to the impairment of water quality in the state. Indications of I/E/I problems impacting WWTFs, lift stations, forced mains, and gravity sewer lines and the methods for identifying same, are described below. Also provided below are additional suggested BMPs that can be used to evaluate and correct potential sewer-related contributions of fecal coliform contamination to surface waters. The following discussion pertains to systems that are not designed as combined sewer overflows (CSOs) and are based on situations that occur in Florida.

- WWTF and lift stations
    - An increase in flows at the WWTF during rainfall events is indicative of I/E/I problems. A doubling or tripling in flows during larger storm events is common in systems operated throughout the country. Since flows are usually expressed in a way that masks I/E/I problems, *e.g.*, as 6 month running averages, **the identification of potential problems should begin with the evaluation of daily flow and rainfall data**. In this step, identify all dates on which flows increased by a factor of 2 or more at a given treatment plant or an emergency discharge was made. Then use these dates to identify and isolate potential deficiencies in discrete portions of the sanitary sewer collection system, including the forced mains and gravity sewer lines
    - Develop local ordinances for regulating (permitting, inspecting, and enforcement) of private wastewater systems
    - Monitoring WWTF and lift station influent for special issues that may imply the presence of a cross connection with the stormwater system or illicit industrial connections before reaching the facility. These issues may include, but are not limited to, increased levels of metals or instances of bacteria die-off.
    - Review wet well level and pump station hours of operation, especially for dates identified in review of WWTF flow data
    - Review the wet well alarm level compared to the wet well level to determine if the alarm system is functioning effectively to prevent overflows
    - Evaluate opportunities and existing operations for diverting flows during peak flow events. Also be aware that the ability to divert flows can mask the true source of the inflows and infiltration
    - Implement Time-Out program to enable all pump stations to automatically notify the operator if they do not operate as scheduled
- Forced mains and gravity sewer lines
    - Investigate gravity sewer lines contributing flows to the forced mains using smoke testing, dye testing, and closed circuit television (CCTV), as necessary
    - Evaluate opportunities and existing operations to increase flow and carrying capacity

- Check for cross-connections with stormwater infrastructure, especially in areas subject to flooding, including industrial areas using smoke testing, dye testing, and CCTV, as necessary
  - Implement public outreach and education programs to limit illicit connections to public and private sewer infrastructure
  - Check for leaks and blockages in lines using smoke/dye testing and CCTV
  - Use ultrasonic testing to check for forced main wall thickness
  - Inspect Forced main air release valves (ARVs) within 200 feet of surface waters
  - Improve effectiveness of Fats, Oils and Grease (FOG) program that requires all food-service establishments (FOG generators) connected to GRU sewer to participate (http://www.jea.com/about/pub/downloads/fog/FOGTrainingSlideShow.pdf)
- Manholes
  - Identify welded manholes as likely sources of operational deficiencies
  - Implement a "Pop-Top Program", similar to that employed by JEA in Jacksonville, Florida, that includes the opening and inspection of all accessible manholes with the objective of preventing future sanitary sewer events (SSEs) and sanitary sewer overflows (SSOs).
  - Implement Manhole Monitoring Program, similar to that used by JEA in Jacksonville, Florida, to provide for an early warning system to prevent potential overflows in the gravity collection system by using the existing Supervisory Control and Data Acquisition System (SCADA) infrastructure. The program involves installing a level monitoring device in manholes that are in areas which have been historically known to overflow. Once the level in the manhole has reached the sensing unit, a signal is transmitted from the manhole to the Control Center at which time a maintenance crew is dispatched to take immediate action to determine the cause of the sewer level as well as to take any necessary action to prevent a spill. The process, as described by JEA (personal communication, Ed Cordova, JEA, June 25, 2009) is illustrated in Figure A-1.

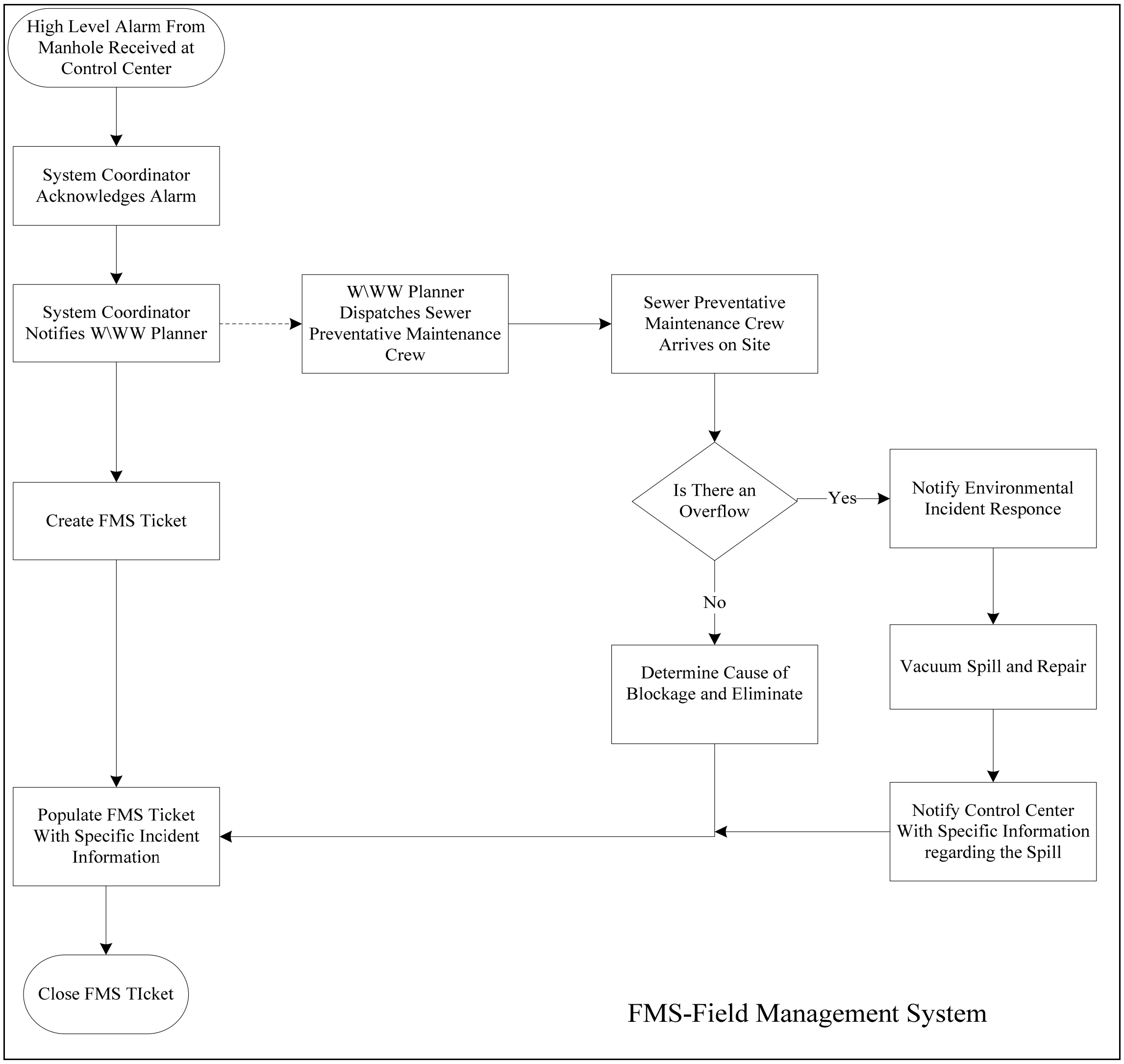

Figure A-1. Manhole Monitoring Program process, as described by JEA (personal communication, Ed Cordova, JEA, June 25, 2009)

In addition to the BMPs listed above, a SSO Root Cause Program should be implemented to help identify city-wide or regional patterns in the causes of sewer overflows. This program should be run by a group of first responders who meet regularly (e.g., every two weeks) to determine the root cause of each SSO. The purpose of this program is to identify any patterns that could be used to implement effective solutions on a city-wide scale. Several of the above BMPs are summarized in an evaluation and implementation matrix provided by GRU (2009; Table A-1).

Table A-1. Evaluation and implementation matrix of sewer-related BMPs for fecal coliform contamination reduction in the Orange Creek watershed (GRU 2009)

BMP	Existing BMP	RATING CRITERIA		
		Effectiveness (1-10)	Feasibility (1-10)	Implementation Score (Effectiveness * Feasibility)
CCTV Inspection	X	8	9	72
Smoke Testing	X	7	9	63
Trenchless Repairs	X	10	8	80
Lift Station Inspections (Visual and Operational)	X	9	10	90
Creek Crossing Inspections	X	8	10	80
Advanced Biological Testing	X	5	6	30
Lateral Inspections		8	3	24
Inspection and Repair Upstream of Residential Point of Service		8	2	16
Inspection and repair upstream of commercial and private system point of service		8	2	16
Education/Public Outreach	X	8	10	80

A.2 On-site Treatment and Disposal Systems (OSTDS)

As discussed in Section 5.2, in some situations, OSTDS provide a better health protection alternative than the public sewer system as, by their nature, they include the provision for passive wastewater treatment and are relatively cost-effective. As these systems are privately owned, one of the most important aspects to increasing their effectiveness is public education and outreach with the objective of leading to the adoption of desired behaviors. In addition, since even one failing OSTDS may contribute a considerable and chronic source of bacteria contamination, the situation conveys a need to have consistent city-wide measures to: 1) educate property owners to properly maintain their systems, to repair failing systems in a timely manner and/or connect to sanitary sewer for proper treatment; 2) to educate professionals in the business of installing and repairing OSTDS; and 3) to carefully monitor and inspect properties with active OSTDS. The Clearwater Information Exchange implemented in Victoria State, Australia is one example of an outreach activity aimed at encouraging homeowners to properly maintain their systems (McKenzie-Mohr & Associates). This program involves website-based resources aimed at homeowners and communities. Most notably is the "Smart Septics Community Education Kit" which is designed to help develop community on-site wastewater management education programs. Another online resource, the National Small Flows Clearinghouse, provides guidance on how to maintain septic systems.

Public education and outreach should be conducted by the ACHD and other local groups (e.g., the Florida Onsite Wastewater Association (FOWA)] on various levels ranging from the legislators who vote on state and city statutes to local plumbers and environmental health professionals. This would be beneficial for implementing county-wide septic tank ordinances to proactively avoid future water quality impacts. Components of these ordinances should include:

- development and implementation of a county-wide mandatory septic system inspection and maintenance program headed by the ACHD;
- continuation of a county-wide mandatory septic system tracking program headed by the ACHD;
- requirements for systems in need of repair to comply with current standards; and
- requirement for which septic tanks must be inspected when home ownership changes or in regular time intervals, such as five years.

Furthermore, the grandfathered clause for systems that do not meet separation requirements should be removed.

In order to best utilize available resources, outreach efforts should also target homeowners in communities with a high incidence or likelihood of OSTDS failures (e.g., homeowners in close proximity to surface waters) and educate the owners on proper preventative maintenance practices. Local professionals should also be certified by the ACHD for the proper pumping, transportation, disposal and documentation of OSTDS maintenance procedures.

In areas designated as environmentally suitable for the use of standard OSTDS, a community-based onsite management system program, in which clusters of conventional septic tanks are drained into centralized advanced wastewater treatment areas and are managed by a designated responsible party (e.g., local utility or health department) (NESC 2006), could be implemented. In areas where traditional OSTDS systems are not a viable option due to environmental conditions, “failure areas” should be identified using a standard ranking protocol (see ranking protocol used by the Duval County Health Department, Appendix C). These areas should then be evaluated for possible transition to centralized sewer. If a transition is deemed appropriate, an OSTDS Phase-Out Program should be implemented in conjunction with a subsidized OSTDS Pumping Program. This would help to immediately alleviate impacts during the transition period. For those areas identified as environmentally sensitive, but do not qualify for transition to centralized sewer, an ordinance should be implemented such that operating permits are required. New performance-based systems may also provide a practical and cost-effective alternative in these areas. According to Scott Turner, Duval County Health Department (personal communication, March 5, 2007), newer performance-based systems are now available to meet advanced secondary treatment levels. These systems are permitted in areas with decreased setbacks and smaller drainfields. As a result, failure of these systems can be more problematic and are therefore subject to annual inspections. It is suggested that owners of these systems be subject to a mandatory educational course instructing them in the proper maintenance of their systems.

A.3 Stormwater and Non-Point Sources

"Non-point sources" are used to describe intermittent, rainfall driven, diffuse sources of pollution (e.g., stormwater runoff) associated with everyday human activities, including runoff from urban land uses, agriculture, and silviculture; discharges from failing septic systems; and atmospheric deposition. Additional non-point sources may include areas with concentrated wildlife (e.g., bird rookeries) or domestic animals (e.g., dog parks).

A.3.1 Stormwater Treatment

As discussed in Section 5.3, although the first priority for effectively reducing contamination in stormwater should always focus on the elimination of the sources contributing pollution to stormwater conveyance systems, stormwater must also be considered as a source unto itself in order to manage it more effectively. Corrective actions using stormwater treatment benefit a tributary by reducing the sediment, oil and grease, and nutrient and bacteria loadings discharged to the affected water body (Harper et al. 1998, Kurz 1999, Dycus 2004). When focusing corrective efforts on stormwater treatment, it is important to realize that reduction of the sediment load to a tributary is critical because bacteria can adsorb to sediment particles where they can survive, grow and be transported from one area to another (Gerba & McLeod 1976, LaLiberte & Grimes 1982, Marino & Gannon 1991, Davies et al. 1995).

Improvements to the stormwater system, including retrofits, and associated programs already underway in the Orange Creek watershed should continue and will supplement additional, more focused efforts. If programs already in place are no longer functioning efficiently, reorganization/redesign may be a good place to start. These improvements will most likely benefit the following project areas: 1) highly urbanized landscapes; 2) neighborhoods with a high propensity for illicit discharges or where illicit discharges have been identified; and 3) more natural settings supportive of wildlife populations. In already developed areas, the BMPs discussed below would be most effectively applied in targeted areas and should be evaluated for selection on a site-specific basis.

Included at the end of this section is a comparative analysis of the cost, level of maintenance, and design effort required to successfully implement the different BMPs (see Table A-6).

