Appendix A
North Merritt Island HydroDEM Update Memo
prepared by Atkins, September 2020

ATKINS
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Memo

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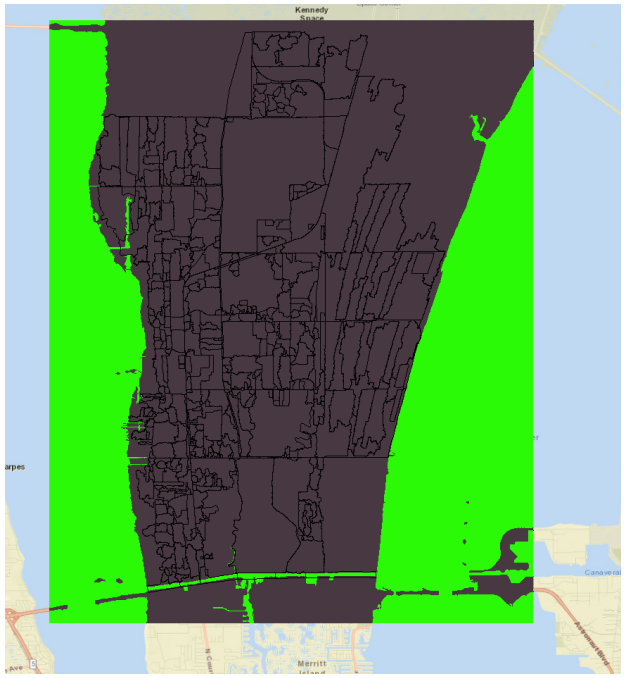
From:	Joe Walter, PE	Email:	joe.walter@atkinsglobal.com
Date:	28 September 2020	Phone:	407-806-4486
Ref:	Atkins Project 100071502	cc:	Chris Thompson, PE File
Subject:	**Draft North Merritt Island HydroDEM update**		

The purpose of this memo is to summarize the steps taken to develop the Hydro DEM. This DEM represents bathymetric updates for channels; natural inland submerged depressional areas; and Indian River Lagoon, Banana River and Canaveral Barge Canal area within the project domain. The purpose of the hydro corrections is to enable a connection between groundwater and surface waters within the 2D model domain and to cut irregular cross sections for channel segments in the 1D model domain.

Data Used

- Channel inverts and dimensions from ICPRv3 model updated by DRMP (*NMI_BREVARD_w_NASA.ICP)*
- NOAA navigational charts
- SWAMP database
- Morgan & Eklund Channel Cross Section Survey August 13, 2020
- 2007 DEM
- 2019 Aerials – to delineate extent of update

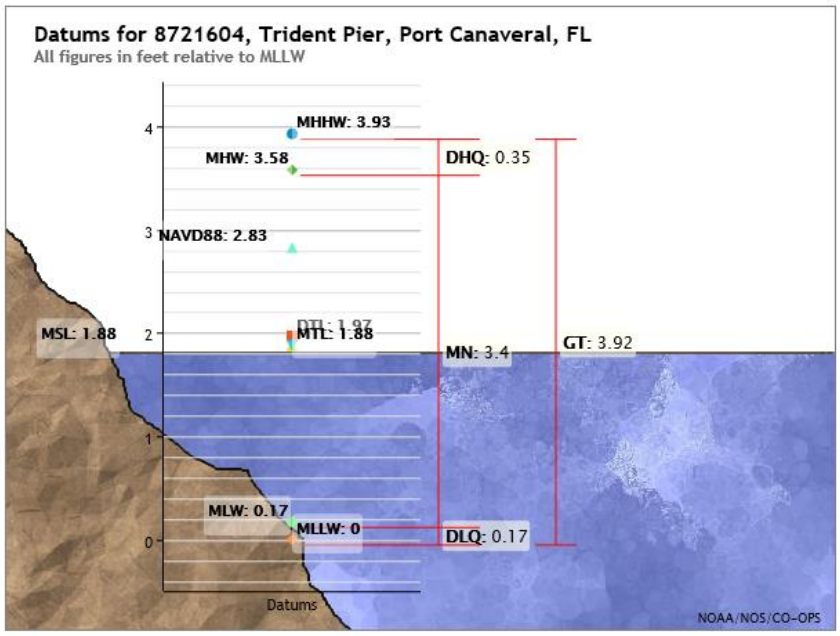
HydroDEM update process

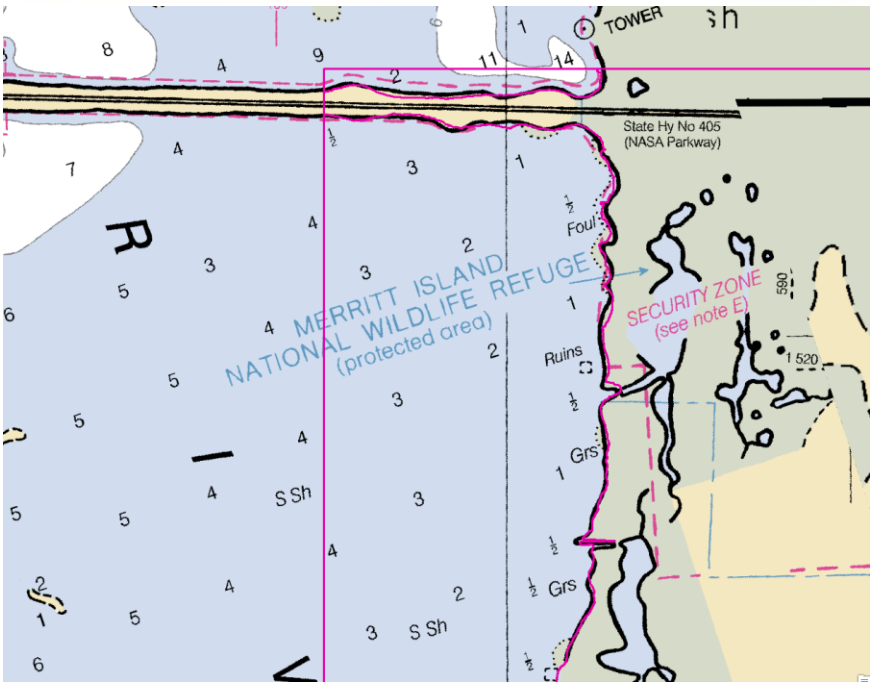
1. Identify the Extent of the DEM update
    - Indian River Lagoon, Banana River, and Canaveral Barge Canal portions of the DEM, this extent represented the area in green in the figure below, which include portions of the 2007 DEM identified as NULL.
        - 
    - For interior portions of the DEM, the update extent included modeled channels and naturally ponded areas identified from the DEM. Update extent is shown in pink in the image below.

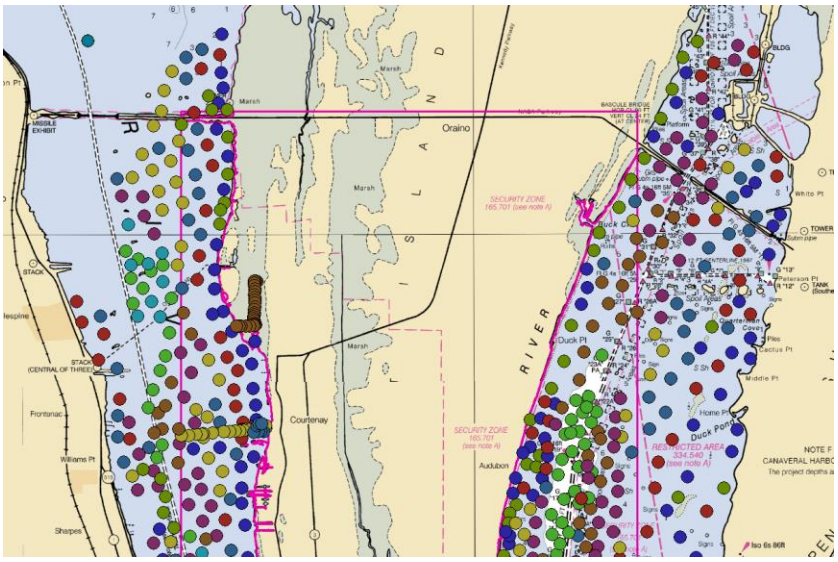
2. Generate a 3D line at the boundary to tie the updated area into the existing topography.
    - The figure below shows the extent of the 3D line extracting elevations from the existing DEM. A similar data was generated for the interior area.

3. Develop 3D data points and breaklines to update the interior of the update extents
    - Indian River Lagoon and Banana River extent used data extracted from NOAA navigational charts and aerial imagery. NOAA navigational charts provided depths for boaters referenced to Mean-Lower-Low Water (MLLW). For the project area, using the Trident Pier as the closest reference elevation the MLLW was converted to NAVD88 using a -2.83 conversion factor. Depth points were digitized, MLLW depths recorded,

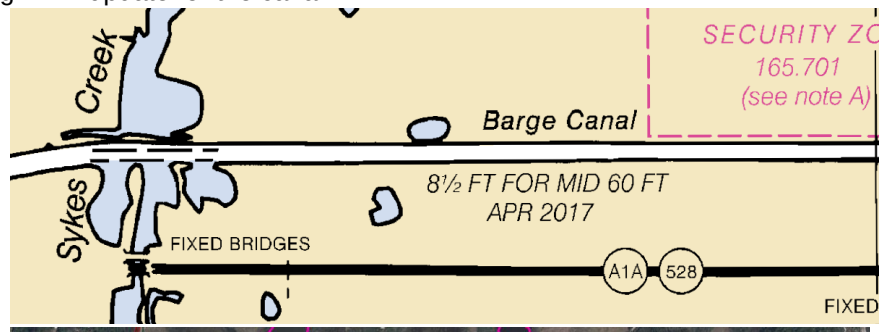
and adjusted. The images below show Datums at Trident Pier, NOAA navigational chart depths, and a represented section of the digitized depths.

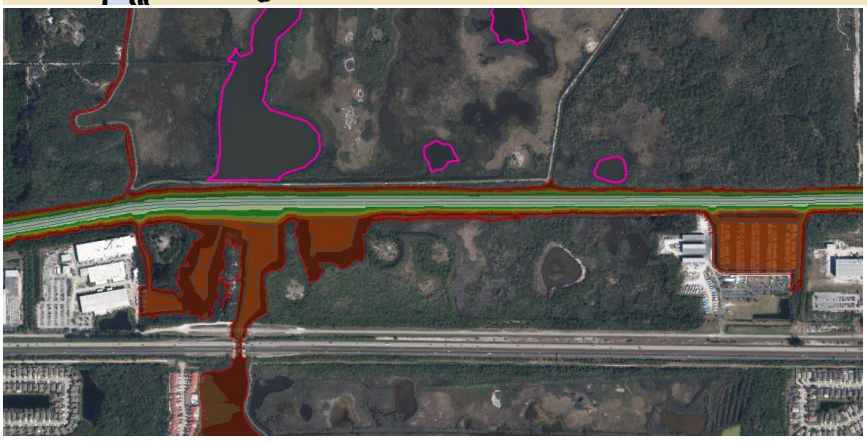
- 

- 



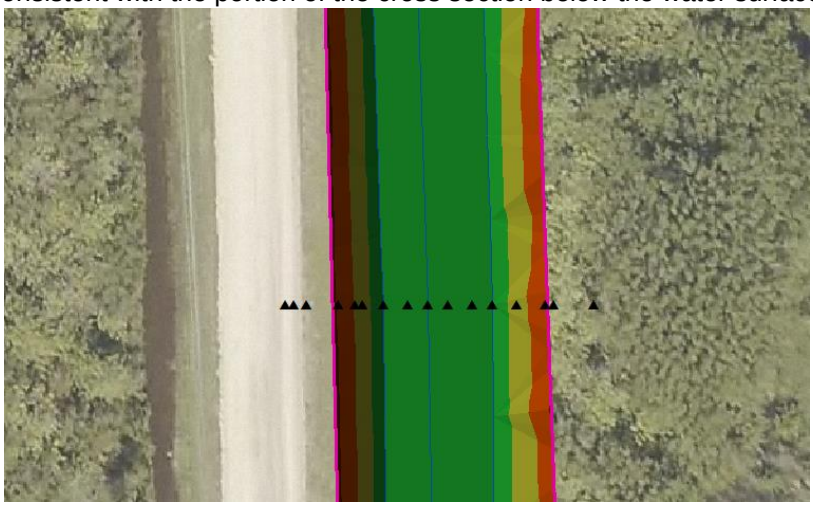
- Canaveral Barge Canal update used a reference on the NOAA navigational chart to establish both a width and depth for the center of the canal. This depth was adjusted to NAVD88. The images below include an excerpt from the NOAA navigational chart and resulting DEM update for the canal.



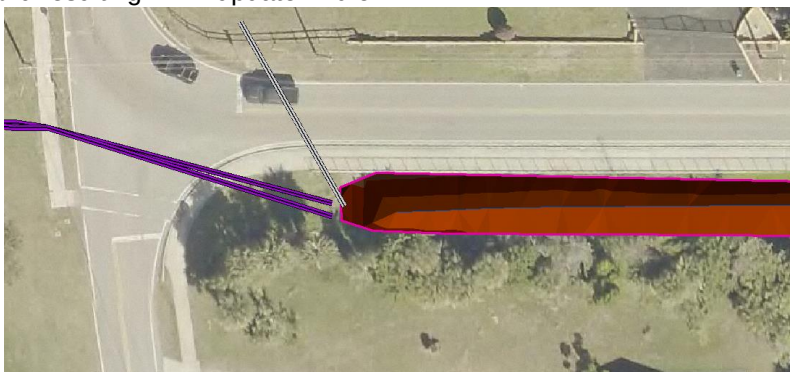


- Interior DEM channel updates were based upon channel invert elevations and geometry. This data was supplemented with Morgan & Eklund cross section survey and invert data from the SWAMP database, in areas that included survey without existing modeled channel.
  - The majority of the channel segments in the model were simulated as trapezoidal. For these segments, the bottom width specified in the model was digitized and sloped based upon channel inverts and surveyed segments. The

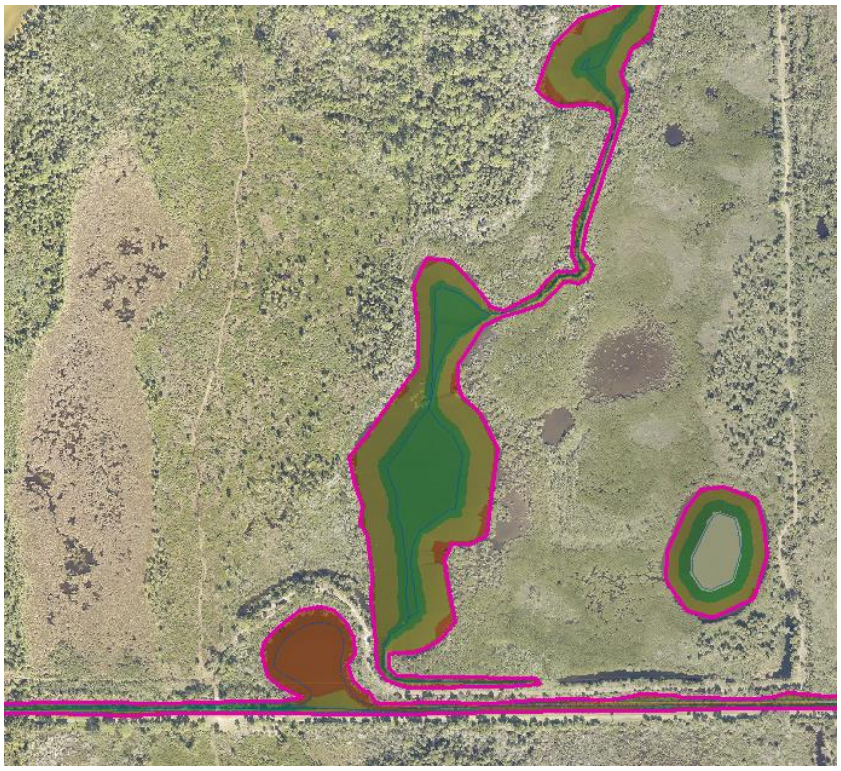
image below shows the digitized lines (blue lines) , the cross section survey (black triangles), and resulting terrain update piece. For channels that used irregular cross sections, the cross section data was evaluated and breaklines drawn consistent with the portion of the cross section below the water surface.



- In portions of the DEM update extent with only cross sectional survey, the survey was supplemented with invert data from the SWAMP database. The only area this was relevant was the segment of Hall Road west of Courtenay Parkway. It is of note that the SWAMP culvert inverts were consistent with the Morgan & Eklund survey. The image below shows the SWAMP culvert lines in purple and resulting DEM update in brown.



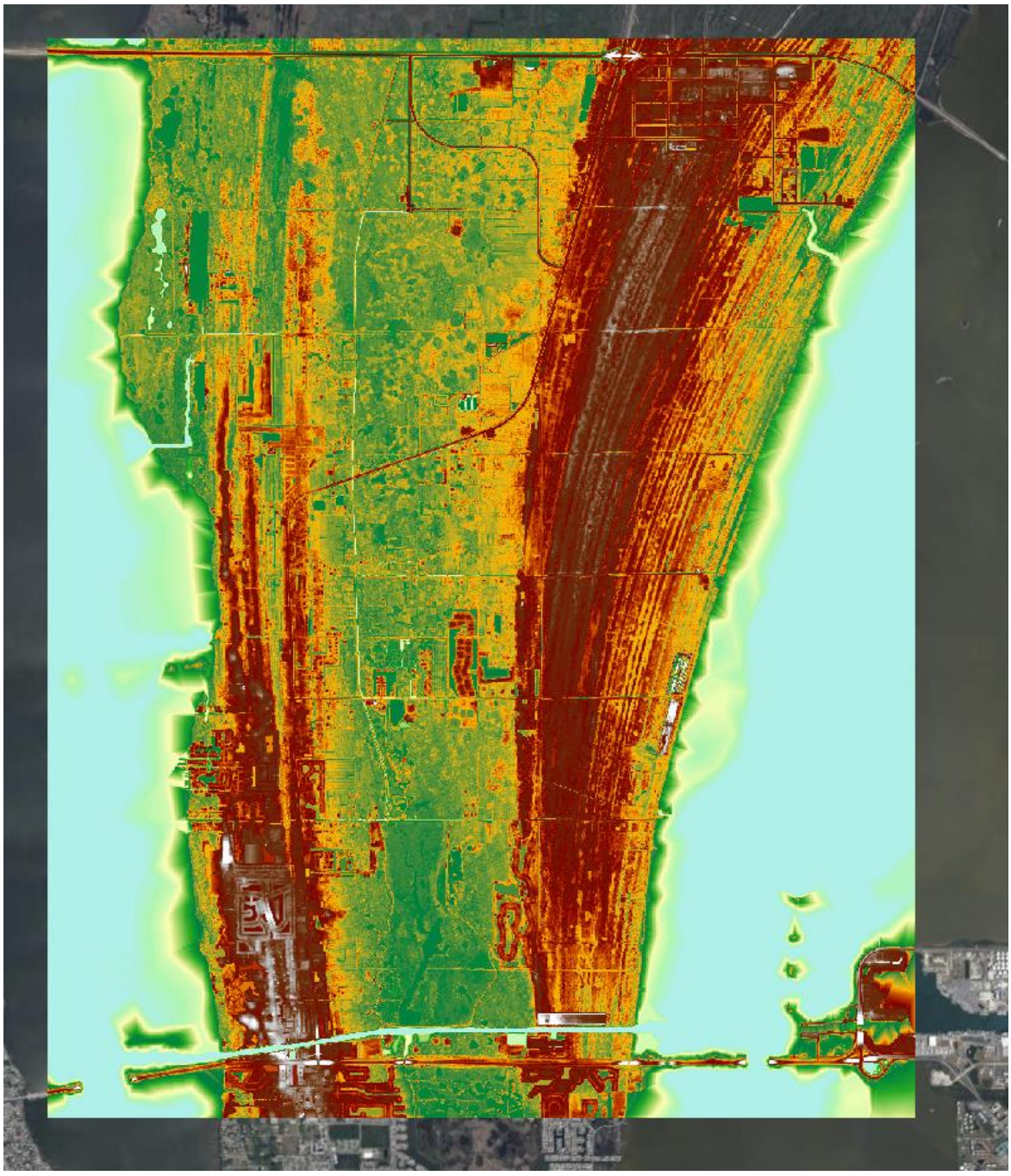
- Interior DEM ponding areas updated based upon the DEM extent of open water and aerial imagery to estimate the extent and depth of water. For the majority of areas a depth of -3.0 feet NAVD88 was used to approximate the open water portion. This depth is consistent with canals and provides sufficient connection for the groundwater model to interact with the surface water model. The interconnected lakes west of the Pine Island Stormwater Facility a depth of -5.0 feet was used based upon channel inverts in the model imagery. The resulting depth DEM was then used to “push down” the DEM an elevation of zero at the edge down to the approximated depths in the middle. The figure below shows a portion of the DEM update extent and resulting update.



4. Generate a DEM update piece and integrate the updated portion into the DEM.
    - Generation of an updated DEM piece includes generating a TIN from update pieces noted above then converting the TIN to a raster with the same raster cell size. The image below shows the TIN creation features and the corresponding height source for each element.

Input Features	Height Field	Type
NOAA_nauticalDepths	ElevNAVD88	Mass_Points
CanalLines2D	ElevNAVD88	Hard_Line
TieInLine3D	SHAPE.Z	Hard_Line
UpdateExtent	<None>	Soft_Clip

    - The updated DEM piece is then Mosaiced back into the original DEM to create the hydrocorrected DEM for areas outside of ERPs. The resulting DEM is shown in the image below.
    - It was noted that some areas, particularly in the NASA updated area on the East side of the watershed, the elevations resulting methodology specified above revealed isolated areas where the existing DEM was lower then the draft version of the hydrocorrected DEM, due to a dip in a shallow swale between the upstream and downstream ends of the modeled channel. In these cases the lower of the draft hydrocorrected DEM and the original DEM was used as the final hydrocorrected DEM.



Appendix B
ICPR4 Lookup and Reference Tables

Table B.1: Impervious Data Set

Land Use	% Impervious	% DCIA
1100: Residential, Low Density-Less than two dwelling units/acre	30%	15%
1180: Residential, Rural < or = 0.5 dwelling units/acre	12%	0%
1190: Low Density Under Construction	38%	20%
1200: Residential, Medium Density-Two-five dwelling units per acre	50%	30%
1300: Residential, High Density	65%	45%
1390: High Density Under Construction	72%	55%
1400: Commercial and Services	85%	70%
1480: Cemeteries	10%	0%
1550: Other Light Industrial	72%	55%
1560: Other Heavy Industrial	72%	55%
1700: Institutional (Educational, religious, health and military facilities)	65%	45%
1750: Governmental	65%	45%
1800: Recreational	2%	0%
1820: Golf Course	10%	0%
1840: Marinas and Fish Camps	25%	10%
1850: Parks and Zoos	10%	0%
1860: Community Recreational Facilities	10%	0%
1890: Other Recreational (Riding stables, go-cart tracks, skeet ranges, etc.)	10%	0%
1900: Open Land	2%	0%
2110: Improved Pasture	2%	0%
2130: Woodland Pasture	2%	0%
2200: Tree Crops	5%	0%
2210: Citrus groves	5%	0%
2240: Abandoned tree crops	5%	0%
2410: Tree nurseries	5%	0%
2430: Ornamentals	2%	0%
2510: Horse Farms	5%	0%
3100: Herbaceous Dry Prairie	0%	0%
3200: Shrub and Brushland	0%	0%
3300: Mixed Rangeland	0%	0%
4110: Pine flatwoods	0%	0%
4200: Upland Hardwood Forest	0%	0%
4210: Xeric oak	0%	0%
4280: Cabbage palm	0%	0%
4340: Hardwood Conifer Mixed	0%	0%
4370: Australian pine	0%	0%
5100: Streams and waterways	0%	0%
5200: Lakes	0%	0%
5201: Pond	0%	0%
5300: Reservoirs	0%	0%
5400: Bays and estuaries	0%	0%
5430: Enclosed saltwater ponds within a salt marsh	0%	0%

Land Use	% Impervious	% DCIA
6110: Bay swamps	0%	0%
6120: Mangrove swamp	0%	0%
6170: Mixed wetland hardwoods	0%	0%
6181: Cabbage palm hammock	0%	0%
6182: Cabbage palm savannah	0%	0%
6210: Cypress	0%	0%
6250: Hydric pine flatwoods	0%	0%
6300: Wetland Forested Mixed	0%	0%
6410: Freshwater marshes	0%	0%
6420: Saltwater marshes	0%	0%
6430: Wet prairies	0%	0%
6440: Emergent aquatic vegetation	0%	0%
6460: Mixed scrub-shrub wetland	0%	0%
6500: Non-vegetated Wetland	0%	0%
7400: Disturbed land	0%	0%
7430: Spoil areas	0%	0%
8120: Railroads	50%	30%
8140: Roads and Highways	65%	45%
8150: Port facilities	85%	70%
8180: Auto parking facilities - not directly related to other land uses	85%	70%
8200: Communications	0%	0%
8300: Utilities	72%	55%
8310: Electrical power facilities	72%	55%
8320: Electrical power transmission lines	0%	0%
8340: Sewage Treatment	50%	30%
8370: Surface Water Collection Basin	0%	0%

Table B.2: Initial Rainfall Excess parameters for Green-Ampt Infiltration Method (by MuKey)

Soil Zone	Kv Sat	Moisture Content Saturated	Moisture Content Residual	Moisture Content Initial	Moisture Content Field	Moisture Content Wilting	Pour Size Index	Bubble Pressure	Water Table Initial
1473327	70.0	0.389	0.011	0.079	0.079	0.021	0.586	1.641	5.413
1473441	26.0	0.382	0.013	0.081	0.081	0.026	0.595	1.768	0.000
1473288	26.0	0.382	0.013	0.081	0.081	0.026	0.595	1.768	1.509
1473305	9.3	0.416	0.047	0.170	0.170	0.093	0.397	2.549	4.003
1473290	70.0	0.392	0.006	0.044	0.044	0.012	0.588	1.671	6.594
1473299	3.4	0.391	0.043	0.166	0.166	0.086	0.334	2.595	0.000
1473349	26.0	0.397	0.009	0.049	0.049	0.017	0.595	1.613	4.987
1473302	15.1	0.436	0.038	0.149	0.149	0.076	0.363	3.413	0.262
1473356	11.4	0.415	0.045	0.166	0.166	0.090	0.416	2.049	4.003
1473340	21.4	0.384	0.019	0.101	0.101	0.038	0.574	1.715	2.986
1473314	20.4	0.391	0.017	0.090	0.090	0.033	0.578	1.658	4.003
1473341	58.3	0.407	0.016	0.087	0.087	0.031	0.555	1.566	0.000
1473308	8.4	0.438	0.070	0.214	0.214	0.140	0.333	2.567	0.984
1473322	22.2	0.386	0.015	0.085	0.085	0.029	0.581	1.905	2.001
1473338	26.1	0.392	0.008	0.052	0.052	0.015	0.579	1.691	3.510
1473306	16.0	0.416	0.020	0.096	0.096	0.040	0.435	1.379	0.492
3102932	48.1	0.375	0.009	0.071	0.071	0.017	0.603	1.853	4.167
1473292	70.0	0.404	0.013	0.068	0.068	0.026	0.586	1.544	0.000
1473289	26.1	0.430	0.032	0.141	0.141	0.063	0.531	1.400	0.262
1473296	70.0	0.475	0.017	0.089	0.089	0.034	0.567	1.067	3.740
1473324	17.1	0.428	0.015	0.087	0.087	0.029	0.569	1.354	0.000
1473376	26.1	0.430	0.032	0.141	0.141	0.063	0.531	1.400	0.262
1473351	17.7	0.689	0.063	0.358	0.358	0.195	0.273	0.554	0.000
1473344	14.4	0.703	0.018	0.352	0.352	0.183	0.145	1.865	0.000
1473294	13.8	0.436	0.043	0.168	0.168	0.085	0.334	1.496	1.017
1473348	26.1	0.515	0.046	0.267	0.267	0.099	0.527	0.861	0.492
1473310	13.6	0.411	0.030	0.127	0.127	0.060	0.410	1.543	0.000
1473337	26.0	0.374	0.007	0.067	0.067	0.014	0.609	1.864	4.003
1473309	13.6	0.418	0.054	0.182	0.182	0.108	0.406	1.358	0.984
1473293	26.0	0.390	0.015	0.090	0.090	0.029	0.576	1.616	4.003
1473295	70.0	0.475	0.017	0.089	0.089	0.034	0.567	1.067	1.936
1473331	70.0	0.443	0.005	0.027	0.027	0.009	0.575	1.247	6.594
1473329	70.0	0.384	0.005	0.056	0.056	0.009	0.603	1.752	6.594
1473354	17.1	0.428	0.015	0.087	0.087	0.029	0.569	1.354	1.017
1473307	16.0	0.416	0.020	0.096	0.096	0.040	0.435	1.379	0.000
1473346	26.1	0.451	0.018	0.091	0.091	0.035	0.514	1.201	2.264
1473333	13.5	0.398	0.027	0.130	0.130	0.053	0.486	2.324	4.003
1473336	50.9	0.414	0.006	0.046	0.046	0.012	0.586	1.459	2.756
1473332	17.5	0.428	0.031	0.132	0.132	0.062	0.382	1.503	1.017
1473291	70.0	0.392	0.006	0.044	0.044	0.012	0.588	1.671	6.594
1473342	70.0	0.408	0.005	0.057	0.057	0.010	0.589	1.508	6.594
1473325	17.1	0.428	0.015	0.087	0.087	0.029	0.569	1.354	1.017
1473345	26.1	0.449	0.006	0.040	0.040	0.011	0.554	1.213	6.594
1473377	26.0	0.382	0.013	0.081	0.081	0.026	0.595	1.768	0.000

Table B.3: Manning's Roughness Coefficient Data Set

Land Use / Roughness Zone	Shallow Manning's N	Deep Manning's N	Depth Range
1009: Mobile home units any density	0.12	0.06	1.5
1100: Residential, low density - less than 2 dwelling units/acre	0.12	0.06	1.5
1110: Low density residential (.2-2 DU/AC)	0.12	0.06	1.5
1120: Low density residential mobile	0.12	0.06	1.5
1130: Low density residential mixed	0.12	0.06	1.5
1140: Ranchettes fixed (>5 AC/DU)	0.12	0.06	1.5
1150: Ranchettes mobile	0.12	0.06	1.5
1160: Ranchettes mixed	0.12	0.06	1.5
1180: Rural residential	0.12	0.06	1.5
1190: Low density under construction	0.12	0.06	1.5
1200: Residential, medium density - 2-5 dwelling units/acre	0.12	0.06	1.5
1210: Medium density residential (2-5 DU/AC)	0.12	0.06	1.5
1220: Medium density residential mobile	0.12	0.06	1.5
1230: Medium density residential mixed	0.12	0.06	1.5
1280: Medium density residential	0.12	0.06	1.5
1290: Medium density under construction	0.12	0.06	1.5
1300: Residential, high density - 6 or more dwelling units/acre	0.12	0.06	1.5
1310: High density residential (>6 DU/AC)	0.12	0.06	1.5
1320: High density residential mobile	0.12	0.06	1.5
1330: Multiple DU low rise (<= 2 stories)	0.12	0.06	1.5
1340: Multiple DU high rise (>= 3 stories)	0.12	0.06	1.5
1350: High density residential mixed	0.12	0.06	1.5
1390: High density under construction	0.12	0.06	1.5
1400: Commercial and services	0.12	0.06	1.5
1410: Retail sales and services	0.12	0.06	1.5
1411: Shopping center	0.12	0.06	1.5
1420: Wholesale sales and services	0.12	0.06	1.5
1423: Junk yard	0.12	0.06	1.5
1424: Farmers market	0.12	0.06	1.5
1430: Professional services	0.12	0.06	1.5
1440: Cultural and entertainment	0.12	0.06	1.5
1443: Open air theater	0.12	0.06	1.5
1450: Tourist services	0.12	0.06	1.5
1452: Motel	0.12	0.06	1.5
1453: Travel trailer park	0.12	0.06	1.5
1454: Campground	0.12	0.06	1.5
1460: Oil & gas storage (except areas assoc. with industrial)	0.12	0.06	1.5
1470: Mixed commercial and services	0.12	0.06	1.5
1480: Cemeteries	0.12	0.06	1.5
1490: Commercial & services under construction	0.12	0.06	1.5
1500: Industrial	0.12	0.06	1.5
1510: Food processing	0.12	0.06	1.5
1513: Seafood processing	0.12	0.06	1.5
1514: Meat packing facility	0.12	0.06	1.5
1515: Poultry and/or egg processing	0.12	0.06	1.5
1516: Grain and legume processing	0.12	0.06	1.5
1520: Timber processing	0.12	0.06	1.5
1521: Sawmill	0.12	0.06	1.5
1522: Plywood and veneer mill	0.12	0.06	1.5

Land Use / Roughness Zone	Shallow Manning's N	Deep Manning's N	Depth Range
1523: Pulp and paper mills	0.12	0.06	1.5
1526: Log home prefabrication	0.12	0.06	1.5
1527: Woodyard	0.12	0.06	1.5
1530: Mineral processing	0.12	0.06	1.5
1532: Phosphate processing	0.12	0.06	1.5
1533: Limerock processing	0.12	0.06	1.5
1535: Heavy minerals processing	0.12	0.06	1.5
1540: Oil & gas processing	0.12	0.06	1.5
1544: Liquified gases	0.12	0.06	1.5
1545: Asphalt plant	0.12	0.06	1.5
1550: Other light industrial	0.12	0.06	1.5
1551: Boat building and repair	0.12	0.06	1.5
1552: Electronics	0.12	0.06	1.5
1554: Aircraft building and repair	0.12	0.06	1.5
1555: Container manufacturer	0.12	0.06	1.5
1556: Mobile home manufacturer	0.12	0.06	1.5
1560: Other heavy industrial	0.12	0.06	1.5
1561: Ship building & repair	0.12	0.06	1.5
1562: Pre-stressed concrete plants (includes 1564)	0.12	0.06	1.5
1563: Metal fabrication plants	0.12	0.06	1.5
1564: Cement plant	0.12	0.06	1.5
1565: Plastic pipe plant	0.12	0.06	1.5
1570: Chemical processing	0.12	0.06	1.5
1580: Industrial	0.12	0.06	1.5
1590: Industrial under construction	0.12	0.06	1.5
1600: Extractive	0.12	0.06	1.5
1610: Strip mines	0.12	0.06	1.5
1611: Clays	0.12	0.06	1.5
1612: Peat	0.12	0.06	1.5
1613: Heavy metals	0.12	0.06	1.5
1614: Phosphate mine	0.12	0.06	1.5
1620: Sand & gravel pits (must be active)	0.12	0.06	1.5
1630: Rock quarries	0.12	0.06	1.5
1631: Limerock quarry	0.12	0.06	1.5
1632: Limerock or dolomite	0.12	0.06	1.5
1633: Phosphates	0.12	0.06	1.5
1634: Heavy minerals	0.12	0.06	1.5
1640: Oil and gas fields	0.12	0.06	1.5
1650: Reclaimed lands	0.12	0.06	1.5
1660: Holding ponds	0.12	0.06	1.5
1670: Abandoned mining lands	0.12	0.06	1.5
1700: Institutional	0.12	0.06	1.5
1710: Educational facility	0.12	0.06	1.5
1720: Religious site	0.12	0.06	1.5
1730: Military	0.12	0.06	1.5
1736: National Guard installation	0.12	0.06	1.5
1740: Medical and health care	0.12	0.06	1.5
1741: Hospital	0.12	0.06	1.5
1742: Nursing home	0.12	0.06	1.5
1750: Governmental - for Kennedy Space Center only	0.12	0.06	1.5

