

D.3.6 FUNCTIONAL GROUP 34 – ESTERO CREEKS AND HEADWATERS FLOW-WAYS

D.3.6.1 Pre-Development Environmental Conditions

Functional Group 34 (FG 34) is located in Lee County and is bordered to the north by the Caloosahatchee River, to the west by the San Carlos and Estero Bays, to the south by the Lee County line, and extends inland east of I-75 (*Figure D-2*). Historically, the Estero Bay watershed encompassed more than 75,000 acres of wetlands that drained into Estero Bay. The vegetative communities were dominated by mangrove swamp and tidal marsh along the coast, and mesic, xeric, and hydric flatwood habitats inland with areas of cypress marsh and wet prairie scattered throughout. The sediment remains primarily comprised of muck and sand. Shallow overland water flows occurred for much of the wet season and into the dry season in the deeper strands and sloughs in the more inland portions of the area. Numerous tidal creeks extended inland maintaining a prolonged hydrated period over much of the coastal area.

D.3.6.2 Environmental Concerns

This functional group area has been heavily urbanized due to its desirable location on the coast. Urban development now accounts for over a quarter of the Estero Bay watershed. Over the past five years this portion of the Florida Gulf coast has been one of the most rapidly expanding areas of human population growth in the nation. The area is characterized by residential and commercial expansion interspersed with preservation areas and agriculture. As of 2007, 28 percent (~20,000 acres) of wetlands in the watershed had been lost. While there are remnants of the original wetland communities in the inland portions of the area, drainage is so severe that the wetlands are virtually non-functional and many have converted to unnatural upland communities susceptible to invasion by exotics. The extensive development has led to channelization of flows from inland to the coast; reduced residency time for inland waters; loss of wetland, riparian, and dune habitat, increased impervious surfaces; decreased water quality, reduced sheetflow; and habitat fragmentation. Remaining natural areas are being degraded by invasion of exotics, recreation overuse, suppression of natural fire regime, ditching & draining, habitat fragmentation, shoreline hardening (loss of mangroves, intertidal zones), erosion, poor water quality, altered hydrology, over-fishing, and mining.

The major surface water features in the functional group are Hendry Creek, Mullock Creek, Ten Mile Canal, Six Mile Cypress Slough, the Estero River, Spring Creek, Imperial River, and Green Meadows Creek. Of these, Hendry Creek, Mullock Creek, Spring Creek, the Estero River, and the Imperial

River are all tidally influenced to some degree, and flow directly into the coastal estuaries within the bounds of the Estero Bay Aquatic and State Buffer Preserves. All of these tidal creeks now exhibit altered hydrology due to development.

Mullock Creek historically carried very little water and drained only a small localized watershed. Today however, waters from as far west as the Orange River basin are channeled into Six Mile Cypress and Ten Mile Canal and shunted to the coast by way of Mullock Creek. The mouth of the creek empties into Estero Bay where excess flows cause damage to managed natural habitat. Land use surrounding Six Mile Cypress Slough ranges from extensive agriculture at the headwaters to high density residential at its intersection with Ten Mile canal. As a result the drainage into these waterways is comprised primarily of agricultural and residential run-off resulting in poor water quality. This nutrient and pollutant laden water flows to the coast by way of Mullock Creek in unnatural pulses, sending excess fresh water to the estuary in the wet season and too little water in the dry season. Not only does this lower the inland water table as a result of over drainage, but it also alters the natural salinity regime of the tidal creeks and coastal estuaries. Excess fresh water in the wet season results in the migration of the estuary off shore, damaging existing sessile estuarine communities such as seagrass and oyster beds that provide critical habitat to fish and macroinvertebrates. Too little flow in the dry season results in an abrupt inland migration of the estuary, damaging freshwater seagrasses and other species intolerant to salt, and posing the threat of salt water intrusion into urban well fields.

Similar to Mullock Creek, the Imperial River now carries significantly more flows than it did prior to development. The drainage basin of the river has been substantially extended due to artificial connections to the Kehl Canal and Green Meadows Creek which drain portions of the Corkscrew watershed. The River regularly flushes the estuary with unnatural pulses of fresh water in the wet season. Inland areas have been significantly drained and developed, and much of the River bed now runs through high urban density development and golf courses which poses the threat of water quality degradation.