A.3.2 BMPs for Highly Urbanized Landscapes

A.3.2.1 Structural BMPs

Many urbanized areas have existing stormwater systems that are permitted under environmental resource permit (ERP) requirements. These systems typically provide for removal of solids and suspended solids. In areas with a low water table and soils with high permeability, infiltration systems may be utilized. In addition to removal of the total suspended solids (TSS), these systems when properly maintained according to the permitted requirements, remove nitrogen and phosphorus which are contributors to bacteria's growth (re-growth). As an initial step, all systems should be evaluated for potential maintenance issues. Evaluations should include observation of the system for proper function and potential blockages and the use of closed circuit television (CCTV) to identify areas with sediment accumulation in closed conveyance systems. Maintenance should be regularly provided to ensure systems are functioning properly to maximize efficiency. Testing of surface water and the underlying sediments could also be performed to help differentiate residual or new bacteria contributions. This could be achieved by using library-based *Enterococcus* rep-PCR tests to compare the pattern of the genomic profile in the sediments to those in the water column. If the pattern in the sediments demonstrates greater similarity than that of the water column, this indicates that the sediments are harboring a bacteria population that, when disturbed during a re-suspension event, may cause elevated concentrations of contamination in the associated surface waters (PBS&J 2006). As these types of techniques are continuously evolving, additional methodologies should be explored prior to testing. Lastly, areas that are not designed to regulate under an ERP tend to have higher runoff rates and may not provide for the effective removal of solids or nutrients as part of the system. However, proper maintenance of the system can help to reduce downstream sedimentation and lower nutrient levels in the receiving waterbody. As with ERP systems, an initial step with non-regulated systems should be to evaluate the system for potential maintenance issues.

Five primary BMPs have been identified as possible stormwater treatment and/or retrofit alternatives for urbanized areas; 1) filtration/dry detention with filtration; 2) infiltration/dry retention; 3) bioretention; 4) baffle boxes; and 5) treatment trains. The basic structures, mechanisms, and treatment efficiencies of these five BMPs are provided below. Additionally, non-structural BMPs, are discussed as an effective method to provide education and outreach to the general public.

Filtration/Dry Detention with Filtration

Stormwater filtration BMPs (also known as dry detention with filtration) capture stormwater runoff, temporarily store the water in a small settling basin, and then allow the water to filter through an engineered media, most commonly a natural sand filter. The filtered water is then collected in an underdrain and transported back to the storm drain system. Because of the short detention times in this type of structure, biological processes such as nutrient uptake do not play a role in pollutant removal. Alternatively, physical processes such as sedimentation, and chemical processes, such as precipitation and absorption, are the major mechanisms of pollutant removal.

Filtration systems are useful BMPs in urban retrofit projects because they do not require large areas and can be easily constructed into road right-of-ways and medians, parking lot perimeters and medians, within recreational facilities, as part of commercial landscaping, and within existing shallow swales. In addition, these methods are practical in areas where open space is not available because the filter system can be located underground.

Filtration systems are not designed to serve as flood storage. As a result, treatment processes requiring longer exposure times, such as biological uptake necessary to remove dissolved constituents, are extremely limited in this type of BMP. Furthermore, although this BMP can be constructed in areas with high water tables, the removal efficiencies will be reduced. This is because the primary mechanisms of pollutant removal used with this method are physical and chemical processes resulting from the infiltration of the water through the permeable soil layer before entering the drain system below. As a result, a deeper pipe system will generate greater pollutant removal efficiencies from the stormwater before it enters the drain.

Generally, filtration provides good removal of most pollutants with the exception of soluble nutrients and they are best suited to remove total suspended solids and oil and grease from stormwater flows (EPA 2007). Kurz (1999) demonstrated that although sand filtration resulted in greater removal efficiencies for *Cryptosporidium* surrogate (fluorescent bead) and MS2 coliphage, approximately 65% of fecal coliforms were removed. Ranges of average pollutant removal efficiencies for filtration/dry detention with filtration BMPs are given in Table A-2. It should also be noted that this system should not be utilized where large amounts of trash or debris can cause the system to become clogged.

Table A-2. Ranges of Pollutant Removal Rates for Filtration/Dry Detention with Filtration BMPs (EPA 2007)

Pollutant	Pollutant Removal Efficiency (25th Percentile -75th Percentile) (%)
Total Suspended Solids	80-90
Total Phosphorus	40-65
Soluble Phosphorus	(-10)-65
Total Nitrogen	30-50
Organic Carbon	40-70
Total Zinc	70-90
Total Copper	35-70
Bacteria	25-70
Hydrocarbons	80-95
Chloride	0-0
Trash/Debris	85-95

Infiltration/Dry Retention

Infiltration BMPs (also known as dry retention) capture and store stormwater runoff in a dry basin before allowing the water to infiltrate into underlying soils and eventually return to the local aquifer. The stormwater runoff, along with the pollutants of concern, are then trapped in the dry retention area and underlying soils and not allowed to be transported into the storm drain system. In this type of system, biological, physical, and chemical processes all contribute to pollutant removal. Sedimentation and limited evaporation occur in the standing water immediately following a storm event. Sides and bottoms of all infiltration systems must be fully vegetated over sandy soils. The vegetation serves to stabilize the soils and maintain permeability in the underlying bed while also removing pollutants through nutrient uptake. The sandy bed then works to remove pollutants through both physical and chemical processes (Harper & Baker 2007). The bottom of the infiltration basin can often be covered in loose stones to provide storage for the stormwater before it enters the soils. In this case, the stormwater runoff will first pass through some type of pretreatment, such as a swale or sediment basin, before passing into the infiltration chamber to prevent the loose stone layer from becoming clogged (EPA 2007).

Infiltration systems are useful BMPs because they can be easily constructed into road right-of-ways and medians, parking lot perimeters and medians, within recreational facilities, as part of commercial or residential landscaping, and within existing shallow swales. In this regard, infiltration systems can be useful BMPs in urban retrofit projects that are implemented in constrained areas where the entire flow often cannot be retained. In these instances a design to capture and infiltrate the first flush of stormwater flow should be utilized while the excess runoff would be routed to a traditional storm drain. Typically, all flow is retained within the infiltration basin, pollutants and nutrients in the stormwater flow are removed from the storm drain system while also reducing runoff volumes. Another advantage to this type of BMP is ground water recharge. One disadvantage to this method is that infiltration systems can only be constructed in areas with low ground water tables and permeable soils. In addition, because all stormwater is retained in the infiltration basin, the runoff volumes treated are limited by the available storage in the treatment area (EPA 2007).

In theory, because all water is returned to the native soils and ground water, all pollutant loads should be removed from the storm drain system as a result of infiltration. Infiltration systems are best suited to remove total suspended solids, metals, possibly bacteria, organic carbon, and oil and grease from stormwater flows. Pollutant removal data for infiltration systems are limited, so the ranges of average pollutant removal efficiencies for bacteria, hydrocarbons, chloride and trash/debris in Table A-3 are largely based on the assumption that pollutant removal efficiencies will be similar to those in filtration/dry detention with filtration studies (EPA 2007). Also, similar to the filtration/dry retention with filtration BMP, infiltration/dry retention is not suitable where there are large amounts of trash and debris as they can cause the system to become clogged.

Table A-3. Ranges of Pollutant Removal Rates for Infiltration/Dry Retention BMPs (EPA 2007)

Pollutant	Pollutant Removal Efficiency (25th Percentile -75th Percentile) (%)
Total Suspended Solids	60-95
Total Phosphorus	50 95
Soluble Phosphorus	55-95
Total Nitrogen	0-65
Organic Carbon	80-95
Total Zinc	65-85

Pollutant	Pollutant Removal Efficiency (25th Percentile -75th Percentile) (%)
Total Copper	60-90
Bacteria	25-70
Hydrocarbons	60-95
Chloride	0-0
Trash/Debris	85-95

Bioretention

Bioretention is a landscape feature that serves as a stormwater BMP and typically treats watersheds less than 1 acre in area. The bioretention cell is a shallow landscaped depression that treats stormwater in much the same way as a forested area. The cell contains trees and shrubs planted in a mulch layer above an 18-to 48-inch deep sand/soil bed. Stormwater is routed to the bioretention cell where it ponds temporarily and then filters through the mulch layer and into the sand/soil bed below. The bioretention cell generally stores approximately 6-9 inches of standing water during a storm event. The trees and vegetation in the landscape feature clean the standing water through biological uptake of nutrients by plant surfaces and roots. Sedimentation and limited evaporation occur in the standing water immediately following a storm event. Sides and bottoms of all infiltration systems must be fully vegetated over sandy soils. The sandy bed then works to remove pollutants through both physical and chemical processes. The water filters through this bed and into either a perforated drain to carry the stormwater downstream into the drainage system, or else the stormwater drains directly into the native soils and continues to infiltrate into the local aquifer (EPA 2007). An example of this system would be a depression landscape island within a parking lot, which can be part of an existing system or be used independently depending on local soils types. Bioretention is a landscaped and aesthetic use of infiltration and/or filtration stormwater BMPs.

Bioretention systems are useful BMPs in urban retrofit projects because they do not require large areas and can be easily constructed into road right-of-ways and medians, parking lot perimeters and medians, within recreational facilities, as part of commercial landscaping, and within existing shallow swales. They are aesthetic and are often easily blended into a residential or commercial area. When a bioretention cell is built to infiltrate all water into the native soils, it provides substantial water quality treatment. Because all flow is retained within the bioretention cell, all pollutants and nutrients in the stormwater flow are removed from the storm drain system while also reducing runoff volumes. In this case, another advantage of bioretention is ground water recharge. When a bioretention cell is built to filter the stormwater into the storm drain system below, care must be taken to ensure that the ground water table is low and the soils are permeable to provide the maximum removal of pollutants from the stormwater before it enters the storm drain system. Similar to infiltration systems, one disadvantage is that because all stormwater is retained in the bioretention cell, the runoff volumes treated are limited by the available storage in the treatment area. However, this BMP has more storage and will provide more flood attenuation than a standard underground filtration system.

Bioretention systems are best suited to remove metals, bacteria, and oil and grease from stormwater flows. Bacteria removal data for bioretention systems are limited, so the ranges of average pollutant removal efficiencies in Table A-4 are largely based on the assumption that they will be similar to those in filtration/dry detention with filtration studies (EPA 2007).

Table A-4. Ranges of Pollutant Removal Rates for Bioretention BMPs (EPA 2007)

Pollutant	Pollutant Removal Efficiency (25th Percentile -75th Percentile) (%)
Total Suspended Solids	15 -75
Total Phosphorus	(-75) -30
Soluble Phosphorus	(-10) -50
Total Nitrogen	40 -55
Organic Carbon	40 -70
Total Zinc	40 -95
Total Copper	40 -95
Bacteria	25 -70
Hydrocarbons	80 -95
Chloride	0 -0
Trash/Debris	80 -95

Baffle Box

Baffle boxes use the physical process of settling to remove trash, sediment, suspended particles and associated pollutants from stormwater runoff. The BMP is comprised of a concrete or fiberglass structure that contains several settling basins separated by baffles. An initial trash screen can be installed to prevent large debris, floatables or trash from passing into the assembly with the inflow of stormwater. Once flow enters the box, sediment is removed from the runoff as the water enters each settling chamber and is impeded by the baffle walls. As the settling chamber begins to fill, flow velocity is slowed and allows the sediment to settle out of the water. This continues in series removing the majority of the sediment from the flow (EPA 2001).

Baffle boxes are generally placed in-line or at the outfall of a storm drain system. They are particularly well suited for urban retrofit projects because of the ease and low cost of installing the boxes directly into existing storm drain systems. While installation cost can be very low if pre-cast boxes are used, maintenance costs can be rather large. It is critical that the accumulated sediment be removed from the baffle boxes on a regular basis to prevent the sediment basins from filling. If sediment is allowed to accumulate in the basins, re-suspension of sediments and associated bacteria into the water column may occur during high flow events. The frequency of cleaning depends on the land use, rainfall, and accumulation of sediment. Another disadvantage to baffle boxes is they are not designed for nutrient removal, so this would not be a suitable BMP if nutrients are the main concern in the area. However, nutrients, similar to bacteria, attached to suspended sediment will be removed from the flow as the sediment settles out (EPA 2001).

Baffle Boxes are best suited for the removal of sediments from stormwater. Average pollutant removal efficiencies for baffle box BMPs are given in Table A-5; removal efficiencies for bacteria are unknown.

Table A-5. Average Pollutant Removal Efficiencies for Baffle Box BMPs (ASCE 2001)

Pollutant	Pollutant Removal Efficiency (%)
Total Suspended Solids	80
Total Phosphorus	30
Total Nitrogen	0

Treatment Train

Treatment train BMPs are a combination of two or more structural and/or non-structural BMPs in series. By passing water through multiple BMPs the stormwater runoff is treated using different methods resulting in higher pollutant removal efficiency. For example an impervious parking lot may drain through curb cuts into a bioretention swale. This bioretention swale would outfall/drain into a baffle box which removes sedimentation from the stormwater. Final treatment may be provided by an infiltration/dry retention area.

Low Impact Developments

Low impact developments (LID) employ a variety of natural and/or engineered features that are used in combination throughout the area to help reduce runoff. LID differs from other BMPs in that instead of being utilized as a single end of pipe system, it incorporates multiple distinct features that manage stormwater runoff at the micro level. LID takes a decentralized approach that disperses flows and manages runoff closer to where it originates (U.S. Department of Defense 2004). Figure A-2 identifies the key elements of LID that would typically be employed in newly developed areas; however, elements of LID can be utilized as retrofit or on an individual basis.