Land Use / Roughness Zone	Shallow Manning's N	Deep Manning's N	Depth Range
1756: Maintenance yard	0.12	0.06	1.5
1760: Correctional facilities	0.12	0.06	1.5
1761: State prison	0.12	0.06	1.5
1765: Municipal prison	0.12	0.06	1.5
1770: Other institutional facility	0.12	0.06	1.5
1780: Commercial child care	0.12	0.06	1.5
1790: Institutional under construction	0.12	0.06	1.5
1800: Recreational	0.12	0.06	1.5
1810: Swimming beach	0.12	0.06	1.5
1820: Golf courses	0.12	0.06	1.5
1830: Race tracks	0.12	0.06	1.5
1831: Automobile racing track	0.12	0.06	1.5
1832: Horse racing track	0.12	0.06	1.5
1833: Dog racing track	0.12	0.06	1.5
1840: Marinas & fish camps	0.12	0.06	1.5
1850: Parks and zoos	0.12	0.06	1.5
1851: City park	0.12	0.06	1.5
1852: Zoo	0.12	0.06	1.5
1860: Community recreational facilities	0.12	0.06	1.5
1870: Stadiums - facilities not associated w/ high schools, colleges, universities	0.12	0.06	1.5
1880: Historical sites	0.12	0.06	1.5
1890: Under construction or other recreational	0.12	0.06	1.5
1900: Open land	0.12	0.06	1.5
1910: Undeveloped urban land	0.12	0.06	1.5
1920: Inactive development land (with streets)	0.12	0.06	1.5
1923: Inactive development land nonforested	0.12	0.06	1.5
1924: Inactive development land forested	0.12	0.06	1.5
1930: Urban land in transition, no indicators of intended activity	0.12	0.06	1.5
1940: Other open land	0.12	0.06	1.5
2100: Pasture	0.12	0.06	1.5
2110: Improved pastures (monocult, planted forage crops)	0.12	0.06	1.5
2111: Pasture	0.12	0.06	1.5
2120: Unimproved pastures	0.12	0.06	1.5
2130: Woodland pastures	0.12	0.06	1.5
2140: Row crops	0.12	0.06	1.5
2143: Potatoes and cabbage	0.12	0.06	1.5
2150: Field crops	0.12	0.06	1.5
2153: Hay fields	0.12	0.06	1.5
2156: Sugar cane	0.12	0.06	1.5
2160: Mixed crop	0.12	0.06	1.5
2200: Tree crops	0.12	0.06	1.5
2210: Citrus groves	0.12	0.06	1.5
2220: Fruit orchard	0.12	0.06	1.5
2221: Peaches	0.12	0.06	1.5
2224: Blueberries	0.12	0.06	1.5
2230: Other groves	0.12	0.06	1.5
2231: Pecans	0.12	0.06	1.5
2240: Abandoned tree crops	0.12	0.06	1.5
2300: Feeding operations	0.12	0.06	1.5
2310: Cattle feeding operations	0.12	0.06	1.5

Land Use / Roughness Zone	Shallow Manning's N	Deep Manning's N	Depth Range
2320: Poultry feeding operations	0.12	0.06	1.5
2330: Swine feeding operations	0.12	0.06	1.5
2400: Nurseries and vineyards	0.12	0.06	1.5
2410: Tree nurseries	0.12	0.06	1.5
2420: Sod farms	0.12	0.06	1.5
2430: Ornamentals	0.12	0.06	1.5
2431: Shade ferns	0.12	0.06	1.5
2432: Hammock ferns	0.12	0.06	1.5
2440: Vineyards	0.12	0.06	1.5
2450: Floriculture	0.12	0.06	1.5
2460: Timber nursery	0.12	0.06	1.5
2500: Specialty farms	0.12	0.06	1.5
2510: Horse farms	0.12	0.06	1.5
2520: Dairies	0.12	0.06	1.5
2530: Kennels	0.12	0.06	1.5
2540: Aquaculture	0.12	0.06	1.5
2550: Tropical fish farms	0.12	0.06	1.5
2590: Other specialty farm	0.12	0.06	1.5
2600: Other open land, rural	0.12	0.06	1.5
2610: Fallow cropland	0.12	0.06	1.5
2620: Old field	0.12	0.06	1.5
3100: Herbaceous upland nonforested	0.3	0.15	3
3200: Shrub and brushland	0.3	0.15	3
3210: Palmetto prairie	0.3	0.15	3
3220: Coastal scrub	0.3	0.15	3
3290: Other shrubs and brush	0.3	0.15	3
3300: Mixed upland nonforested	0.3	0.15	3
3430: Mixed upland	0.3	0.15	3
3460: Mixed upland	0.3	0.15	3
4100: Upland coniferous forests	0.3	0.15	3
4110: Pine flatwoods or mesic flatwoods	0.3	0.15	3
4119: Pine flatwoods - melaleuca infested	0.3	0.15	3
4120: Longleaf pine - xeric oak or longleaf sandhill	0.3	0.15	3
4130: Sand pine or sand pine scrub	0.3	0.15	3
4140: Pine - mesic oak	0.3	0.15	3
4190: Hunting plantation woodlands	0.3	0.15	3
4200: Upland hardwood forests	0.3	0.15	3
4210: Xeric oak or oak sandhill	0.3	0.15	3
4220: Brazilian pepper	0.3	0.15	3
4230: Oak - pine - hickroy	0.3	0.15	3
4240: Melaleuca	0.3	0.15	3
4250: Temperate hardwood	0.3	0.15	3
4260: Tropical hardwood	0.3	0.15	3
4270: Live oak	0.3	0.15	3
4271: Oak - cabbage palm forest	0.3	0.15	3
4280: Cabbage palm	0.3	0.15	3
4290: Wax myrtle - willow	0.3	0.15	3
4300: Upland mixed forest	0.3	0.15	3
4310: Beech - magnolia	0.3	0.15	3
4320: Sand live oak or oak scrub	0.3	0.15	3

Land Use / Roughness Zone	Shallow Manning's N	Deep Manning's N	Depth Range
4330: Western Everglades hardwoods	0.3	0.15	3
4340: Upland mixed coniferous/hardwood	0.3	0.15	3
4350: Dead trees	0.3	0.15	3
4360: Trees	0.3	0.15	3
4370: Australian pine	0.3	0.15	3
4380: Mixed hardwoods	0.3	0.15	3
4390: Maritime hammock or other hardwoods	0.3	0.15	3
4400: Tree plantations	0.3	0.15	3
4410: Pine plantations	0.3	0.15	3
4420: Hardwood plantations	0.3	0.15	3
4430: Forest regeneration	0.3	0.15	3
4440: Experimental tree plots	0.3	0.15	3
4450: Seed plantations	0.3	0.15	3
4610: Upland	0.3	0.15	3
4630: Upland	0.3	0.15	3
5000: Water	0.06	0.06	1.5
5100: Streams and waterways	0.06	0.06	1.5
5110: Natural river, stream, waterway	0.06	0.06	1.5
5120: Channelized waterways	0.06	0.06	1.5
5200: Lakes	0.06	0.06	1.5
5210: Lakes larger than 500 acres (202 hectares)	0.06	0.06	1.5
5220: Lakes larger than 100 acres (40 hectares) but less than 500 acres	0.06	0.06	1.5
5230: Lakes larger than 10 acres (4 hectares) but less than 100 acres	0.06	0.06	1.5
5240: Lakes less than 10 acres (4 hectares) which are dominant features	0.06	0.06	1.5
5250: Open water within a freshwater marsh / Marshy Lakes	0.06	0.06	1.5
5300: Reservoirs - pits, retention ponds, dams	0.06	0.06	1.5
5310: Reservoirs larger than 500 acres (202 hectares)	0.06	0.06	1.5
5320: Reservoirs larger than 100 acres (40 hectares) but less than 500 ac.	0.06	0.06	1.5
5330: Reservoirs larger than 10 acres (4 hectares) but less than 100 acres	0.06	0.06	1.5
5340: Reservoirs less than 10 acres (4 hectares) which are dominant features	0.06	0.06	1.5
5400: Bays and estuaries	0.06	0.06	1.5
5410: Embayments opening directly to the gulf or ocean	0.06	0.06	1.5
5420: Embayments not opening directly to the gulf or ocean	0.06	0.06	1.5
5430: Enclosed saltwater ponds within a salt marsh	0.06	0.06	1.5
5500: Major springs	0.06	0.06	1.5
5600: Slough waters	0.06	0.06	1.5
5700: Ocean and gulf	0.06	0.06	1.5
5710: Atlantic Ocean	0.06	0.06	1.5
5720: Gulf of Mexico	0.06	0.06	1.5
6000: Wetlands	0.6	0.4	3
6100: Wetland hardwood forests	0.6	0.4	3
6110: Bay swamp (if distinct)	0.6	0.4	3
6111: Bayhead	0.6	0.4	3
6120: Mangrove swamps	0.6	0.4	3
6130: Gum swamps	0.6	0.4	3
6140: Titi swamps	0.6	0.4	3
6150: River/lake swamp (bottomland, may include cypress)	0.6	0.4	3
6160: Inland ponds and sloughs	0.6	0.4	3
6170: Mixed wetland hardwoods	0.6	0.4	3
6171: Mixed wetland hardwoods - willows	0.6	0.4	3

Land Use / Roughness Zone	Shallow Manning's N	Deep Manning's N	Depth Range
6172: Mixed wetland hardwoods - mixed shrubs	0.6	0.4	3
6180: Cabbage palm savannah	0.6	0.4	3
6181: Cabbage palm hammock	0.6	0.4	3
6182: Cabbage palm savannah	0.6	0.4	3
6191: Wet melaleuca	0.6	0.4	3
6200: Wetland coniferous forests	0.6	0.4	3
6210: Cypress	0.6	0.4	3
6215: Cypress - domes/heads	0.6	0.4	3
6216: Cypress - mixed hardwoods	0.6	0.4	3
6218: Cypress - melaleuca infested	0.6	0.4	3
6219: Cypress - with wet prairies	0.6	0.4	3
6220: Pond pine/wet flatwoods	0.6	0.4	3
6230: Southern red cedar/Atlantic white cedar	0.6	0.4	3
6240: Cypress - pine - cabbage palm	0.6	0.4	3
6250: Hydric pine flatwoods	0.6	0.4	3
6260: Wetlands savannah	0.6	0.4	3
6300: Wetland forested mixed	0.6	0.4	3
6310: Hydric hammock	0.6	0.4	3
6320: Tidal swamp	0.6	0.4	3
6400: Vegetated non-forested wetlands	0.6	0.4	3
6410: Freshwater marshes	0.6	0.4	3
6411: Sawgrass marshes	0.6	0.4	3
6412: Cattail marshes	0.6	0.4	3
6420: Saltwater marshes	0.6	0.4	3
6430: Wet prairies	0.6	0.4	3
6439: Wet prairies - with pine	0.6	0.4	3
6440: Emergent aquatic vegetation	0.6	0.4	3
6450: Submergent aquatic vegetation	0.6	0.4	3
6451: Hydrilla	0.6	0.4	3
6460: Mixed scrub-shrub wetland	0.6	0.4	3
6464: Wetland	0.6	0.4	3
6500: Non-vegetated wetland	0.6	0.4	3
6510: Tidal flats	0.6	0.4	3
6520: Intertidal areas	0.6	0.4	3
6530: Intermittent ponds	0.6	0.4	3
6540: Oyster bars	0.6	0.4	3
6600: Cut over wetlands	0.6	0.4	3
6900: Wetland scrub	0.6	0.4	3
7100: Beaches other than swimming beaches	0.12	0.06	1.5
7200: Sand other than beaches	0.12	0.06	1.5
7300: Exposed rock	0.12	0.06	1.5
7400: Disturbed land	0.12	0.06	1.5
7410: Rural land in transition without positive indicators of intended activity	0.12	0.06	1.5
7420: Borrow areas	0.12	0.06	1.5
7430: Spoil areas	0.12	0.06	1.5
7440: Levees/fill areas	0.12	0.06	1.5
7450: Burned areas	0.12	0.06	1.5
7470: Dikes and levees	0.12	0.06	1.5
7500: Riverine sandbars	0.12	0.06	1.5
8100: Transportation	0.12	0.06	1.5

Land Use / Roughness Zone	Shallow Manning's N	Deep Manning's N	Depth Range
8110: Airports	0.12	0.06	1.5
8111: Commercial airport	0.12	0.06	1.5
8112: General aviation	0.12	0.06	1.5
8113: Private airports	0.12	0.06	1.5
8115: Grass airports	0.12	0.06	1.5
8120: Railroads	0.12	0.06	1.5
8130: Bus and truck terminals	0.12	0.06	1.5
8140: Roads and highways (divided 4-lanes with medians)	0.12	0.06	1.5
8141: Limited access highway (interstate)	0.12	0.06	1.5
8142: Divided highway (federal-state)	0.12	0.06	1.5
8143: Two lane highway	0.12	0.06	1.5
8147: Transportation corridor	0.12	0.06	1.5
8150: Port facilities	0.12	0.06	1.5
8152: Piers	0.12	0.06	1.5
8153: Cargo terminals	0.12	0.06	1.5
8155: Repair facilities	0.12	0.06	1.5
8156: Shipyards	0.12	0.06	1.5
8160: Locks and dams	0.12	0.06	1.5
8170: Oil, water, or gas transmission lines	0.12	0.06	1.5
8180: Auto parking facilities	0.12	0.06	1.5
8190: Transportation facilities under construction	0.12	0.06	1.5
8191: Highways under construction	0.12	0.06	1.5
8192: Railroads under construction	0.12	0.06	1.5
8193: Airports under construction	0.12	0.06	1.5
8194: Port facilities under construction	0.12	0.06	1.5
8195: Pipelines under construction	0.12	0.06	1.5
8200: Communications	0.12	0.06	1.5
8210: Transmission towers	0.12	0.06	1.5
8220: Communication facilities	0.12	0.06	1.5
8290: Communication facilities under construction	0.12	0.06	1.5
8300: Utilities	0.12	0.06	1.5
8310: Electrical power facilities	0.12	0.06	1.5
8311: Coal-fired electrical power generating plant	0.12	0.06	1.5
8315: Electrical power substation	0.12	0.06	1.5
8320: Electrical power transmission lines	0.12	0.06	1.5
8330: Water supply plants	0.12	0.06	1.5
8340: Wastewater treatment	0.12	0.06	1.5
8350: Solid waste disposal	0.12	0.06	1.5
8360: Treatment ponds	0.12	0.06	1.5
8370: Surface water collection basins	0.12	0.06	1.5
8390: Utilities under construction	0.12	0.06	1.5
8410: Utilities	0.12	0.06	1.5
9110: Sea grass	0.12	0.06	1.5
9999: Missing	0.12	0.06	1.5
0: Unknown	0.12	0.06	1.5

Appendix C

Development of Input Rainfall and Stage Conditions Data for North Merritt Island

prepared by Applied Ecology, Inc., March 2021

Development of Input Rainfall and Stage Condition Data for North Merritt Island

FINAL TECHNICAL REPORT

5/19/2021

Prepared For:

SINGHOFEN & ASSOCIATES INCORPORATED

Prepared By:

APPLIED ECOLOGY

Executive Summary

Applied Ecology's (AEI) objective for this project was to create rainfall and surface water stage estimated input datasets for use in the Interconnected Channel and Pond Routing Model (ICPR4) for North Merritt Island, FL (NMI). These input datasets provide year-long representations of either existing conditions (based on 2017 historical record) and future conditions (based on year 2040/2041).

The data produced by AEI provided the client the ability to run up to five long-term (annual) hydrologic simulation. The first scenario would be representative of 2017 conditions, a year that represented significant storm surge conditions due to Hurricane Irma. The other four scenarios correspond to synthetic estimated rainfall and water level conditions, in an attempt to represent all the combinations of El Niño/La Niña years and average or high storm conditions. The data provided by AEI can be incorporated into the North Merritt Island ICPR custom modeling and provide the following five scenarios:

Scenario Timeframe	Rainfall Condition	Storm Surge Condition
Historic/present (2017)	Measured 2017 conditions	Measured/estimated based on 2017 data
Future (20 years from current condition:2040)	El Niño conditions (wet year)	Intermediate high sea level rise scenario with average storm surge conditions
Future (20 years from current condition: 2040)	El Niño conditions (wet year)	Intermediate high sea level rise scenario with 13.1 ft (4 m) storm surge conditions (high storm surge)
Future (20 years from current condition: 2041)	La Niña conditions (dry year)	Intermediate high sea level rise scenario with average storm surge conditions
Future (20 years from current condition: 2041)	La Niña conditions (dry Year)	Intermediate high sea level rise scenario with 13.1 ft (4 m) storm surge conditions (high storm surge)

This project utilized the National Weather Service (NWS) Next Generation Radar (NEXRAD) to create bias-corrected 2017 rainfall estimates over NMI and then applied the Coupled Model Intercomparison Project Version 5 (CMIP5) climate projections to generate wet (El Niño) and dry (La Niña) rainfall estimates for 2040. The 2017 bias-corrected rainfall estimate was created using the NEXRAD Level 3 1-Hour Digital Accumulation Array (DAA) product from the NWS Melbourne, FL station (KMLB). A python script was written that created a 5-minute, 0.15 km^2 pixel rainfall time series and then applied a bias correction based on a SJRWMD 1-Hour radar rainfall product. The resulting product was validated against the SJRWMD Ransom Road rain gauge station, with a R^2 of 0.72 between the hourly bias-corrected rainfall estimates and gauge readings for all of 2017. A pattern of underestimation was identified with an annual rainfall of 63.4 inches (1,610 mm) measured at the rain gauge with the bias-corrected rainfall estimating 51.2 inches (1,300 mm).

The 2040 wet and dry rainfall projections were created by applying a monthly percent change based on the Multi-Model Mean (MMM) of the CMIP5 Local Constructed Analogs (LOCA) downscaled models to

the 2017 bias-corrected rainfall estimate. The 2017 MMM was chosen as the baseline and the projected annual increase of 3% to 2040 was used as the wet year, and 6% decrease to 2041 used for the dry year.

The North Indian River Lagoon (NIRL) and Banana River (BR) bound the NMI area to the west and east, respectively. The 2017 stage estimates for these two water bodies was created from the St Johns River Water Management District's (SJRWMD) Continuous Monitoring (CM) stations. A Coastal Modeling System (CMS-Flow) model was developed for 2017 and then for 2040 with a sea level rise offset identified from the National Oceanographic and Atmospheric Administration (NOAA) 2017 intermediate-high projections. The 2017 NIRL and BR surface water stage estimations were created from the SJRWMD CM depth of sensor readings and the CMS-Flow model. The CM depth of sensor readings were transformed into stage estimations through a demeaned transformation with the NOAA Trident Pier Atlantic Ocean stage station. The CMS-Flow model utilized three ocean boundaries at Ponce de Leon Inlet, Wabasso Bridge, and Sebastian Inlet, along with wind and freshwater inputs.

Both the CM and CMS-Flow stage estimations averaged -0.79 ft (-0.24 m) NAVD88 for both NIRL and BR from January to August, captured the storm surge from Hurricane Irma, and detected the late October Gulf Stream high sea levels. The CM estimated stages between NIRL and BR for several months ranged between 0.82 – 2.46 ft (0.25 – 0.75 m), compared to the 1-3 day long 0.32 in (10 cm) variation in the CMS-Flow model. The CMS-Flow model was validated against the United States Geological Survey (USGS) Haulover Canal station with a R^2 value of 0.84 with a 0.32 in (10 cm) underestimation of stage throughout the year.

The methods outlined in this report made use of the limited data available in the NMI area to generate the rainfall and surface water stage estimates for the ICPR4 model. The bias-corrected NEXRAD radar rainfall estimates underestimated both the annual rainfall and for intense rainfall such as Hurricane Irma, though a portion of this is due to the challenge of using radar rainfall estimates and the higher spatial resolution around a single validation location. The CM stage estimates of NIRL and BR are the only long-term measurements in those basins, however as they are indirect measurements and with potential errors from drift and sensor biofouling, they best represent short term variations in stage. The CMS-Flow model had good agreement with the Haulover Canal reference site and the underestimation is potentially due to the complex flows that pass through the canal which connects the NIRL to Mosquito Lagoon.

Contents

Introduction

In 2019 Brevard County passed Ordinance 19-26 which requires future development projects on Merritt Island, FL to demonstrate that no adverse flooding impacts will occur as the result of new development. An Interconnected Channel and Pond Routing Model 4 (ICPR4) hydrological model was selected to be developed for the area to serve as a base model to evaluate potential flood control and natural system improvement projects and other physical changes to watershed. This model requires, as critical input datasets, rainfall and surface water stage time-series which, in turn, rely on the availability of sufficiently spatially and temporally dense data points.

This project focused on the North Merritt Island (NMI) watershed of between the NASA Parkway and Highway US-A1A (Figure 1). The NMI area is characterized by two north-south ridges with the Sykes Creek between draining into the east-west running Barge Canal. It is bordered by the Indian River Lagoon to the west and the Banana River to the east. There are clusters of agricultural and residential land cover on the ridges with scrub and wetland between, intercut with drainage ditches and canals.

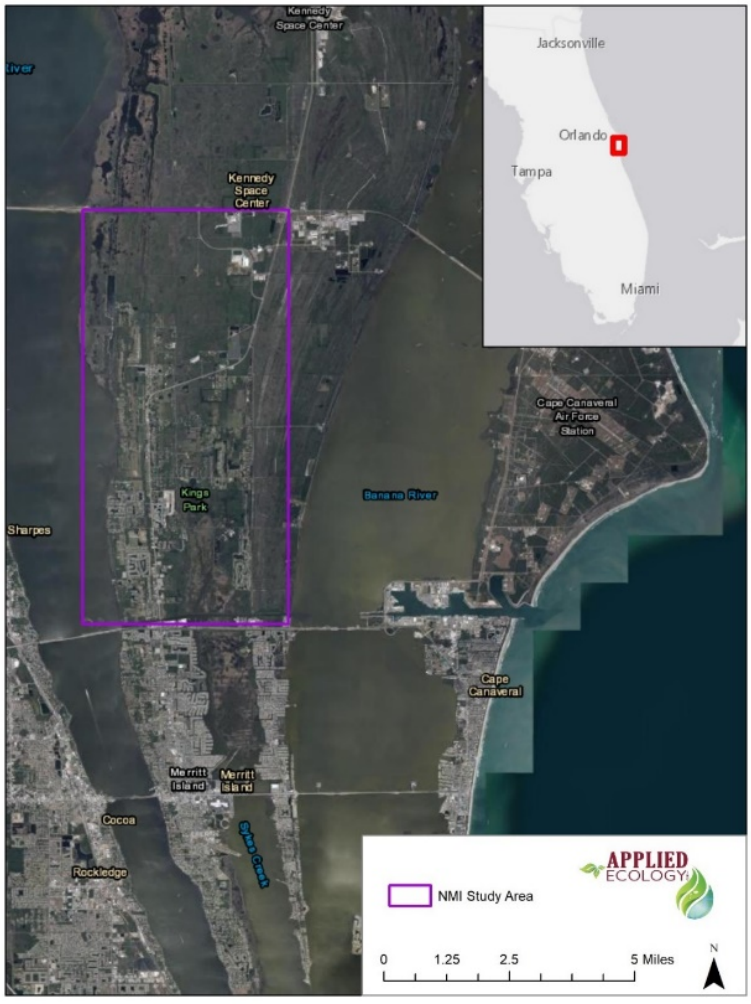


Figure 1 – Location of the North Merritt Island study area

Rainfall

The creation of a rainfall surface can be accomplished through spatial interpolation of measurements from rain gauges or estimations from radar returns (Bredesen & Brown, 2018). Generation of areal rainfall estimates historically relied on rain gauges as accurate point measures and applied statistical methods to interpolate within a gauge network. This requires a dense network of gauges across a region to capture the spatial variability of storms and account for local factors.

Rainfall in Florida is characterized as highly seasonal with intense storms with small footprints during the wet season (Skinner *et al*., 2009; Mahjabin & Abdul-Aziz, 2020). The wet season spans from June to October, when 2/3rds of the annual rainfall occurs. The storms during the wet season can vary from regionwide fronts to storms small enough to pass between rain gauges, complicating the accurate representation of local rainfall patterns when using rain gauges.

The Next Generation Radar (NEXRAD) network of the National Weather Service (NWS) was chosen to provide the rainfall surface for this study as radar rainfall estimates can provide a spatially contiguous rainfall surface. Radar rainfall estimates are based on the Z-R relationship which is the principal that more intense rainfall results in a stronger radar return (NOAA, 2017). Radar rainfall estimates can also incorporate available rain gauge data to determine a Gauge-Radar (GR) ratio, which is the ratio of rainfall measured at a rain gauge over the estimated radar rainfall over the rain gauge. This bias correction is required to account for how NEXRAD estimates rainfall from the cloud to the ground along with other errors and limitations. An accurate estimation of rainfall can be created with the GR bias correction, however error can still occur with extremely heavy or light rainfall (Bredesen & Brown, 2018; NOAA, 2017; Skinner *et al.*, 2009).

Surface Water Stage

Within the Indian River Lagoon (IRL) variations in surface water stages are driven by wind, rainfall runoff, and ocean tides. Of these forces wind has the strongest influence on the variation of surface water stage with the direction of the wind also having a significant impact. North and south winds can result in the stage of some segments of the IRL varying up to 40-50 cm (Weaver *et al.*, 2016). However, there is limited continuous surface water stage measurements in the IRL, with the USGS Haulover Canal and Wabasso stations being the only long-term stations in the IRL. The St Johns River Water Management District (SJRWMD) maintains a network of continuous monitoring stations which this study used to provide an indirect estimation of water surface stage through a depth measurement.

The Coastal Modeling System (CMS) was also selected to model water stage changes in this study, which was developed by the U.S. Army Engineer Research and Development Center (ERDC) and Coastal and Hydraulics Laboratory (CHL). CMS is a coupled group of numerical models for calculating waves, circulation, sediment transport, constituent transport, and morphological change. The water stage module, CMS-Flow, is a two dimensional (2-D), finite-volume model that solves the mass conservation and shallow-water momentum equations of water motion. CMS-Flow can be forced by water surface stage (e.g., from tide), wind and river discharge at the model boundaries, and wave radiation stress and wind field over the model computational domain. A significant study for model verification and validation of the CMS is documented in Demirbilek and Rosati (2011), Lin *et al.* (2011), Sanchez (2011a) and Sanchez (2011b). Further documentation of the CMS, including processes and numerics, are documented in Wu (2010) and Buttolph (2006).

Climate Modeling

In recent years climate projection information and methods have become more available and applicable on the smaller scale to Florida (Infanti *et al.*, 2020). The Lawrence Livermore National Laboratory Program's Coupled Model Intercomparison Project Version 5 (CMIP5) is a collection of global models with varying assumptions and conditions that when considered together can account for the inherent uncertainty in projecting future climates. One assumption the CMIP5 includes and is of particular concern to Florida, is the impact of the El Niño-Southern Oscillation (ENSO), which El Niño events can drive wetter conditions and La Niña result drier conditions (Wang & Asefa, 2018). Through the Localized Constructed Analogs (LOCA) a downscaling process was applied to the global CMIP5 models which used local climate observations in the United States to improve both the spatial resolution and accuracy in projecting the full range of future conditions (Pierce *et al.*, 2014). The CMIP5 LOCA projected precipitation was used to determine the likely change in precipitation from 2017 to 2040/2041 for NMI.

Similarly, future sea level rise (SLR) has been modeled and projected globally by the Intergovernmental Panel on Climate Change (IPCC) in 2014 and then by NOAA in 2017 with a focus on incorporating regional effects relevant to the United States. The South Florida Climate Compact evaluated these two sets of projected SLR to qualify their use in planning and provide guidance on how to select a projected sea level for a given project (Compact, 2019). These models account for a portion of uncertainty based on global climatic models like thermal expansion of the ocean and specific events such as the melting of various glaciers. Of the available models, the NOAA Intermediate-High Curve was selected as it recommended for inundation and infrastructure planning.

Methods

This report summarizes the methods utilized to generate estimations of rainfall and surface water conditions for the year 2017 and then future climatic projections in 2040. The year 2017 was selected as a historical input to capture the impact of Hurricane Irma on NMI. The rainfall of 2017 was estimated by NEXRAD radar rainfall and surface water stage estimated by indirect measurements and CMS hydraulic modeling. Four scenarios were created from the 2040 projections, based on high and low annual rainfall along with average and extreme storm surge. The future CMIP5 LOCA climate projections were evaluated to identify likely future conditions during El Niño (Wet) and La Niña (Dry) periods. Then CMS models were run with projected sea level rise and an additional extreme storm surge.

Development of 2017 Historic Rainfall Conditions

The creation of the simulated rainfall surface over the NMI area utilized radar rainfall estimates and limited rain gauge data for 2017. An inventory of existing rain gauges identified an insufficient number of stations in the region that collect hourly or better data. The National Weather Service (NWS) Next Generation Radar (NEXRAD) was chosen to provide rainfall estimates at 5-minute intervals. Also due to the lack of rain gauges in the NMI area to use for data correction, the SJRWMD processed hourly NEXRAD rainfall estimate was used as a stand-in for gauge readings to determine the bias correction.

To generate the 2017 radar rainfall of the NMI area, the nearest NEXRAD station (Melbourne KMLB 28°6'48"N 80°39'15"W) was selected. The daily rainfall archives for 2017 were downloaded from the NOAA National Centers for Environmental Information (NCEI) (https://www.ncdc.noaa.gov/cdo-web/datasets/NEXRAD3/stations/NEXRAD:KMLB/detail). The SJRWMD NEXRAD grid and the Ransom Road rain gauge data were acquired from the SJRWMD Bureau of Water Resource Information (https://www.sjrwmd.com/data/hydrologic/). The Kennedy Space Center (KSC) rain gauges were not used in this analysis due to systematic data gaps and the NOAA managed rain gauges were not used due to only being available at daily intervals.

The NEXRAD Level 3 product 1-Hour Digital Accumulation Array (DAA) was selected due to its higher spatial resolution. The DAA is available at a 0.13-nm x 1-degree grid, compared to the 1.1-nm x 1-degree grid of the One-Hour Accumulation (OHA) product. All available DAA rasters for 2017 were extracted as GeoTIFFs using the NOAA Weather and Climate Toolkit (WTC) and then resampled to a 380 m grid in ArcMap 10.8, which aligns as a 5x5 grid with the SJRWMD NEXRAD grid (Figure 2).

The DAA time series was recorded at KMLB in a variable time interval format, time steps could range from 3-5 minutes during a rain event. As each interval represented the accumulated rainfall for the last hour for a given grid cell, accumulated rainfall for a time step was determined by subtracting the current accumulation from the previous accumulation. A custom python script was created to standardize the time series and accumulated rainfall to a 5-minute interval.

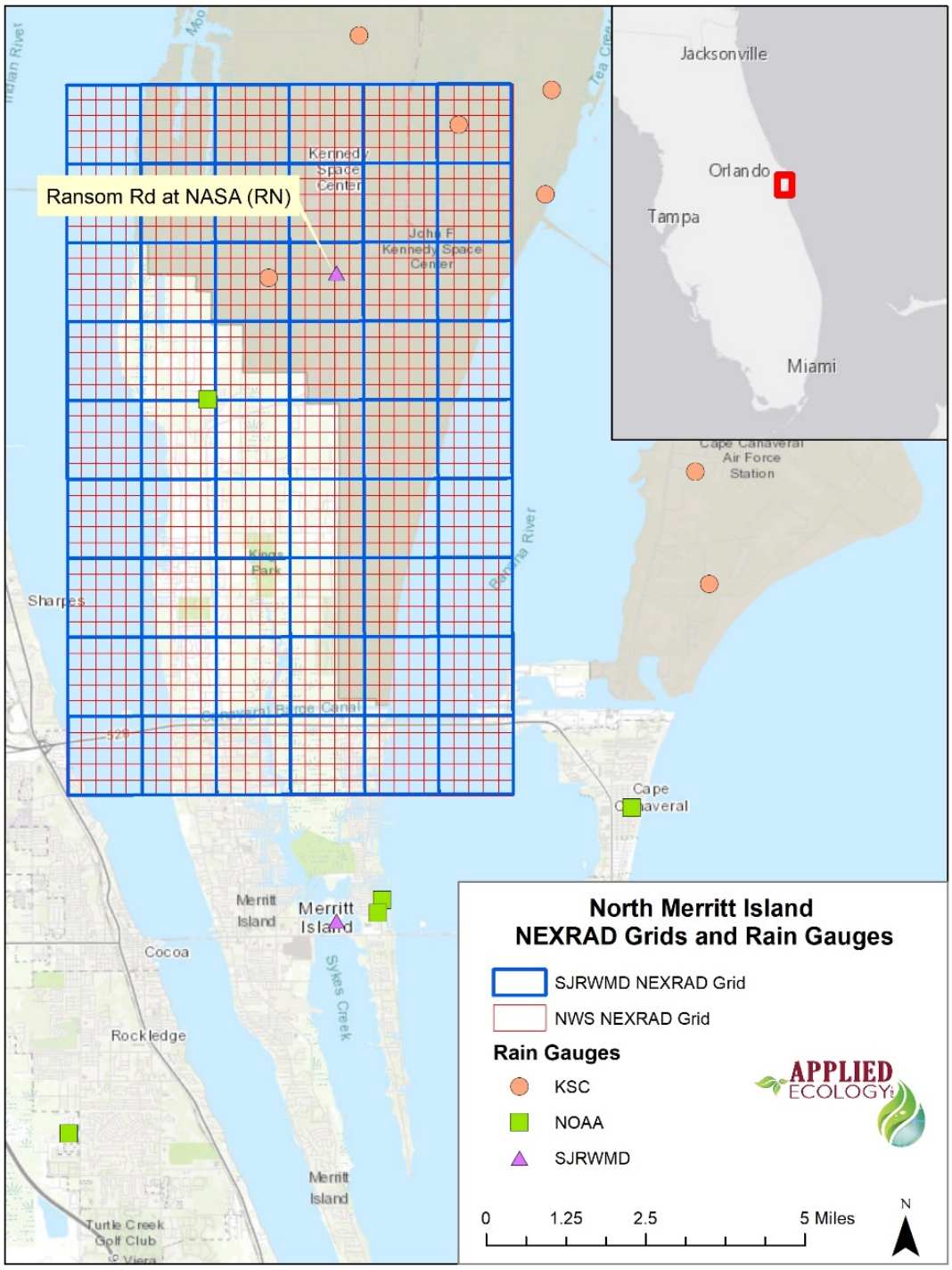


Figure 2 – Location of the Ransom Road rain gauge in the North Merritt Island study area with the St Johns River Water Management District (SJRWMD) NEXRAD and National Weather Service NEXRAD grids overlain. The Kennedy Space Center (KSC) and NOAA rain gauges were evaluated and not used in the development of the rainfall surfaces due to formatting or data quality.