The hydrology of Spring Creek has also been significantly altered due to surrounding development. The creek was historically spring fed, but the spring has since been capped and the headwaters now drain into Halfway Creek and Imperial River. As a result the creek now exhibits an unnatural tidal signature. The existing creek bed flows through high density residential areas draining urban and golf course run-off. The creek's remaining riparian and wetland buffers are minimal and degraded.

The Estero River basin is relatively healthy and currently carries flows similar to pre-development. However, the headwaters abut major agricultural and mining operations east of US41 which contribute to some water quality degradation down stream and in the Estero Bay estuary.

Major issues compounding water quality degradation in this basin in addition to significant loss of wetlands are increasing impervious surfaces, canals, water control structures, drainage ditches, berms, and roads that increase wet season flows to the estuary, decrease dry season base-flows resulting from canal draw-down, mining and consumptive use impacts, decreased riparian buffer and decreased nutrient uptake. South Florida is a very low nutrient environment and increases in phosphorus and nitrogen from fertilizers and septic systems can drastically change the species composition and structure of downstream wetland plant and animal communities as well as the ecological processes operating in these systems.

There is significant use of the Shallow, Intermediate and Floridan Aquifer Systems for multiple uses in this watershed. Drawdown impact, saltwater intrusion, and well field interactions are a possibility. There is also still prevalent use of septic systems in this FG despite the density of development, shallow water table, and proximity to the coast. Septic leakage has led to groundwater contamination and nitrification.

Exotic vegetation is widespread on this severely drained developing residential landscape. Some of these exotics are intentionally cultivated, including a variety of fruits and vegetables, as well as landscaping plants and lawn grasses. Most of these species are not considered to be invasive in natural landscapes, although some, such as the grasses, can be very difficult to eradicate when one is trying to restore these sites to natural communities. Other exotic plant species come in on their own, particularly on disturbed or drained landscapes where they can often out-compete native species when becoming established on newly cleared land surfaces. Some of these latter exotic species are extremely invasive and different mixes of them can quickly dominate large areas, if no efforts are made to control them.

D.3.6.3 Environmental Solutions

Most of the components in this FG are small parcels of relatively intact natural areas in the coastal region and large parcels of agricultural or mining property inland east of US41 (*Figure D-12*). The greatest threat to many of these components is conversion to residential development over the long term. The goals of restoration in this area are as follows; to restore flow-ways and provide water storage on the larger inland portions of the FG, to rehabilitate and preserve the smaller natural areas interspersed amongst the

coastal development, to re-establish more natural flows to the coast, and to connect remaining natural areas with the extensive public and private conservation lands in the area where ever possible. The watershed contains a significant portion of public and private conservation lands including the Estero Bay Aquatic and State Buffer Preserves, Corkscrew Swamp Sanctuary, Corkscrew Regional Ecosystem Watershed, Six-Mile Cypress, and Corkscrew Regional Mitigation Bank. In addition, the Lakes Park Restoration CERP Project is located within this basin and is expected to address the restoration of Lakes Park in the headwaters area of Hendry Creek.

Flow-way recreation is proposed for several areas within this FG. These restoration projects would involve the removal of exotic vegetation, berms, and ditches, partial backfill of canals, improved conveyance under roadways and crossings, and the installation of step down weirs on a 1ft contour interval along existing creeks and canals. The study suggests weir installation along portions of Hendry Creek, Spring Creek, Briarcliff Canal, Imperial River, and on the Alico Mine property north of the Alico Rd. Canal. Flow-way restoration would allow for increased groundwater recharge, increased landscape connectivity, improved water quality, and improved wetland habitat.

Water flowing through natural flow-ways are affected by conveyance structures at roads, which can impound flows and interfere with natural exchange in the coastal lagoons. Creating larger openings could deal with impoundment affects of existing structures, while placing numerous smaller structures with a large total conveyance capacity across flow-ways could reduce impoundment as well as improve exchange across the affected area. Conveyance improvements are proposed for the Agripartners Property, along Spring Creek roads and crossing, on Hendry Creek under Gladiolus Dr., at the headwaters of Six Mile Cypress, in the Green Meadows agricultural area, and on the Cypress Arm Canal off of Six Mile Cypress under I-75.