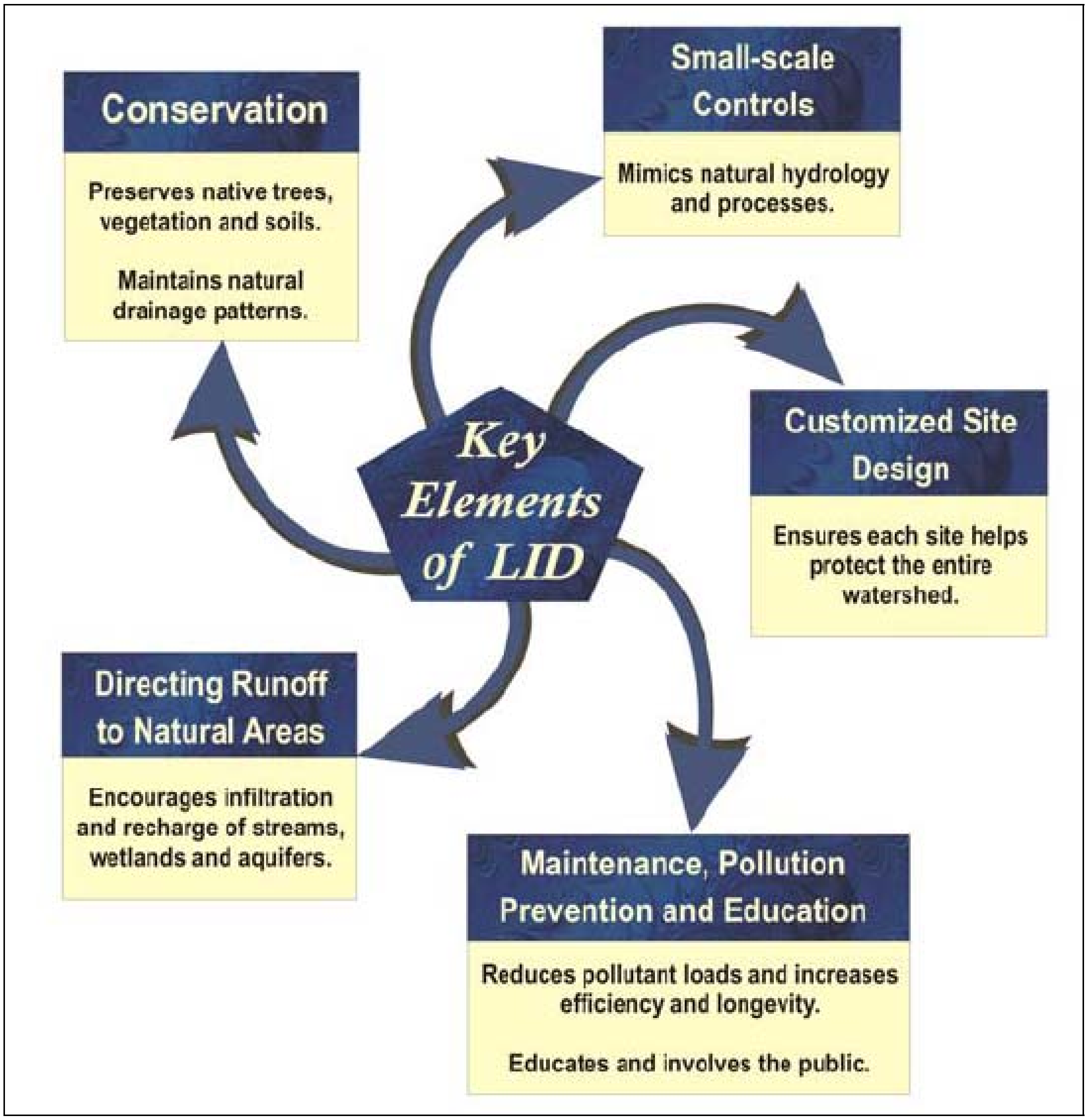

Figure A-2. Key elements of low impact development (LID) (U.S. Department of Defense 2004)

Multi Chambered Treatment Train

A hybrid treatment train/baffle box, the Multi Chambered Treatment Train (MCTT), has been developed for treatment of stormwater at critical source areas, such as vehicle service facilities, parking areas, paved storage areas and fueling stations. The MCTT is a stormwater treatment device that uses different treatment mechanisms in each of three sequential chambers. An MCTT device primarily removes TSS pollutants (sediments and metals) from runoff by sedimentation and filtering, and may also be effective for some dissolved metals, litter and nutrients.

The initial chamber, also called a 'grit' chamber, captures the larger sized sediments; this may be configured as a catch basin with a sump. Some variations are employed in this chamber, such as including a trash rack. The second chamber, referred to as the main settling chamber, is designed to capture fine sediments; this chamber may also be configured with sorbent pads designed to capture hydrocarbons. The third chamber, also called the filter chamber, employs a media bed often configured as a combination of sand and peat moss; it removes even finer sized particles than were captured in the previous chambers and acts as a sorption area for some dissolved constituents (Caltrans 2007).

Guidelines for Arranging BMPs in Series

It may be necessary or desirable to use a series of BMPs in a treatment train to provide adequate TSS and/or nutrient removal. In selecting the order or arrangement of the individual BMPs, the following general guidelines should be followed:

1. Arrange the BMPs from upstream to downstream in ascending order of TSS removal rate. In this arrangement, the BMP with the lowest TSS removal rate would be located at the upstream end of the treatment train. Downstream BMPs should have progressively higher TSS removal rates.

2. Arrange the BMPs from upstream to downstream in ascending order of nutrient removal rate. Similar to 1 above, the BMP with the lowest nutrient removal rate would be located at the upstream end of the treatment train in this arrangement. Downstream BMPs should have progressively higher nutrient removal rates.

3. Arrange the BMPs from upstream to downstream by their relative ease of sediment and debris removal. In this arrangement, the easiest, largest sediments and debris would be removed by the BMP located at the upstream end of the treatment train. Downstream BMPs should be more effective at removing the more difficult, finer sediment and debris.

In applying these guidelines, it is recommended that they generally be implemented in the order presented above. As such, a series of BMPs would be originally arranged in accordance with their relative TSS removal rates. This preliminary arrangement would then be refined by the relative nutrient removal rate of the BMPs and then by their ease of sediment and debris removal. Two or more iterations may be necessary to select the optimum arrangement. The final implementation scheme should also consider site conditions, construction and maintenance costs, and the abilities and available equipment of the party responsible for maintenance of the BMPs.

Finally, it should be noted that, unless otherwise approved by the applicable reviewing agencies or specifically indicated in the certification of a specific manufactured treatment device, all manufactured treatment devices that achieve TSS removal primarily through swirling and/or baffles should be placed at the upstream end of a treatment train (Blick et al. 2004).

Although wet detention systems have been reported to have removal efficiencies of up to 98.2% for fecal coliforms (Kurz 1999), in some cases, these systems may have the potential for exporting bacteria. These instances likely include wet detention systems that attract birds or other wildlife and domestic pets that may contribute fecal contamination to the surface waters while those systems that are highly exposed to sunlight may perform better at removing bacteria (Clary et al. 2008). Wet detention systems are not included as an independent suggested alternative as they are primarily designed to reduce suspended sediments and may attract additional sources of bacteria loading; however, they are ubiquitous in the Florida landscape. It may be possible to provide additional treatment for already existing ponds connected to surface waters that have been identified as impaired for bacteria. As discussed below, additional treatment can be provided using: 1) flocculation via alum injection; 2) ultra-violet light disinfection; and 3) ozone disinfection. These forms of supplemental treatment can also be applied to other systems that retain water for an extended period of time.

A.3.2.2 Supplemental Structural BMPs

Flocculation via Alum Injection

Alum injection systems involve the addition of alum (an aluminum sulfate salt) solution to stormwater so as to cause fine particles to flocculate and settle out as chemical precipitates. The removal of substances such as suspended solids, algae, phosphorus, heavy metals and bacteria results from the adsorption of these particles onto the aluminum hydroxide precipitate (Harper et al. 1998). These treatment systems are typically comprised of a flow-weighted dosing system that has been designed to fit within a storm sewer manhole, remotely located storage tanks where alum injection and mixing occur, and a downstream pond which acts as a settling basin and collects the “floc” or “alum sludge” (Kurz 1999). When this treatment technique, under semi-controlled conditions using jar tests, was compared to above-ground sand filtration and the use of a wet detention pond, alum coagulation proved to be the most efficient overall for removing total and fecal coliform bacteria, MS2 coliphage, and turbidity (Kurz 1999). The greatest advantage of this method is the ability to effectively treat large volumes of water. Disadvantages that should be considered include: 1) potentially high costs which depend on watershed size and the number of outfalls that need to be treated; 2) the need for chemical storage and delivery; 3) a relatively high amount of maintenance as a result of being an ongoing operation that requires a trained on-site operator; and 4) the need to dispose of the floc layer which may contain bacteria and viruses that remain viable after coagulation. The floc layer can generally be disposed of using sump pumps to transport the sludge to a sanitary sewer or, for larger systems, a portable remote-control dredge could be utilized from the shoreline to pump the material to an upland drying area or sewer system. If an upland drying area is used, the resulting material could either be transported for land application or to a landfill, depending on the composition (e.g., presence of metals) of the original stormwater.

Ultra-Violet Light Disinfection

Given certain water quality characteristics of the tributary in question, ultra-violet (UV) light may be selected as the technique that would best remove fecal coliform bacteria and viruses from the surface waters. This method is generally selected because of the relatively low operation and maintenance costs and lack of negative environmental impacts associated with the treatment. Bacteria removal using UV light as treatment can be extremely high. For example, the City of Encinitas reported removal efficiencies from influent to effluent of 99.97% for total coliform, 99.80% for fecal coliform, and 99.65% for *Enterococcus* (City of Encinitas Clean Water Program 2005). In addition, the use of UV light generally requires the use of relatively little mechanical equipment and therefore has smaller space requisites, does not involve any residual or disinfection by-products, and is suitable for tributaries with variable flow rates. UV light disinfection would not be suggested as the method of treatment for waters with high levels of turbidity and suspended solids since the effectiveness of the BMP relies upon the exposure of bacteria to light.

Ozone Disinfection

Ozone is very effective in water treatment for disinfection against bacteria. It is a powerful oxidant able to achieve disinfection with less contact time and concentration than all weaker disinfectants, such as chlorine, chlorine dioxide, and monochloramine (DeMers & Renner 1992); however, ozone can only be used as a primary sanitizer because of the high decay rate of the residual and should therefore be coupled with one of the weaker decontamination agents for a complete disinfection system (EPA 1999).

According to Caltrans (2004), an ozone treatment system has four basic components: a gas feed system, an ozone generator, an ozone contactor, and an off-gas destruction system (Figure A-3). The gas feed system provides a clean, dry source of oxygen to the generator. The ozone contactor transfers the ozone-rich gas into the water to be treated and provides contact time for disinfection (or other reactions). The final process step, off-gas destruction, is required as ozone is toxic in the concentration present in the off-gas. A quench chamber to remove ozone residual in solution may also be added to the treatment train.

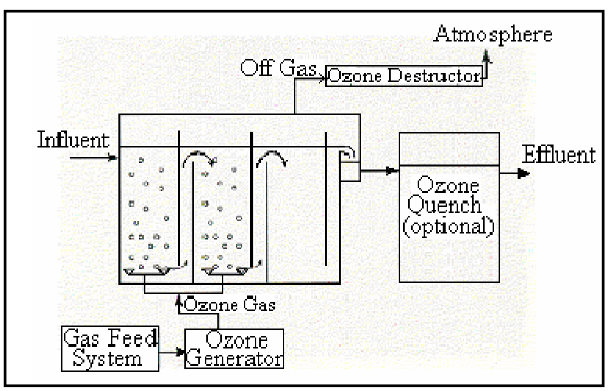

Figure A-3. Example of an ozone treatment system showing the four basic components as described by (Caltrans 2004)

Ozone systems are most applicable for continuous flow. For wet weather intermittent flow, a water sensor will be needed to start the ozone generator (the first flush of the runoff would not be treated unless an equalization/storage basin is provided). It should be noted that the necessary controls for regulating flow can be complicated and difficult to maintain (Dycus 2004).

An advantage to using ozone for disinfection is that the system only requires low doses to complete disinfection and has a limited number of by-products. The process does not provide residual ozone concentration in the effluent, which will minimize the impact to the receiving watershed. The systems are highly automated and have been proven to be very reliable. Because treatment by ozone disinfection is most successful on waters with low levels of turbidity, suspended solids, and total organic carbon, pretreatment using sand filtration or screens may be necessary (Dycus 2004).

When deciding on a treatment system, the very high energy requirement and initial cost of the equipment associated with ozonation technology should be considered. Other disadvantages include: 1) a relatively high level of maintenance and operator skill are required; 2) ozone is highly corrosive and toxic; 3) some ozonation by-products may be harmful to the receiving water; 4) in the presence of many of the compounds commonly encountered in water treatment, ozone decomposition forms hydroxyl free radicals; and 5) ozone escaping into the atmosphere may contribute to air pollution problems.

Bacteria Removal Filters

There are several companies that market products specifically for the removal of bacteria from stormwater conveyances using filter-based systems (e.g., AbTech Industries-Storm Water Antimicrobial Treatment-Smart Sponge®; Best Management Products, Inc.-The Bio-Skirt®; Filterra-Bacterra™). Most of these are passive systems in that the product is placed in the path of stormwater flow, typically within a stormwater inlet, and as the stormwater flows through the media bacteria is removed from the water. The overall success of these products at consistently removing bacteria from stormwater over time is unclear; however, their effectiveness appears to be highly dependent on contact time with the media making the products most beneficial in areas with low flow.   Lastly, as the maintenance requirements of these products can be considerable, their usage should be limited to areas where the necessary practices for proper operation can be adequately upheld.

A.3.2.3 Non-Structural BMPs

Non-structural BMPs are used in lieu of or to supplement structural BMPs. Non-structural measures may include minimization and/or disconnection of impervious surfaces; development design that reduces the rate and volume of runoff; restoration or enhancement of natural areas such as riparian areas, wetlands, and forests; and vegetated areas that intercept roof and driveway runoff. In this regard, “non-structural BMP” is a generic term for many of the techniques under the umbrellas of Green Infrastructure and Low-Impact Development. Non-structural BMPs can also refer to educational program elements aimed at changing behaviors that lead to polluted runoff. Examples include storm drain marking, outreach programs (e.g., pet waste campaigns), yard fertilizer education programs, reduction of impervious areas, street sweeping, smart growth practices, and re-vegetating with native species (Hirschman & Kosco 2008).

A.3.3 Illicit Discharges

Contamination of the stormwater drainage system and receiving waters by illegal and/or improper discharges occurs in a variety of ways. Such discharges may include, but are not limited to: sanitary sewer flow; industrial process water; chlorinated pool water; and laundry releases. Sanitary sewer flow, for example, may result from improper connections to sanitary sewage pipes or the direct connection of septic systems to stormwater conveyance networks, thus short-circuiting treatment provided by the drain field.