A second custom python script was created to summarize the 5-minute DAA radar rainfall pixels to an hourly average rainfall at the corresponding scale of the SJRWMD NEXRAD rainfall pixels. This script generated the Gauge-RADAR Ratio between the DAA and SJRWMD NEXRAD pixels, and then applied the hourly bias correction to the 5-minute DAA radar rainfall pixels. The output was formatted for use by the ICPR4 model as a CSV shown in Table 1. The bias-corrected NWS DAA NEXRAD radar rainfall estimates were then evaluated by their deviation from the Ransom Road rain gauge.

Table 1 - ICPR4 time series input format. The black, non-bolded text are the characters in the text file while the blue, bolded text describes what it represents.

A3			File Name (Grid reference)	
0			**Data Type (Precipitation)**	
5			**Packet Time Increment (min)**	
Year	**Month**	**Day**	**Decimal Hour**	**Rainfall Amount (in)**
2017	1	2	6.6667	0.012053
2017	1	2	6.75	0.013057
2017	1	2	6.8333	0.004269
2017	1	2	6.9167	0.003515
2017	1	2	7	0.003534

Development of 2040 Rainfall Conditions

Based on available literature, the CMIP5 Local Analogue (LOCA) downscaled models were selected to identify future climate projections for the NMI area (Bracken, 2016; Dessalegne *et al*., 2016; Infanti *et al*., 2020). A monthly percent change in precipitation was calculated between those years and 2017 and then applied to the NEXRAD radar rainfall estimates to generate projected rainfall.

The projected dry and wet precipitation conditions for NMI were generated through a monthly percent change determined from the Multi-Model Mean (MMM) of the CMIP5 LOCA models. The CMIP5 LOCAL rainfall projections were downloaded from the Lawrence Livermore National Laboratory Program's Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections database (https://gdo-dcp.ucllnl.org/downscaled_cmip_projections/). The years 2040 and 2041 were chosen to represent a dry and wet season based on their relative variation from the 5 year mean in precipitation. These years were chosen as the MMM annual rainfall of 2040 was high (55.4 inches) and 2041 low (50.8 inches) relative to the 5-year average (53.8 inches).

To create the La Niña and El Niño projected rainfalls, monthly adjustments were calculated from the CMIP5 precipitation projections. These adjustments were determined by the percent change of monthly rainfall from the CMIP5 2017 for each of the 6 pixels that cover North Merritt Island (Figure 3). Each 2017 NWS NEXRAD ICPR grid cell was then apportioned to the CMIP5 grid. A custom python script was used to apply the corresponding percent adjustment for 2040 (Table 2) and 2041 (Table 3) to each of the previously generated ICPR 2017 precipitation files.

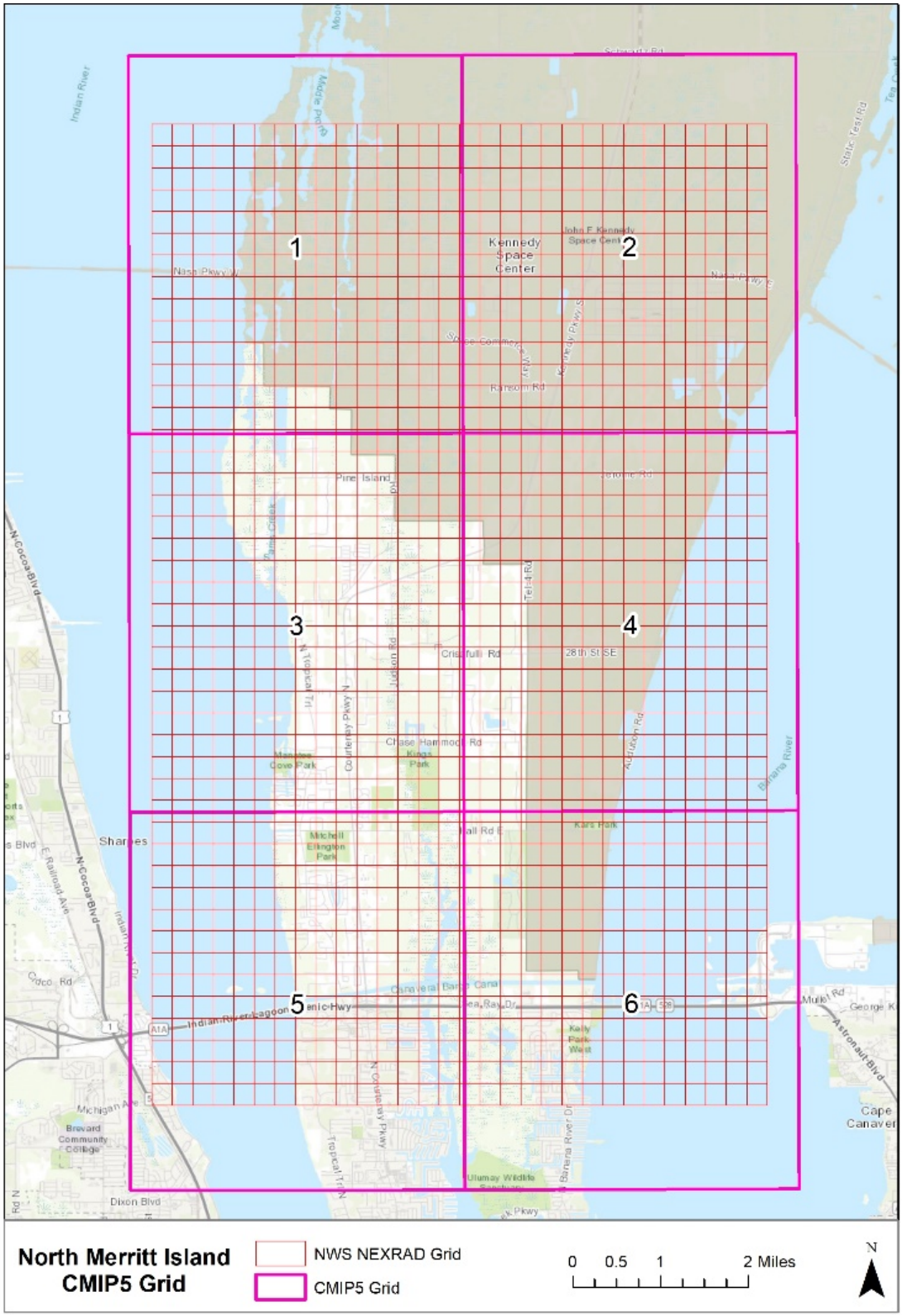


Figure 3 – Comparison of the CMIP5 grid cells with the NWS NEXRAD bias corrected grid cells.

Table 2 – Monthly percent adjustments calculated from the change between CMIP5 2017 and 2040 precipitation applied to the 2017 ICPR dataset to create a La Niña precipitation projection (drier conditions).

2040	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6
Jan	66%	65%	65%	65%	64%	64%
Feb	94%	93%	94%	93%	92%	91%
Mar	110%	109%	109%	109%	111%	110%
Apr	78%	79%	79%	79%	79%	79%
May	78%	79%	79%	80%	80%	81%
Jun	94%	95%	95%	95%	95%	96%
Jul	87%	87%	87%	87%	87%	86%
Aug	98%	98%	98%	99%	99%	99%
Sep	92%	91%	91%	91%	90%	91%
Oct	99%	99%	99%	98%	98%	97%
Nov	127%	125%	123%	122%	119%	117%
Dec	137%	132%	132%	127%	125%	123%

Table 3 - Monthly percent adjustments calculated from the change between CMIP5 2017 and 2041 precipitation applied to the 2017 ICPR dataset to create a El Niño precipitation projection (wet conditions).

2041	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6
Jan	87%	86%	86%	85%	83%	83%
Feb	88%	88%	90%	89%	91%	91%
Mar	114%	115%	116%	116%	119%	119%
Apr	86%	86%	87%	87%	87%	87%
May	90%	91%	92%	93%	94%	95%
Jun	134%	135%	135%	135%	135%	135%
Jul	104%	104%	105%	104%	103%	103%
Aug	101%	102%	102%	103%	103%	103%
Sep	98%	98%	99%	99%	100%	100%
Oct	99%	99%	99%	98%	99%	99%
Nov	105%	103%	104%	103%	103%	102%
Dec	125%	123%	123%	121%	121%	120%

Development of 2017 Historic Surface Water Stage Conditions

Within the Indian River Lagoon (IRL) there is limited surface water stage data, with no long-term stations present in the immediate area around NMI. The closest surface water stage data station is in the northernmost reach of IRL at the USGS Haulover Canal station in the North IRL, while NOAA has the Atlantic Ocean Trident Pier station east of Banana River. The SJRWMD Continuous Monitoring (CM) stations measure depth of sensor which was transformed into estimated stage using the Trident Pier time series.

To create an estimation of the surface water stage on the west and east sides of NMI, the SJRWMD CM station's depth of measurement was used (Figure 4). The North Indian River Lagoon estimated stage level is represented by the CM data collected at "Titusville Max Brewer Memorial Parkway (WQ)" (Station ID 33954622). The Banana River estimated stage level is represented by a composite time series of the CM "Merritt Island Causeway at SR 520 (WQ)" (Station ID 33964621) which was moved to "IRLB04 Banana River (WQ)" (Station ID 33844736) in April 2017. The CMs located at Cocoa and Melbourne were not used due to significant data gaps in 2017. Brevard County Natural Resources Management Department maintained a series of staff gauges within the NMI area but were only read daily in September and October 2017. A logging station was maintained by Florida Institute of Technology at Kars Park but was not available in NAVD88 and had data only for January and February 2017.

The SJRWMD CM stations utilize a YSI EXO2 multiparameter sonde with a vented strain gauge to determine depth of sensor. Strain gauge pressure transducers can have drift and calibration issues over their deployment. The CM sensors are deployed for three-to-five-week periods, after which maintenance is performed for calibration and removal of biofouling. The entire sensor system is removed and then replaced. The SJRWMD Bureau of Water Resource Information provided both depth of sensor readings and the maintenance periods (https://www.sjrwmd.com/data/hydrologic/). The depth of sensor value measured before and after maintenance activities was then evaluated for drift. An offset was applied to the data after each maintenance activity to account for variation in depth due to reinstallation.

Data gaps were identified for the CM stations and were replaced with USGS Haulover Canal stage levels obtained from the USGS Water Data service (https://waterdata.usgs.gov/usa/nwis/uv?site_no=02248380). The Haulover Canal data was first demeaned and then applied to the CM time series by a time weighted bias correction to account for drift.

The Banana River series is a composite of two stations along the SR 520 causeway. The series begins at "CM Merritt Island Causeway at SR 520 (WQ)" and was moved to "IRLB04 Banana River (WQ)" on 4/26/2017. Measurements between 4/19/2017 and 4/26/2017 at "CM Merritt Island Causeway at SR 520 (WQ)" was determined to be suspect when compared with trends at the other stations. The USGS Haulover Canal stage readings were first shifted to the Banana River stage of -0.018 m on 0:00 4/19/2017 and then over the next 192 hours shifted down by 0.139 m to -0.157 m at 23:00 4/26/2017.

The Indian River Lagoon station located near Titusville, FL had three data gaps between 4/10/2017 to 5/3/2017, 8/6/2017 to 8/8/2017, and 9/10/2017 to 10/11/2017. The first patch of USGS Haulover Canal stage readings were first shifted to the Titusville stage of -0.196 m at 19:00 4/19/2017 and did not need to be fitted. The second patch of USGS Haulover Canal stage readings were first shifted to the Titusville stage of -0.254 m at 01:00 8/6/2017 and then over the next 192 hours shifted down by 0.01 m to -0.270

m at 23:00 4/26/2017. The third patch of USGS Haulover Canal stage readings were first shifted to the Titusville stage of -0.212 m at 00:00 9/10/2017 and then over the next 742 hours shifted up by 0.166 m to 0.024 m at 12:00 4/26/2017.

The gap filled CM depth of sensor time series were then demeaned and shifted to estimated stage (NAVD88) using the NOAA Trident Pier dataset. The Trident Pier data were acquired from the NOAA Tides and Currents service (https://tidesandcurrents.noaa.gov/stationhome.html?id=8721604) and a 25-Hour low pass filter was applied to remove tidal signal.

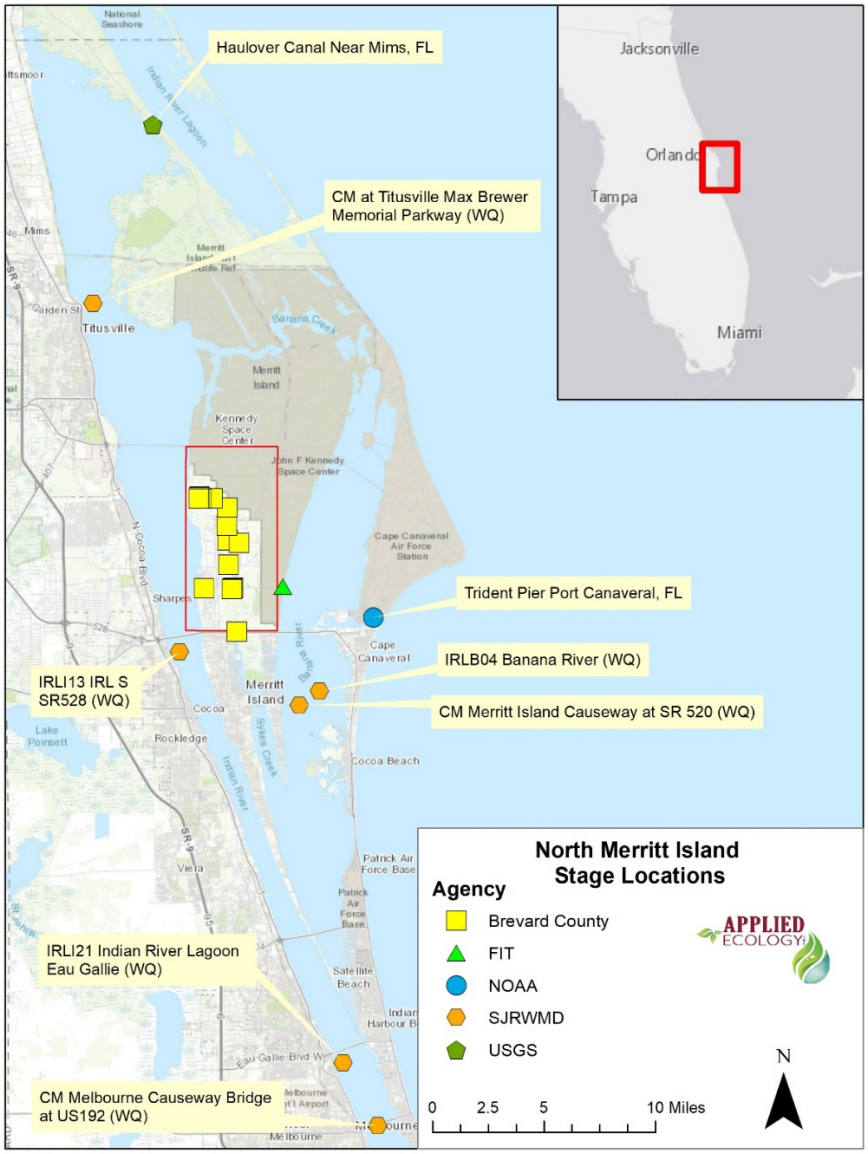


Figure 4 – Locations of surface water measurement stations in the Indian River Lagoon listed by their managing entity. The USGS Haulover Canal and NOAA Trident Pier stations were used to adjust and correct the SJRWMD Titusville, Banana River, and Merritt Island Causeway stations. The Brevard County and Florida Institute of Technology (FIT) gauges were not used in the development of the surface water stage due to limited data availability.

Development CMS-Flow Surface Water Model

The CMS-Flow model was also utilized to generate stage estimates of North IRL (NIRL) and Banana River (BR) for 2017 and 2040. The CMS-Flow model utilized the closest ocean connections with monitoring stations at Ponce de Leon Inlet, Wabasso Bridge, and Sebastian Inlet as water level boundaries. The NOAA projection of 0.852 ft (0.259 m) of SLR for 2040 was chosen to inform the CMS-Flow model of future conditions around NMI and a second model was run with a potential extreme storm surge event of 13.1 ft (4 m).

Grid Generation

A CMS-Flow model grid was constructed covering the Mosquito Lagoon and the north compartment of the Indian River Lagoon and extending to the Sebastian Inlet area and ending at the Wabasso Bridge in north Indian River County (Figure 5). The CMS model grid resolution was set at 50 meters.

Boundary Water Level and Discharge Time Series

Water level boundary conditions for the model were set at the closest ocean connections at the north end of the model near Ponce de Leon Inlet (Volusia County) and at the south end of the model at the Wabasso Bridge (Indian River County) and Sebastian Inlet (Brevard County). The non-tidal portion of the record is also shown. At the three coastal ocean boundary locations, water level time series were established from a combination of predicted tides based on up to 34 tidal constituents along with measured lower frequency water level time series. Since sea levels outside of the tidal frequency can vary over a range of up to 3 feet in any given year, it was important for model water level boundary conditions to include all sea level components. The tidal component for model boundary water level time series was obtained from NOAA tidal prediction stations at New Smyrna, FL, Sebastian Inlet, and Wabasso FL. The non-tidal sea levels were acquired by filtering off the tidal signal from the National Oceanic and Atmospheric Administration (NOAA) Trident Pier water level gauge records. The Trident Pier records processes with a 25-hour low pass filter were then added to the predicted tides. Figure 6 shows the water level records applied at the north boundary of the model, including the storm surge from the passing of Hurricane Irma in 2017. Similarly, compiled water level records were applied to both Sebastian Inlet and the Wabasso Bridge model boundaries. The period of record for the model experiments was set to 2017 due to the completeness of the available data during this year to set appropriate model boundary conditions.

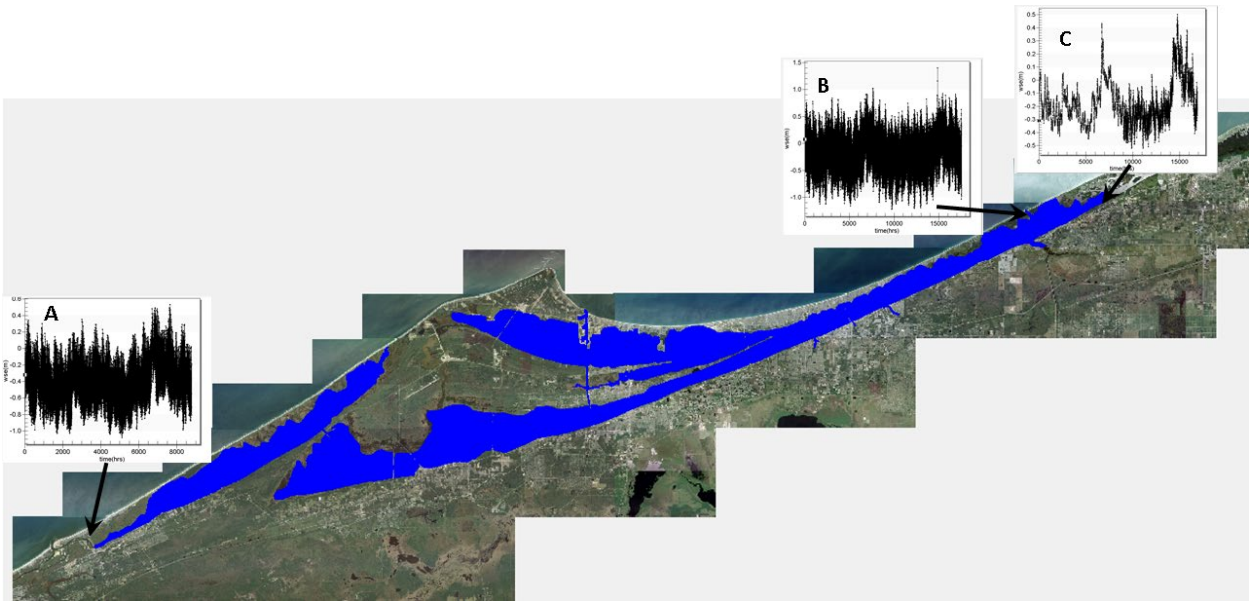


Figure 5. Configuration of the regional model grid. Water level boundary time series are shown at the New Smyrna Bridge (A), Sebastian Inlet (B) and the Wabasso Bridge (C).

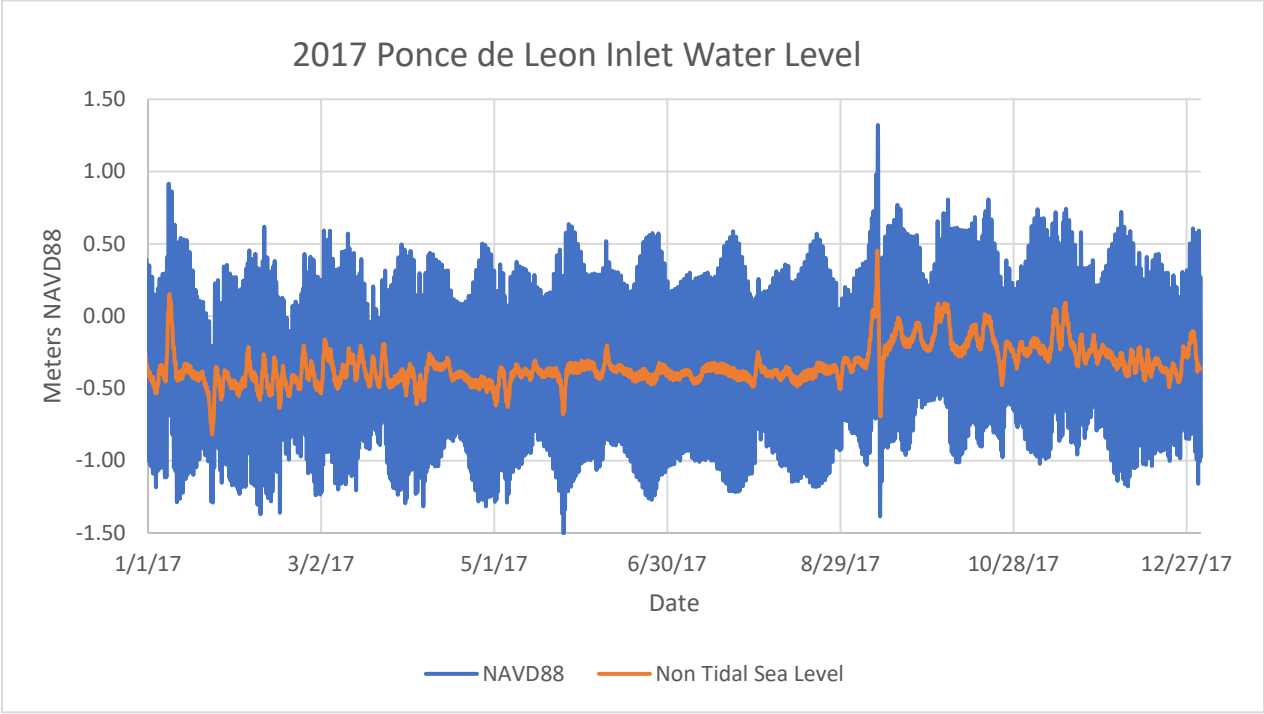


Figure 6. Water level time series applied at the north boundary of the model. Data were derived from a combination on tidal predictions and measured non-tidal data.

Wind Time Series

CMS-Flow will assimilate wind data as multiple inputs over selected cells or as global input over the entire model domain. In this study, wind records from NOAA Station 8721604 located at Cape Canaveral were applied. Wind speed from the NOAA station is shown in Figure 7 and approaching wind directions with respect to true north are shown in Figure 8.

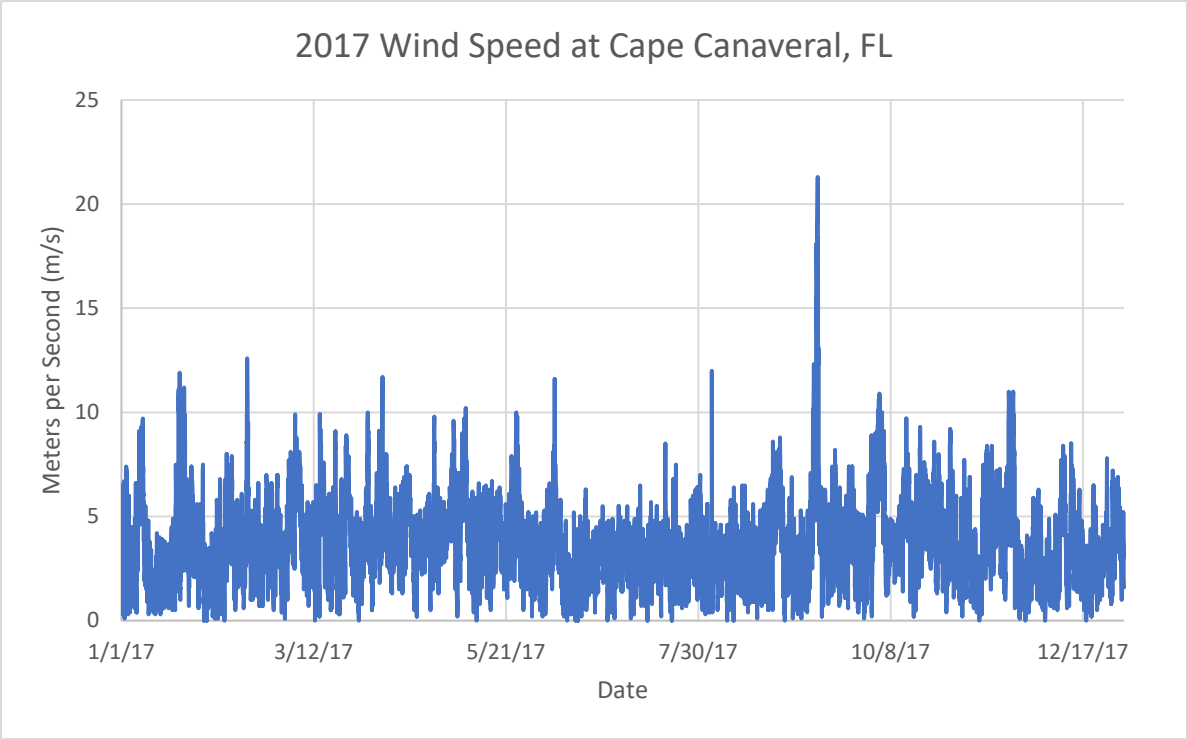


Figure 7. Wind speeds recorded at NOAA Station 8721604 Cape Canaveral, FL.

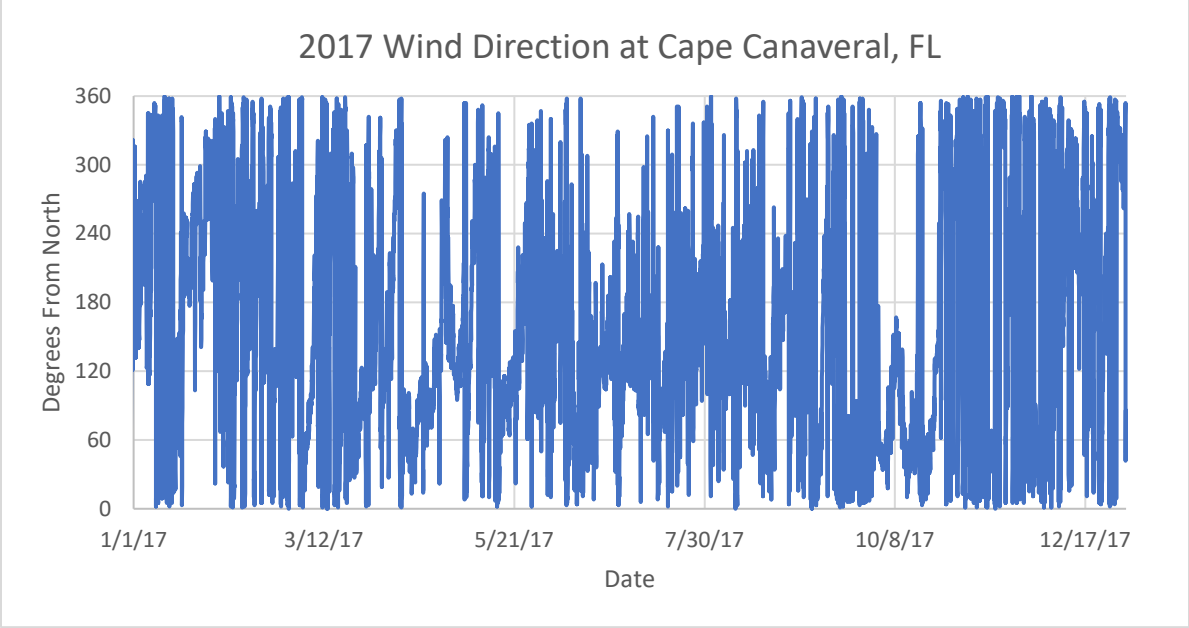


Figure 8. Wind direction recorded at NOAA Station 8721604 Cape Canaveral, FL.

Freshwater Time Series

Freshwater discharge time series were also applied as a boundary condition to the model. Records of major inflows were obtained from the United States Geological Survey (USGS) gauging stations maintained at the Eau Gallie River, Crane Creek, and Turkey Creek. In the Sebastian River, the gauged discharges from the S-157 structure and the Fellsmere Canal were combined. Gauges freshwater inflows in the north compartments of the IRL and the Banana are lacking. However, model outputs from the Spatial Watershed Iterative Loading Model or SWIL (Listopad, 2015; Zarillo & Listopad, 2018) were used to specify freshwater inflows flows for sub-basin surrounding the northern IRL and Banana River.

Model Runs

Three model runs were made starting with 2017 and then two more for conditions projected in 2040. The first run has a storm surge of about 1 meter in the coastal ocean water level boundary condition corresponding to the passage of Hurricane Irma over Florida in early September of 2017. The second model applied a projected sea level rise of 0.852 feet (0.259 meter) to the model boundary conditions according the intermediate-high projections from NOAA (Sweet *et al.*, 2017). Then the third model run had 13.1 ft (4 m) of storm surge applied in early September on top of the projected sea level rise.

Results & Discussion

2017 NEXRAD Rainfall Estimation

The bias corrected NWS NEXRAD rainfall estimates for 2017 were substantially improved over the non-bias corrected estimates (Table 4). The annual rainfall for the NEXRAD pixels in the Ransom Road area for unbiased was 25.9 inches, bias corrected was 51.2 inches, compared to the 63.4 inches recorded at the rain gauge. However, in comparison to the Ransom Road rain gauge and the SJRWMD NEXRAD estimation there was around a 12 in underestimation of rainfall. The SJRWMD NEXRAD rainfall estimation is close to the rain gauge as it was bias corrected by the OneRain proprietary process which utilized the SJRWMD rain gauge network.

Table 4 - Comparison of the annual rainfall at the Ransom Road rain gauge, SJRWMD NEXRAD 112745 cell, and the corresponding NWS NEXRAD bias corrected and non-bias corrected cells.

Site	Rainfall (in)
Ransom Road Rain Gauge	63.4
SJRWMD NEXRAD 112745	64.1
NWS NEXRAD Bias Corrected Average	51.2
NWS NEXRAD Unbiased Average	25.9

A portion of the underestimation between the NWS NEXRAD and the rain gauge can be explained by the spatial variability in the rainfall patterns between the ICPR cells (Table 5). Within the boundary of SJRWMD NEXRAD 112745 cell there was range of 18.8 in between the NEXRAD cells. The L19 cell which contains the Ransom Road rain gauge had an annual rainfall of 56.3 in while the M19 cell to the south had the much closer 63.9 in of annual rainfall. Due to the nature of a point measurement from the rain gauge and the characteristics of storms in Florida, it is not unexpected for this variability to occur (NOAA, 2017).

Table 5 - Annual rainfall of the ICPR rainfall cells in the SJRWMD NEXRAD 112745 cell. Cell L19 contains the Ransom Road rain gauge and is bolded.

Grid Y Axis	***Grid X Axis***				
	16	*17*	*18*	*19*	*20*
K	47.2	48.8	47.2	48.0	45.4
L	46.0	51.1	50.3	**56.3**	54.0
M	47.6	53.0	47.9	63.9	58.7
N	48.4	47.4	45.1	61.6	58.2
O	49.4	45.9	45.3	55.5	56.6

During 2017 the seasonality of rainfall was apparent with the wet (June-October) season totaling 53.9 in and the dry (November-May) season at 7.6 in measured at the Ransom Road rain gauge (Table 6). The dry season NWS NEXRAD bias corrected rainfall estimates were 6.9 in, similar to the Ransom Road rain gauge. The wet season estimates were 42.4 in, an underestimation of 11.5 in. The underestimation of larger and more severe storm events has been observed in Florida NEXRAD data and is partially due to wind patterns, the size of the storm, and the differing nature of how rain gauges and NEXRAD measure

rainfall (Skinner *et al.*, 2009). September and October had the highest rainfall of the year with Hurricane Irma in September and an unusually wet October. These two months also had the highest underestimation by the NWS NEXRAD bias corrected rainfall estimates.

Table 6 – 2017 Monthly rainfall accumulations between the Ransom Road rain gauge, SJRWMD NEXRAD rainfall, and the NOAA NEXRAD bias-corrected rainfall.

Month	SJRWMD Ransom Road Gauge	SJRWMD NEXRAD 112745	NOAA NEXRAD
Jan	2.1	1.9	1.9
Feb	2.7	2.6	2.1
Mar	0.9	1.0	1.0
Apr	0.1	0.2	0.2
May	1.8	1.8	1.7
Jun	9.6	9.4	8.1
Jul	6.1	6.4	6.3
Aug	8.2	8.2	8.1
Sep	16.5	16.9	12.0
Oct	13.7	13.8	7.9
Nov	1.5	1.5	1.4
Dec	0.4	0.5	0.5

Between September 8 – 11th Hurricane Irma passed over the region, with a total of 13.4 in of rainfall measured at the Ransom Road rain gauge. In ICPR cell L19, 9.3 in of rainfall was estimated to have fallen during the same period. As the spatial distribution of rainfall over the month was uniform (Table 7), it is likely that the NWS NEXRAD bias corrected rainfall estimate underestimated the hurricane rainfall.

Table 7 - Rainfall accumulation of September 2017 for the ICPR cells in the SJRWMD NEXRAD 112745 cell. Cell L19 contains the Ransom Road rain gauge and is bolded.

Grid Y Axis	***Grid X Axis***				
	16	*17*	*18*	*19*	*20*
K	12.9	11.9	11.6	11.7	11.2
L	13.2	12.7	12.0	**11.7**	11.5
M	13.2	12.3	11.9	12.1	11.7
N	13.1	11.7	11.4	12.1	11.8
O	12.8	11.5	11.3	11.5	11.8

During October 2017 there were several high rainfall storms that passed over NMI. As the spatial distribution of rainfall in Table 8 shows, these storms did not pass equally over the area and appear to have resulted in a higher accumulated rainfall in the east to southeast of the cell. The Florida wet season is characterized by intense storms with smaller footprints and the spatial variation in rainfall in the cells the result of one or more of these types of storms.

Table 8 - Rainfall accumulation of October 2017 for the ICPR cells in the SJRWMD NEXRAD 112745 cell. Cell L19 contains the Ransom Road rain gauge and is bolded.