Existing wetland, riparian, and estuarine habitat could benefit greatly from the reduction of excess wet season flows to the coast. This could be accomplished through the construction of several inland above ground water storage reservoirs that could be operated to capture excess flows in the wet season for slow release in the dry season. Peak flows in the existing waterways would be reduced and the hydroperiod extended to more closely mimic pre-development conditions. The study proposes reservoirs at the following locations; at the intersection of Six Mile Cypress and Ten Mile Canal, on Alico Rd. Canal, on Eagle Ridge Canal, at the headwaters of Six Mile Cypress, and on Alico Mine Property west of Alico Rd. Canal, although the exact number, size, and location of the reservoirs would have to be decided by hydrologic modeling.

Initial Rough Order of Magnitude (ROM) model output from the STELLA hydrologic model for this functional group showed that with all study suggested wetland restoration and above ground water storage reservoirs in place and operating, the hydroperiod for Estero River virtually mimics pre-development conditions, peak flows in 10 Mile Canal and Mullock Creek were significantly reduced, and the waterways exhibited improved hydroperiods.

Nutrient outflows from urban lands would be reduced to varying degrees depending on what mix of management measures were implemented. Any of the management measures that increased water storage would improve water quality in downstream receiving waters. Managed Aquatic Plant Systems are recommended along Mullock Creek, Spring Creek, and Ten Mile Canal to provide water quality improvement for water being sent downstream into the coast. In addition, conversion of septic systems to centralized sewer and the installation of storm water retrofits are recommended for water quality improvement in San Carlos Park and Estates.

Any lands that are to be restored to their natural pre-development condition would likely require a significant effort to bring nuisance exotic and native vegetation under control. In some cases this would be largely accomplished by any earth-moving activity involved in restoring a more natural topography. In other cases, it would require scouting the area to locate nuisance exotic and native vegetation and treating it with herbicides as often as is necessary to eliminate each population on the site. Nuisance vegetation control would be required for a number of years on any disturbed construction footprint. Nuisance exotic and native vegetation can easily dominate newly created bare soil surfaces. Controlling these species until natural vegetation has an opportunity to colonize and dominate these sites would greatly reduce the scale of future nuisance vegetation control efforts.

D.3.6.4 Original Components and Associated Management Measures in Functional Group 34 (Table D-9)

1. Conservation easements or acquisition would avoid the possibility of the eventual loss of lands in FG 34 to residential development. Restoration of developed lands to their pre-development habitats could help to eliminate nutrients problems. (1, 2, 3, 6, 7, 10, 11, 16, 22, 24, 25, 26, 27, 29, 30, 31, 36, 90, SLL02)
2. Reduce impediments to sheetflow through conveyance structures (1, 2, 11, 90, 236, SLL02)
3. Provide improved habitat through the creation of littoral zones in borrow pits (1, 7)
4. Backfill canals to restore sheetflow (7)

5. Reduce impediments to sheetflow by eliminating mosquito ditches (32, 33, 34, 39)
6. Eliminate exotic vegetation (1, 7, 9, 10, 11, 14, 16, 22, 24, 25, 30, 31, 32, 33, 34, 38, 39, 90)
7. Improve downstream hydrologic regimes by constructing weirs at 1 ft contour intervals in canals (8, 10, 11, 22, 38)
8. Remove portions or all of spoil berms in wetlands next to dredged channels (11, 34)
9. Improve the quality of water in inland canals and flow-ways through the construction of filter marshes (5, 8, 10/W1, 14/W21, 36)
10. Reduce impediments to sheetflow by regrading vehicle trails (34)
11. Construct Managed Aquatic Plant Systems to improve quality of water flowing through canals and coastal lagoon tributaries (W156/16, W15/38, W185)
12. Improve groundwater and surface water quality through conversion of septic to central sewer systems and construction of a storm water retrofit (9, W19, W25)
13. Construct above-ground reservoirs to reduce point discharges to coastal waters (SW24, SW26, SW27, SW28, SW29)

D.3.6.5 Components and Associated Management Measures in UMAP

FG 34 was not included in the UMAP.