These potential illicit discharges can often be detected via field investigations of the stormwater system. Field investigations should target locations in close proximity and upstream of areas with high bacteria concentrations. Components of the field investigation should include: (1) inspection of stormwater outfalls and inlets to identify those with flow, very high turbidity, strong odors and colors; (2) inspections of drainage ditches and surface waters in close proximity to residential and industrial/commercial areas to identify illicit pipes and other suspicious connections and/or discharges; (3) and the collection of samples from suspicious discharges (e.g., sewage odor) for fecal coliform analysis. For supplemental information for the IDDE Program including program development and technical assessments, please refer to The "Illicit Discharge Detection and Elimination *A Guidance Manual for Program Development and Technical Assessments* (EPA 2004a) and associated technical appendices (EPA 2004b).

It is suggested that programs dedicated to the mapping, detection and elimination of illicit discharges be continued as mandatory components of stormwater management plans. In addition, targeted campaigns with social marketing elements should be implemented to determine the effectiveness of distributing educational pamphlets and informational door hangers and employing a storm drain-stenciling program. Those educational outreach programs identified as most effective should be continued to inform the public of the associated impacts on water quality. Volunteers can also be trained through programs like Watershed Action Volunteers (WAV) to perform a variety of tasks to improve the environmental quality of their local watersheds. These tasks can include: water quality monitoring; surveying streams for pollution sources; and the distribution of public outreach materials.

Wildlife and Natural Sources

In addition, since natural (i.e., wildlife-related) impairments are considered relatively low risk to human health and may be difficult or unreasonable to restore, it is suggested that signs alerting the public to the potential for health risk be posted at the necessary locations. In some areas conveyance systems may be easily identified. In this case the installation of screens at the outfalls should be investigated as an effective BMP in targeted areas. It is anticipated, however, that a great deal of effort would be required to maintain the screens and prevent clogging of outfalls and associated flooding.

Domestic Pets

Lastly, domestic pets (e.g., dogs) can also contribute to the fecal loading of surface waters. Considering that an estimated 40% of residents in America have at least one dog and that approximately 40% of dog owners do not pick up their dog's feces (Tyler 2006), there is a need to educate the public and enforce pet waste management actions to reduce pet waste loads within the watershed.

Public outreach and education efforts may include the distribution of flyers, plastic bag dispensers, and brochures depicting the proper pet waste disposal methods and/or describing the potential negative impacts of pet waste to water quality and human health. Public outreach programs can also follow a more active approach to include the education of homeowners associations, apartment managers, and local neighborhood groups concerning the importance of proper disposal of pet wastes via community education booths, poster awareness campaigns, and interactive community-based initiatives (e.g., community games) (McKenzie-Mohr & Associates). Several examples of programs to involve communities in the reduction of pet wastes are included in the "Reducing Pet Waste" Paper by McKenzie-Mohr & Associates (McKenzie-Mohr & Associates). For example, one program in Tampa, "Pooches for the Planet", increased the awareness of dog waste impacts on water quality by setting up an information station in a residential neighborhood near surface waters. This program provided educational materials (e.g., magnets, and plastic bag dispensers) to the community on proper pet waste disposal practices and promoted community involvement; several volunteers were recruited to help with the information station and refill plastic bag dispensers at pet waste stations. Education and outreach programs are relatively cost effective and should be considered in the Elizabeth Creek basin. These programs should target dog walking areas and those locations in close proximity to surface waters. The City should also continue to enforce pet waste ordinances and provide pet waste stations in areas frequented by dog walkers.

(All of the above, alone or in combination, can be effective in helping to reduce fecal coliform loadings to surface waters in areas that have been identified as having potential stormwater-related contributions; however, each must be targeted and evaluated based on the area in question, the cost required, and the level of public acceptance. It is recommended that analysis be conducted on a life-cycle cost basis and factors such as capital costs, operation and maintenance costs, degree of engineering design needed for implementation and regulatory issues be considered in order to determine the most feasible approach. The suggested BMPs are summarized in this regard in Table A-6.

Table A-6. Suggested BMPs and how they compare to one another in terms of relative cost, level of maintenance necessary for proper function and degree of design effort necessary to implement the BMP. (H=High, M=Medium, L=Low)

BMP	RATING CRITERIA		
	Cost	**Maintenance**	**Design Effort**
Filtration	H	M	H
Infiltration	L	L	H
Bioretention	L	L	M
Baffle Box	M	H	M
Treatment Train	M	H	M
Flocculation/Alum Treatment	H	H	M
UV Disinfection	L	L	M
Ozone Disinfection	H	H	H
Non-Structural BMPs	L	L	L

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Web Resources

JEA Fats, Oils, and Grease (FOG) Program Workshop:
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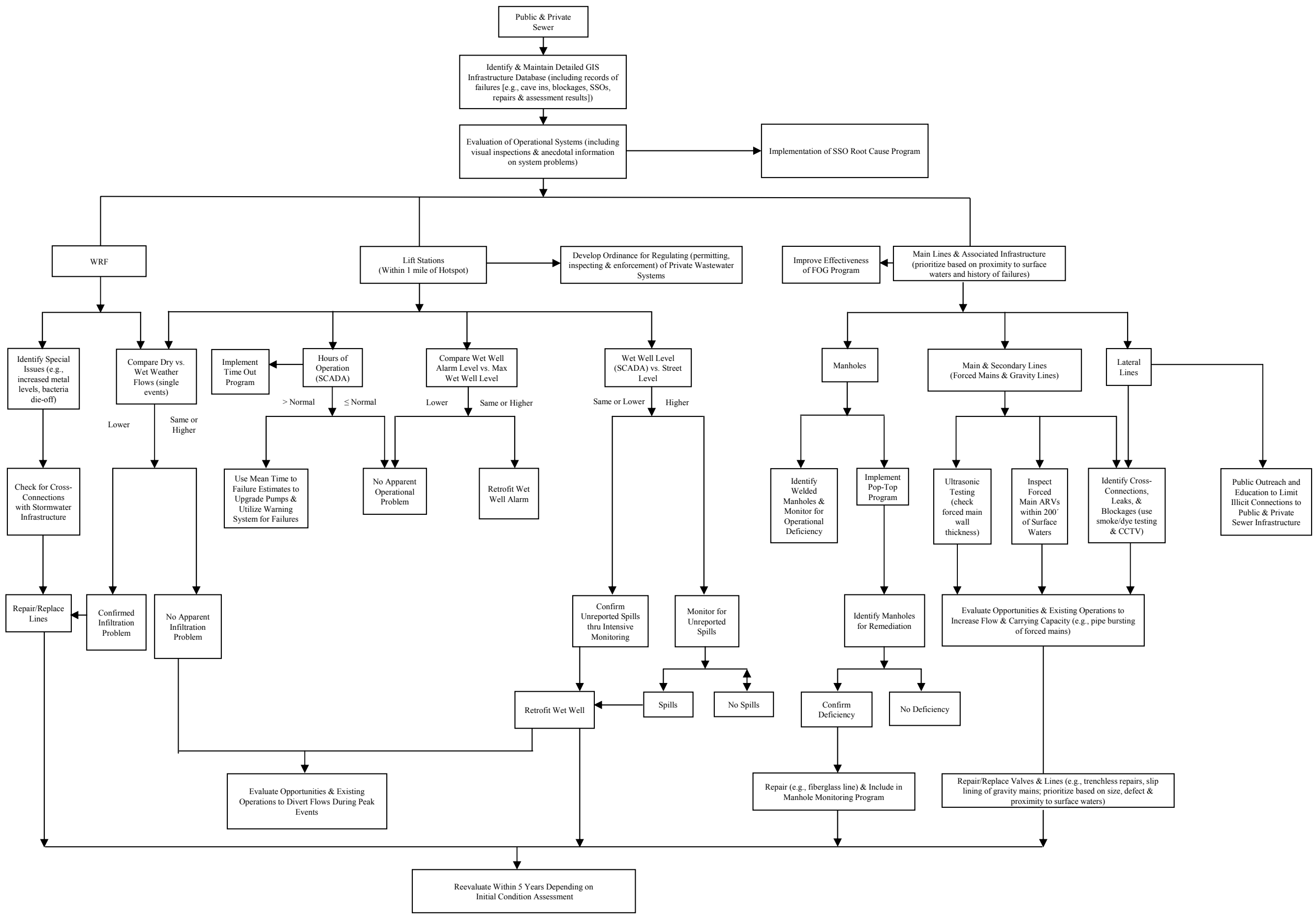
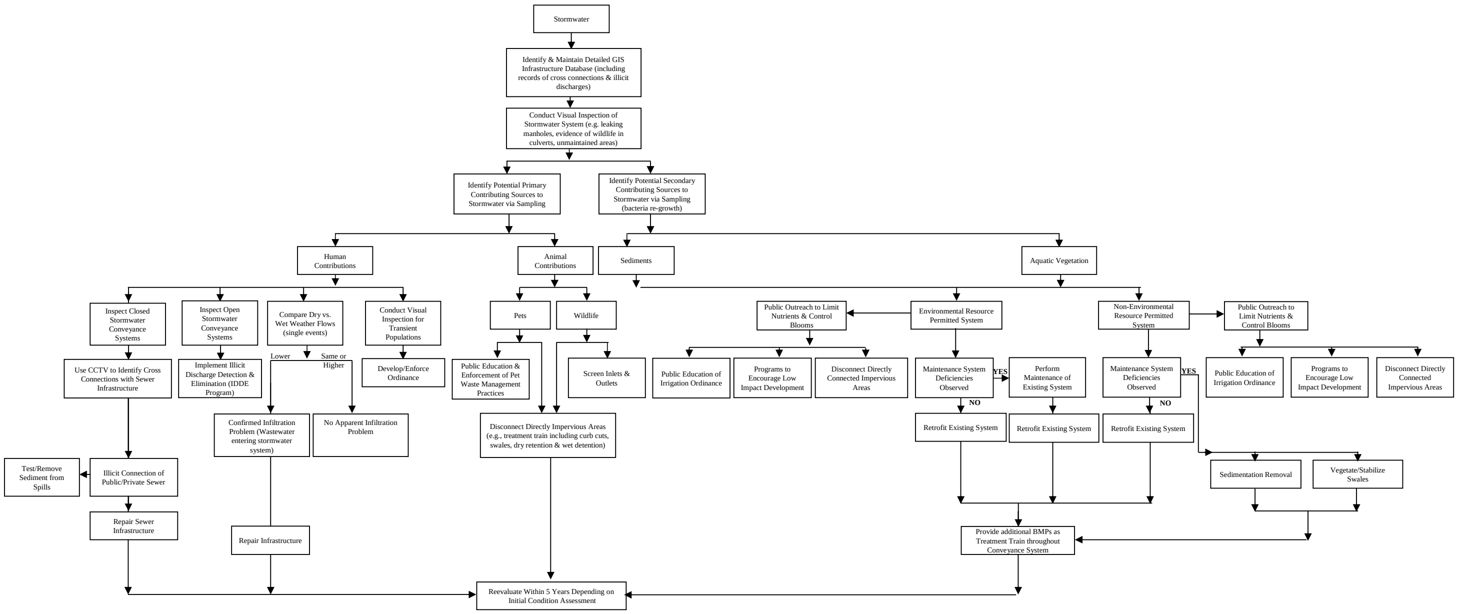
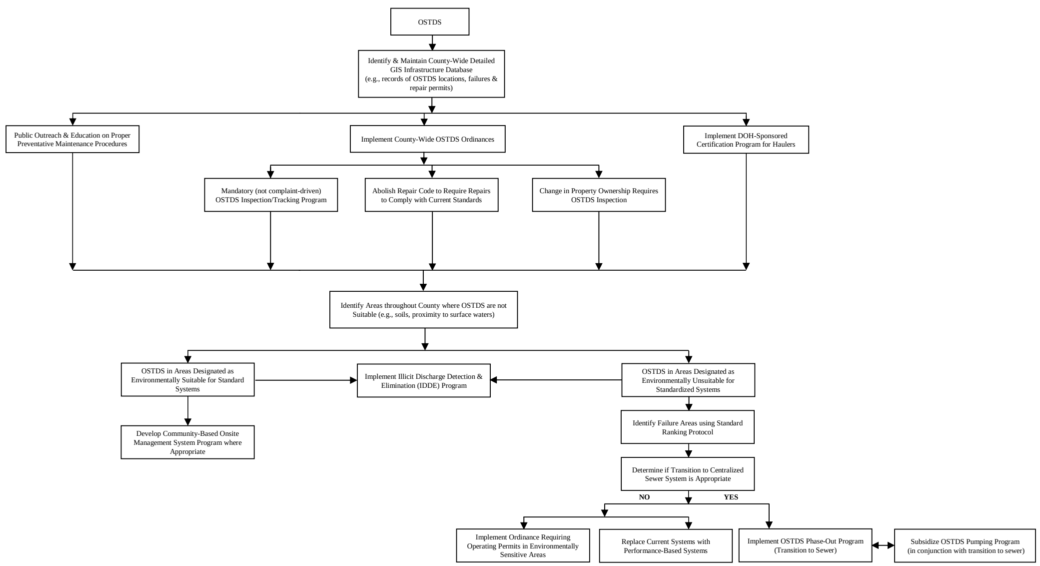
Public & Private Sewer Decision Tool Draft



Stormwater Decision Tool Draft



OSTDS Decision Tool



Appendix B

Elizabeth Creek Infrastructure Map Legend

- IWR Sampling Stations
- Hot Spots (ACEPD Sampling Station)
- ACEPD SamplingStations
- Watersheds
- SSO Events (2001-07; ACEPD)
- Illicit Discharge (ACEPD)
- WWTP (ACEPD)
- Facilities & Rec. Parks (ACEPD)
- Sewer Lift Sations (GRU)
- Sewer Private Lift Stations (GRU/FDEP)
- Private Systems (GRU)
- Unverified Septic Tanks (GRU)
- Excavation & Land-Fill (ACEPD)
- Brown Field Areas (FDEP)
- Groundwater Contamination (FDEP)
- Sewer Private Lift Stations (FDEP)
- Sewer Manhole (GRU)

Storm Catch Basin (COG)