Grid Y Axis	***Grid X Axis***				
	16	*17*	*18*	*19*	*20*
K	4.3	6.5	5.5	7.5	5.4
L	4.7	4.5	4.3	**11.4**	10.6
M	5.3	6.0	4.4	14.4	12.0
N	5.5	5.0	4.9	16.6	13.9
O	5.6	6.8	6.2	14.0	12.6

Overall hourly NWS NEXRAD bias corrected rainfall estimates exhibit a pattern of underestimation of rainfall in 2017 when compared to the measured rainfall at the Ransom Road rain gauge (Figure 9). With more intense storms there does appear to be a consistent pattern of over and under estimation between the two datasets. With a correlation of 0.72, there is still an overall good agreement between the estimated and measured rainfall.

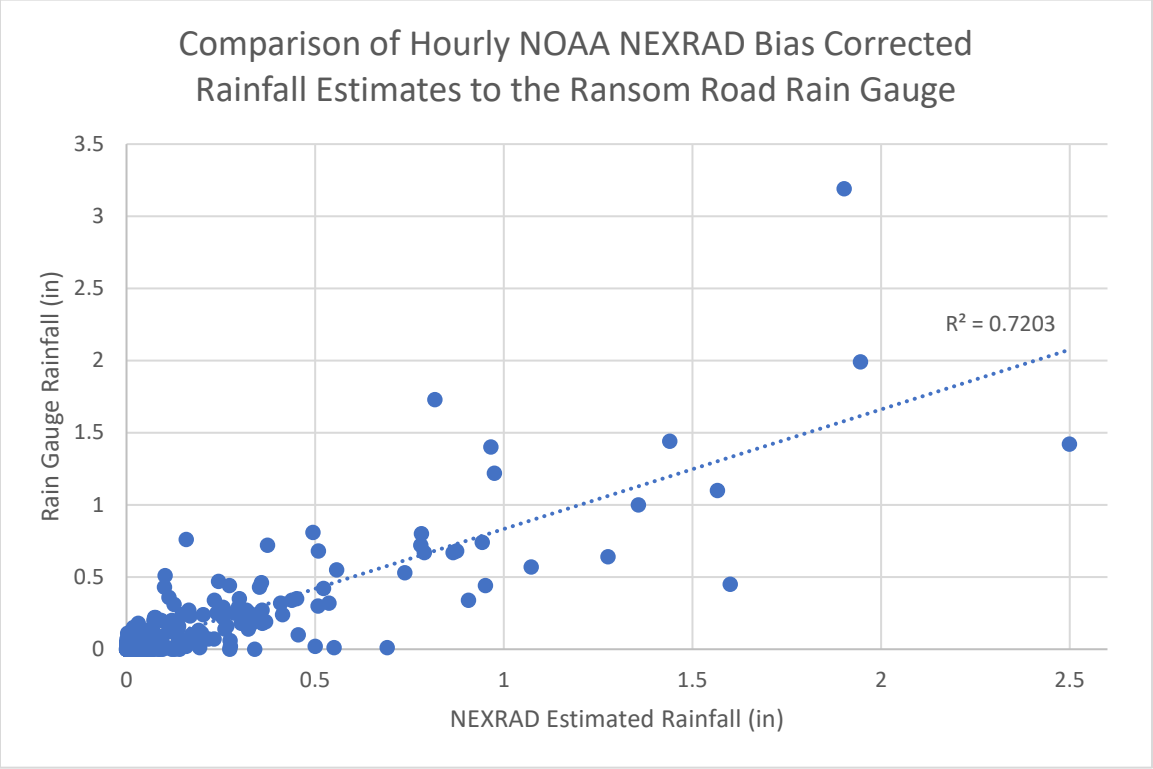


Figure 9 – Paired NWS NEXRAD bias corrected rainfall estimates in 2017 with measurements at the SJRWMD Ransom Road rain gauge.

August 16, 2017 was chosen to reflect the excellent agreement between measured and estimated rainfall during an average storm event. The day's accumulated rainfall was 4.1 in at the Ransom Road rain gauge and 4.3 in for the NWS NEXRAD bias corrected cell L19. There were two distinct periods of rain between 17:00 – 23:00. The NEXRAD estimation was summarized to every 15 minutes as the rain gauge collects data at this interval. Rainfall intensity varied over the course of the storm and between the measurement methods which is expected from the two systems.

Table 9 – Rainfall accumulations in inches at the SJRWMD Ransom Road rain gauge and the NWS NEXRAD bias corrected rainfall estimate for August 16, 2017 at a 15-minute timestep. Two storm events are shown, starting at 5 PM and 9:30 PM.

Date	Ransom Road Rain Gauge	NWS NEXRAD Bias Corrected Rainfall Estimate
8/16/2017 17:00	0.0	0.0
8/16/2017 17:15	0.7	0.8
8/16/2017 17:30	1.0	1.0
8/16/2017 17:45	0.3	0.2
8/16/2017 18:00	0.0	0.0
8/16/2017 21:30	0.0	0.1
8/16/2017 21:45	0.5	1.0
8/16/2017 22:00	0.9	0.7
8/16/2017 22:15	0.8	0.6
8/16/2017 22:30	0.0	0.0
8/16/2017 22:45	0.0	0.0
Daily Total	**4.1**	**4.3**

2040 Synthetic Simulation of Future Rainfall

CMIP5 projected rainfall patterns in 2040 and 2041 were able to represent a La Niña dry year and El Niño wet year, respectively (Figure 10). From 2017 to 2040 the annual precipitation is projected to decrease by 6% and to 2041 an increase of 3%. For both 2040 and 2041, the dry season (Nov-May) is projected to be drier overall. The 2041 wet year projection of June is to be 35% wetter than the 2017 project baseline.

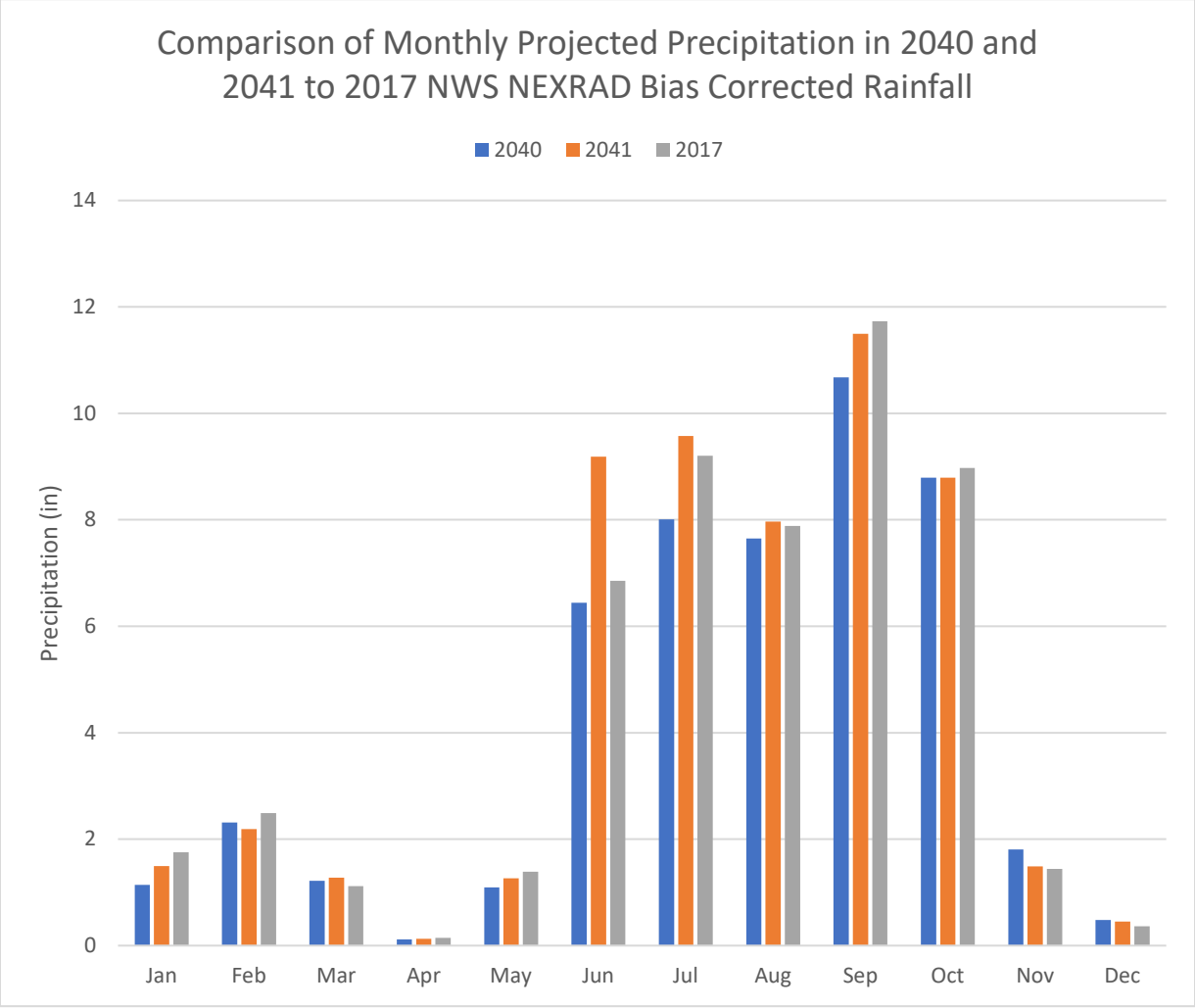


Figure 10 – Comparison of projection adjusted NEXRAD rainfall estimates for 2040 (Dry year) and 2041 (Wet year) to 2017 NWS NEXRAD bias corrected rainfall estimates.

Table 10 – Projected percent rainfall over North Merritt Island in 2040 and 2041 relative to 2017.

Month	2040	2041
Jan	65%	85%
Feb	93%	90%
Mar	110%	117%
Apr	79%	86%
May	79%	93%
Jun	95%	135%
Jul	87%	104%
Aug	98%	102%
Sep	91%	99%
Oct	98%	99%
Nov	122%	103%
Dec	129%	122%
Annual	**94%**	**103%**

2017 Stage Level Simulation

Continuous Monitoring Stations

The estimated surface water stages monthly statistics for BR and NIRL in 2017 are shown in Table 11 and Table 12, respectively. The time series largely reflects the expected variability on both the short and long term. On a week-by-week basis, basin stages are expected to vary due to wind strength and direction along with rainfall (Weaver *et al.*, 2016). This is observed in both the BR (Figure 11) and NIRL (Figure 12) throughout the year. There is a notable deviation between NIRL and BR estimated stages starting in January and continuing to March, with BR estimated to be continually higher than NIRL (Figure 13). After Hurricane Irma in September the deviation in estimated stage between the two basins returns with NIRL having a higher estimated stage for the remainder of the year.

These surface water stages contain significant sources of error and represent the best available estimations of stage for the NIRL and BR around NMI. This data was created from measurement of sensor depth and the strain gauge style sensor that the CM stations use to measure depth can have drift and biofouling issues. The CM station location changed in Banana River in March, which corresponds with the decrease in estimated water stage for the basin. The estimated surface water stages from the CM stations can show general trends in the estimated stage but have notable error in the beginning and end of the time series.

Table 11 - Banana River Continuous Monitoring Stations "Merritt Island Causeway at SR 520 (WQ)" (Station ID 33964621) and "IRLB04 Banana River (WQ)" (Station ID 33844736) surface stage summary statistics by month in meters NAVD88.

Month	Average	Max	Min	Std Dev
Jan	-0.14	0.02	-0.39	0.09
Feb	-0.21	-0.03	-0.39	0.06
Mar	-0.18	-0.01	-0.38	0.08
Apr	-0.21	-0.15	-0.29	0.03
May	-0.33	-0.17	-0.45	0.05
Jun	-0.25	-0.05	-0.39	0.07
Jul	-0.31	-0.18	-0.42	0.05
Aug	-0.26	-0.14	-0.37	0.05
Sep	-0.03	0.32	-0.23	0.14
Oct	0.02	0.26	-0.29	0.14
Nov	-0.20	-0.08	-0.30	0.05
Dec	-0.30	-0.07	-0.47	0.11

Table 12 – North Indian River Lagoon (NIRL) Continuous Monitoring station "Titusville Max Brewer Memorial Parkway (WQ)" (Station ID 33954622) 2017 surface stage summary statistics by month in meters NAVD88.

Month	Average	Max	Min	Std Dev
Jan	-0.26	-0.09	-0.52	0.10
Feb	-0.36	-0.16	-0.53	0.07
Mar	-0.31	-0.18	-0.47	0.07
Apr	-0.19	-0.03	-0.36	0.07
May	-0.25	-0.05	-0.40	0.07
Jun	-0.17	-0.02	-0.26	0.05
Jul	-0.25	-0.06	-0.43	0.09
Aug	-0.30	-0.13	-0.40	0.06
Sep	0.01	0.29	-0.29	0.18
Oct	0.20	0.44	-0.17	0.13
Nov	-0.03	0.11	-0.16	0.06
Dec	-0.07	0.14	-0.28	0.09

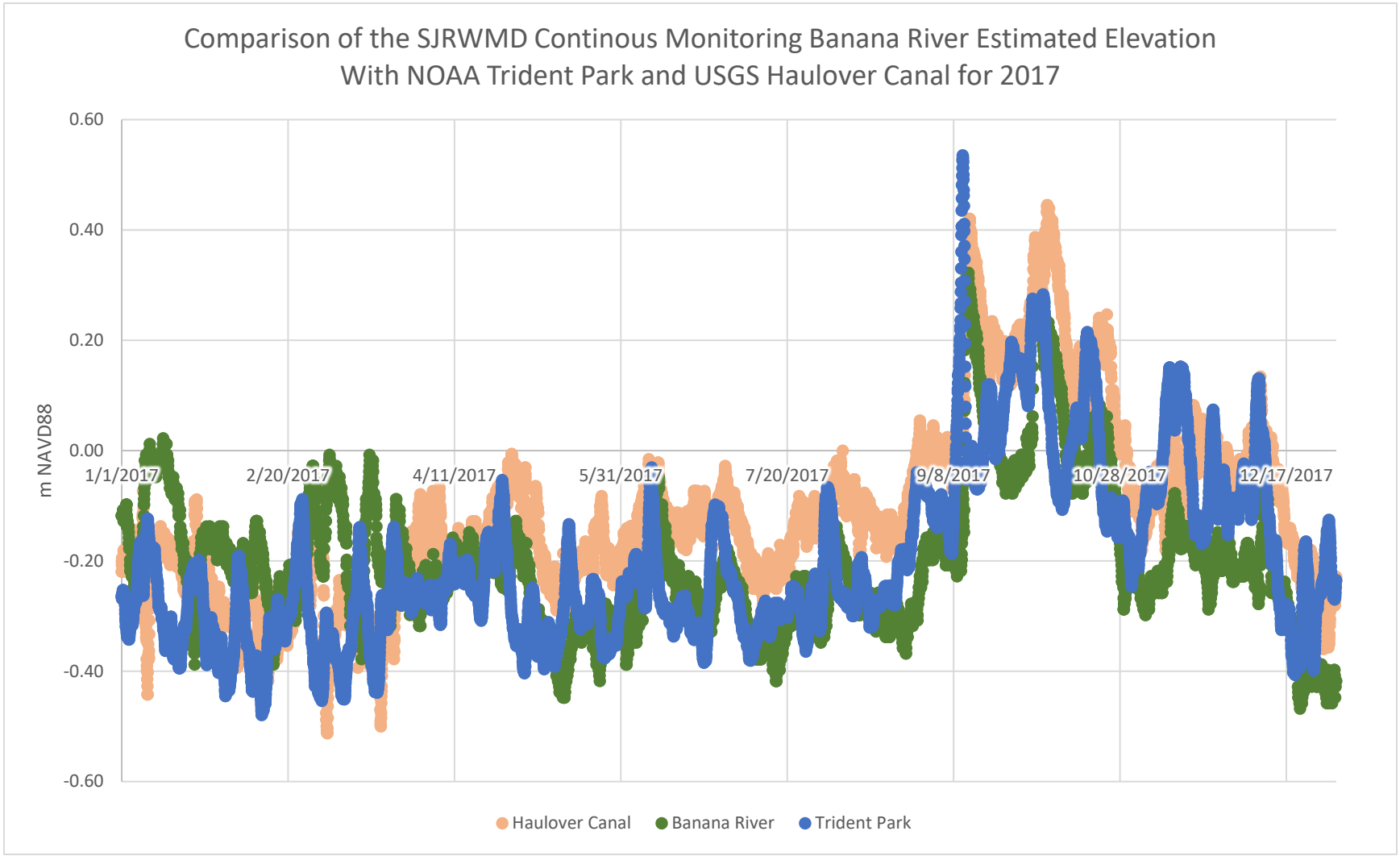


Figure 11- Water level estimations in m NAVD88 for the Banana River (East) side of North Merritt Island for 2017 from the SJRWMD Continuous Monitoring (CM) stations compared against the NOAA Trident Park and USGS Haulover Canal readings.

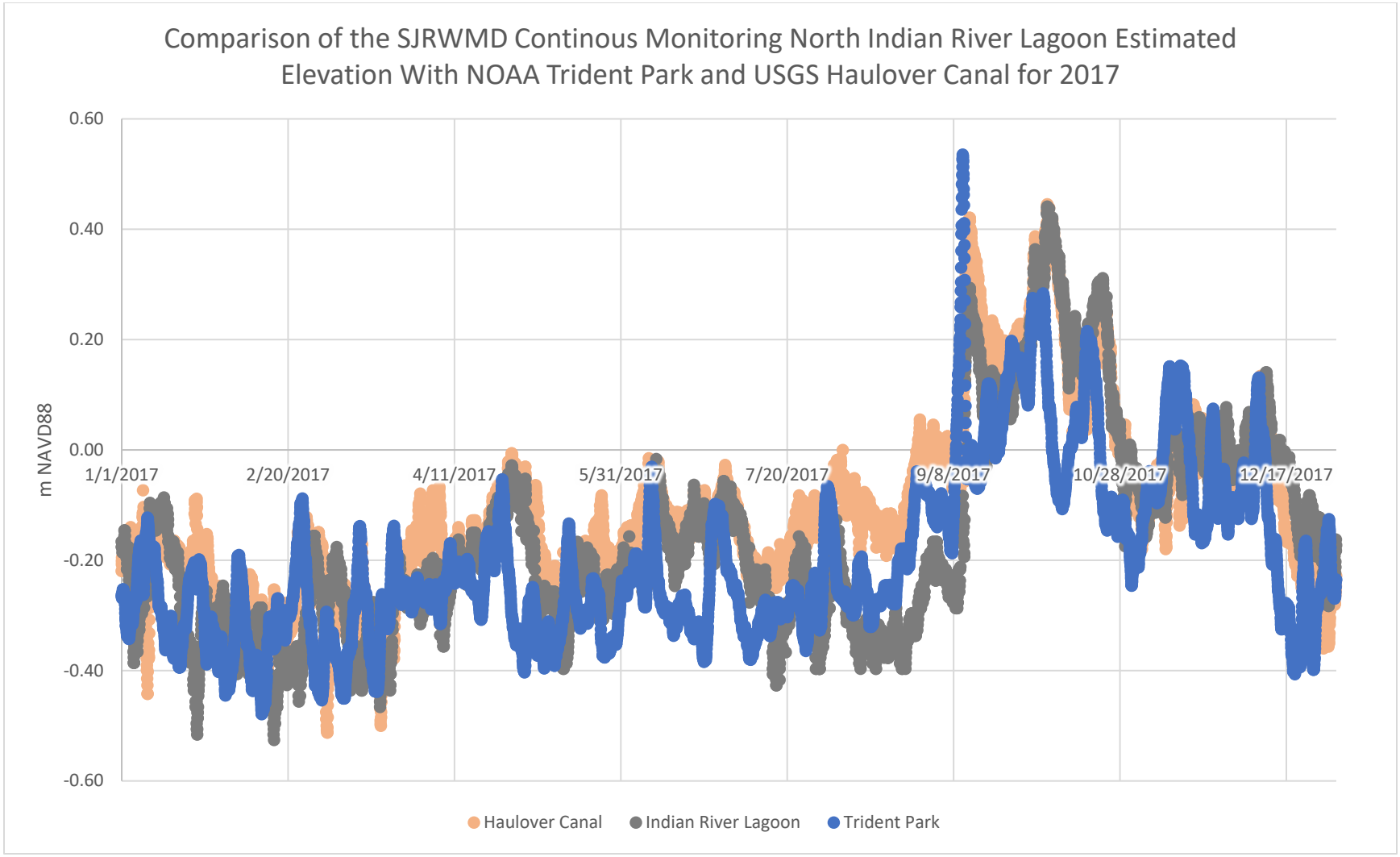


Figure 12 – Water level estimations in m NAVD88 for the Indian River Lagoon (West) side of North Merritt Island for 2017 from the SJRWMD Continuous Monitoring (CM) stations compared against the NOAA Trident Park and USGS Haulover Canal readings.

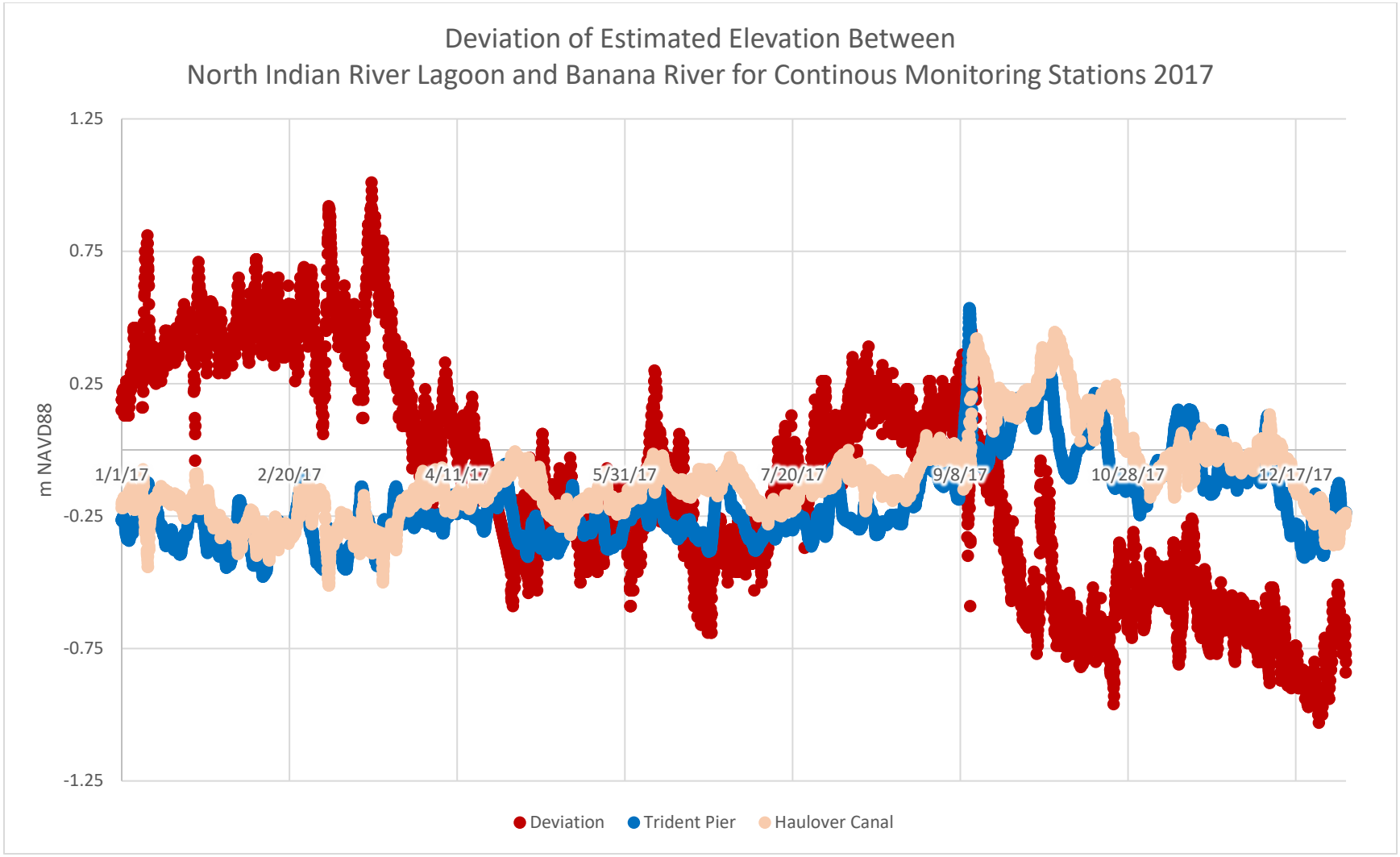


Figure 13 - Water level estimation deviation in m NAVD88 from the North Indian River Lagoon (West) and Banana River (East) side of North Merritt Island for 2017 from the SJRWMD Continuous Monitoring (CM) stations.

Coastal Modeling System (CMS) Model

The CMS model has been previously calibrated with respect to the match between predicted and measured water levels (Zarillo, 2015, 2018). To further verify the model calibration, measured water levels at the USGS monitoring station at Haulover Canal were compared to model predictions for 2017 (Figure 14). The Haulover Canal connects the north compartment of the IRL with the southern compartment of the Mosquito Lagoon and is the water level monitoring station closest to North Merritt Island (NMI). No vertical adjustments or filters were applied to either the measured or model data before making the comparison. The comparison is considered very good considering the limitations of both the model and measured data.

Both the model and measured data capture the annual sea level cycle that includes the typically low sea levels of late July, followed by high sea levels in late October. The sea level shifts are related to the dynamics of the Gulf Stream as explained by Ezer *et al.* (2013). There is little to no tidal signal in both the observed and model data. The low frequency season shifts of sea level in the coastal ocean are not filtered by the tidal inlets of the IRL system and propagate throughout the system. The annual sea level cycle can be as large as 1 meter and drives water mass exchanges with the coastal ocean over a 12-month period. Shorter term circulation patterns in the IRL can be attributed to wind forcing as well as tidal water flow near inlets. Although the trend of the model data is slightly below the observed data for portions of 2017, there is a good correlation between observed and model data.

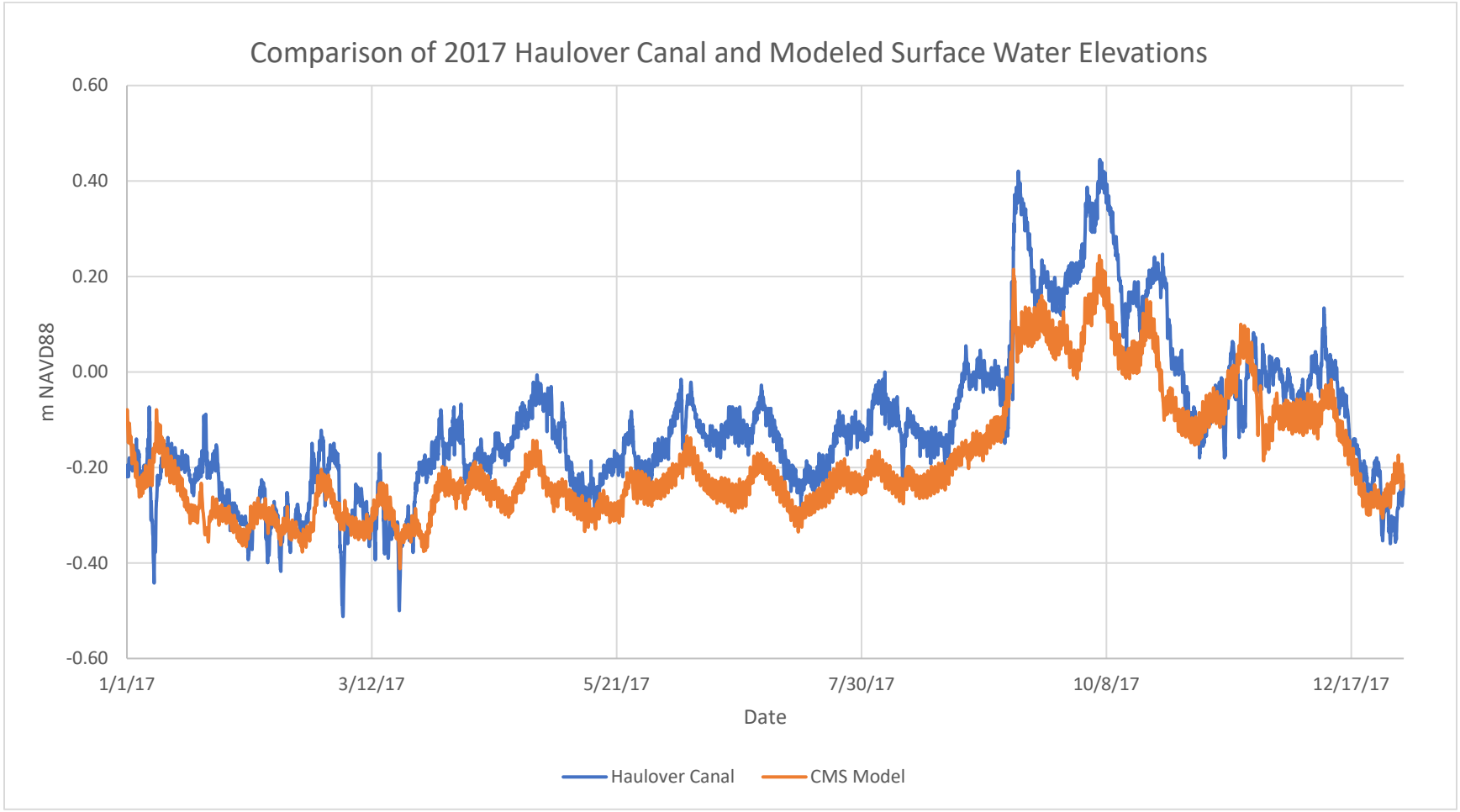


Figure 14 - Comparison of 2017 measured and model water level data at Haulover Canal. R-value is 0.91 and R2 value is 0.84.

The 2017 monthly summary statistics of the modeled stages for NIRL and BR are shown in Table 13 and Table 14, respectively. Over 2017 the modeled stage between the two basins trended closely (Figure 15) and under normal conditions typically varied less than 10 cm (Figure 16). This contrasts with the variation in the continuous monitoring estimated stages.

Table 13 – North Indian River Lagoon (NIRL) modeled surface stage summary statistics by month in meters NAVD88.

Month	Average	Max	Min	Std Dev
Jan	-0.23	-0.04	-0.33	0.06
Feb	-0.30	-0.20	-0.36	0.04
Mar	-0.31	-0.20	-0.40	0.03
Apr	-0.21	-0.11	-0.27	0.03
May	-0.26	-0.17	-0.33	0.03
Jun	-0.21	-0.12	-0.28	0.04
Jul	-0.23	-0.14	-0.32	0.04
Aug	-0.18	-0.06	-0.25	0.04
Sep	0.09	0.46	-0.12	0.13
Oct	0.11	0.30	-0.12	0.11
Nov	-0.03	0.13	-0.17	0.07
Dec	-0.15	0.04	-0.32	0.10
Annual	**-0.16**	**0.46**	**-0.40**	**0.15**

Table 14 – Banana River (BR) modeled surface stage summary statistics by month in meters NAVD88

Month	Average	Max	Min	Std Dev
Jan	-0.22	-0.03	-0.33	0.06
Feb	-0.30	-0.19	-0.37	0.04
Mar	-0.32	-0.15	-0.44	0.04
Apr	-0.21	-0.10	-0.27	0.04
May	-0.25	-0.13	-0.33	0.04
Jun	-0.21	-0.11	-0.28	0.04
Jul	-0.23	-0.14	-0.32	0.04
Aug	-0.18	-0.04	-0.26	0.05
Sep	0.09	0.47	-0.12	0.14
Oct	0.11	0.31	-0.13	0.10
Nov	-0.04	0.14	-0.19	0.07
Dec	-0.14	0.05	-0.33	0.11
Annual	**-0.16**	**0.47**	**-0.44**	**0.15**

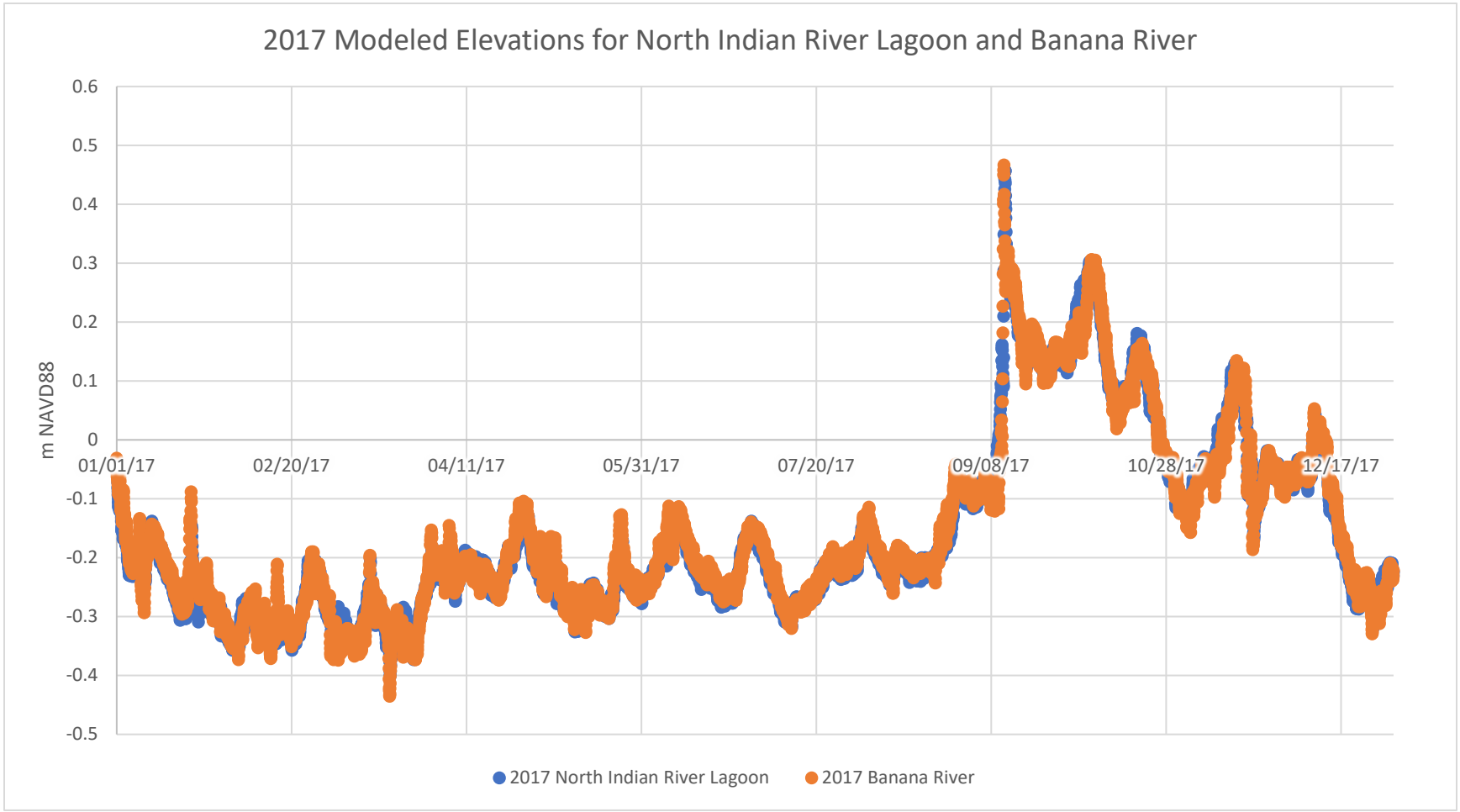


Figure 15 – Comparison of the 2017 modeled stages of the North Indian River Lagoon (NIRL) and Banana River (BR).