TABLE D-9: FUNCTIONAL GROUP 34 - ESTERO CREEKS AND HEADWATERS FLOW-WAYS DETAILED COMPONENT DESCRIPTIONS

Functional Group 34-Estero Creeks and Headwaters Flow-ways			
<u>BAT ID Number</u>	<u>Component Title</u>	<u>Component Justification</u>	<u>Component Description</u>
1	Agripartners Properties	Dan Arnoff is the current owner. The agripartners property alternative name is Arnoff. This property is headwaters for halfway Creek, habitat for Florida panther, woodstork, Eastern indigo snake (confirmed), Florida black bear, Big Cypress fox squirrel, and other listed wading birds.	This is a 6-square mile property, east of I-75, opposite the Brooks. This includes Section 5, 6, 7, 8 of T47 R26 and Sections 1 and 12 of T47 R25. The purpose of this component is to preserve through acquisition and restore the site through exotic removal, and removal of hydrologic alterations, including unculverted power line road and enhancement of three borrow pits paralleling I-75.
2	Halfway Creek Flow-ways	The area suffers from inadequate flows in Estero and Halfway Creeks that flow into Estero Bay.	This is a privately owned area in Sections 2, 3, 4, 9, 10, 11 of T47 R25, totaling approximately 1000 acres. This includes existing conservation areas in the Brooks and adding buffer property through acquisition. This component will re-establish north and south branch of Halfway Creek and the south branch of Estero River. Fix: Construct / replace connections at across I-75, US 41, and RR grade.
3	Spring Creek Hydrologic Improvement	The component connects Spring Creek with its headwaters. It is just north of Imperial Harbor and Highlands Woods. The break was caused by Seaboard Coastline Railroad construction.	The component is located in section 27 of T46 R25 and includes acquisition, hydrologic restoration, wetland restoration, and invasive exotic vegetation control.

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<u>BAT ID Number</u>	<u>Component Title</u>	<u>Component Justification</u>	<u>Component Description</u>
5	North side of Section 25 in 4725	The surrounding area is impaired for nutrients. This site is predominately agricultural fields with a large pond, and is strategically located for a water quality component.	The component is located in section 25 of 4725 and includes construction of a filter marsh.
6	Bonita Springs Utilities	The site is a flow-way connection to Spring Creek that has water quality issues and is located in Section 24 in T47 R25. There is potential for a water quality improvement with a filter marsh. The location for the marsh may be in the southeast corner of the property. The northeast corner is suggested for hydrologic and habitat benefits.	The component would involve acquisition, hydrologic restoration, habitat preservation, a potential filter marsh, and invasive exotic removal.
7	Benson Property	This property includes I-75 borrow pit. Restoration would re-establish the flow-way connection and be based on original watershed locations.	The component is located in Section 13 4725 and includes acquisition, hydrologic restoration, habitat preservation, and invasive exotic removal.
8	Leitner Creek Connector	A canal runs north to south connects to the original Leitner Creek, which runs east to west, connecting to Imperial River. This is restoration and improvement of the historic Leitner Creek property. It starts off as an agricultural canal, and then goes through residential property.	This component is located in section 25 of 4725 and includes acquisition, hydrologic restoration, creek bank restoration, marsh system expansion, and invasive exotic vegetation control.

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<u>BAT ID Number</u>	<u>Component Title</u>	<u>Component Justification</u>	<u>Component Description</u>
9	Imperial River Corridor Flow-way	The Imperial River system has been impacted by surrounding development.	This component is in Sections 35 and 36 of 4725, approximately 100 acres. The component would involve acquisition and hydrologic restoration of the flow-way, exotic vegetation removal, and re-establishing native plants along the river.
10	Flow-way north of Alico Road (Alico Mine Flow-way) (Tam-Alico)	Mining, agricultural, and other development have impacted the area that contains valuable habitat types including pine flatwoods, cypress, historic flowways, and open marshes.	The component is located in section 2 4625 east of I-75, and section 3, 4, 5, and 6 4625 west of I-75. The component includes spoil berms removal, backfill/plugging ditches, weir removal/refitting, road culverting, filter marsh construction, restoring agricultural areas to original grade, invasive exotic vegetation removal, and smoothing the existing 90 degree bends to improve flow and habitat.
11	Lakes Park/Hendry Creek Connector	The site has a strategic location and is connected to a CERP restoration component (Lakes Park) and is located within the Estero Bay buffer.	This component is located in section 35 of 4524 and includes acquisition, hydrologic restoration, creek bank restoration, marsh system expansion, and invasive exotic vegetation control.
14	Island Park Road/Hendry Creek Filter Marsh	The area has been listed as impaired for nutrients.	This component is located in section 12 of 4624 and includes hydrologic restoration, filter marsh construction, and invasive exotic vegetation control.