- Drainage Inlet

Storm Discharge Point (COG)

- FES
- Headwall
- MES
- Outfall

Storm Network Structure (COG)

- DischargeStructure
- Ditch Block
- DiversionChamber
- DiversionPoint
- Filter Box
- JunctionChamber
- LiftStation
- Outlet Control Structure
- ProductionWell
- PumpStation
- Sediment Trap
- Spillway
- SplitManhole
- TideChamber
- Weir
- Storm Manhole

Storm Basin (COG)

- Depression
- Dry Detention
- Inline Storage
- Natural Pond
- Natural Sink
- other
- Retention Basin
- Sinkhole
- Wet Detention
- Sewer Slip-Lined Gravity Mair
- Sewer Gravity Main (GRU)
- Sewer Force Main (GRU)

Storm Structure (COG)

- Barrier Wall
- Headwall

Storm Gravity Main (COG)

- Collector
- Culvert
- InlineStorage
- Outfall
- Underdrain

Storm Open Channel (COG)

- Ditch
- Creek
- Swale
- Trench Drain
- COG Creeks (COG)
- Roads
- NRCS Pits/Dumps (NRCS)

Storm Feature (COG)

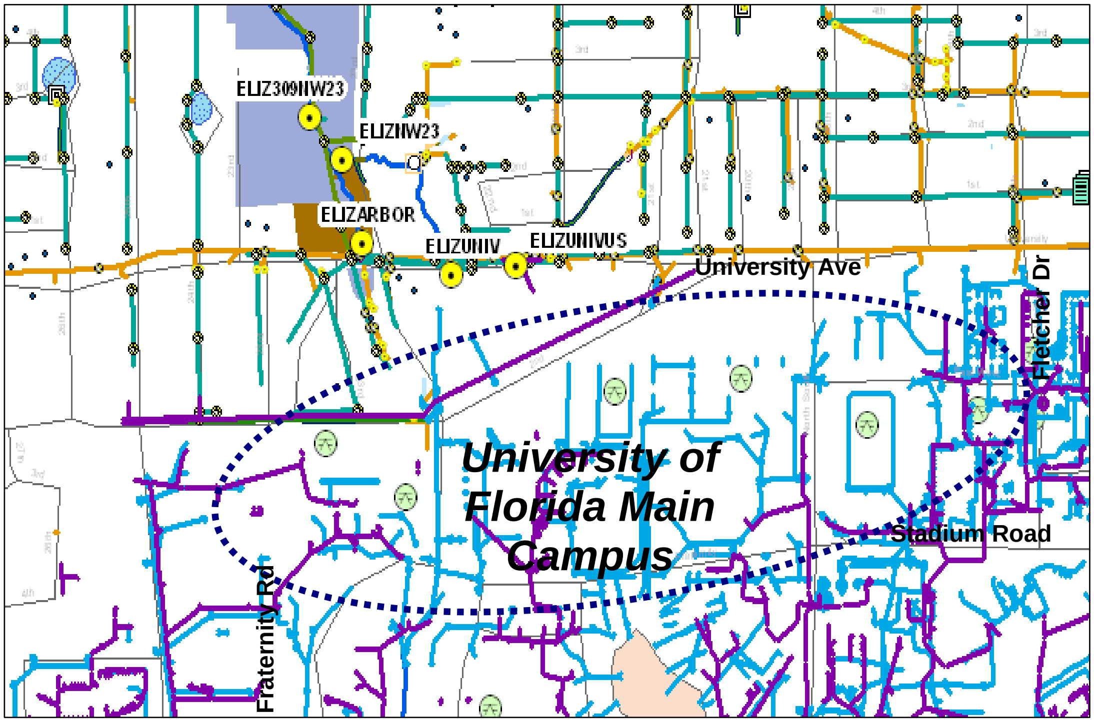
- Depression
- Dry Detention
- Inline Storage
- Natural Pond
- Natural Sink
- other
- Retention Pond
- Sinkhole
- Wet Detention
- Stormwater Issues (OCG)

Septic system Impact (ACHD)

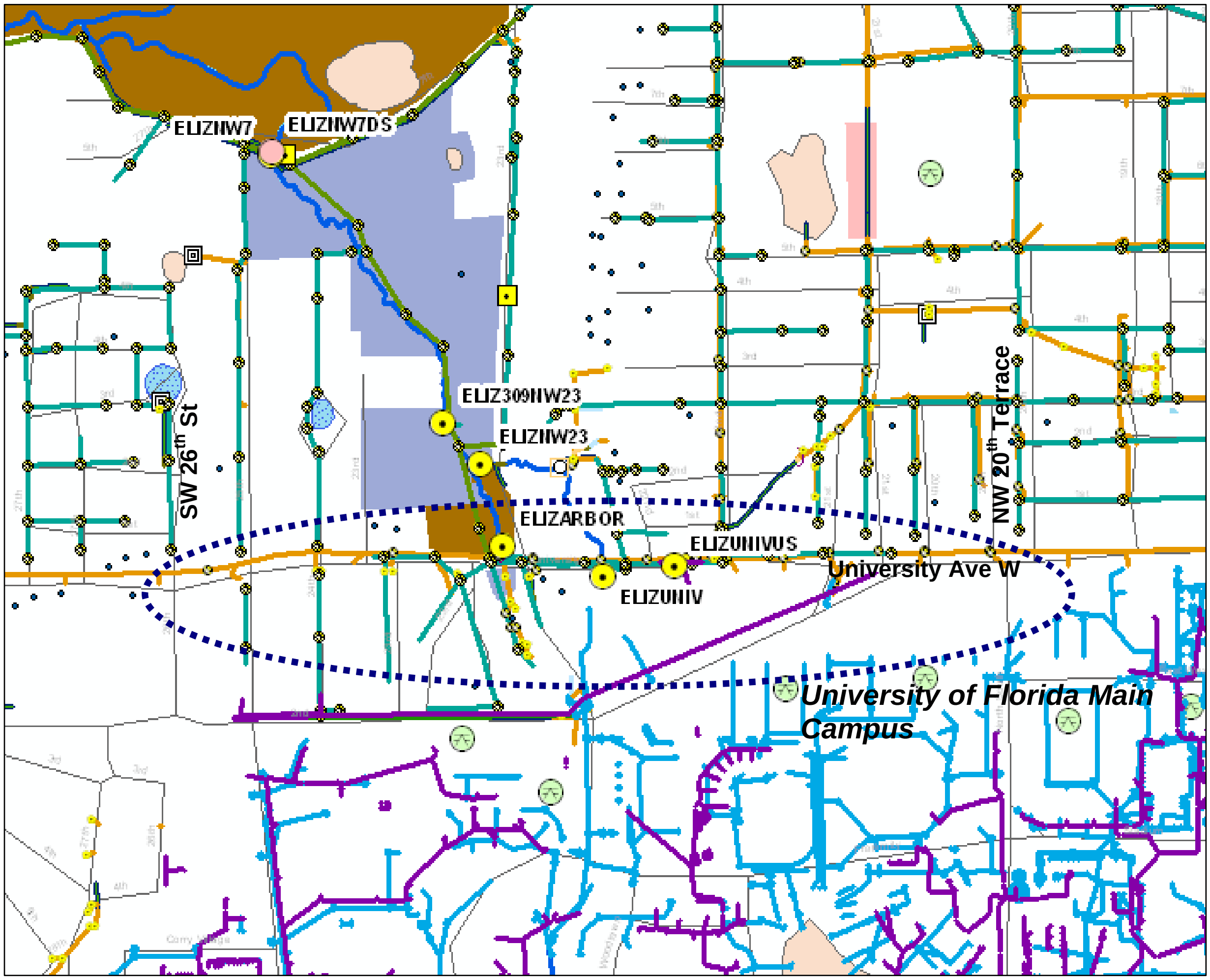
- Significant
- Vacant/Unimproved
- Minor
- No Access
- Sewer

UF Infrastructure

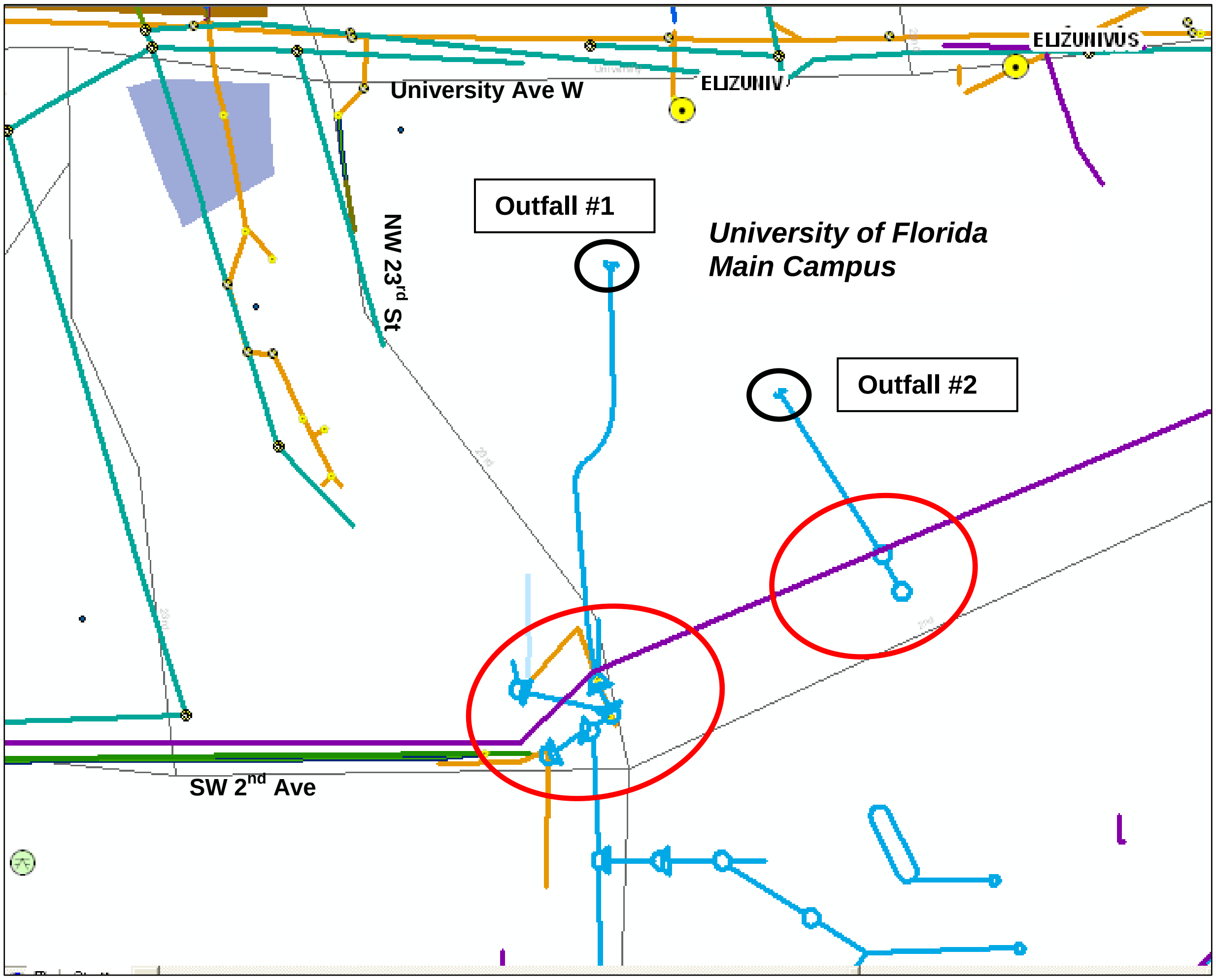
- UF sewer lines
- UF stormwater infrastructure



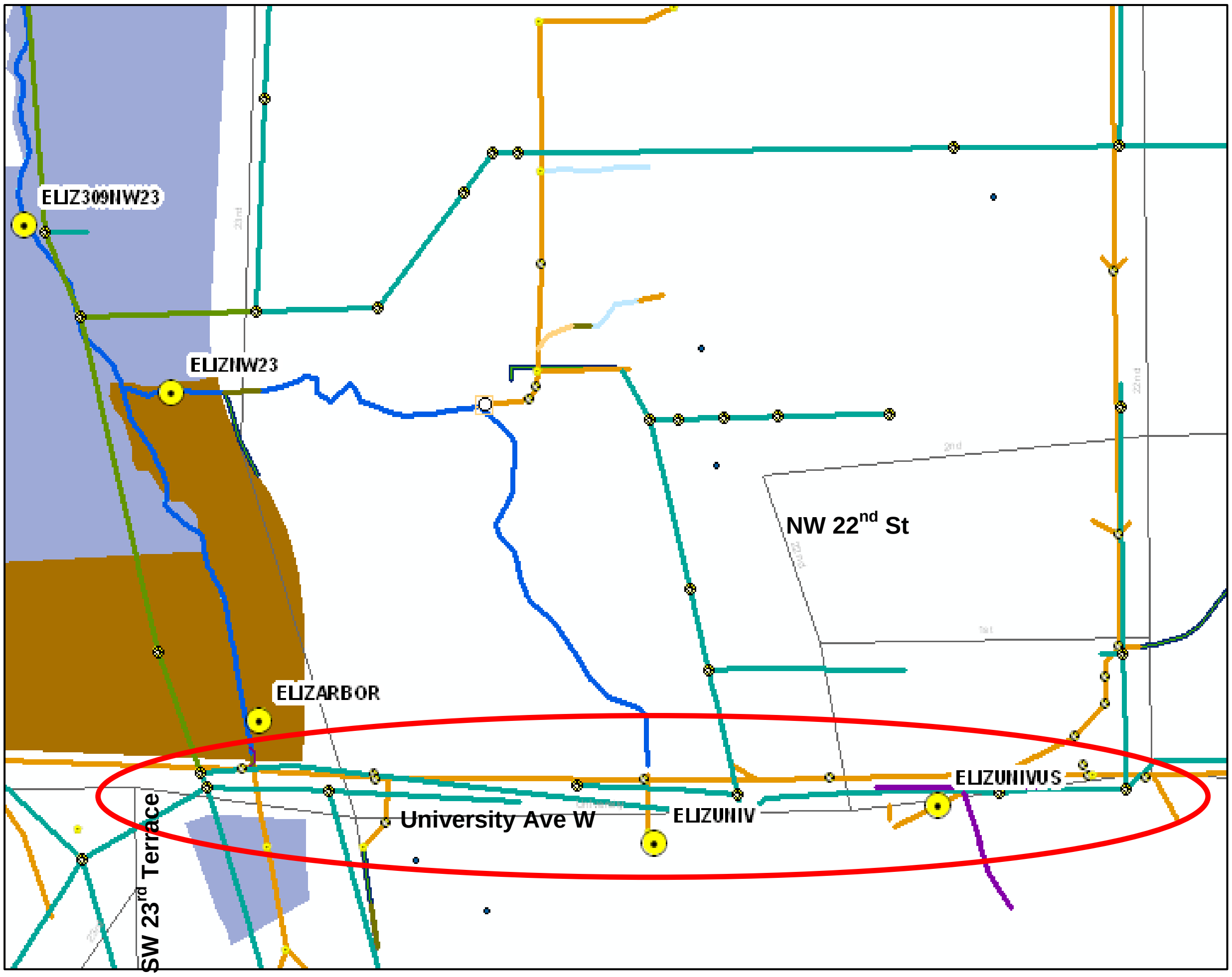
Map A: The dotted blue circle indicates the area of investigation for Priority #9 - visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations) and where detailed field reconnaissance as part of an IDDE Program should be performed to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS)