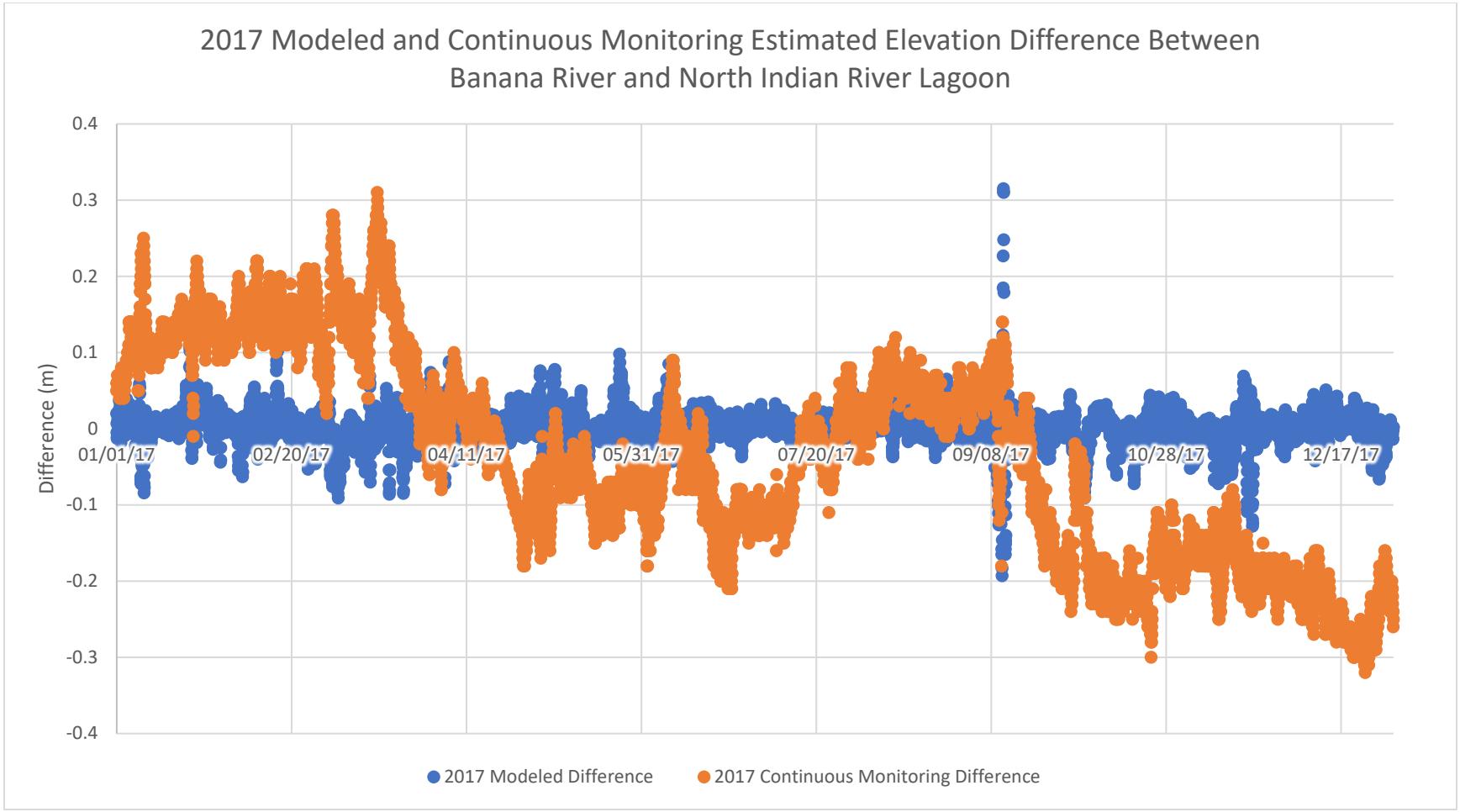


Figure 16 – Comparison of the 2017 differences between Banana River (BR) and North Indian River Lagoon (NIRL) for modeled and continuous monitoring estimated stages.

2040 Synthetic Simulation of Future Stage Level

Summary statistics for 2040 under average conditions for NIRL and BR are listed in Table 15 and Table 16, respectively. The modeled 2040 surface water stages under average conditions are displayed in Figure 17 and with an extreme storm surge event in Figure 18. Model results for NIRL and BR were similar, varying in stage by not more than about 5 cm except under the extreme storm surge event Maximum storm surge stages reached about 2 m above normal levels in the IRL west of Merritt Island. In the BR to the east of Merritt Island, maximum predicted surge levels are about 1.5 m above normal levels. Although storm surge is known to penetrate though the IRL system, storm surge is attenuated as it moves north through the narrow entrance to the BR.

Table 15 - North Indian River Lagoon (NIRL) 2040 modeled average condition surface stage summary statistics by month and annually in meters NAVD88.

Month	Average	Max	Min	Std Dev
Jan	0.02	0.13	-0.08	0.05
Feb	-0.04	0.08	-0.11	0.04
Mar	-0.05	0.07	-0.16	0.04
Apr	0.05	0.15	-0.02	0.03
May	0.00	0.09	-0.08	0.03
Jun	0.04	0.15	-0.04	0.04
Jul	0.02	0.12	-0.07	0.04
Aug	0.07	0.20	0.01	0.05
Sep	0.35	0.76	0.14	0.13
Oct	0.37	0.58	0.14	0.11
Nov	0.23	0.41	0.07	0.07
Dec	0.11	0.31	-0.07	0.10
Annual	**0.10**	**0.76**	**-0.16**	**0.16**

Table 16 - Banana River 2040 modeled average condition surface stage summary statistics by month and annually in meters NAVD88.

Month	Average	Max	Min	Std Dev
Jan	0.03	0.17	-0.07	0.05
Feb	-0.04	0.08	-0.12	0.05
Mar	-0.06	0.11	-0.18	0.05
Apr	0.05	0.16	-0.02	0.04
May	0.00	0.13	-0.07	0.04
Jun	0.05	0.15	-0.03	0.05
Jul	0.03	0.12	-0.07	0.05
Aug	0.08	0.22	0.00	0.05
Sep	0.35	0.74	0.14	0.14
Oct	0.37	0.58	0.14	0.10
Nov	0.22	0.41	0.07	0.07
Dec	0.11	0.32	-0.07	0.11
Annual	**0.10**	**0.74**	**-0.18**	**0.15**

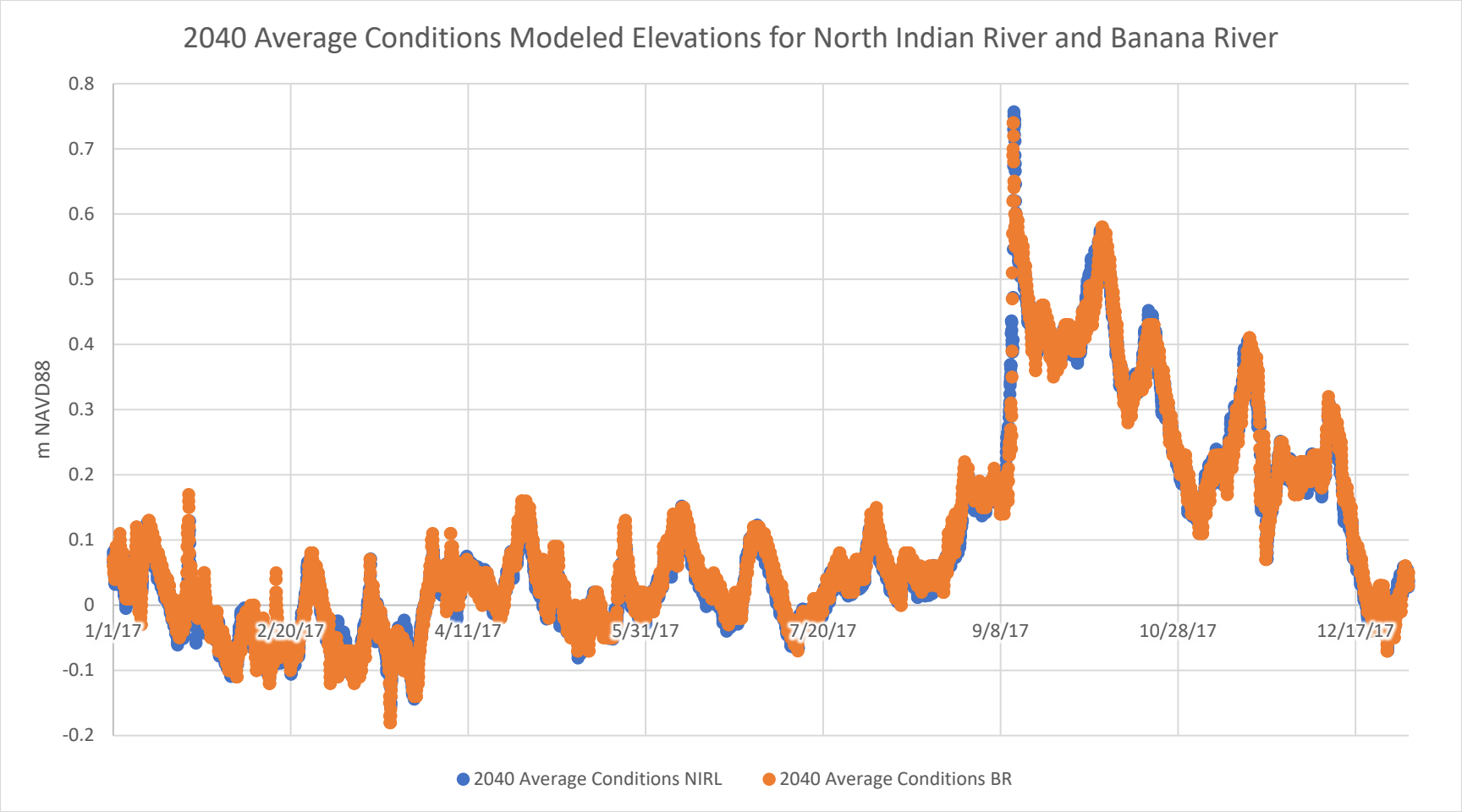


Figure 17 – Comparison of the 2040 North Indian River Lagoon (NIRL) and Banana River (BR) modeled stages under average conditions.

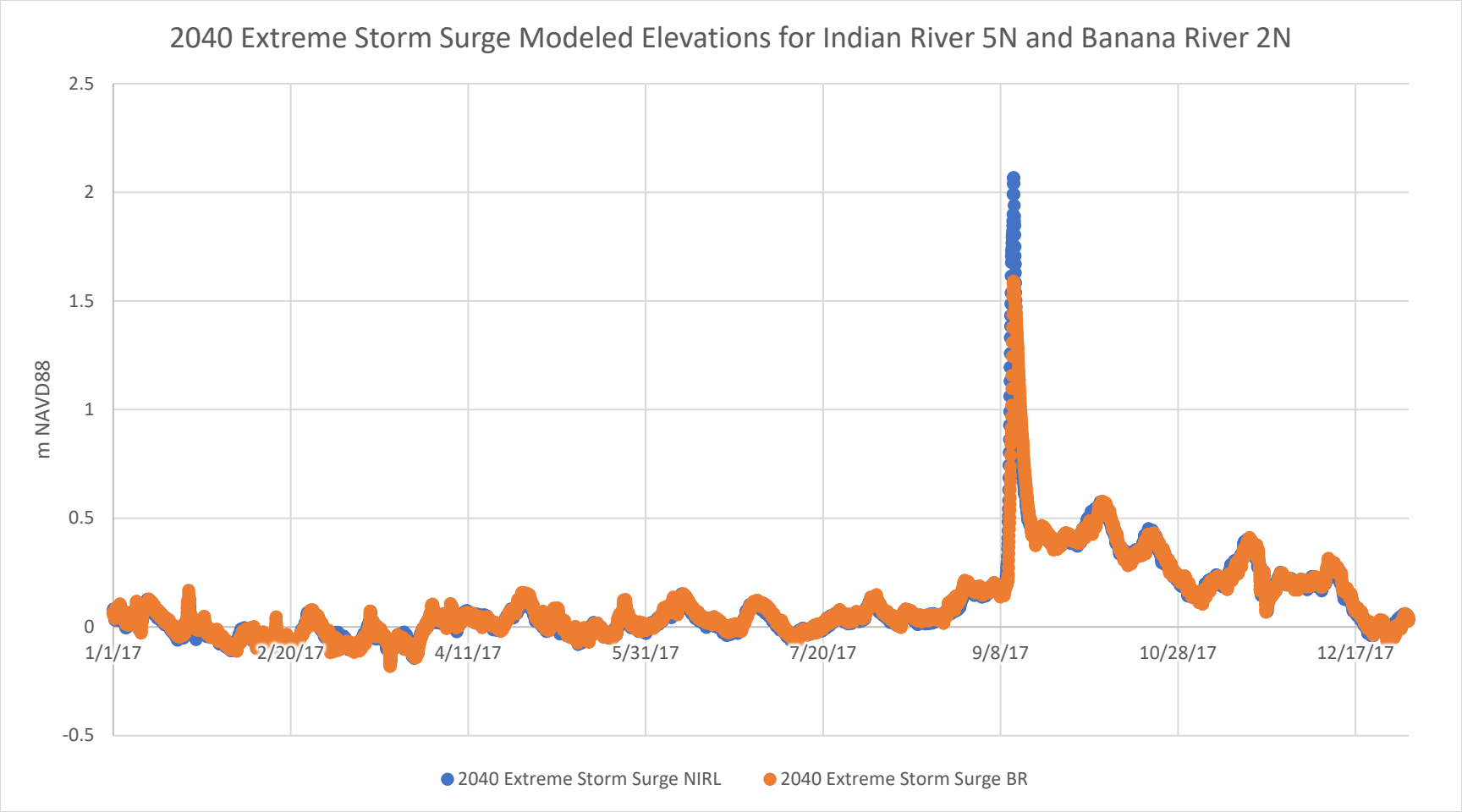


Figure 18 - Comparison of the 2040 North Indian River Lagoon (NIRL) and Banana River (BR) modeled stages with an extreme storm surge.

Summary

The estimation of rainfall and modeled surface water stage for 2017 and 2040 should provide reliable inputs to the ICPR4 model for the NMI area. Rainfall, surface water stage estimations, and models for NMI utilized a variety of datasets to overcome sparse data availability. The NWS NEXRAD rainfall estimates were able to provide a spatially and temporally high-resolution coverage over the NMI area. The SJRWMD Continuous Monitoring (CM) station 2017 estimated stages were able to capture the short-term variations in stage, but the Coastal Modeling System Flow (CMS-Flow) modeled stages were more representative of long-term trends.

The resulting rainfall surfaces were validated against the SJRWMD Ransom Road rain gauge station, with a R^2 of 0.72 between the hourly bias-corrected rainfall estimates and gauge readings for all of 2017. A pattern of underestimation was identified with an annual rainfall of 63.4 inches (1,610 mm) measured at the rain gauge, and the bias-corrected rainfall estimated 51.2 inches (1,300 mm). While there is underestimation of Hurricane Irma, this could be due to the extreme conditions experienced at the rain gauge and other factors confounding NEXRAD. Additionally, due to the higher spatial resolution of the NEXRAD DAA and the small footprint, intense storm characteristic of Florida could result in the one rain gauge missing storm events.

Both the CM and CMS-Flow stage estimations averaged -0.79 ft (-0.24 m) NAVD88 for both NIRL and BR from January to August, captured the storm surge from Hurricane Irma, and detected the late October Gulf Stream high sea levels. The CM estimated stages between NIRL and BR for several months ranged between 0.82 – 2.46 ft (0.25 – 0.75 m) NAVD88, compared to the 1-3 day long 0.32 in (10 cm) variation in the CMS-Flow model. The CMS-Flow model was validated against the USGS Haulover Canal station with a R^2 value of 0.84 though with a 0.32 in (10 cm) underestimation of stage throughout the year.

The 2017 Multi Model Mean (MMM) was chosen as the baseline and the projected annual increase of 3% to 2040 was used as the wet year and 6% decrease to 2041 used for the dry year. The 2040 surface water stages were generated in the CMS-Flow model using a 0.852 ft (0.259 m) sea level rise from the NOAA intermediate-high projection. NIRL and BR continued to have similar variations in the modeled 2040 series as they did in the 2017 model. A second 2040 model was run that applied an extreme storm surge of 13.1 ft (4 m) to the system, which identified BR as having a 1.6 ft (0.5 m) lower projected stage than NIRL during the storm surge.

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Appendix D
Field Data Collection Memorandum
prepared by Atkins, December 2020

ATKINS
Member of the SNC-Lavalin Group

Field Data Collection Memo

To:	Allyson Hunt, PE		
From:	Joe Walter, PE	Email:	joe.walter@atkinsglobal.com
Date:	30 December 2020	Phone:	407-806-4486
Ref:	Atkins Project100071502	cc:	Chris Thompson, PE File
Subject:	**North Merritt Island Field Data Review**		

The purpose of this memo is to summarize the field data collection effort as part of the North Merritt Island Basin Update. Field crews visited 85 sites where data evaluated from SWAMP database or ERP documentation was inconsistent or absent. Field crews photographed and documented each hydraulic feature visited noting condition, material and dimensions. As appropriate crews also verified drainage patterns where available digital data proved inconclusive or did not provide enough information to determine the drainage pattern. Depending upon the field observations, recommendations were made to provide immediate maintenance and/or provide a survey of the observed structures. **Figure 1** provides a spatial view of the links visited.

Table 1 summarizes the data collection effort indicating model link name, type of structure, SWAMP feature ID, date surveyed, and the recommendation to survey or provide maintenance. Field data collection sheets, including field data collection notes and structure photograph are provided in **Appendix A**. As a separate attachment, the feature class for the field visits, survey recommendations, and maintenance recommendations are provided in the NMI_fieldCollection.mdb geodatabase.

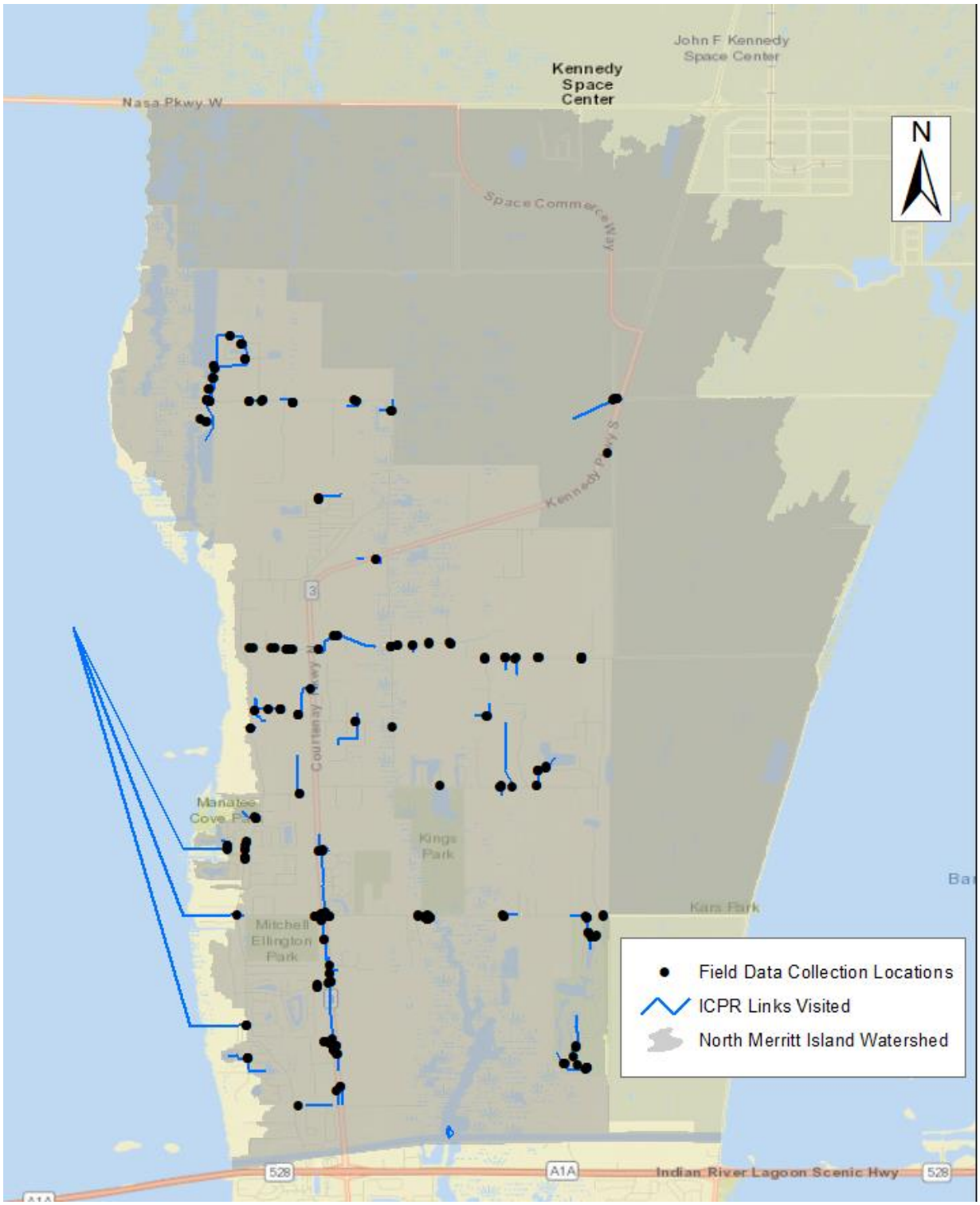


Figure 1: North Merritt Island Field Data Collection Sites

Table 1: North Merritt Island Field Data Collection Summary

Link Name	Link Type	SWAMP ID	Date Visited	Survey	Maint
DSykesN_1	Drop Structure	BCE602CS110	05-Nov-20		
DSykesN_2	Drop Structure	BCE602CS109	05-Nov-20		
DSykesN_3	Drop Structure	BCE602CS108	05-Nov-20		
DSykesS_1	Drop Structure	BCE611CS012		Y	
DSykesS_2	Drop Structure	BCE611CS010		Y	
DSykesS_3	Drop Structure	BCE611CS008		Y	
DB1000_1	Drop Structure	233634CU44AB	03-Nov-20		
PB2020_1	Pipe	P016D634021022	03-Nov-20		Y
PB4040_1	Pipe	233634CU47AB	03-Nov-20	Y	Y
WB3060_1	Weir	Not in SWAMP	03-Nov-20		Y
PC1020_1	Pipe	P040E602086085	05-Nov-20		
PC1060_1	Pipe	0000CU0000	03-Nov-20		
PC1080_1	Pipe	NO FEATURE CODE	03-Nov-20		Y
PC1085_1	Pipe	P018D627035032	03-Nov-20		
PC1090_1	Pipe	In SWAMP wo Feature Code	03-Nov-20		
PC1092_1	Pipe	Not in SWAMP	03-Nov-20	Y	Y
PC1130_1	Pipe	Not in SWAMP	03-Nov-20	Y	Y
PC1160_1	Pipe	In SWAMP wo Feature Code	03-Nov-20	Y	Y
PCC1100_1	Pipe	Not in SWAMP	03-Nov-20		
PD1070_1	Pipe	0000CU0000	03-Nov-20		Y
PDD1002_1	Pipe	BC233624CU009	03-Nov-20	Y	Y
PDD1010_1	Pipe	BC233624CU008	03-Nov-20	Y	
PDD3315_1	Pipe	P015D623029030	03-Nov-20		Y
PDD3335_1	Pipe	P021D623042041	03-Nov-20		Y
PDD3345_1	Pipe	P012D623024023	03-Nov-20		Y
PDD3405_1	Pipe	P007D623013014	03-Nov-20		Y
DEE3100_1	Drop Structure	BCE611CS048	05-Nov-20		
PEE1060_1	Pipe	P094D634135133	03-Nov-20		Y
PEE3010_1	Pipe	Not in SWAMP	05-Nov-20		
PEE3010_2	Pipe	P052E602100081	05-Nov-20		
PEE3020_1	Pipe	In SWAMP wo feature code	03-Nov-20	Y	
PEE3030_2	Pipe	Not in SWAMP	05-Nov-20		
PEE3040_1	Pipe	In SWAMP wo feature code	03-Nov-20	Y	Y
PEE3110_1	Pipe	BCE611CS047	05-Nov-20		
PEE3280_1	Pipe	Not in SWAMP	03-Nov-20	Y	Y
PEE3310_1	Pipe	Not in SWAMP	05-Nov-20		
PEE4160_1	Pipe	P161E603217218	03-Nov-20	Y	Y
PEE5060_1	Pipe	P023E610033034	03-Nov-20	Y	Y

Link Name	Link Type	SWAMP ID	Date Visited	Survey	Maint
PEE5060_2	Pipe	P025E610039040	03-Nov-20	Y	Y
DF1180_1	Drop Structure	BCD623CS135	03-Nov-20		
PF2080_1	Pipe	P053D626110109	05-Nov-20		
PF2110_1	Pipe	NO FEATURE CODE	03-Nov-20		Y
PF2110_2	Pipe	Not in SWAMP	03-Nov-20		
DFF1060_1	Drop Structure	BCE602CS158	05-Nov-20		
DFF1090_1	Drop Structure	BCE602CS146	05-Nov-20		
DFF1230_1	Drop Structure	BCE611CS096	05-Nov-20		Y
PFF1010_2	Pipe	P047E602080077	05-Nov-20		
PFF1060_1	Pipe	P088E602133134	05-Nov-20	Y	
PFF1180_1	Pipe	P042E611074075	05-Nov-20		Y
PFF1210_1	Pipe	P045E611079080	05-Nov-20		Y
WFF2010_1	Weir	BCE602CS111	05-Nov-20		
DG1840_1	Drop Structure	BCE602CS069	05-Nov-20		
DG6050_1	Drop Structure	P130D63516816	03-Nov-20		
PG1790_1	Pipe	P035E602091088	05-Nov-20		
PG6040_1	Pipe	P110D635140141	05-Nov-20		
DGG1030_1	Drop Structure	BCE601CS001	05-Nov-20		
PGG1010_1	Pipe	P001E601011010	05-Nov-20	Y	
PGG1020_1	Pipe	0000CU0000	05-Nov-20		
PGG1060_2	Pipe	Not in SWAMP	05-Nov-20		Y
PGG1110_2	Pipe	P004E612005006	05-Nov-20		
PGG1150_1	Pipe	P014E612021022	05-Nov-20		Y
DJ1900_1	Drop Structure	BCE601CS086	05-Nov-20		
DL1270_1	Drop Structure	BCD625CS092	05-Nov-20		
DL1790_1	Drop Structure	BCD625CS099	05-Nov-20	Y	
PL1345_1	Pipe	BC233625CU010	03-Nov-20	Y	Y
PM2940_1	Pipe	0000CU0000	03-Nov-20		
PM2970_1	Pipe	P006D624008007	03-Nov-20		Y
PM2980_1	Pipe	0000CU0000	03-Nov-20	Y	Y
PM3000_1	Pipe	0000CU0000	03-Nov-20	Y	Y
PO1300_1	Pipe	Not in SWAMP	05-Nov-20		
PO2960_1	Pipe	Not in SWAMP	03-Nov-20	Y	
PO3030_2	Pipe	BC233636CU003	05-Nov-20	Y	
PP2641_1	Pipe	P024D626038037	05-Nov-20		
PP2641_2	Pipe	P023D626036039	05-Nov-20		
DPI1030_2	Drop Structure	BCE610CS011	03-Nov-20		
DPI1030_3	Drop Structure	BCD610CS001	03-Nov-20		
DPI2020_1	Drop Structure	0000CU000	03-Nov-20		

Link Name	Link Type	SWAMP ID	Date Visited	Survey	Maint
PPI2010_1	Pipe	0000CU0000	03-Nov-20	Y	Y
PPI2010_2	Pipe	0000CU0000	03-Nov-20	Y	Y
PPI2020_3	Pipe	P015D610016017	03-Nov-20		
PR3200_1	Pipe	0000CU0000	03-Nov-20	Y	
DS1140_1	Drop Structure	0000SC0000	03-Nov-20	Y	
PT2440_2	Pipe	0000CU0000	03-Nov-20		
DU4030_1	Drop Structure	Not in SWAMP	03-Nov-20		
PU1120_1	Pipe	Not in SWAMP	03-Nov-20		
PU2450_1	Pipe	0000CU0000	03-Nov-20		
PU4220_1	Pipe	0000CU0000	03-Nov-20	Y	Y
PZZ2010_1	Pipe	Not in SWAMP	03-Nov-20		

Appendix A: NMI Field Data Collection Forms

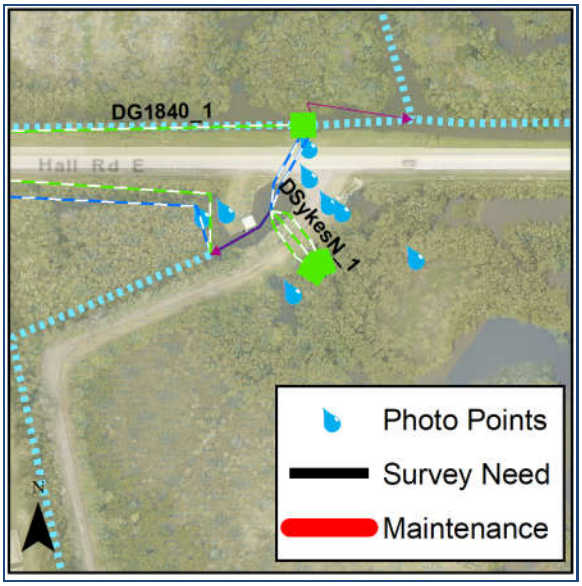
North Merritt Island Field Inspection Form

Link Name:DSykesN_1

Lat: 28.433942972

SWAMPid: BCE602CS110

Long: -80.69646097



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Control Structure is a 48 inch half culvert. SWAMP top El 2.14 NAVD88. Weir opening 43" board 10" from top of structure. Per SWAMP 36" CMP 42 ft long -2.55 NAVD88 upstream -1.92 NAVD88 downstream

Drainage Pattern Verification:

Drainage Pattern Comment:

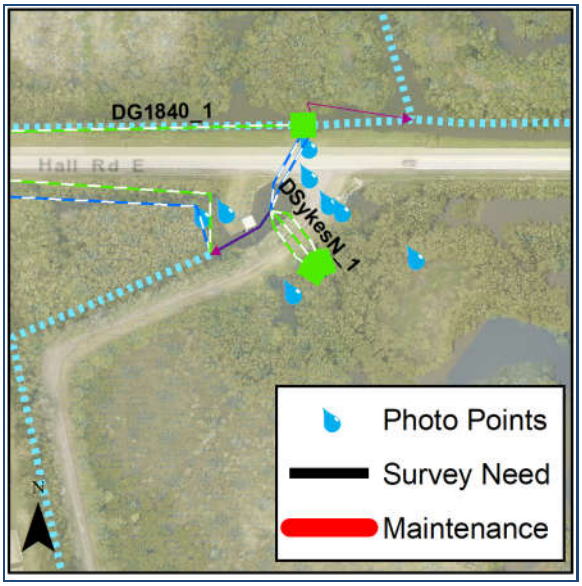
North Merritt Island Field Inspection Form

Link Name:DSykesN_2

Lat: 28.433942972

SWAMPid: BCE602CS109

Long: -80.69646097



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Aluminum box vertical structure 48" x 16 inches. SWAMP top 2.95 NAVD88. 44" opening 21" below top. 48" cmp 42' long upstream -2.21 NAVD88 downstream -2.05 NAVD88.

Drainage Pattern Verification:

Drainage Pattern Comment:

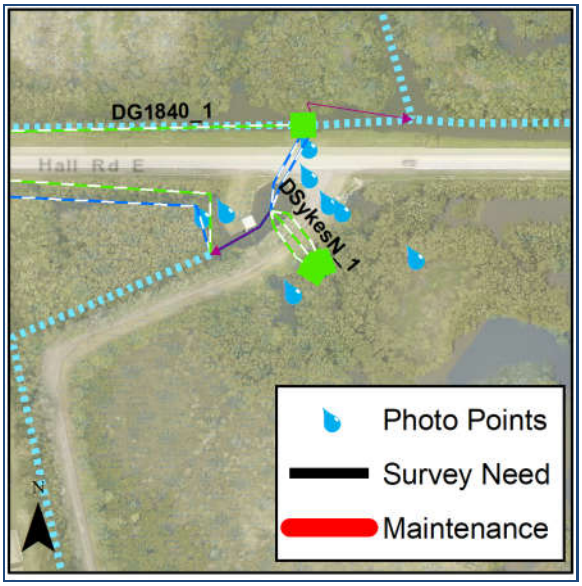
North Merritt Island Field Inspection Form

Link Name:DSykesN_3

Lat: 28.433942972

SWAMPid: BCE602CS108

Long: -80.69646097



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Aluminum box vertical structure 48" x 16 inches. SWAMP top 3.08 NAVD88. 44" opening 25" below top. 48" cmp 42' long upstream -2.19 NAVD88 downstream-1.92 NAVD88.

Drainage Pattern Verification:

Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:DSykesS_1

Lat: 28.409655587

Long: -80.69401797

SWAMPid: BCE611CS012

Location

Field Photo

Survey Need: Yes

SurveyDescription: Weir Structure

Maintenance Need: No

Field Visit Notes: Dual control structure with flashboards. Could not access in the field due to current construction activities.

Drainage Pattern Verification:

Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:DSykesS_2

Lat: 28.409655587

Long: -80.69401797

SWAMPid: BCE611CS010

Location

Field Photo

Survey Need: Yes

SurveyDescription: Weir Structure

Maintenance Need: No

Field Visit Notes: Dual control structure with flashboards. Could not access in the field due to current construction activities.

Drainage Pattern Verification:

Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:DSykesS_3

Lat: 28.409655587

Long: -80.69401797

SWAMPid: BCE611CS008

Location

Field Photo

Survey Need: Yes

SurveyDescription: Weir Structure

Maintenance Need: No

Field Visit Notes: Dual control structure with flashboards. Could not access in the field due to current construction activities.

Drainage Pattern Verification:

Drainage Pattern Comment:

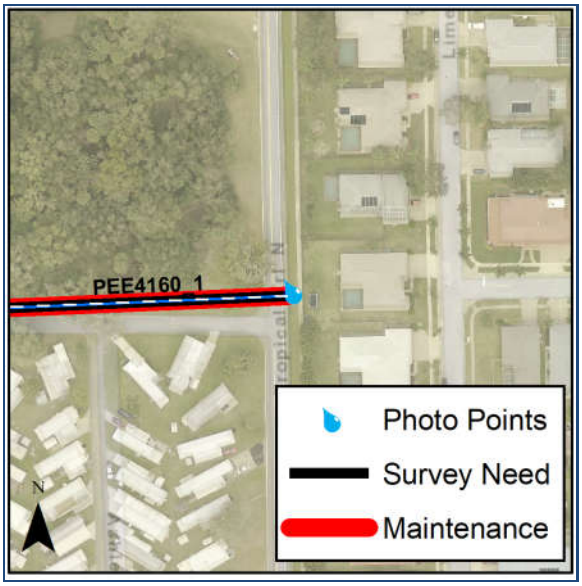
North Merritt Island Field Inspection Form

Link Name:DB1000_1

Lat: 28.421908972

SWAMPid: 233634CU44AB

Long: -80.71693197



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: The structure is on private property. The homeowner indicated that the County had installed the box to drain his yard across the road into the ditch that outfalls into the IRL. This is a minor structure free of debris. Grate size measured is 12” x 12” cast iron with 15” culvert connecting across the roadway.