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<u>BAT ID Number</u>	<u>Component Title</u>	<u>Component Justification</u>	<u>Component Description</u>
16	Bluejack Oak Parcel	Habitat and hydroperiod alterations have allowed exotic plant species such as Brazilian Pepper and Melaleuca to invade the proposed component area displacing native species. The site is straddles existing state land and an eagles nest is located adjacent to the site.	The component includes acquisition, hydrologic restoration, habitat preservation, and invasive exotic removal.
22	Freeman	The site contains valuable habitat including cypress and hydric pine flatwoods, and freshwater marsh.	The component is located in section 34 of 4525 and includes hydrologic restoration, habitat restoration, and invasive exotic vegetation removal.
24	Alico Flow-ways West	This site is an important section of the Alico Flow-ways.	The component would involve acquisition, hydrologic restoration, habitat preservation, and invasive exotic removal.
25	Alico Flow-ways East on Ginn Proposal	A proposed development called "Cypress Shadows" is proposed in the southern portion of the Flow way south of Corkscrew Road.	The component would involve acquisition, hydrologic restoration and invasive exotic removal.
26	Airport Expansion Flow-way	This site is located east of the airport. This is a Conservation 2020 acquisition parcel (#90) and is at the head of Alico flow-ways.	The component would include acquisition, hydrologic restoration through ditch removal, and invasive exotic vegetation control.

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<u>BAT ID Number</u>	<u>Component Title</u>	<u>Component Justification</u>	<u>Component Description</u>
27	Florida Rock Industries Flow-way Buffers	This component is located in Sections 25, 26, 27,28,33,34 of 4526. Mining, agricultural, and other development have impacted the area that contains valuable habitat types including pine flatwoods, cypress, historic flowways, and open marshes.	Recommended restoration includes road and spoil berm removal, ditch filling, weir removal/refitting, restoring agricultural areas to original grade, and invasive exotic vegetation removal.
29	Airport Mitigation Connector	The site lies within sections 31, 32 of T45 R27 and would help maintain an east-west connection between the Woodstork flow-ways and the Airport Expansion Flow-ways. The component would establish a landscape connection between airport mitigation sites in 5, 6, 7, 8, 17, 18, 29, 30 of 46 27. The habitat is a combination of cypress, pine, and natural karstic ponds, and agricultural fields.	The component would involve hydrologic restoration and invasive exotic removal and has high value as a landscape connector as it would establish a landscape connection between airport mitigation sites in 5, 6, 7, 8, 17, 18, 29, 30 of 46 27.
30	Stairstep Connection	The component would connect the FCGU mitigation area and Airport mitigation, and Lee County Wellfield. It protects the flow way from the airport mitigation area which heads to the wellfield.	The component is located in section 11 of 4626 and includes acquisition, hydrologic restoration, wetland restoration, and invasive exotic vegetation control.

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<u>BAT ID Number</u>	<u>Component Title</u>	<u>Component Justification</u>	<u>Component Description</u>
31	Six-mile Cypress Connection under SR 82	Inadequate culverting under SR 82 disrupts the natural flow to the northern 6-mile Cypress watershed.	The component includes acquisition, hydrologic restoration through improved culverting, wetland restoration, and invasive exotic vegetation control.
32	East Estero Bay Buffer	This is part of the Estero Bay buffer preserve, adjacent to extensive development. It is the buffer between the bay water quality and residential development run-off. These mangroves are providing a substantial property value benefit to the developments. This is the view they show in advertising.	This is exotic removal, mosquito control ditch removal, spoil removal, and restoration of high marsh, mangrove, and associated estuarine communities. The land is already acquired by State of Florida. The site is approximately 8 square miles.
33	Mullock Creek Preserve	This area has been recently acquired by the State of Florida. It is a buffer on Mullock Creek, near the juncture with 10-mile canal.	This component includes exotic removal and mosquito control ditch restoration. The approximate acreage is 250.
34	North Estero Bay Buffer	This is land acquired in 1989 through 2003 by the State of Florida, along Matanzas Pass, Hellpeckish Bay, and northern Estero Bay up Hendry Creek to Lakes Park. It is the largest area of high marsh south of Charlotte Harbor proper.	The component includes exotic removal, trash and hazardous waste cleanup, ditch restoration, and vehicle trail damage restoration. It will restore high marsh hydrology.