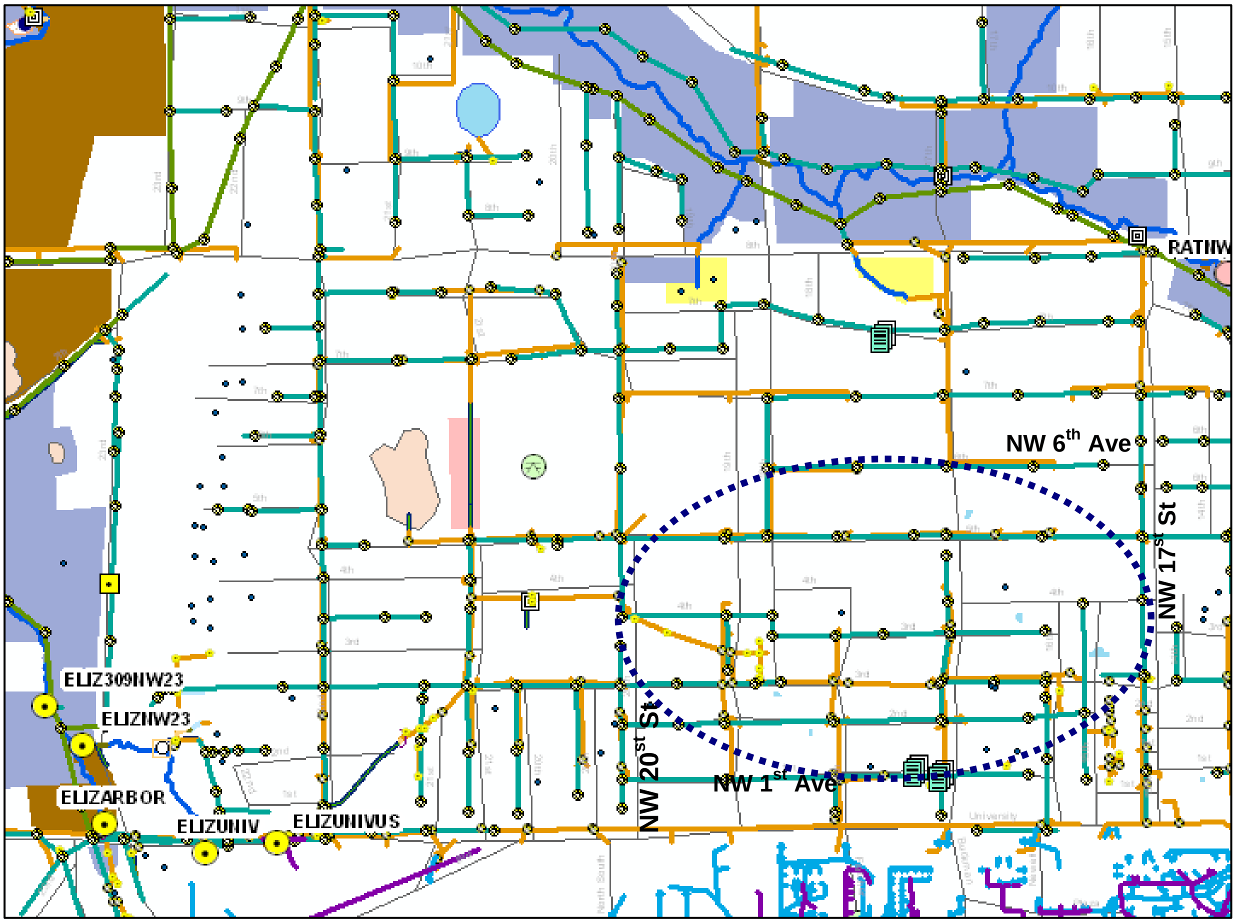
Map B: The dotted blue circle indicates the area of investigation for Priority #10 - visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations) and where detailed field reconnaissance as part of an IDDE Program should be performed to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS)



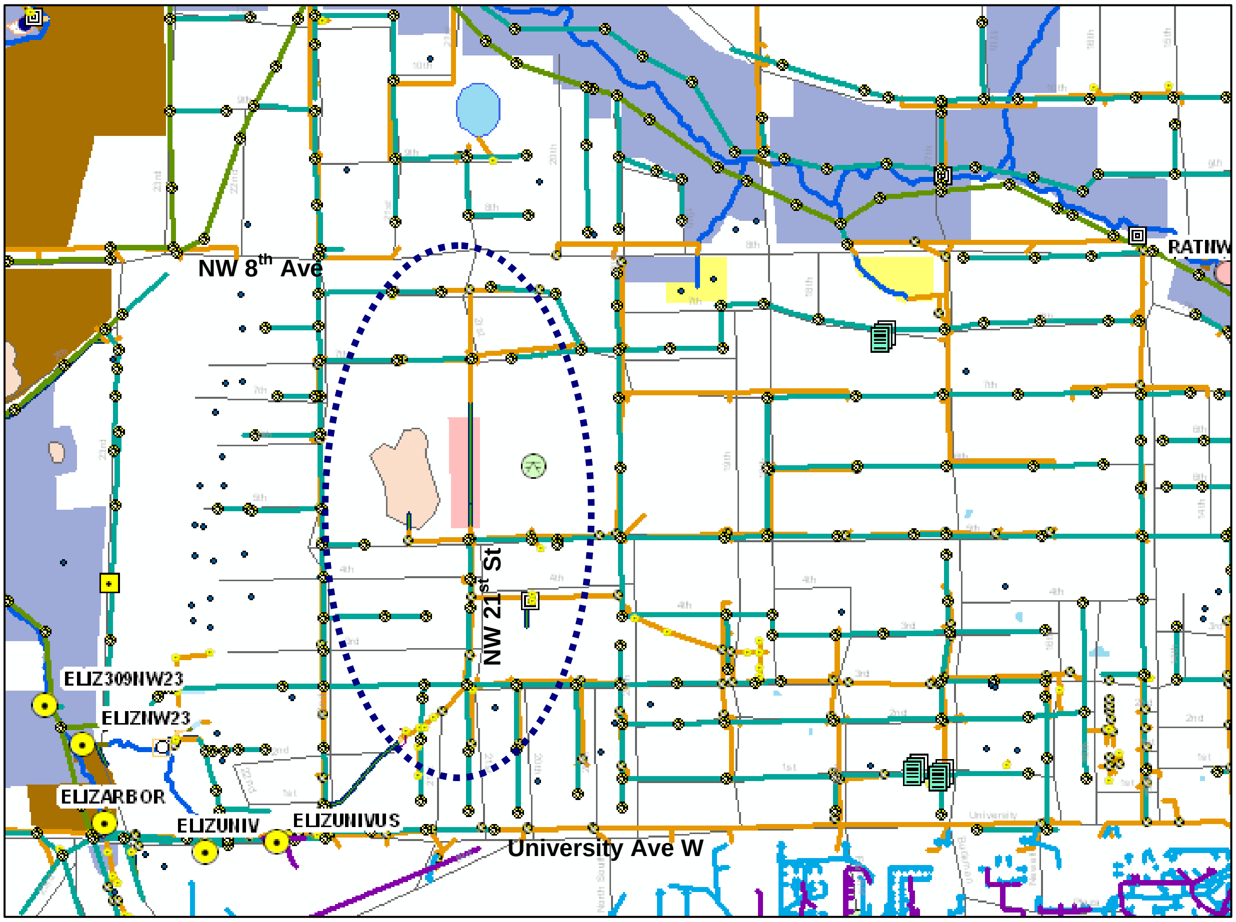
Map C: Priority #11 and #12 infrastructure location. Black circles refer to sampling locations. Red circles indicate areas for further smoke/dye testing, and/or CCTV



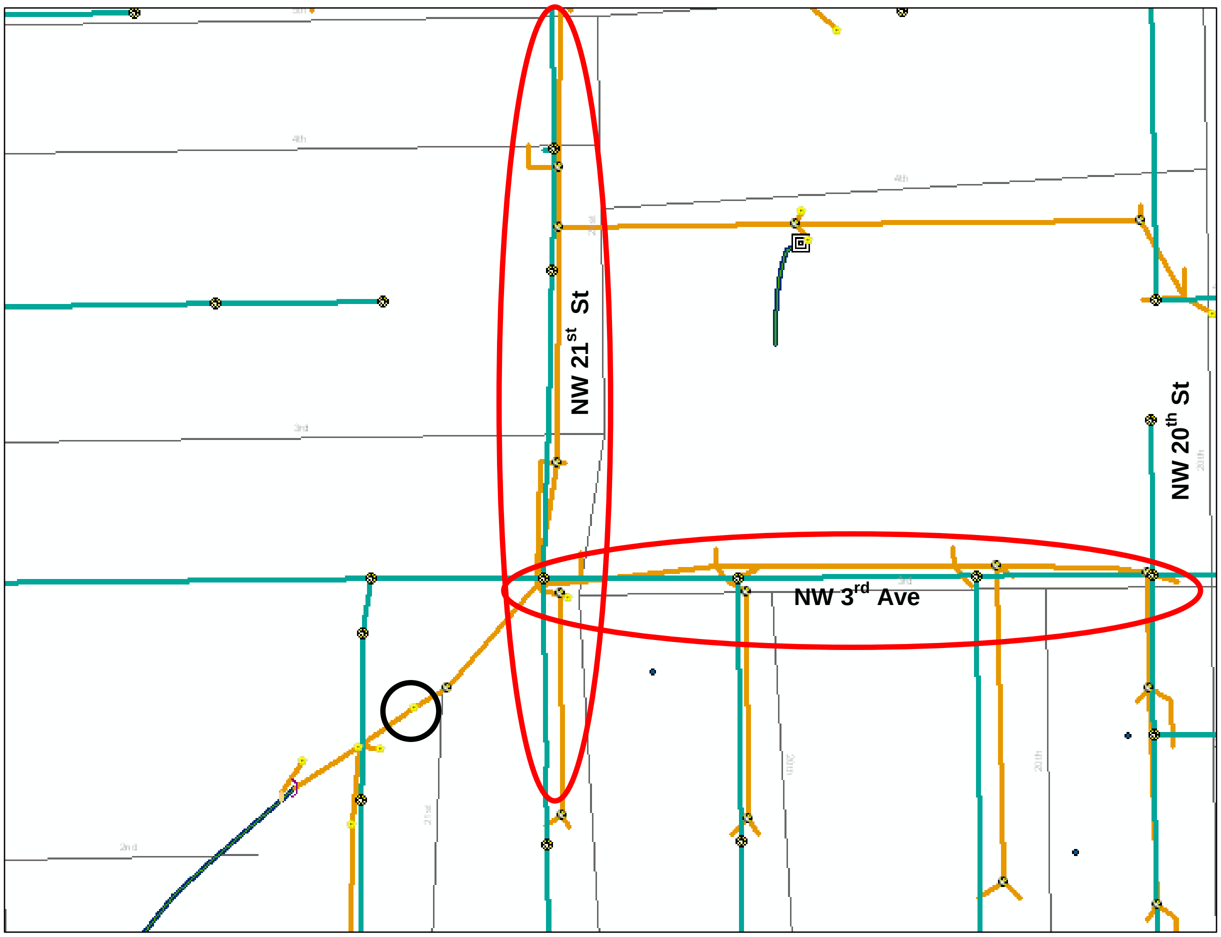
Map D: Priority #15 infrastructure location. The red circle indicates the area for further smoke/dye testing, and/or CCTV