Drainage Pattern Verification: Y

Drainage Pattern Comment: Confirmed that this area connects across Hall Road.

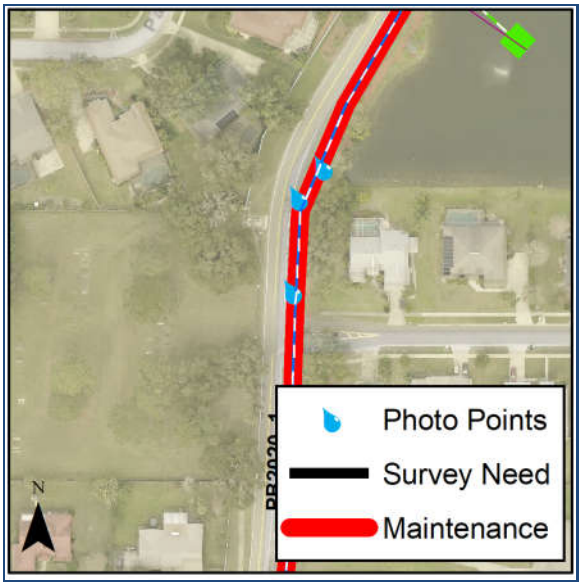
North Merritt Island Field Inspection Form

Link Name:PB2020_1

Lat: 28.442315

SWAMPid: P016D634021022

Long: -80.717027



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Represents multiple culverts along roadway. Use NorthGrove Dr as control 19x30 ERCP SWAMP inverts 1.04 NAVD88 and 0.97 NAVD88. Culverts in swale in disrepair and partially silted.

Drainage Pattern Verification:

Drainage Pattern Comment:

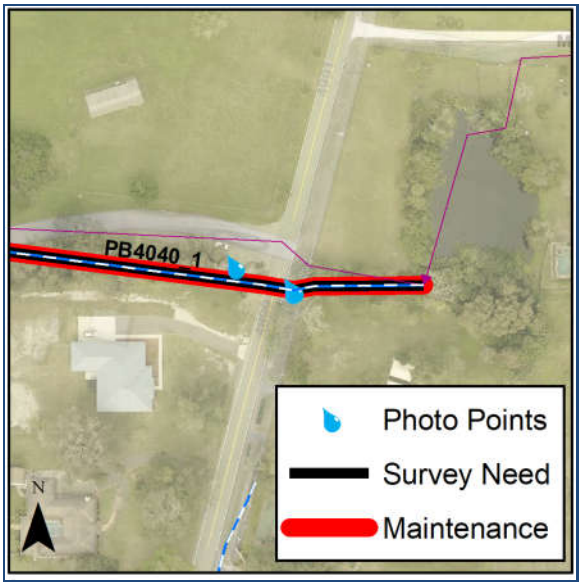
North Merritt Island Field Inspection Form

Link Name:PB4040_1

Lat: 28.445402972

SWAMPid: 233634CU47AB

Long: -80.715845



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Survey pipe inverts

Maintenance Need: Yes

Field Visit Notes: Pipe across Tropical Trail is overgrown. The flow path leading to the County Park is in need of ditch maintenance to function optimally.

Drainage Pattern Verification: Y

Drainage Pattern Comment: Verified flow into County Park prior to discharge into lagoon.

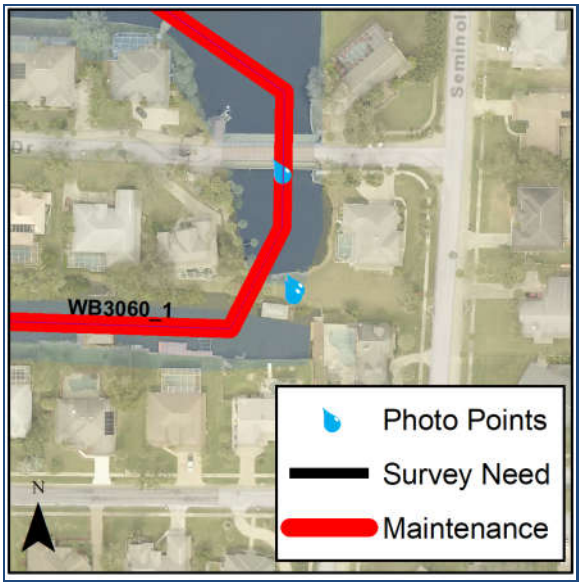
North Merritt Island Field Inspection Form

Link Name:WB3060_1

Lat: 28.441891972

SWAMPid: Not in SWAMP

Long: -80.719127



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Structure is Overgrown with vegetation and appears in disrepair. Field measured an 8 foot rectangular section for shape. Use invert elevation from construction plans.

Drainage Pattern Verification:

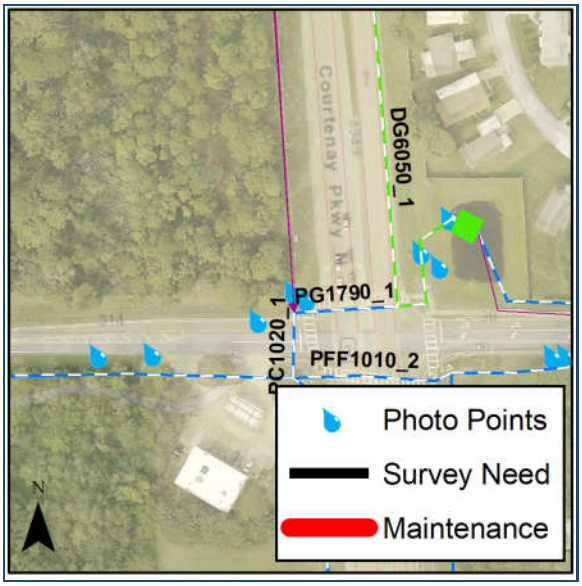
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PC1020_1

Lat: 28.434506972

SWAMPid: P040E602086085 Long: -80.70850697



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Confirmed hydraulic connection to node. Slot in box enables flow in ditch to connect to pipe crossing Hall Road.

Drainage Pattern Verification: Y

Drainage Pattern Comment: Confirmed that a slot in what appeared to be a junction manhole received surface flow from the NW corner of Hall Road and SR3.

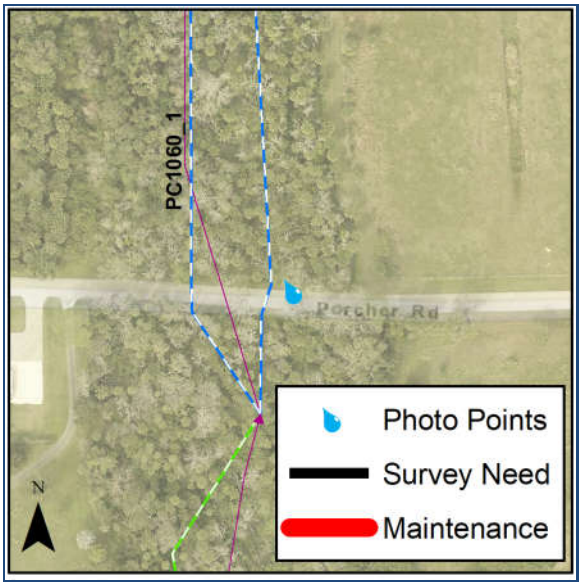
North Merritt Island Field Inspection Form

Link Name:PC1060_1

Lat: 28.448125972

SWAMPid: 0000CU0000

Long: -80.710863



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Crown of pipe below water line. Assume the pipe inverts are the same size as PC1060_2 (FeatureCode P127D63417918), which is a parallel pipe connecting across the road.

Drainage Pattern Verification:

Drainage Pattern Comment:

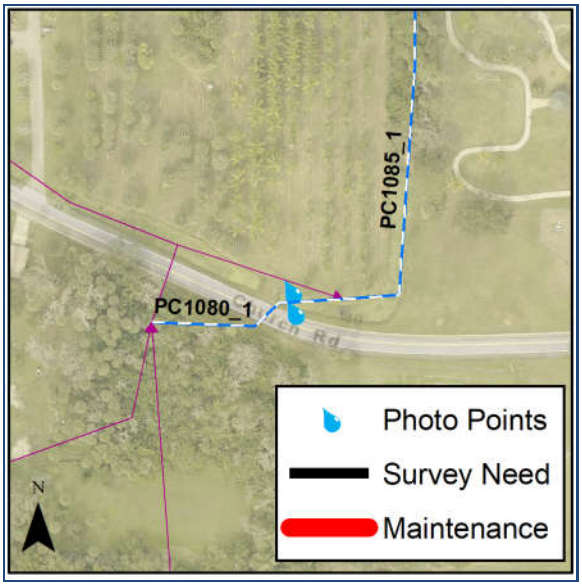
North Merritt Island Field Inspection Form

Link Name:PC1080_1

Lat: 28.457142972

SWAMPid: NO FEATURE CODE

Long: -80.711116



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Culvert is completely silted and not functioning. Does not appear to be designed to continue a flowway across the road, rather to drain a roadside swale. The culvert does not appear to be an integral part of the overall drainage system, however may result in localized roadway flooding during intense rainfall events if not cleaned out.

Drainage Pattern Verification: Y

Drainage Pattern Comment: Does not connect regional flow across the road, rather this culvert is part of the roadway drainage system.

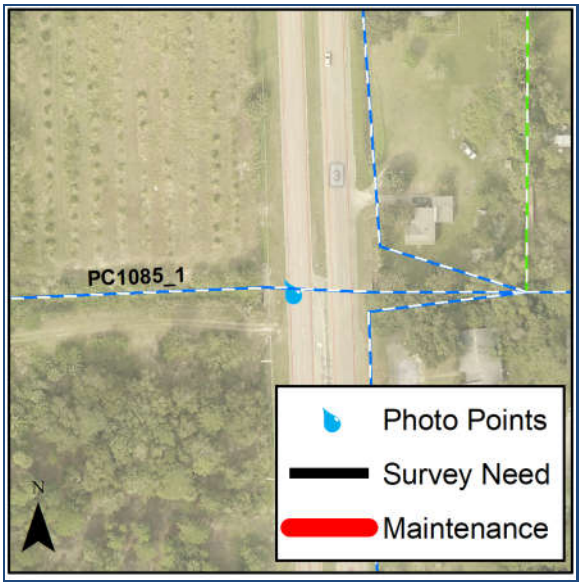
North Merritt Island Field Inspection Form

Link Name:PC1085_1

Lat: 28.460134887

SWAMPid: P018D627035032

Long: -80.70964745



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: In SWAMP without specified inverts. It is a significant structure connecting across SR3. 2x48 inch culverts. Use construction plans for elevations Pg 32 of 82 NMI_123_RD_01.pdf

Drainage Pattern Verification:

Drainage Pattern Comment:

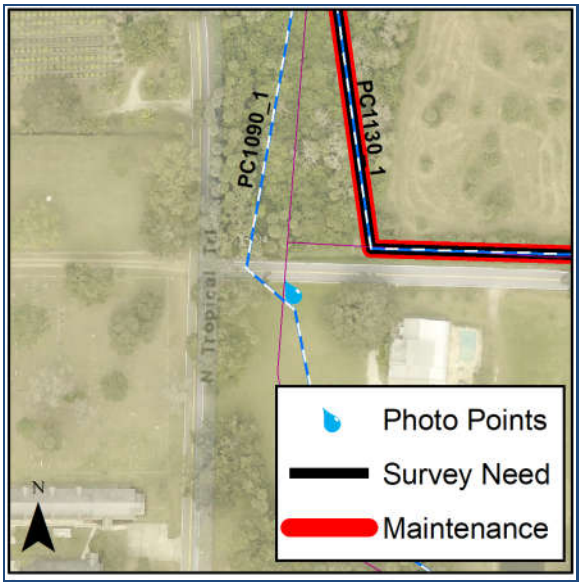
North Merritt Island Field Inspection Form

Link Name:PC1090_1

Lat: 28.45767

SWAMPid: In SWAMP wo Feature Code

Long: -80.71607197



Location

Field Photo

11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Minor drainage connection across. Estimate Crown of pipe as 1 ft below DEM. 4.1 ft NAVD88. Structure size in SWAMP database.

Drainage Pattern Verification:

Drainage Pattern Comment:

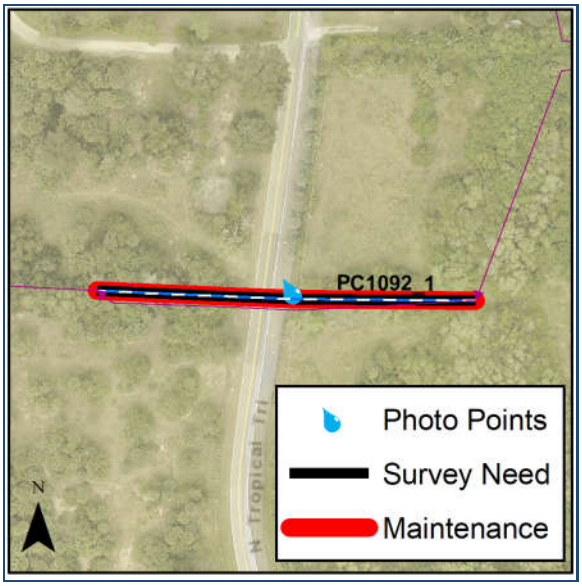
North Merritt Island Field Inspection Form

Link Name:PC1092_1

Lat: 28.455635

SWAMPid: Not in SWAMP

Long: -80.71648



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Culvert and headwall

Maintenance Need: Yes

Field Visit Notes: Recent Maintenance placed a sandbag headwall to mitigate erosion of structure. Consider replacing with a more permanent structure. 36 inch CMP 3.0 ft below roadway crown.

Drainage Pattern Verification:

Drainage Pattern Comment:

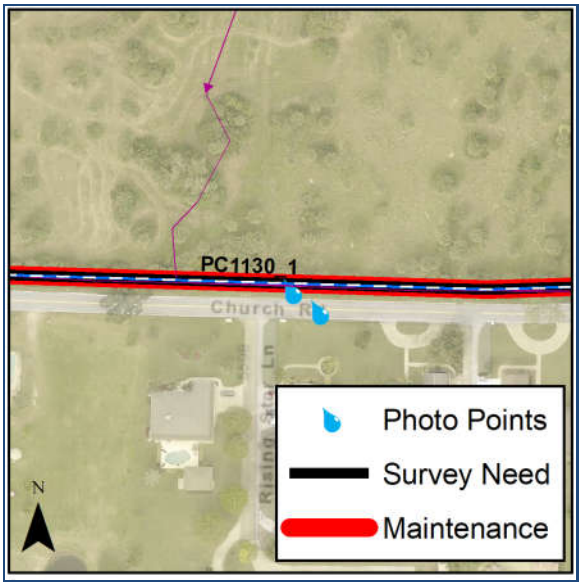
North Merritt Island Field Inspection Form

Link Name:PC1130_1

Lat: 28.457737

SWAMPid: Not in SWAMP

Long: -80.71450097



Location

Field Photo

11/3/2020

Survey Need: Yes

SurveyDescription: Culvert crossing Ditch on the north side of Church Rd

Maintenance Need: Yes

Field Visit Notes: Ditch side culvert along Church Rd to provide access to property to the north. Estimate at 24 inch. DEM 6.4 culvert 36inch flowline 3.4 46ft long.

Drainage Pattern Verification: Y

Drainage Pattern Comment: Roadside Ditch is a significant conveyance way along Church Rd

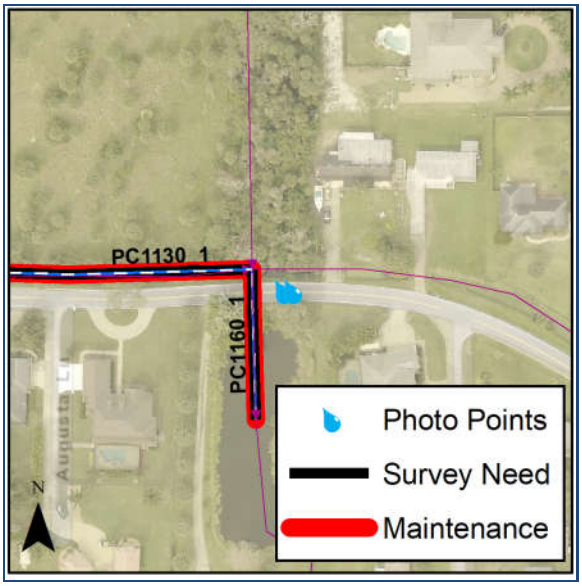
North Merritt Island Field Inspection Form

Link Name:PC1160_1

Lat: 28.457689972

SWAMPid: In SWAMP wo Feature Code

Long: -80.713076



Location

Field Photo

11/3/2020

Survey Need: Yes

SurveyDescription: Connection between pond and ditch including culvert and high point in swale between roadway and pond

Maintenance Need: Yes

Field Visit Notes: Culvert does not appear to be the control between the pond and ditch, rather a high point in swale leading to pond. Recommend regrading for proper function. Culvert is silted on the upstream side.

Drainage Pattern Verification:

Drainage Pattern Comment:

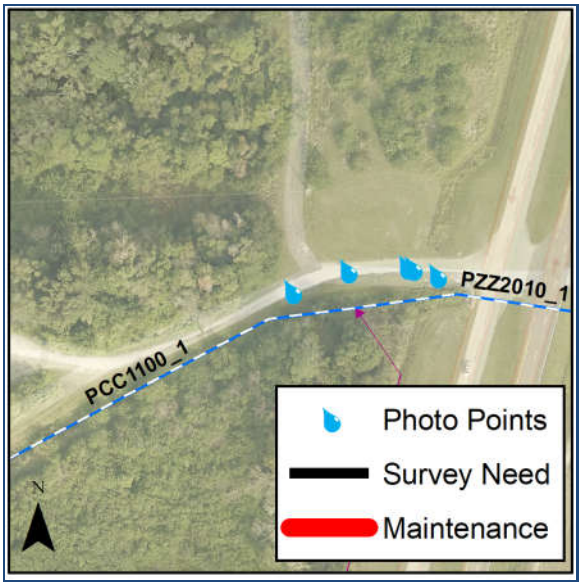
North Merritt Island Field Inspection Form

Link Name:PCC1100_1

Lat: 28.492881

SWAMPid: Not in SWAMP

Long: -80.67534897



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Field observations included 3 CMPs 36 inch. These structures are part of the NASA model under development at the time of this field work. Incorporate data from the NASA model when it is available for this location.

Drainage Pattern Verification:

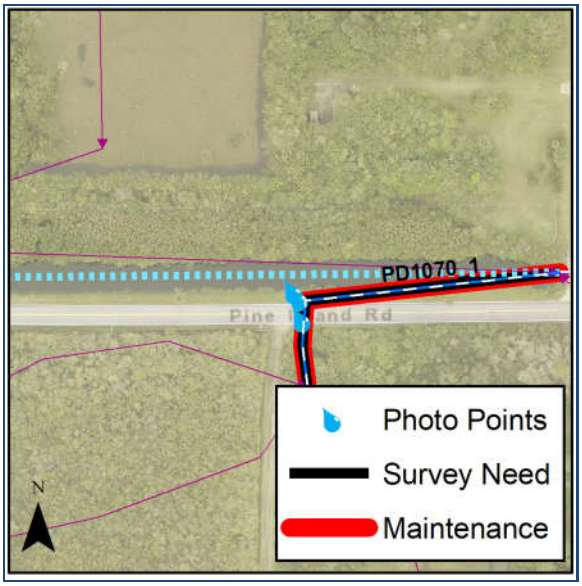
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PD1070_1

Lat: 28.492730972

SWAMPid: 0000CU0000 Long: -80.71669197



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription: JEA RTK from NASA Model

Maintenance Need: Yes

Field Visit Notes: Tideflex product does not appear to be function optimally, the rubber appears still from oxidation. It is recommended that the manufacturer provide an opinion as to how well the structure will function in this condition. Upstream side is mostly silted. Estimate crown is 1 ft below roadway.

Drainage Pattern Verification:

Drainage Pattern Comment:

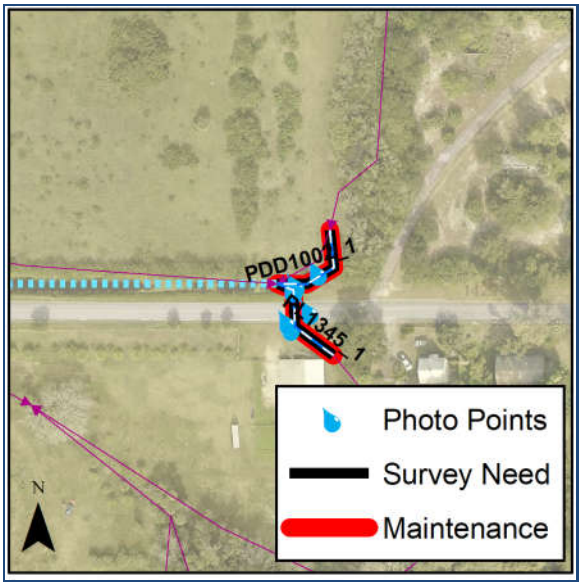
North Merritt Island Field Inspection Form

Link Name:PDD1002_1

Lat: 28.463620972

SWAMPid: BC233624CU009

Long: -80.678937



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Culvert and access overtopping elevation

Maintenance Need: Yes

Field Visit Notes: Sandbag headwall beginning to crumble. Channel is full of vegetation. Estimate crown 2 ft below DEM 3.2 NAVD88. CMP until survey confirms.

Drainage Pattern Verification:

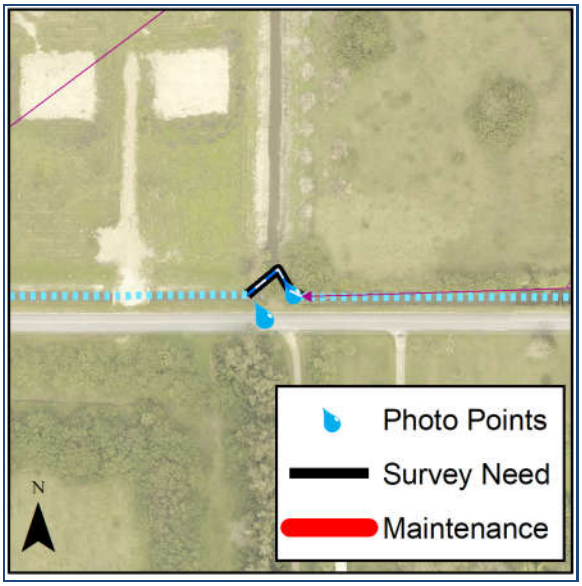
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PDD1010_1

Lat: 28.463671441

SWAMPid: BC233624CU008 Long: -80.68375196



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Culvert and Access Rd overtopping

Maintenance Need: No

Field Visit Notes: ABS pipe, dimension in SWAMP without elevation. Estimate invert at flowline -2.9 NAVD88, until survey confirms

Drainage Pattern Verification: Y

Drainage Pattern Comment: Previous model did not have any obstruction to flow here. Field observation confirmed culvert under access road will serve as a restriction to flow.

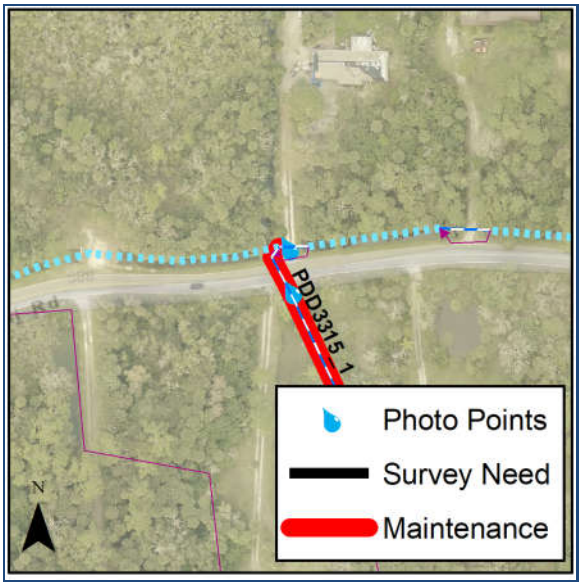
North Merritt Island Field Inspection Form

Link Name:PDD3315_1

Lat: 28.465185

SWAMPid: P015D623029030

Long: -80.69622497



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Upstream end of culvert partially silted. Tideflex pipe end treatment. Tideflex product does not appear to be function optimally, the rubber appears still from oxidation. It is recommended that the manufacturer provide an opinion as to how well the structure will function in this condition.

Drainage Pattern Verification:

Drainage Pattern Comment:

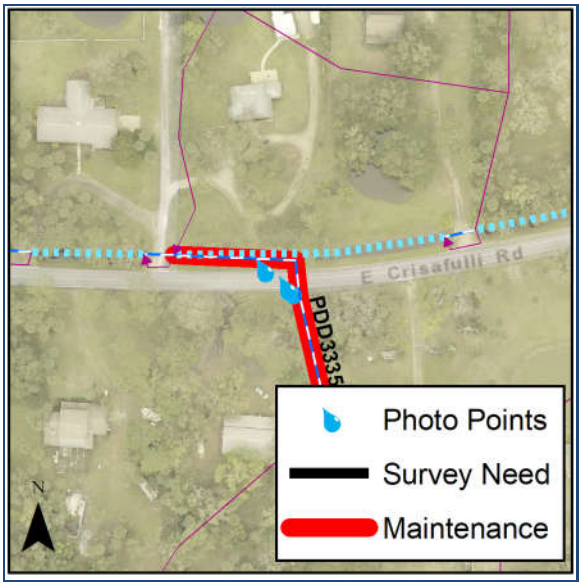
North Merritt Island Field Inspection Form

Link Name:PDD3335_1

Lat: 28.465195

SWAMPid: P021D623042041

Long: -80.69381797



Location

Field Photo

11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Upstream end of culvert partially silted. Tideflex pipe end treatment. Tideflex product does not appear to be function optimally, the rubber appears still from oxidation. It is recommended that the manufacturer provide an opinion as to how well the structure will function in this condition.

Drainage Pattern Verification:

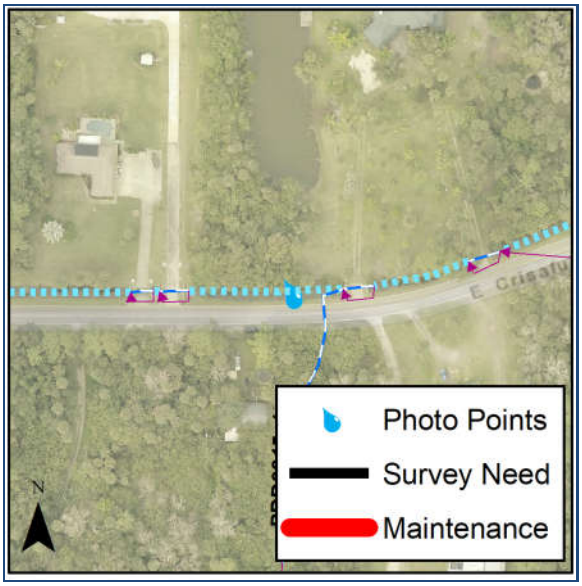
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

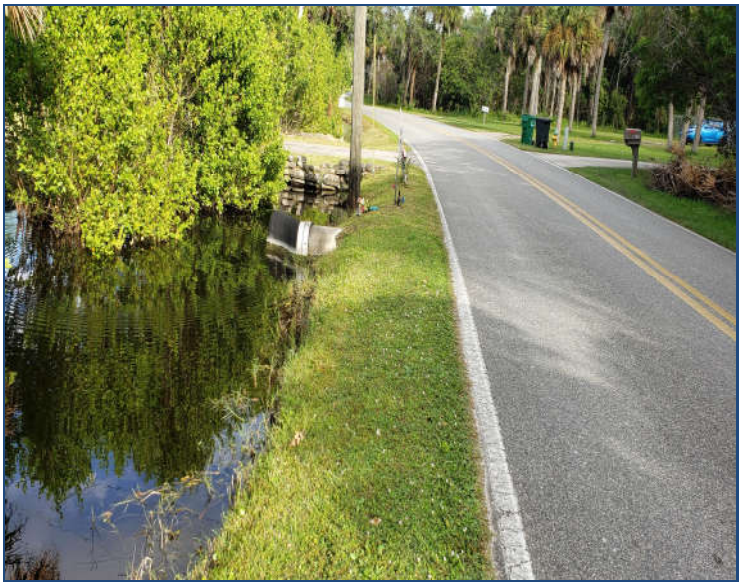
Link Name:PDD3345_1

Lat: 28.465019972

SWAMPid: P012D623024023 Long: -80.698164



Location



Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Tideflex pipe end treatment. Tideflex product does not appear to be function optimally, the rubber appears still from oxidation. It is recommended that the manufacturer provide an opinion as to how well the structure will function in this condition.

Drainage Pattern Verification:

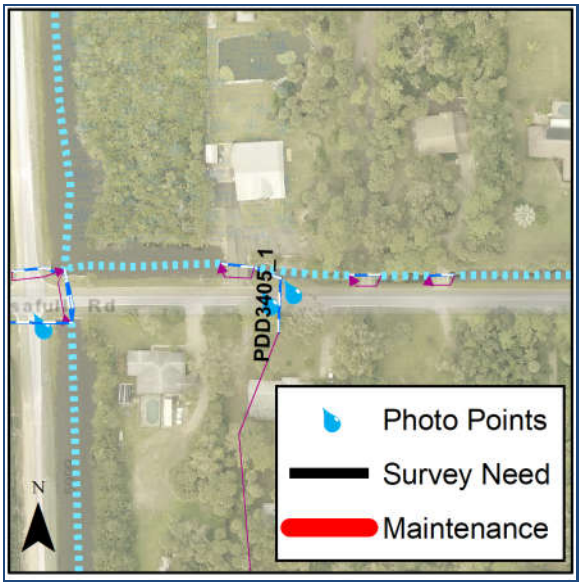
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

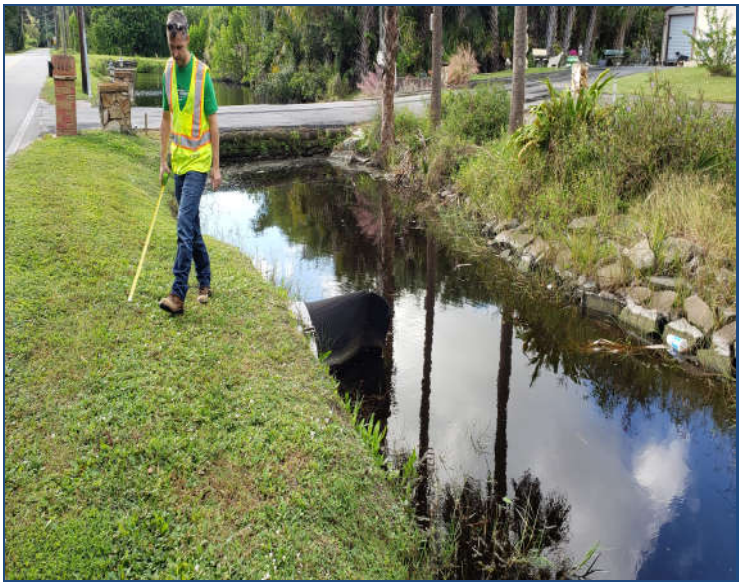
Link Name:PDD3405_1

Lat: 28.464973

SWAMPid: P007D623013014 Long: -80.69977297



Location



Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Tideflex pipe end treatment. Tideflex product does not appear to be function optimally, the rubber appears still from oxidation. It is recommended that the manufacturer provide an opinion as to how well the structure will function in this condition.

Drainage Pattern Verification:

Drainage Pattern Comment:

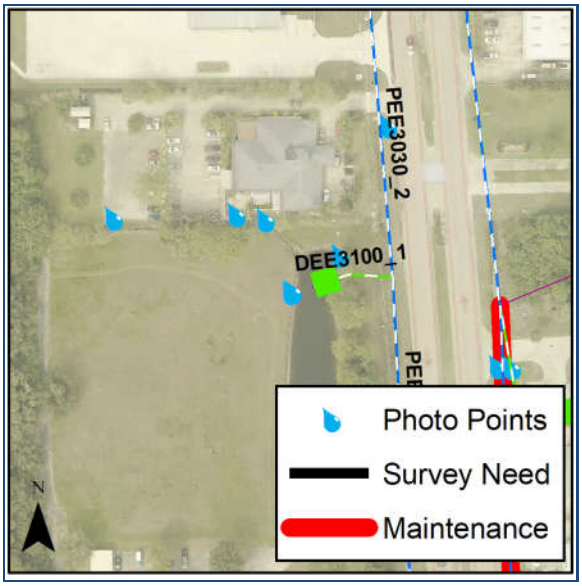
North Merritt Island Field Inspection Form

Link Name:DEE3100_1

Lat: 28.419857

SWAMPid: BCE611CS048

Long: -80.70748797



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: The manhole type structure does not appear to be a significant hydraulic outfall, rather a structure only contains an orifice. Pond's primary discharges is to the west through a narrow concrete and brick lined channel controlled by a weir at the lake.

Drainage Pattern Verification: Y

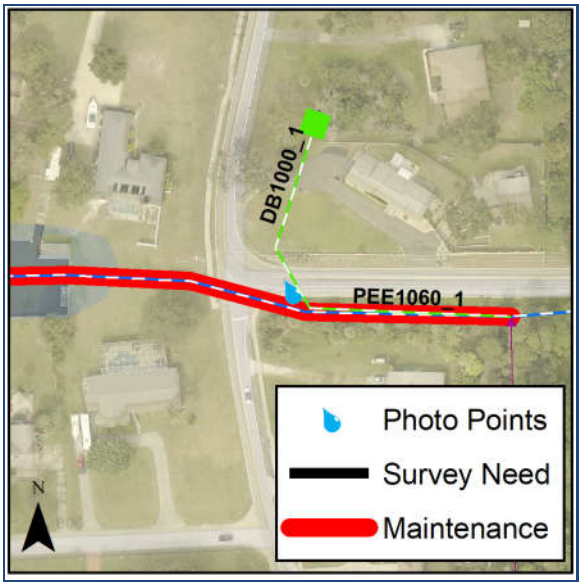
Drainage Pattern Comment: Pond does not discharge into roadway channel, rather it discharges west into wetland through a weir structure.

North Merritt Island Field Inspection Form

Link Name:PEE1060_1

Lat: 28.434349972

SWAMPid: P094D634135133 Long: -80.718051



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Channel leading to the culvert is overgrown. The area has survey flags, indicating that the area has been recently surveyed. The discharge pipe includes flow into a baffle box structure. Elevations are in the SWAMP database. Current water level based upon gauge at the upstream side of the culvert is 0.8 assume NAVD88

Drainage Pattern Verification:

Drainage Pattern Comment:

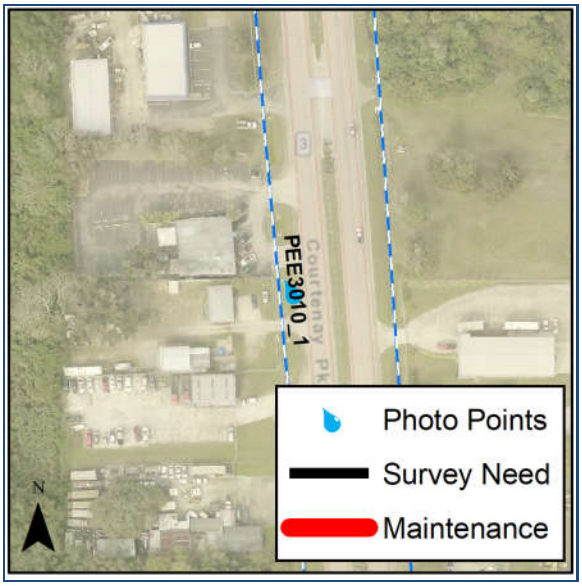
North Merritt Island Field Inspection Form

Link Name:PEE3010_1

Lat: 28.431654

SWAMPid: Not in SWAMP

Long: -80.70816497



Location

Field Photo

11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Conveyance ditch with 18 inch RCP crown, estimated at one foot below driveway (7.5 NAVD88 Driveway per DEM). Invert of 18 inch RCP is 5.0 NAVD88. 60ft.