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<u>BAT ID Number</u>	<u>Component Title</u>	<u>Component Justification</u>	<u>Component Description</u>
36	Estero River North	This component was identified in the first AMB review. It is adjacent to San Carlos Park and could be a regional stormwater treatment area (RSTA).	This is a hydrologic and habitat restoration with a potential water quality component such as a filter marsh. The southern portion includes riparian scrub habitat opposite Koreshan State Park, along the north bank of the Estero River.
38	Spring Creek Flow-way	This includes both private area above mean high water and public areas below mean high water, including all branches of Spring Creek including the central slough at the Bonita Bay development. Problem: Nutrient Pollution	This includes exotic removals, oyster bar restoration, and hydrologic improvements by ditch changes and potentially water control structure changes. It is approximately 3 square miles. The component includes an educational canoe trail, possibly named "Crocodile Trail." Fix: Algal Turf Scrubber (ATS)
39	Imperial River Preserve	This was acquired by Lee County in legal settlement.	The component includes exotic removal, berm removal, and ditch restoration. The component is approximately 40 acres.
90	Six-Mile Cypress Headwaters West	The historical hydrological connection has been blocked by the construction SR 82. Hydrological impacts have encouraged the invasion of exotic vegetation.	The component would involve some acquisition, exotic plant removal, and construction of additional culverts under SR 82 to restore hydrologic connection to cypress domes within the area known as Six Mile Omni.

Functional Group 34-Estero Creeks and Headwaters Flow-ways			
<u>BAT ID Number</u>	<u>Component Title</u>	<u>Component Justification</u>	<u>Component Description</u>
236	Addition to Six-Mile Cypress Slough	The historical hydrological connection has been blocked by the construction I-75. Hydrological impacts have encouraged the invasion of exotic vegetation. This was a Conservation 2020 site (#216).	The component would involve hydrologic restoration and invasive exotic removal.
SLL02	Green Meadows	The site contains valuable wildlife habitat including cypress and hydric pine flatwoods, and freshwater marsh. The hydrology of the area has been severely impacted by surrounding development.	This component contains valuable habitats including pine flatwoods, cypress, and open marshes. Recommended restoration includes road and spoil berm removal, ditch filling, restoring agricultural areas to original grade, and invasive exotic vegetation removal.
SW24	Six-mile Cypress Upper Storage Reservoir	The hydrology of the area is heavily impacted by canal drainage.	This component is designed to capture wet season canal flows for release during the dry season.
SW26	Six-mile Cypress Lower Storage Reservoir	The hydrology of the area is heavily impacted by canal drainage.	This component is designed to capture wet season canal flows for release during the dry season.
SW27	Freeman Storage Reservoir	The hydrology of the area is heavily impacted by canal drainage.	This component is designed to capture wet season canal flows for release during the dry season.
SW28	Alico Road Storage Reservoir	Canal drainage has altered the natural hydrology of the area.	This component is designed to capture wet season canal flows for release during the dry season.

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<u>BAT ID Number</u>	<u>Component Title</u>	<u>Component Justification</u>	<u>Component Description</u>
SW29	Alico Flow-ways West Storage Reservoir	The hydrology of the area is heavily impacted by canal drainage.	This component is designed to capture wet season canal flows for release during the dry season.
W15	Alico Road MAPS	The area has been listed as impaired for nutrients.	The component entails the construction of an Algal Turf Scrubber (ATS).
W185	Ten Mile Canal MAPS	The area has been listed as impaired for nutrients.	The component entails the construction of an Algal Turf Scrubber (ATS).
W19	San Carlos Estates Centralized Wastewater	The area has been listed as impaired for nutrients.	This component involves the conversion of septic/package plants in sub-basin to centralized sewer in San Carlos Estates.
W25	San Carlos Park Centralized Wastewater	The area has been listed as impaired for nutrients.	The component involves conversion of septic/package plants in the sub-basin of San Carlos Park to centralized sewer.