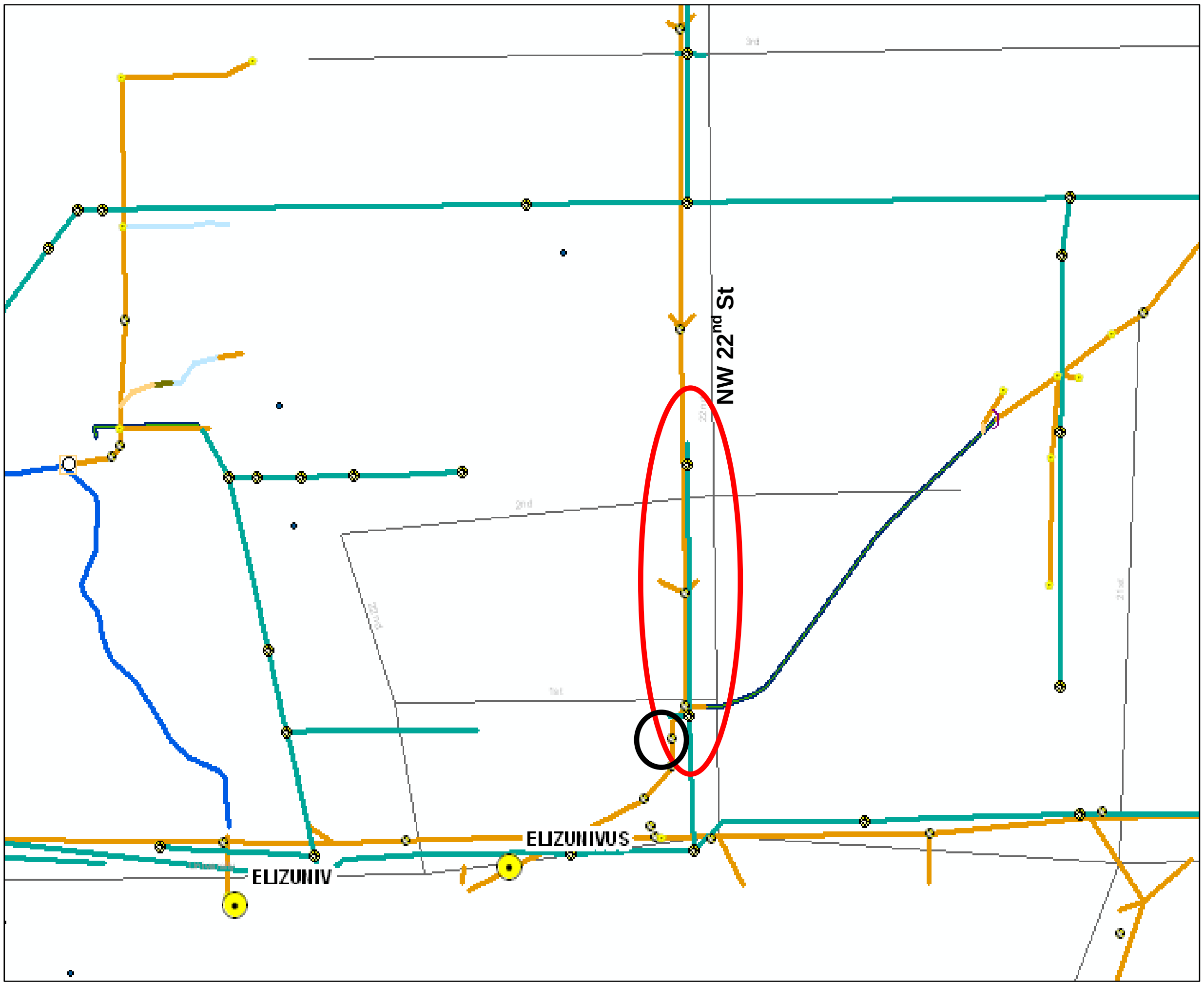
Map E: The dotted blue circle indicates the area of investigation for Priority #16 - visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations) and where detailed field reconnaissance as part of an IDDE Program should be performed to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS)



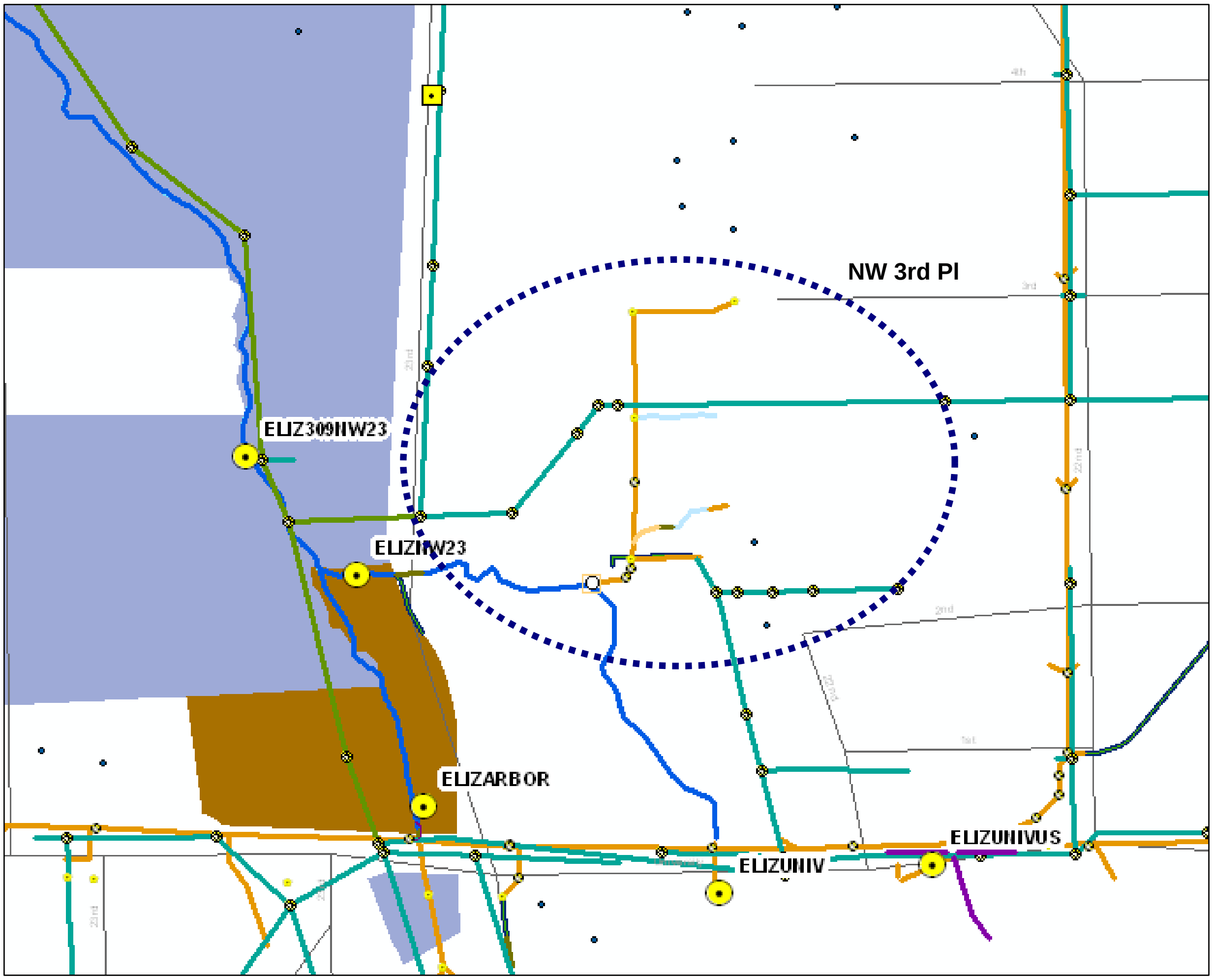
Map F: The dotted blue circle indicates the area of investigation for Priority #17 - visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations); and where detailed field reconnaissance as part of an IDDE Program should be performed to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS)



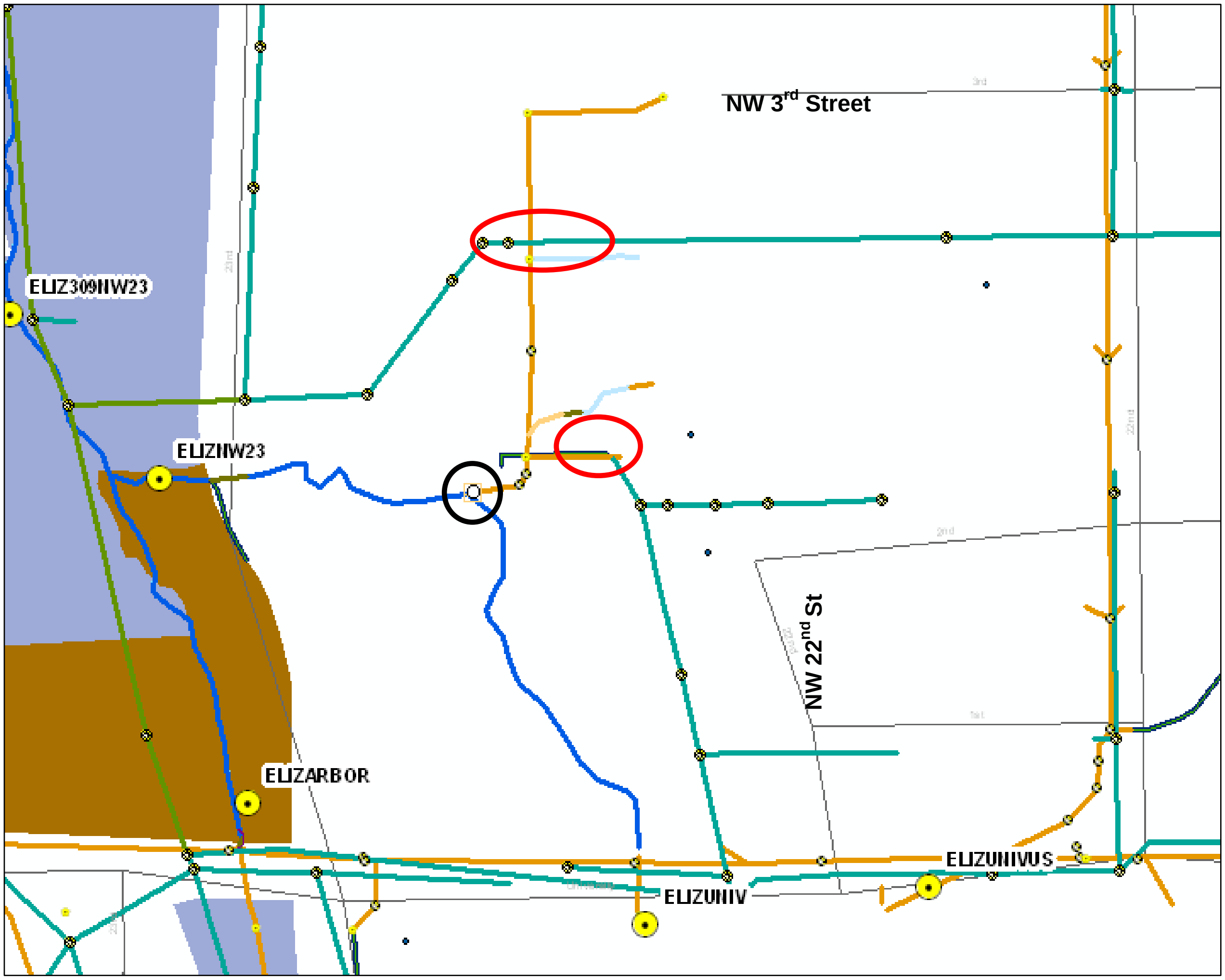
Map G: Priority #18 infrastructure location. The black circle refers to the sampling location. Red circles indicate areas for smoke/dye testing, and/or CCTV



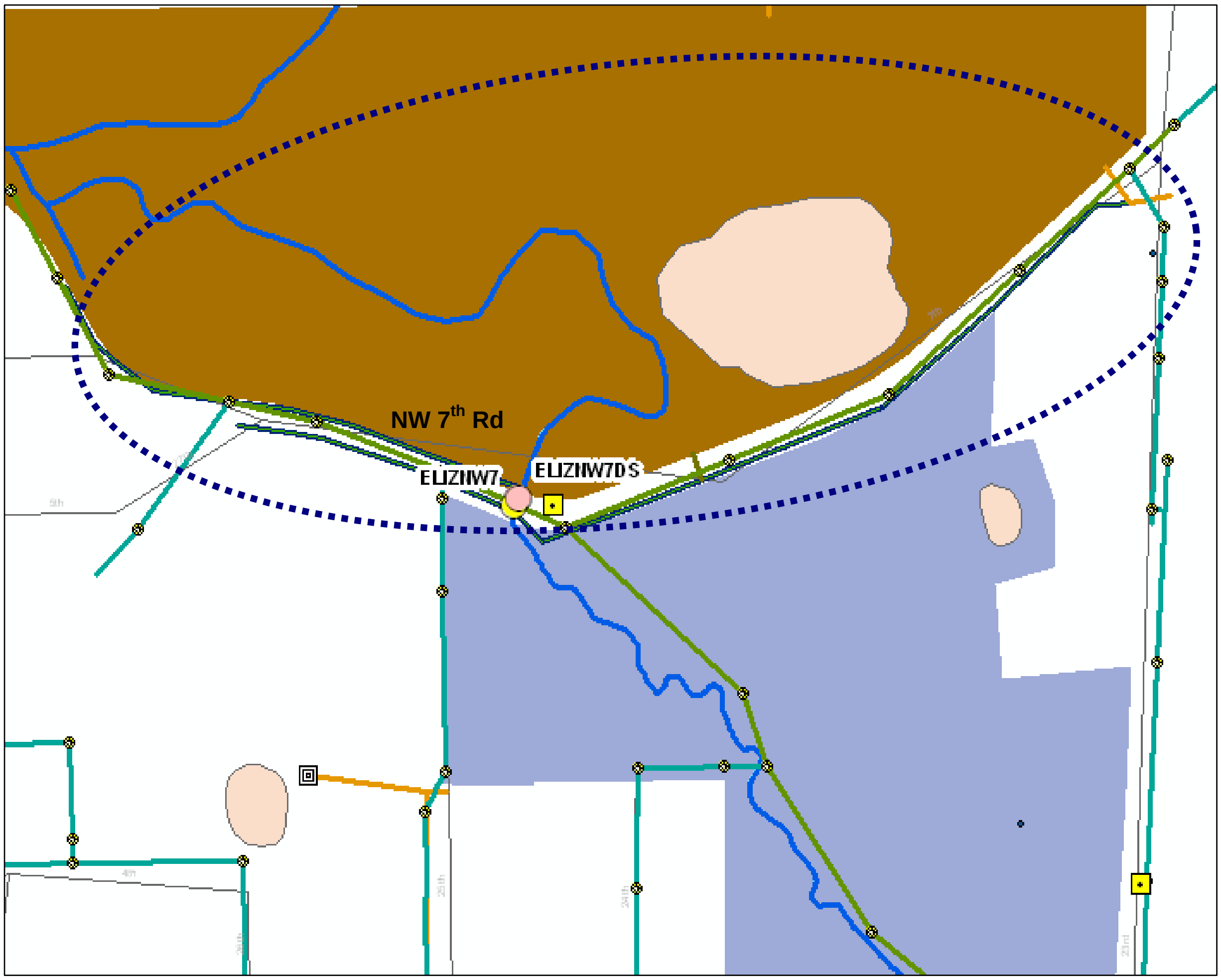
Map H: Priority #19 infrastructure location. The black circle refers to the sampling location. The red circle indicates the area for smoke/dye testing, and/or CCTV