Drainage Pattern Verification: Y

Drainage Pattern Comment: Confirmed ditch flows north in swale to Hall Road

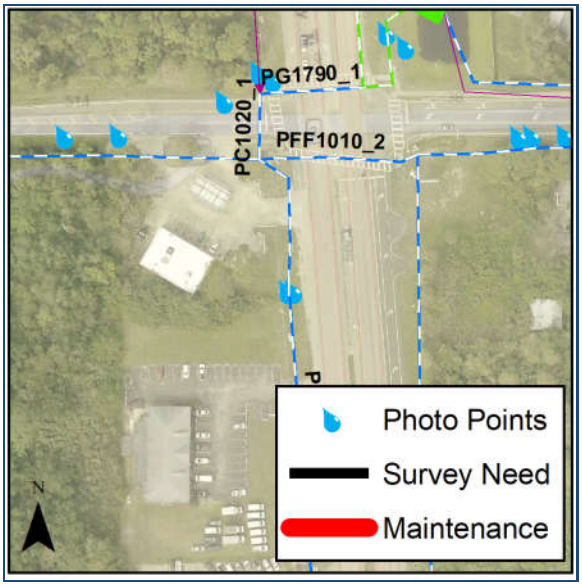
North Merritt Island Field Inspection Form

Link Name:PEE3010_2

Lat: 28.433851

SWAMPid: P052E602100081

Long: -80.708393



Location

Field Photo

11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Culvert in SWAMP without downstream invert. Field observation estimate minimal change in elevation upstream to downstream. For the 36 inch RCP use upstream invert as downstream

Drainage Pattern Verification:

Drainage Pattern Comment:

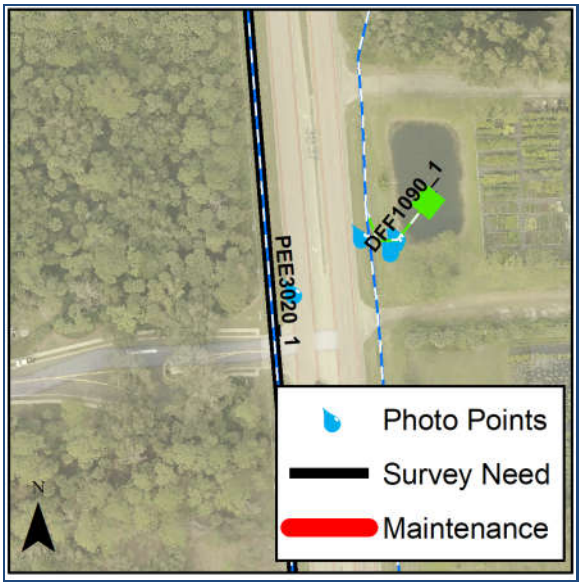
North Merritt Island Field Inspection Form

Link Name:PEE3020_1

Lat: 28.426724821

SWAMPid: In SWAMP wo feature code

Long: -80.70768053



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Culvert inverts

Maintenance Need: No

Field Visit Notes: 2 x 14 x 23ERCP crossing sunset lakes drive. Flowline based upon the DEM is 6.25 NAVD88, use as an approximate until survey confirmation

Drainage Pattern Verification:

Drainage Pattern Comment:

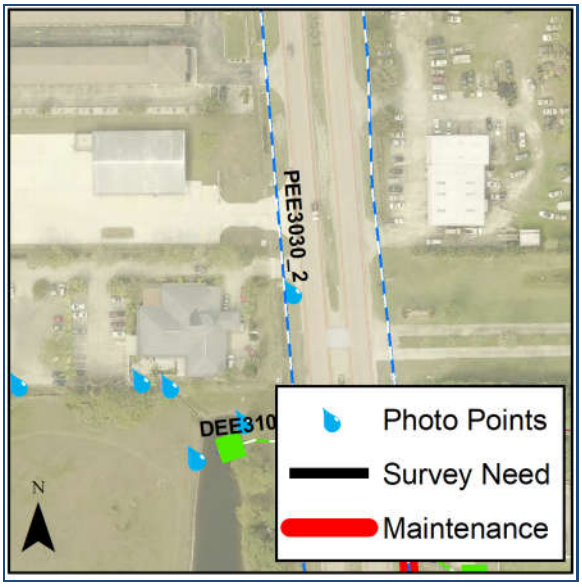
North Merritt Island Field Inspection Form

Link Name:PEE3030_2

Lat: 28.420352972

SWAMPid: Not in SWAMP

Long: -80.70716197



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: 14x23 ERCP. DEM El 8.5. Invert 6.0 NAVD88. 48ft long

Drainage Pattern Verification:

Drainage Pattern Comment:

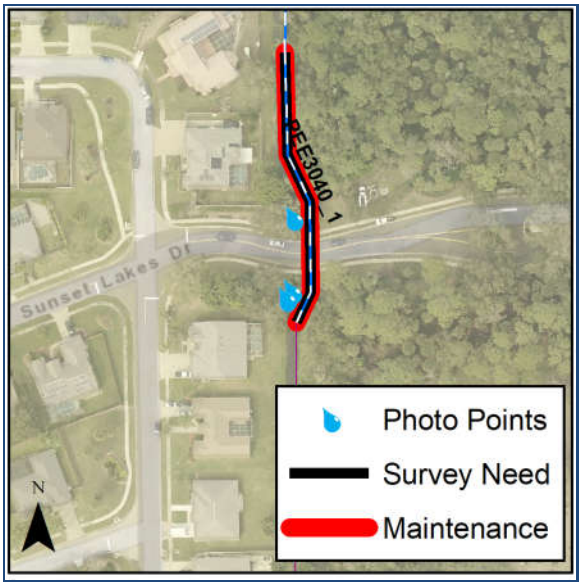
North Merritt Island Field Inspection Form

Link Name:PEE3040_1

Lat: 28.426303972

SWAMPid: In SWAMP wo feature code

Long: -80.70890797



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Culvert inverts and sandbag weir and sketch.

Maintenance Need: Yes

Field Visit Notes: 3 pipes each is a 24 inch RCP. The first one has sandbag weir as bottom clip. Silt partially blocks all culverts.

Drainage Pattern Verification:

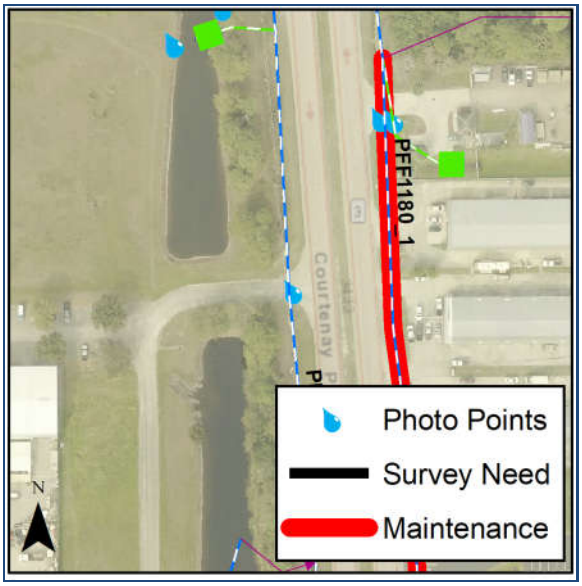
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PEE3110_1

Lat: 28.419115972

SWAMPid: BCE611CS047 Long: -80.70708897



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: 18 inch RCP invert 3 feet below pavement. DEM 9.2 NAVD88. Invert 6.2 NAVD88 72 ft long

Drainage Pattern Verification:

Drainage Pattern Comment:

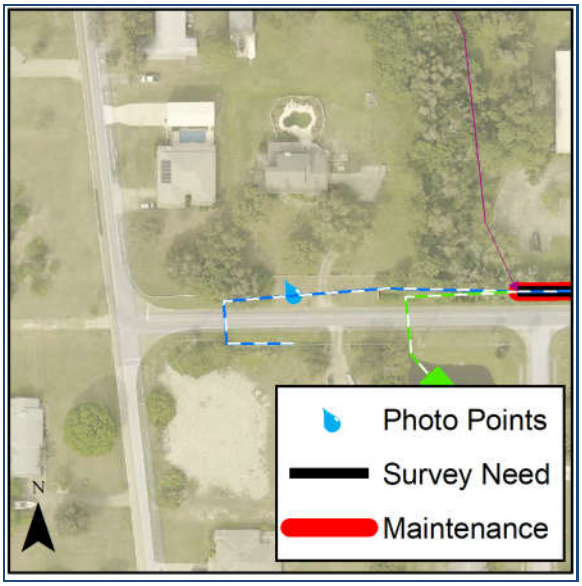
North Merritt Island Field Inspection Form

Link Name:PEE3280_1

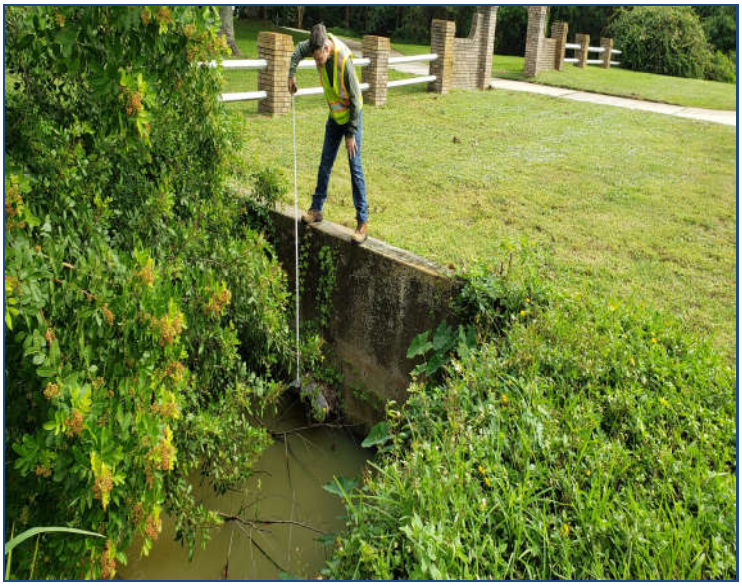
Lat: 28.412780972

SWAMPid: Not in SWAMP

Long: -80.71109197



Location



Field Photo

11/3/2020

Survey Need: Yes

SurveyDescription: Driveway culvert under 210 Grant Rd

Maintenance Need: Yes

Field Visit Notes: As water flows north across Grant Road this link represents the controlling (first) culvert in a series of culverts that conveys water to the west. This culvert under a driveway at 210 Grant Rd is rusted and the channel is overgrown

Drainage Pattern Verification:

Drainage Pattern Comment:

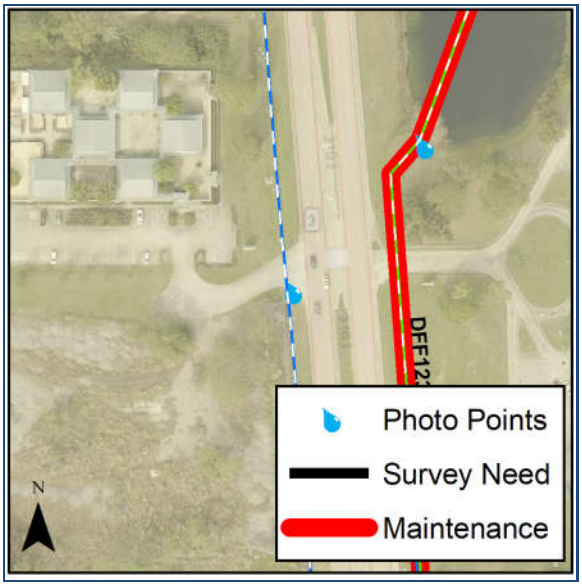
North Merritt Island Field Inspection Form

Link Name:PEE3310_1

Lat: 28.41449

SWAMPid: Not in SWAMP

Long: -80.706669



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: 24" RCP Invert 4 ft below roadway. DEM 8.5. invert 4.5. 24" RCP. 72ft long

Drainage Pattern Verification:

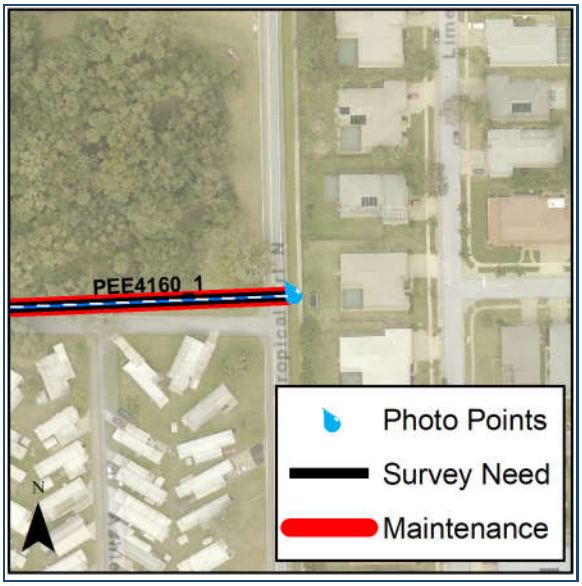
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PEE4160_1

Lat: 28.421908972

SWAMPid: P161E603217218 Long: -80.71693197



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Culvert inverts

Maintenance Need: Yes

Field Visit Notes: Roadway cross culvert is silted significantly on the downstream side. Field estimates culvert has approximately 8 inches of cover from the roadway centerline. Road 7.8 NAVD88. approximate invert 6.0 until survey

Drainage Pattern Verification: Y

Drainage Pattern Comment: Into the roadside ditch near the location of this cross culvert, was an additional outlet from development to the east. The outlet did not appear on the “as builts” however it was included in the original design plans. Field investigation did not uncover

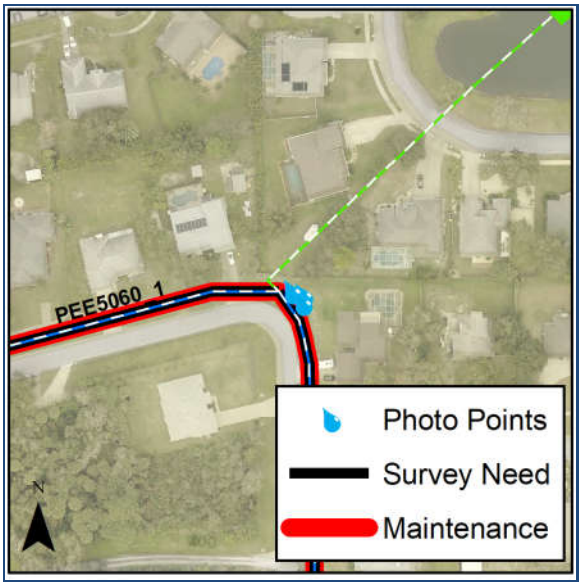
North Merritt Island Field Inspection Form

Link Name:PEE5060_1

Lat: 28.418195972

SWAMPid: P023E610033034

Long: -80.716853



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Driveway culvert and low point in swale around bend in Spartia Ave between Driveway culverts down to Oak Place

Maintenance Need: Yes

Field Visit Notes: Swale silted and sodded partially blocking culvert. 24inch DEM 8ft NAVD88 invert 5ft NAVD until survey confirms.

Drainage Pattern Verification:

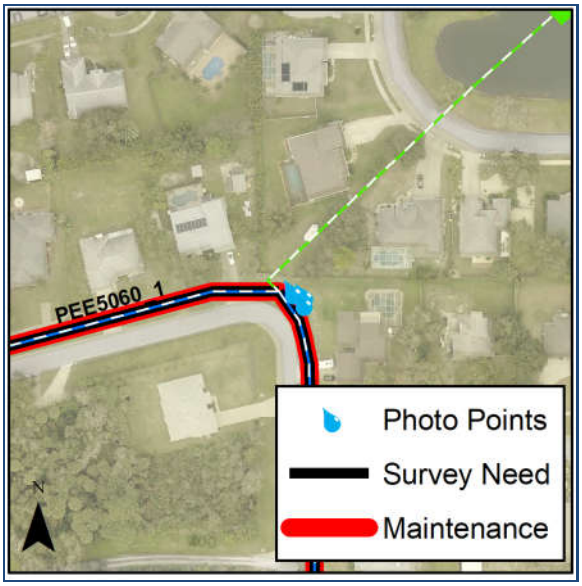
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PEE5060_2

Lat: 28.418195972

SWAMPid: P025E610039040 Long: -80.716853



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Driveway culvert and culvert crossing Oak Place

Maintenance Need: Yes

Field Visit Notes: Swale silted and sodded partially blocking culvert. Control maybe either driveway culvert or culvert crossing Oak Place. 14x23inch ERCP driveway 7.6 NAVD88, which estimates the culvert invert at 5.2 NAVD88, until survey confirms

Drainage Pattern Verification:

Drainage Pattern Comment:

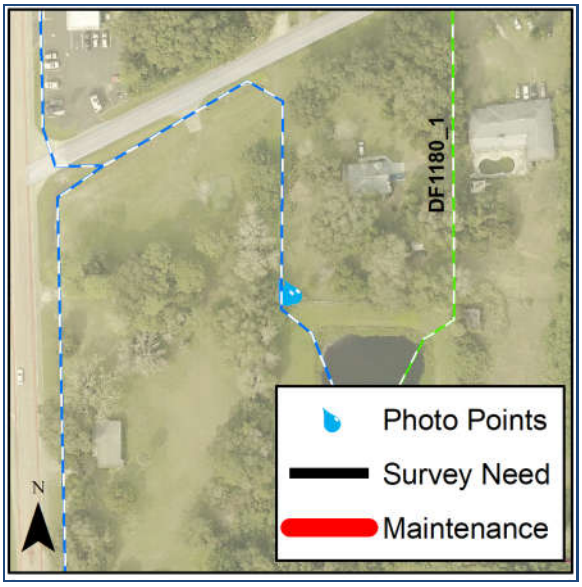
North Merritt Island Field Inspection Form

Link Name:DF1180_1

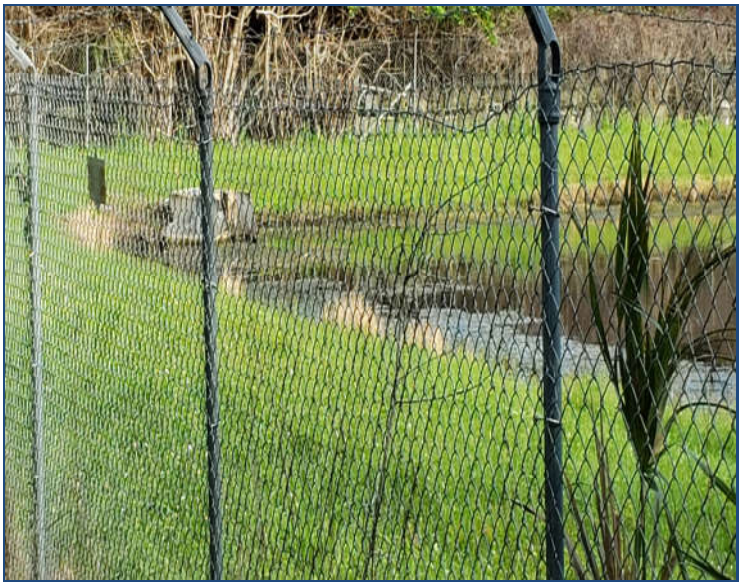
Lat: 28.464559972

Long: -80.70871997

SWAMPid: BCD623CS135



Location



Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: FDOT pond 133 (ph 321-634-6100). SWAMP has elevations missing top dimension and orifice dimension. Field estimated as a Type C structure with a 3 inch orifice

Drainage Pattern Verification:

Drainage Pattern Comment:

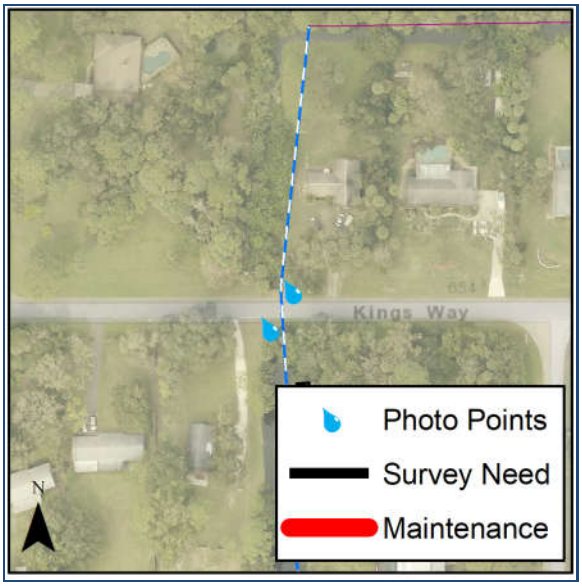
North Merritt Island Field Inspection Form

Link Name:PF2080_1

Lat: 28.456416

SWAMPid: P053D626110109

Long: -80.70454997



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Multiple culvert sizes and/or inverts confirmed, use SWAMP data and add additional culvert link to the model to simulate a total of 4 culverts. (2 sets of 2)

Drainage Pattern Verification:

Drainage Pattern Comment:

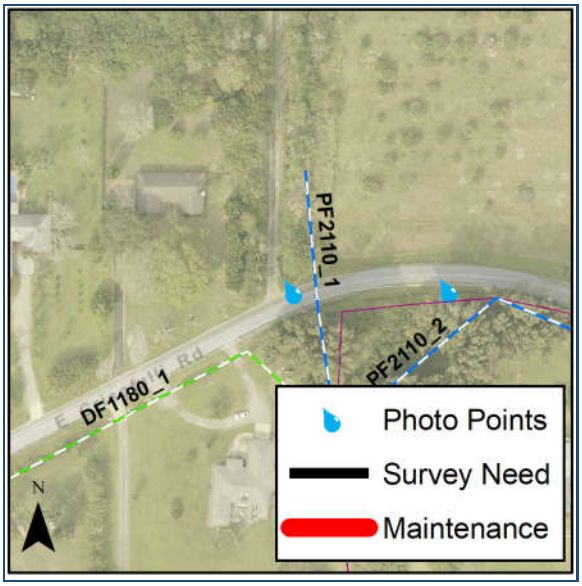
North Merritt Island Field Inspection Form

Link Name:PF2110_1

Lat: 28.466056972

SWAMPid: NO FEATURE CODE

Long: -80.707086



Location

Field Photo

11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Culvert is in SWAMP, but no evidence of the culvert was found in the field. It is likely that the culvert has been silted for many years and no longer functions as the primary outlet for this area. Maintenance to restore functionality of structure.

Drainage Pattern Verification: Y

Drainage Pattern Comment: Water not crossing roadway couldn't find culvert assume fully silted and not functioning.

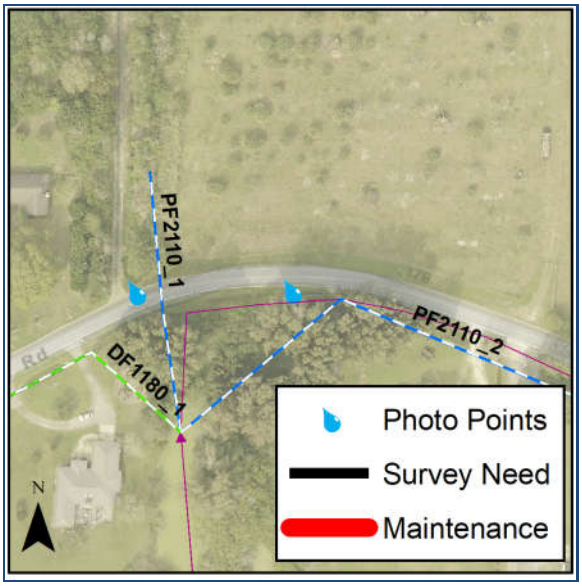
North Merritt Island Field Inspection Form

Link Name:PF2110_2

Lat: 28.466058513

Long: -80.70655614

SWAMPid: Not in SWAMP



Location

Field Photo

11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Series of driveway culverts flowing along roadside ditch towards main channel. 15 inch 30 ft long CMP would simulate the conveyance for this model link. Flood water would likely overtop the roadway. Based upon DEM estimate flowline at 1.0 NAVD88.

Drainage Pattern Verification:

Drainage Pattern Comment:

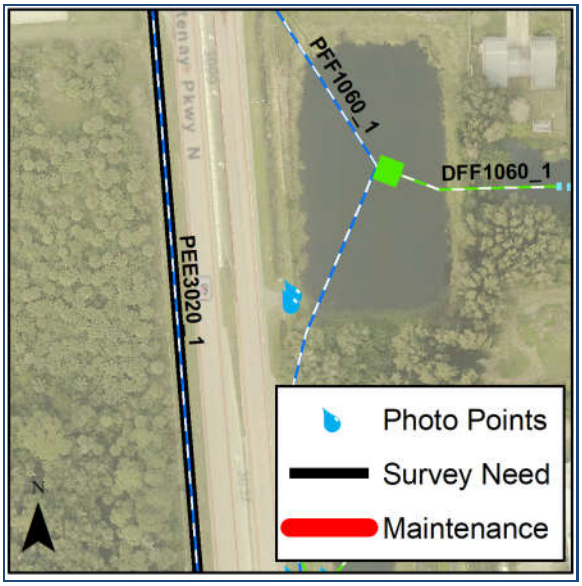
North Merritt Island Field Inspection Form

Link Name:DFF1060_1

Lat: 28.427748972

SWAMPid: BCE602CS158

Long: -80.707447



Location

Field Photo 11/5/2020

Survey Need: Yes

SurveyDescription: Provide detailed sketch of structure to supplement SWAMP elevations.

Maintenance Need: No

Field Visit Notes: FDOT pond 131 (ph 321-634-6100). Could not gain access to the structure. SWAMP has elevations but not weir dimensions.

Drainage Pattern Verification:

Drainage Pattern Comment:

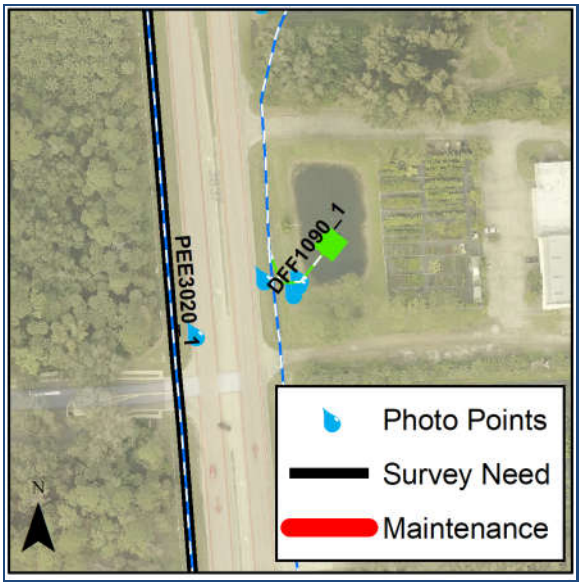
North Merritt Island Field Inspection Form

Link Name:DFF1090_1

Lat: 28.42685

SWAMPid: BCE602CS146

Long: -80.70735



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: The SWAMP database has structure elevations. Dimensions collected in the field to incorporate into the model include: 3" orifice, type C inlet, slot 23" x 7" 15"CMP outlet pipe

Drainage Pattern Verification:

Drainage Pattern Comment:

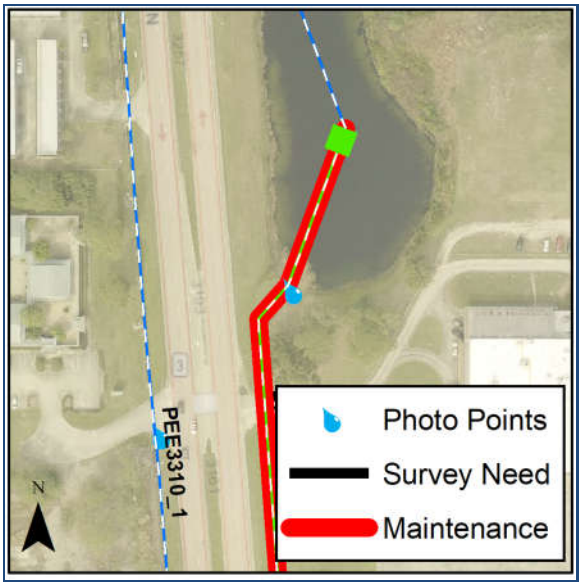
North Merritt Island Field Inspection Form

Link Name:DFF1230_1

Lat: 28.414923972

SWAMPid: BCE611CS096

Long: -80.706218



Location

Field Photo

11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: The SWAMP database has structure elevations without specified dimensions. Dimensions collected in the field to incorporate into the model include: top 54x37; 3 slots 1 and 2 are 36x11.5 and 3 is 54x12.5. orifice is 3". Noted that the Skimmer was damaged and in need of repair or replacement.

Drainage Pattern Verification:

Drainage Pattern Comment:

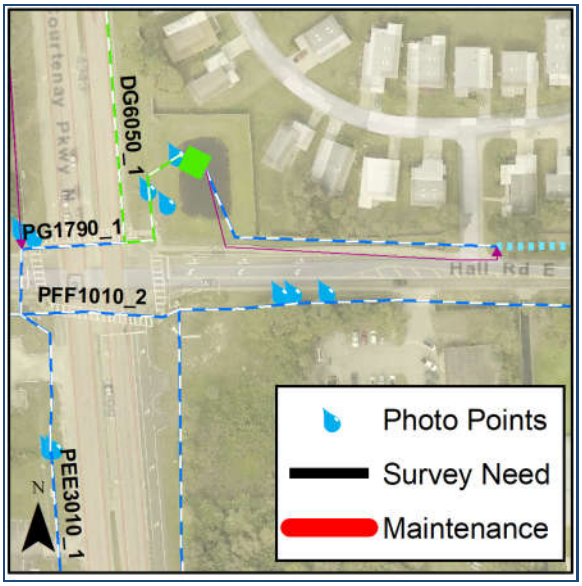
North Merritt Island Field Inspection Form

Link Name:PFF1010_2

Lat: 28.434314

SWAMPid: P047E602080077

Long: -80.70757897



Location

Field Photo

11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Culvert in SWAMP without upstream invert. Field observation estimate minimal change in elevation upstream to downstream. Confirmed culvert connects across SR3. Use downstream invert -1.78 NAVD88 for upstream

Drainage Pattern Verification: Y

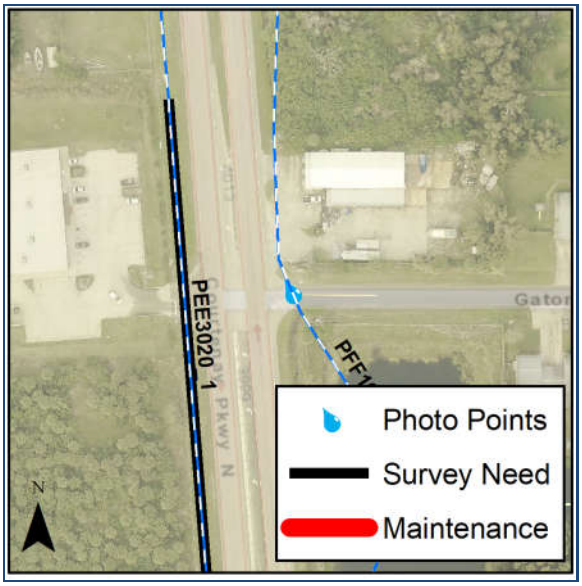
Drainage Pattern Comment: Confirmed culvert crosses SR3 connecting ditch on south side of Hall Road.

North Merritt Island Field Inspection Form

Link Name:PFF1060_1

Lat: 28.428699972

SWAMPid: P088E602133134 Long: -80.70756



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Hydraulic confirmation that culvert is connected to Pond. Use SWAMP elevations.

Drainage Pattern Verification: Y

Drainage Pattern Comment: Confirmed swale is connected to pond directly.

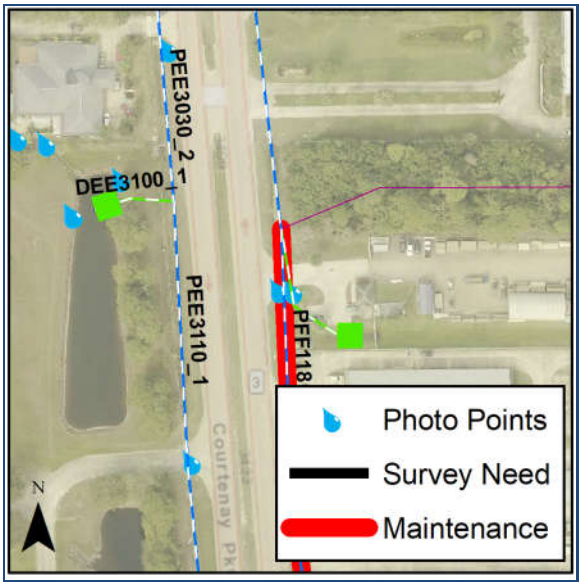
North Merritt Island Field Inspection Form

Link Name:PFF1180_1

Lat: 28.419626972

SWAMPid: P042E611074075

Long: -80.706742



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Confirmed 24 inch RCP connection to the south. Site just to the north is currently under development. Culverts partially silted and in need of maintenance to function property.

Drainage Pattern Verification:

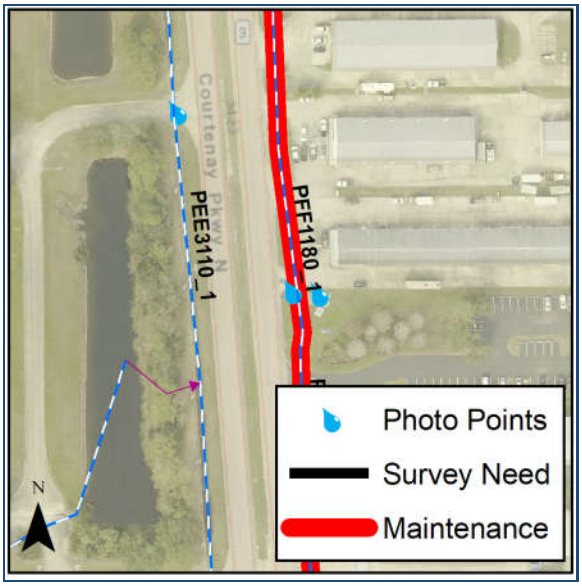
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PFF1210_1

Lat: 28.418579

SWAMPid: P045E611079080 Long: -80.706698



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Culverts partially silted and in need of maintenance to function property.