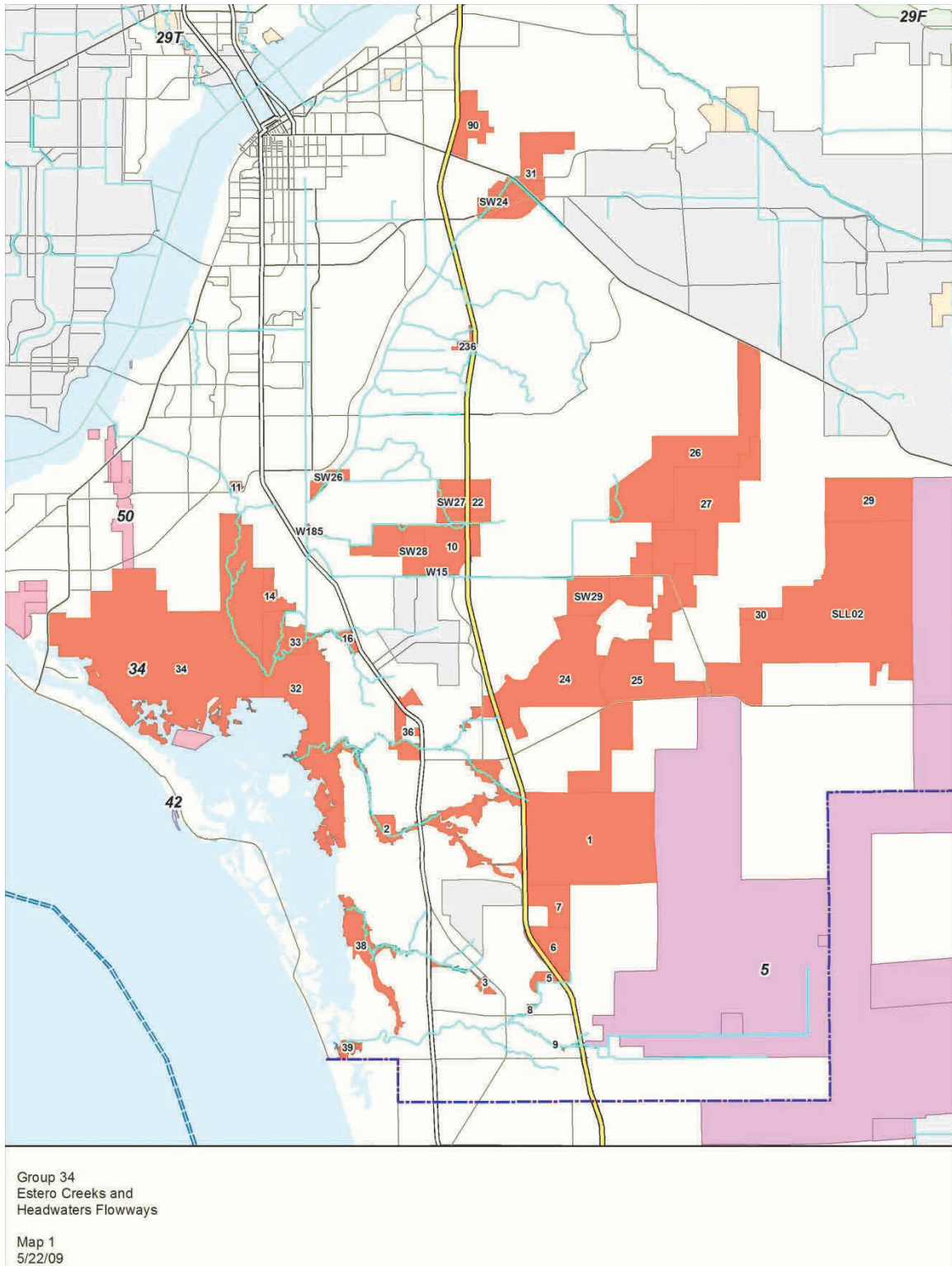


FIGURE D-12: FUNCTIONAL GROUP 34 ESTERO CREEKS AND HEADWATERS FLOW-WAYS COMPONENT BOUNDARIES