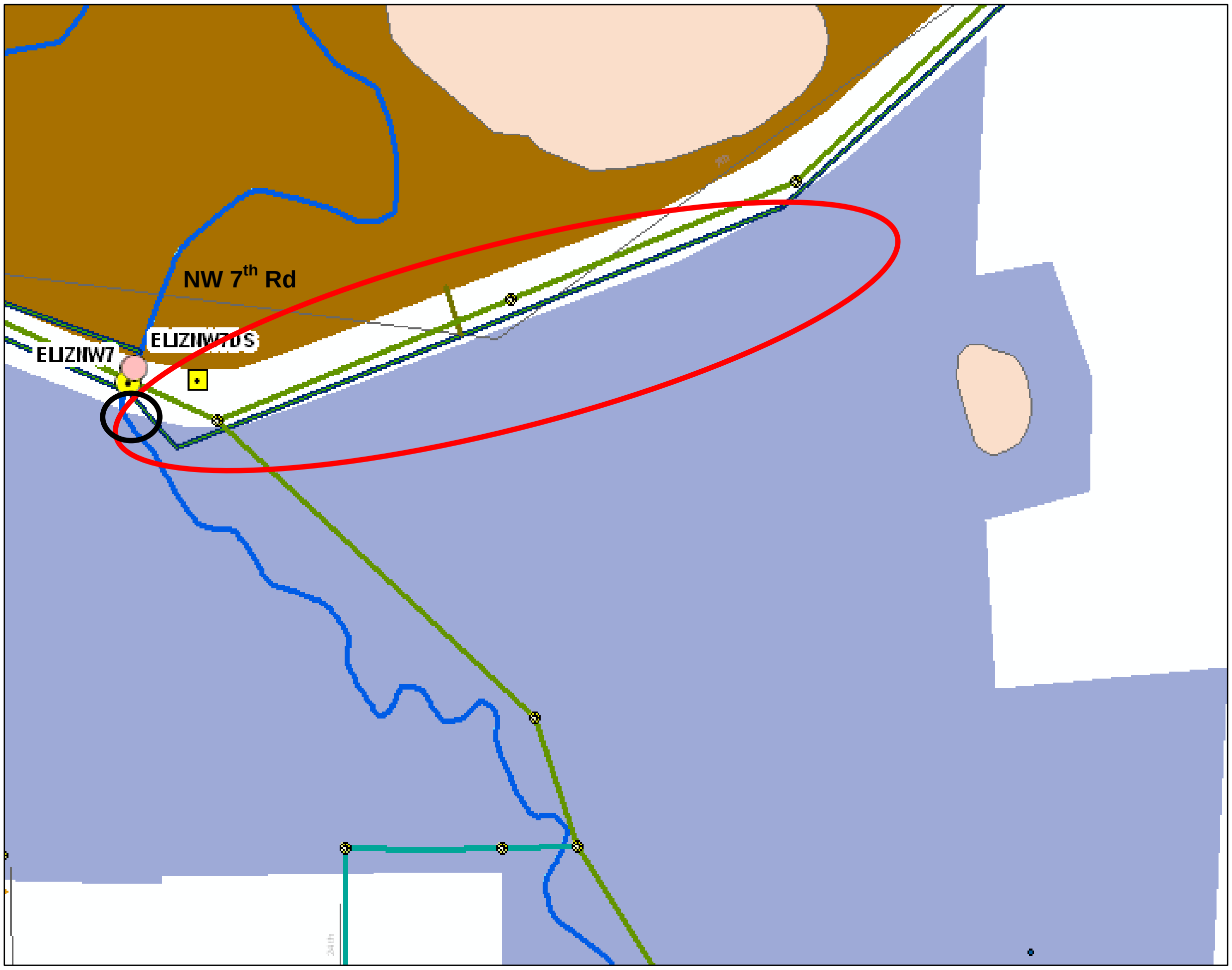
Map I: The dotted blue circle indicates the area of investigation for Priority #20 - visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations); and where detailed field reconnaissance as part of an IDDE Program should be performed to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS)



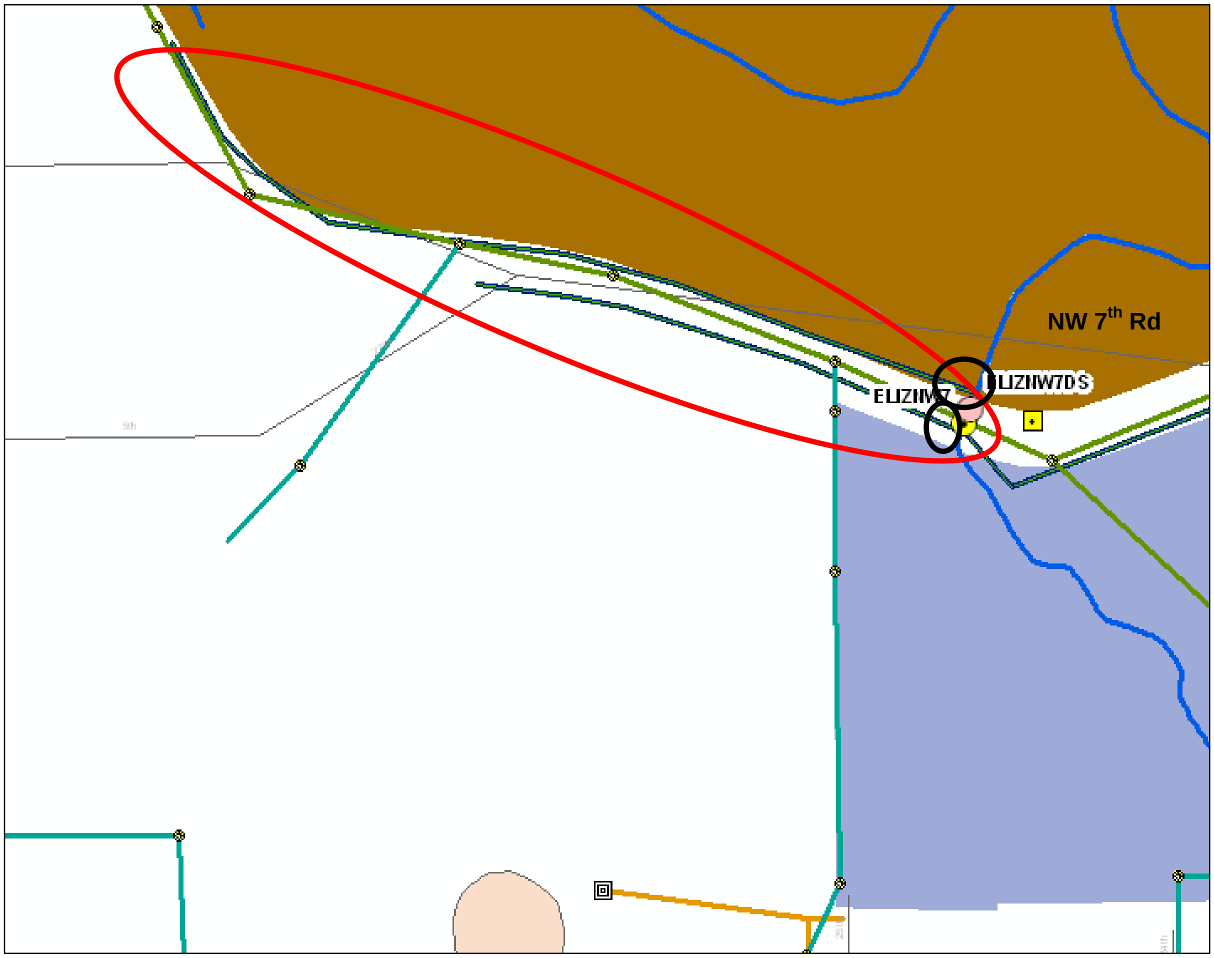
Map J: Priority #21 infrastructure location. The black circle refers to the sampling location. Red circles indicate areas for smoke/dye testing, and/or CCTV



Map K: The dotted blue circle indicates the area of investigation for Priority #22 - visual inspection of the stormwater collection system (e.g., leaking manholes, evidence of wildlife in culverts, unmaintained areas, homeless populations) and where detailed field reconnaissance as part of an IDDE Program should be performed to identify potential illicit discharges (e.g., improper connections of sanitary sewage pipes/OSTDS)



Map L: Priority #23 infrastructure location. The black circle refers to the sampling location. The red circle indicates the area for smoke/dye testing, and/or CCTV



Map M: Priority #24 infrastructure location.   Black circles refer to the sampling locations. The red circle indicates the area for smoke/dye testing, and/or CCTV

Appendix C

DUVAL COUNTY HEALTH DEPARTMENT

Septic Tank Failure Area Ranking Protocol

THE BETTER JACKSONVILLE PLAN

JEA

Building Community

I. Overview

The following is a step-by-step description of how to properly perform a Septic Tank Failure Area Ranking. This document will also provide information on how to format/ calculate data and whom to contact to obtain such data.

Approximately half of the criteria required to complete the Septic Tank Failure Area Ranking are generally static in nature and will not change over time; the criteria are Average Lot Size, Soil Potential, Seasonal High Water Table, and Proximity to the River.

The remaining criteria such as # of OSTDS Failures, Threat to Potable Water, Sanitary Conditions, and Flooding can change depending on the time frame and may be affected by various Public Works initiatives or other outside agencies

II. Contacts for Data

The **# of OSTDS Failures** is calculated from data maintained by the Duval County Health Department; the primary contact for this information is the Environmental Supervisor of the Onsite Sewage Treatment and Disposal System Program, Scott Turner, MPA, RS - (904) 630-3274.

Threat to Potable Water is calculated from data provided by JEA. The # of customers receiving "City Water" from a centralized distribution system within the area in question can be used to determine properties that rely on private potable wells for drinking water. The primary contact for this is Kevin Holbrook and be contacted at (904) 665-4540.

The City of Jacksonville's Air and Water Quality Division supply the data for **Sanitary Conditions**. Point values for each area are provided by Dana Morton - (904) 630-1212 X3128.

The City of Jacksonville's Streets and Drainage Division perform the review of **Flooding** within specified areas. A determination of conditions to new or existing areas in the form of a point rating (severe, moderate, minor, and not significant) may be requested from Jeff Beck - (904) 630-1212 X7003.

III. Calculations for 8 Criteria

A.) OSTDS Failures

The OSTDS Failures are calculated by averaging the latest five years of OSTDS Repair Permit information on the individual failure area polygons and assigning points based on the Table 1. The dates should be from April of the preceding year to the end of March during the current year. This time span is maintained to keep the analysis consistent with the original ranking completed in April of 1999.

B.) Average Lot Size

Calculated with Arc View software. The City of Jacksonville supplies our office with parcel information on all recorded properties in the form of a shape file. The shape file contains lot size data which Arc View can be used to determine total number of lots and total acreage within a failure area. Average Lot Size is calculated based on these results.

C. Soil Potential

Calculated with Arc View software. The Soil Potential for Duval County Layer (created by Frank Watts USGS Soils Survey Leader for Duval County and Tom Mallet City of Jacksonville) measures the potential of an OSTDS to be installed and maintained. A percentage of each soil potential type within the individual failure area polygons is provided. A portion of this polygon may have an amount of acreage that cannot have a soil potential assigned to it. If that is the case the area of the polygon should be normalized. Assigning the fraction of the whole that can be analyzed as the polygon total does this, and new percentages are calculated by dividing the area of individual soil type by this new polygon total. The result for each soil type is then multiplied by the point values from Table 1 (C) for that soil type and totaled for the area score. This can be done because the percentages are determined in units or graphically by the software. [See example calculation in D.) below.

D. Seasonal High Water Table

Calculated with Arc View software. The attributes table of the USGS Soils Survey layer provided by the St. Johns Water Management District is adjusted to map the soil types in Duval County according to their soil Taxonomy characteristic of "Seasonal High Water Table". The program will return a percentage of each soil type within the individual failure area polygons. A portion of this polygon may have an amount of acreage that cannot have a seasonal high water table assigned to it. If that is the case the area of the polygon should be normalized. Assigning the fraction of the whole that can be analyzed as the polygon total does this, and new percentages are calculated by dividing the area of individual soil type by this new polygon total. The result for each soil type is then multiplied by the point values from Table 1 (D) for that soil type and totaled for the area score. This can be done because the percentages are determined in units or graphically by the software.

Example: Typical results from Arc View analysis

SHWT

Very Good.................0.0%
Good.........................0.0%
Moderate..................20%
Poor..........................74%
Note rated..................6.0%

Note the total percentages add up to 94%, therefore 6% is not rated.
The 94 now becomes our new total area and the percentage of moderate soil that can be analyzed is 20 divided by 94, which equals 21.3%. The percentage of poor soil is 74 divide by 94, which equals 78.7%
Referring to Table 1 (C) poor soil is worth 10 points and moderate soil is worth 7 points. Multiply the corresponding percentages by there soil class point value yields 7.87 points for poor and 1.07 points for moderate giving a total of 8.94 points for the Season High Water Table criteria.

This analysis is identical to the soil potential calculation on using different inputs.

E. Threat to Drinking Water

Calculated using the total lots (parcels) for each failure area polygon determined in B.) Average Lot size (above) and the total number of water customer in the same polygon provided by JEA. The result of the total JEA customers minus the number of lots is divided by total lots to give a simple percentage of individuals not connected to City Water in each polygon. A comparison to Table 1(D) will yield the points awarded by percentage.

F. Sanitary Conditions

No calculations required. The City of Jacksonville's Air and Water Quality Division provides data calculation results based upon the geometric mean of ambient water sampling locations throughout Duval County for the given year.
The results are directly transferred to the appropriate score on the ranking form.

G. Proximity to the St. Johns River

Based upon the physical relationship of a conveyance (i.e. ditch creek or waterway) and the physical boundaries of the Failure Area. There are four categories described in Table 1 (G): on the river or tributary; drainage ditch within frequently flooded area and connects to a river or tributary; areas with isolated depressions; and not associated a surface water body. It may be possible to evaluate the conveyance using Arc View only, however if the conveyance is not a creek or tributary, field verification is required to determine if the conveyance is to be considered a surface water body.

H. Potential for Flooding

No calculations required. The City of Jacksonville's Streets and Drainage Division performs a review of Flooding within the specified areas and returns a designated score and the results are directly transferred to the appropriate score on the ranking form.