Drainage Pattern Verification:

Drainage Pattern Comment:

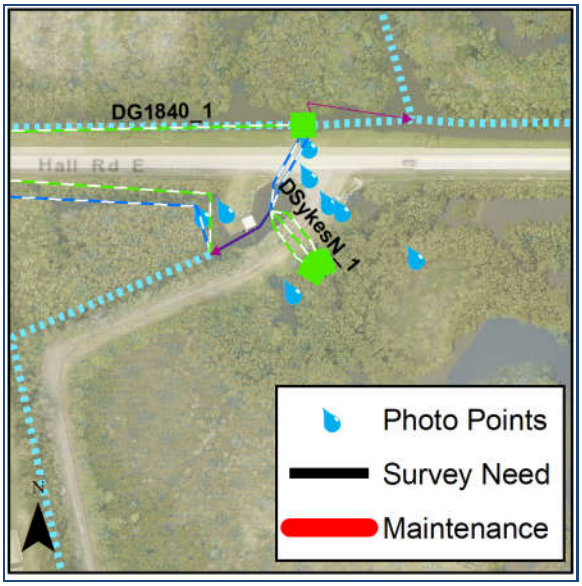
North Merritt Island Field Inspection Form

Link Name:WFF2010_1

Lat: 28.433942972

SWAMPid: BCE602CS111

Long: -80.69646097



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Lower portion of weir 57". Correlating to SWAMP El -3.57 NAVD88. Top portion of weir per SWAMP top El 1.22 NAVD88

Drainage Pattern Verification:

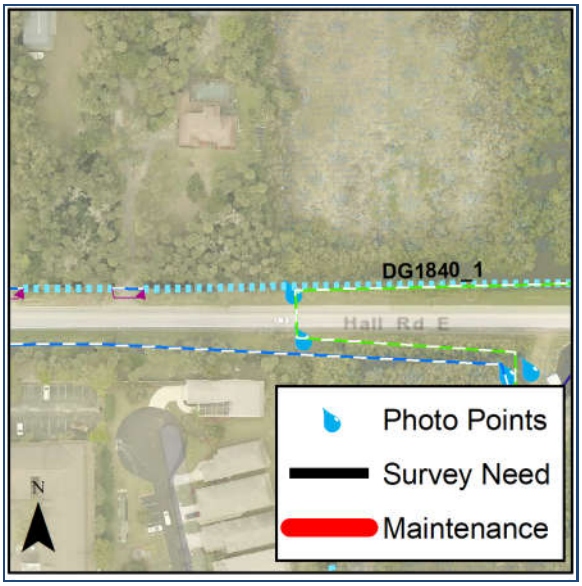
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:DG1840_1

Lat: 28.434418972

SWAMPid: BCE602CS069 Long: -80.69749897



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Structure is a large box with sealed top and slot opening on the ditch side. SWAMP Invert -1.82 NAVD88. Field measurement of opening is 6 ft wide by 5 ft deep.

Drainage Pattern Verification:

Drainage Pattern Comment:

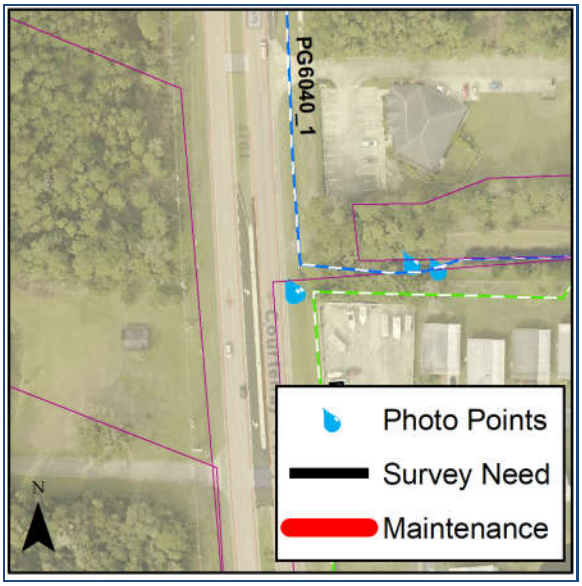
North Merritt Island Field Inspection Form

Link Name:DG6050_1

Lat: 28.441676972

SWAMPid: P130D63516816

Long: -80.708729



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Initial desktop evaluation of this structure appears as though it was a Drop Structure, however field investigation indicated that the pond is actually just offline storage connected to the roadside swale along SR3 swale. The controlling culvert for this node is the pipe under WoodStork Dr, which is in SWAMP.

Drainage Pattern Verification:

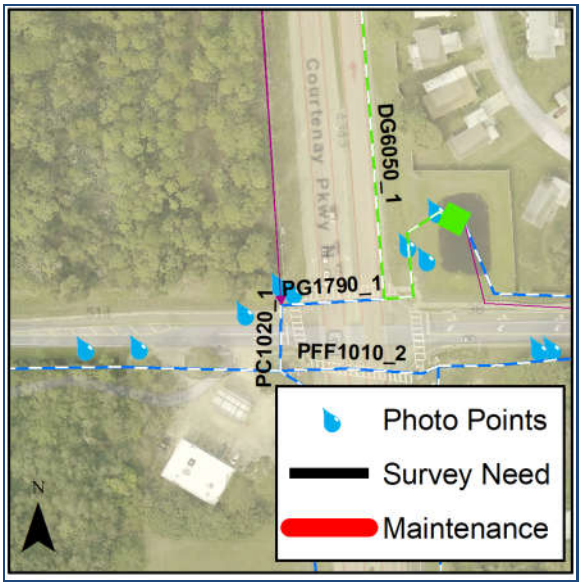
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PG1790_1

Lat: 28.434484972

SWAMPid: P035E602091088 Long: -80.70846297



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: 48" cross culvert is in SWAMP without invert elevations. Flow line specified as -0.63 NAVD88 (converted from NGVD29) per pg 24 of 82 NMI_123_RD_01

Drainage Pattern Verification:

Drainage Pattern Comment:

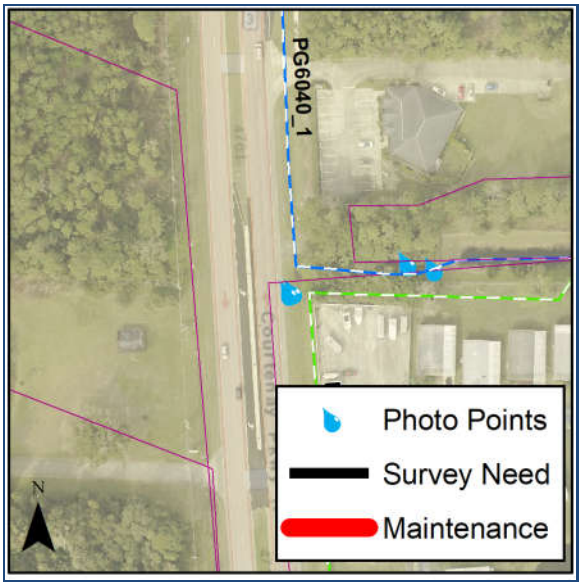
North Merritt Island Field Inspection Form

Link Name:PG6040_1

Lat: 28.441680972

SWAMPid: P110D635140141

Long: -80.70871497



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Pond downstream is an offline retention facility rather than a stand alone pond with discharge structure. Controlling connection downstream is the culvert crossing the pond's access driveway. Culvert is 24 inches with inverts of 2.05 NAVD88 upstream/downstream 40 ft long.

Drainage Pattern Verification:

Drainage Pattern Comment:

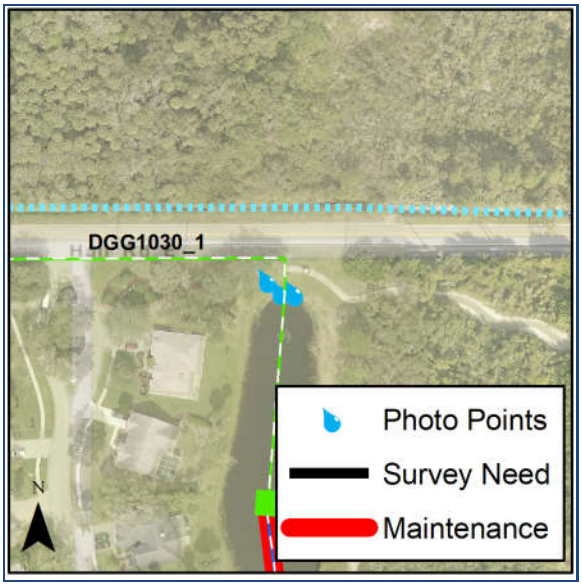
North Merritt Island Field Inspection Form

Link Name:DGG1030_1

Lat: 28.434179

SWAMPid: BCE601CS001

Long: -80.678317



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Construction plans and “as builts” showed various modifications to outfall structure. Field investigation confirms that the box top is 177x44, left slot is regular; right slot has main slot and 2 steps. Elevations are in SWAMP.

Drainage Pattern Verification:

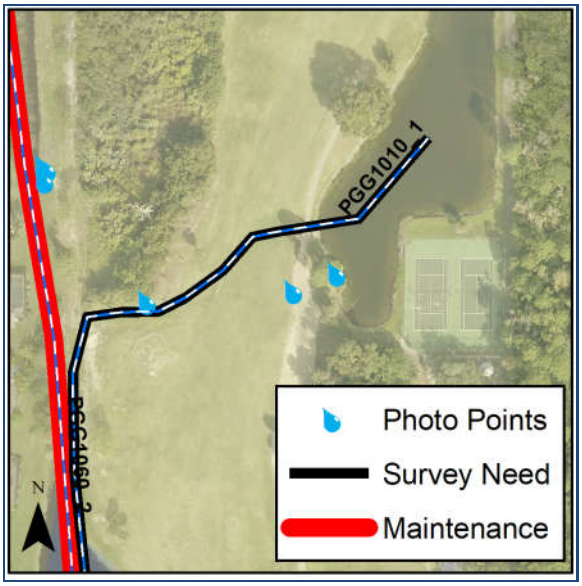
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PGG1010_1

Lat: 28.432013972

SWAMPid: P001E601011010 Long: -80.67733697



Location

Field Photo 11/5/2020

Survey Need: Yes

SurveyDescription: Culvert size and inverts

Maintenance Need: No

Field Visit Notes: 18" HDPE 12" above water level. DEM water level 3.3 NAVD88. Invert 4.3 NAVD88

Drainage Pattern Verification:

Drainage Pattern Comment:

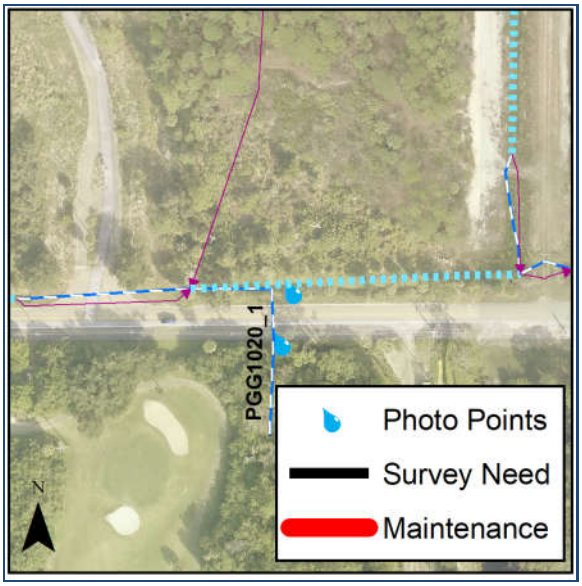
North Merritt Island Field Inspection Form

Link Name:PGG1020_1

Lat: 28.434429

SWAMPid: 0000CU0000

Long: -80.67643597



Location

Field Photo

11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: 18" RCP invert 4 ft below roadway. DEM 6.4, yielding an invert o 2.4 NAVD88

Drainage Pattern Verification:

Drainage Pattern Comment:

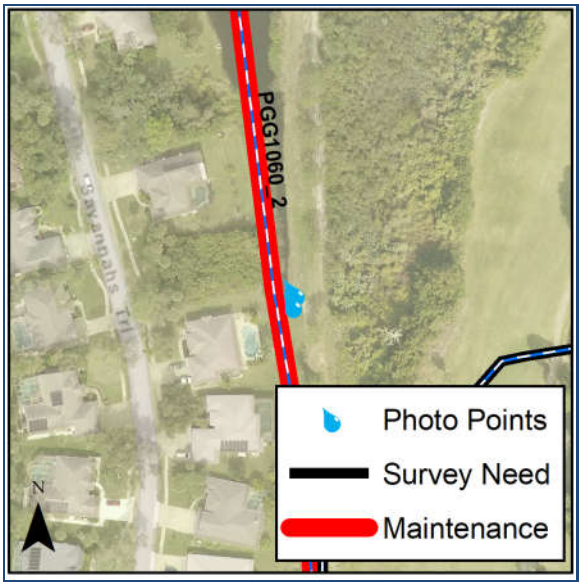
North Merritt Island Field Inspection Form

Link Name:PGG1060_2

Lat: 28.432387972

SWAMPid: Not in SWAMP

Long: -80.678184



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Culvert is presented in construction plans as an equalizer pipe between subdivision ponds. Field measured a 36" culvert 1.0 ft of silt in the pipe. Homeowners says culvert periodically clogs. Elevation culvert invert is 24” above current water level for a resulting invert elevation of 0.75 NAVD88.

Drainage Pattern Verification:

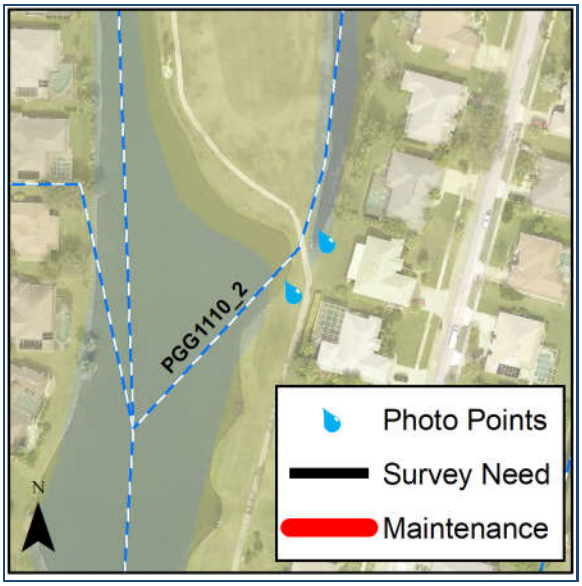
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PGG1110_2

Lat: 28.419405972

SWAMPid: P004E612005006 Long: -80.67958797



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: One foot of silt in 30 inch golf course cart path crossing culvert. Normal water level appears to half submerge the pipe. Crown of pipe is 0.5 feet to sidewalk. DEM 2.5. Water Level 1.0 NAVD88. Culvert invert EL -0.25 NAVD88

Drainage Pattern Verification:

Drainage Pattern Comment:

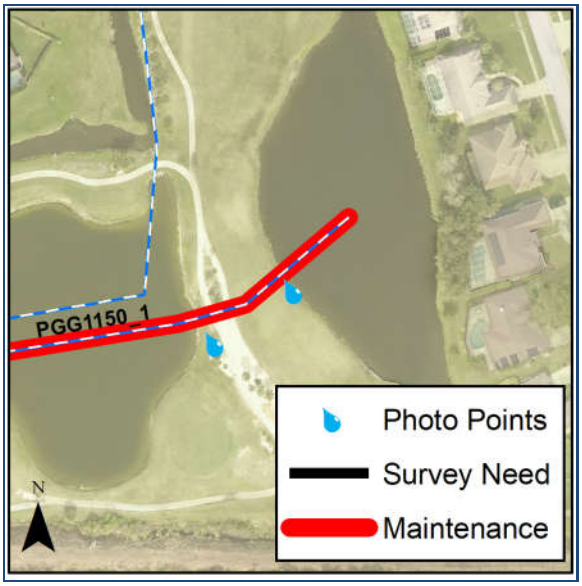
North Merritt Island Field Inspection Form

Link Name:PGG1150_1

Lat: 28.417087972

SWAMPid: P014E612021022

Long: -80.678257



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: 17" from water line to invert 2 x 12" HDPE. The upstream side of the pipe has split at a pipe joint. Water level is 0.57 NAVD88, yielding an invert flowline of -0.25 NAVD88 connecting the two golf course ponds

Drainage Pattern Verification:

Drainage Pattern Comment:

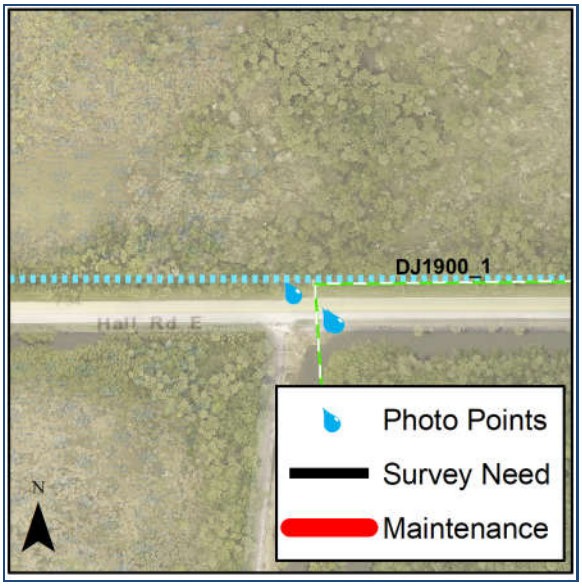
North Merritt Island Field Inspection Form

Link Name:DJ1900_1

Lat: 28.434394972

SWAMPid: BCE601CS086

Long: -80.687825



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Structure is a large box with sealed top and slot opening on the ditch side. SWAMP Invert -1.57 NAVD88. Field measurement opening 6 ft wide by 5 ft deep.

Drainage Pattern Verification:

Drainage Pattern Comment:

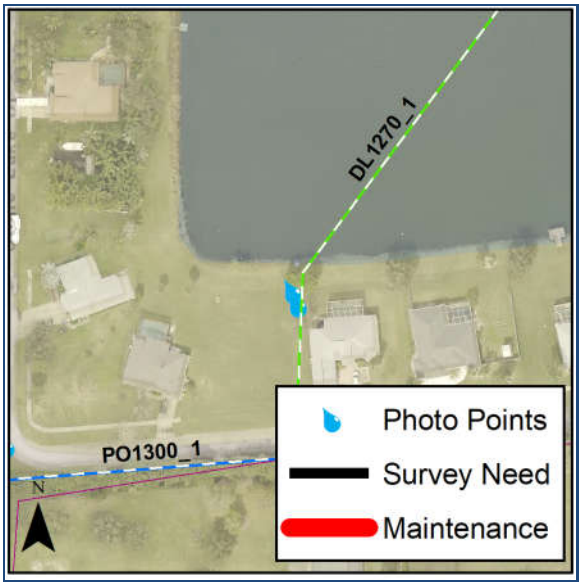
North Merritt Island Field Inspection Form

Link Name:DL1270_1

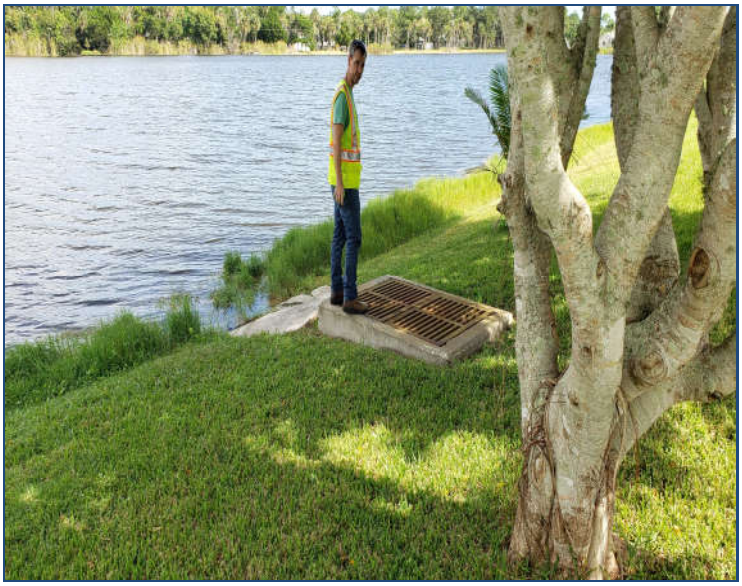
Lat: 28.451221

SWAMPid: BCD625CS092

Long: -80.68288097



Location



Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: The SWAMP database has structure elevations without specified dimensions. Field measurement of structure dimensions are: top 36x54. inside main weir 30" in addition to a notch that is 6 inches wide.

Drainage Pattern Verification:

Drainage Pattern Comment:

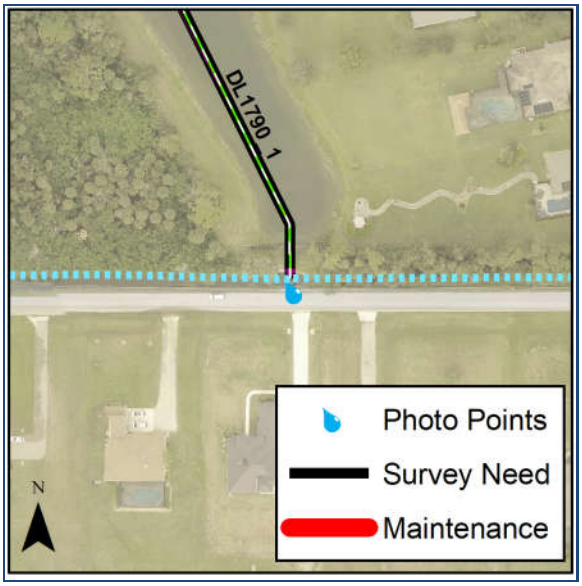
North Merritt Island Field Inspection Form

Link Name:DL1790_1

Lat: 28.448978

SWAMPid: BCD625CS099

Long: -80.68679697



Location

Field Photo 11/5/2020

Survey Need: Yes

SurveyDescription: Detailed Structure Sketch. Survey Structure and broad crest weir representing berm overtopping the pond into Chase Hammock Ditch

Maintenance Need: No

Field Visit Notes: The structure is in the SWAMP database, however, it was not able to be access for field measurements and does not appear to be a typical configuration. Need survey to validate slot openings and structure dimensions.

Drainage Pattern Verification:

Drainage Pattern Comment:

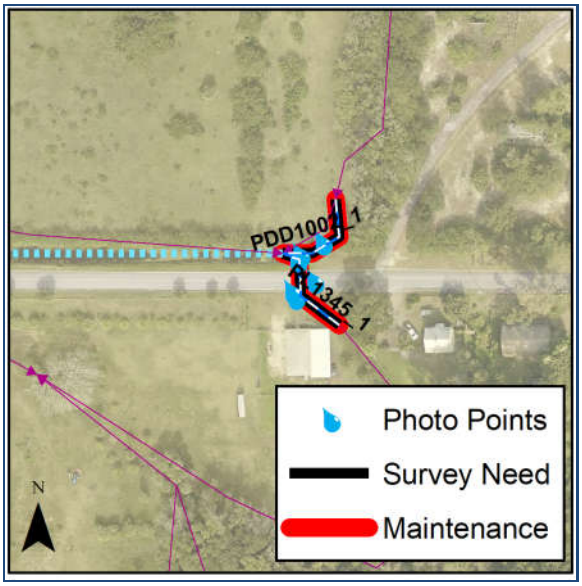
North Merritt Island Field Inspection Form

Link Name:PL1345_1

Lat: 28.463529

SWAMPid: BC233625CU010

Long: -80.67895697



Location

Field Photo

11/3/2020

Survey Need: Yes

SurveyDescription: Culvert and ditch on south side of road to confirm culvert invert is the controlling elevation for water getting to the ditch.

Maintenance Need: Yes

Field Visit Notes: Structure is partially silted and obscured by vegetation. Survey benchmark on the side of the roadway indicates 3.3 ft, no datum specified, assume NAVD88. Until survey confirms estimate invert at 3 ft below roadway edge El 0.3 NAVD88.

Drainage Pattern Verification:

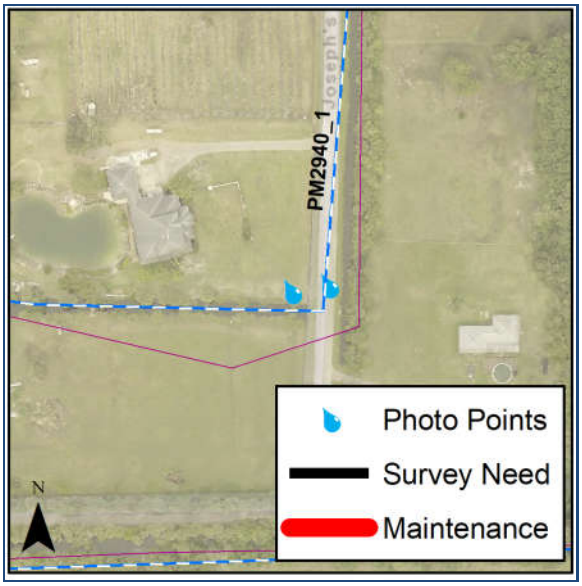
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PM2940_1

Lat: 28.456983

SWAMPid: 0000CU0000 Long: -80.68975297



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Flow line 5 ft below roadway. DEM elevation of roadway is 2.5ft NAVD88 with pipe invert of -2.5ft NAVD88.

Drainage Pattern Verification:

Drainage Pattern Comment:

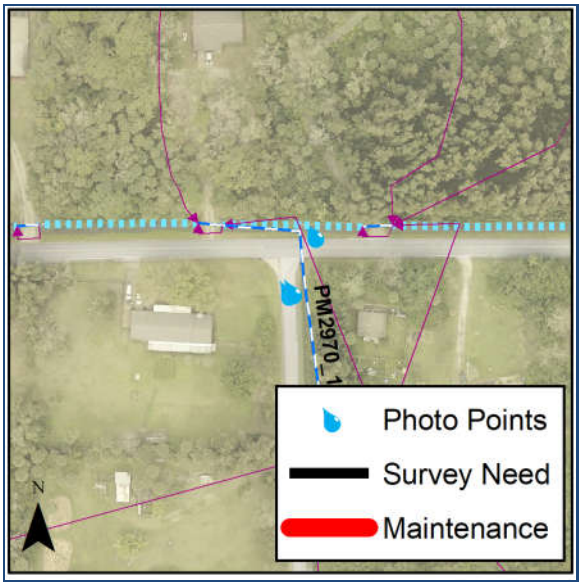
North Merritt Island Field Inspection Form

Link Name:PM2970_1

Lat: 28.463481972

SWAMPid: P006D624008007

Long: -80.68992697



Location

Field Photo

11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: Yes

Field Visit Notes: Tideflex pipe end treatment. Tideflex product does not appear to be function optimally, the rubber appears still from oxidation. It is recommended that the manufacturer provide an opinion as to how well the structure will function in this condition.

Drainage Pattern Verification:

Drainage Pattern Comment:

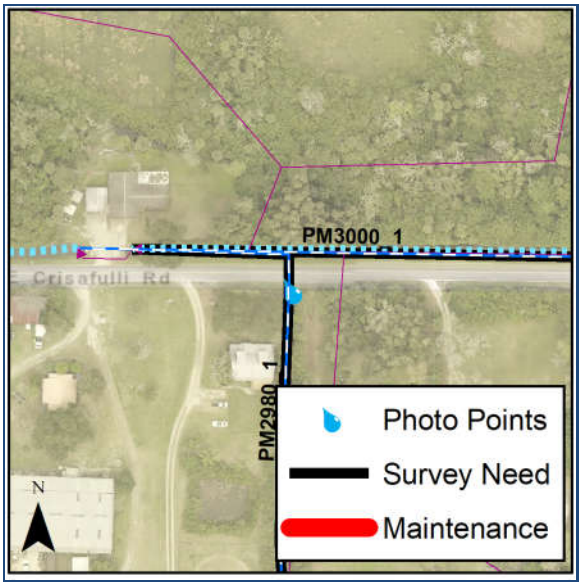
North Merritt Island Field Inspection Form

Link Name:PM2980_1

Lat: 28.463554972

SWAMPid: 0000CU0000

Long: -80.687509



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: culvert inverts

Maintenance Need: Yes

Field Visit Notes: Tideflex pipe end treatment, submerged at current water level. Tideflex product does not appear to be function optimally, the rubber appears still from oxidation. It is recommended that the manufacturer provide an opinion as to how well the structure will function in this condition.

Drainage Pattern Verification:

Drainage Pattern Comment:

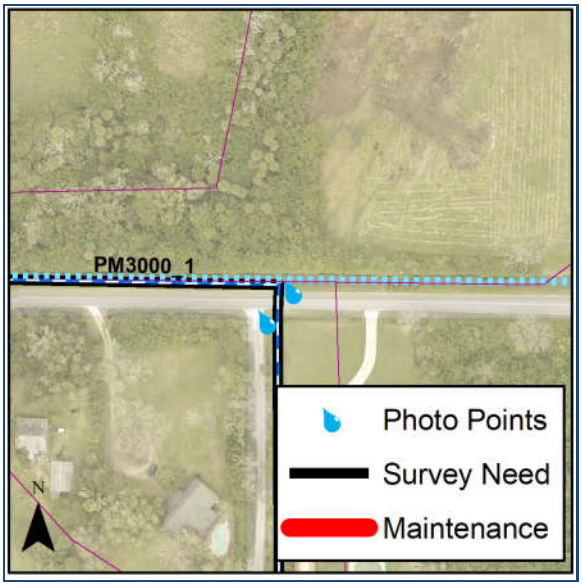
North Merritt Island Field Inspection Form

Link Name:PM3000_1

Lat: 28.463633

SWAMPid: 0000CU0000

Long: -80.686356



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: culvert inverts

Maintenance Need: Yes

Field Visit Notes: Tideflex pipe end treatment. Tideflex product does not appear to be function optimally, the rubber appears still from oxidation. It is recommended that the manufacturer provide an opinion as to how well the structure will function in this condition.

Drainage Pattern Verification:

Drainage Pattern Comment:

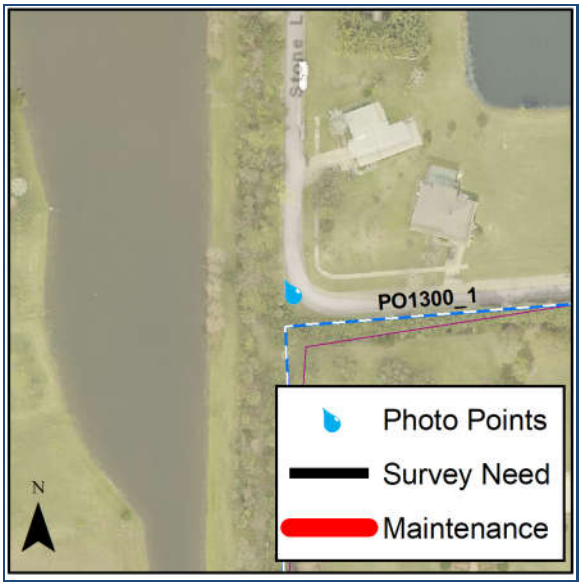
North Merritt Island Field Inspection Form

Link Name:PO1300_1

Lat: 28.450762

SWAMPid: Not in SWAMP

Long: -80.683862



Location

Field Photo

11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Pipe submerged at normal water level. Assume 24". DEM elevation 2.3. Invert -0.5 NAVD88

Drainage Pattern Verification:

Drainage Pattern Comment:

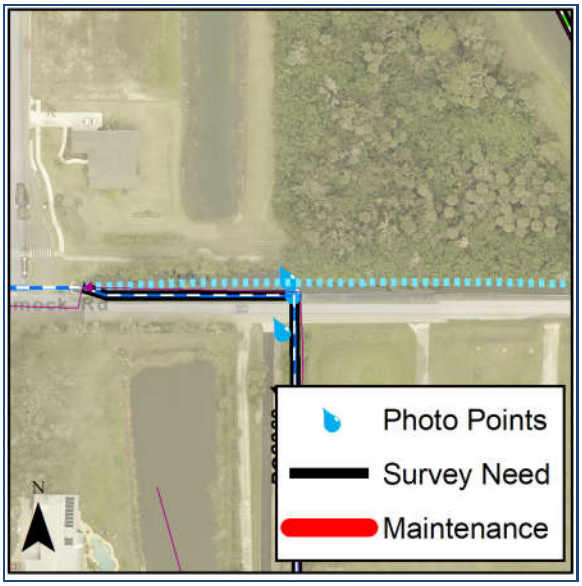
North Merritt Island Field Inspection Form

Link Name:PO2960_1

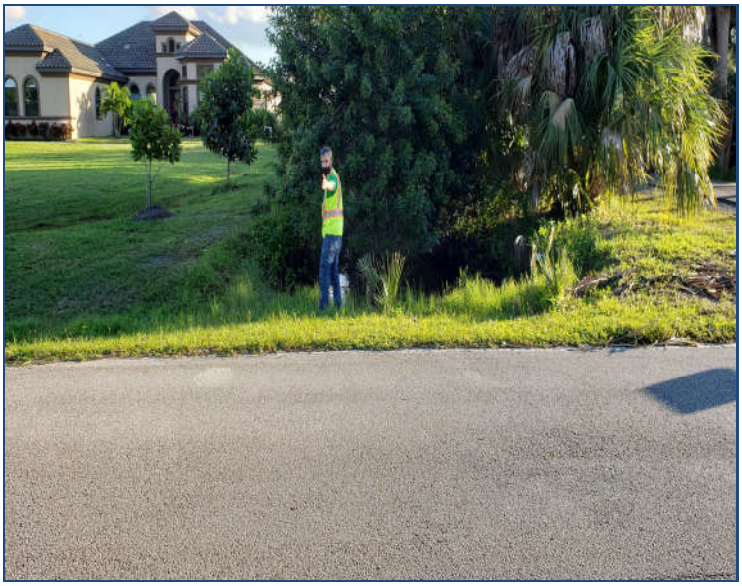
Lat: 28.449003

SWAMPid: Not in SWAMP

Long: -80.68809697



Location



Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Culvert Inverts

Maintenance Need: No

Field Visit Notes: 18 inch RCP. Submerged assume crown at DEM water level.

Drainage Pattern Verification:

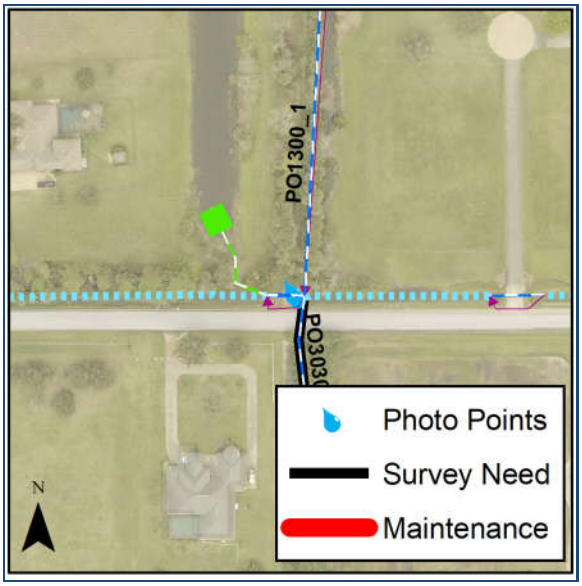
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PO3030_2

Lat: 28.449031

SWAMPid: BC233636CU003 Long: -80.68399497



Location

Field Photo 11/5/2020

Survey Need: Yes

SurveyDescription: Culvert under Chase Hammock Rd

Maintenance Need: No

Field Visit Notes: Pipe below water level. Assume 24" invert -0.5 NAVD88. until survey confirmation.

Drainage Pattern Verification:

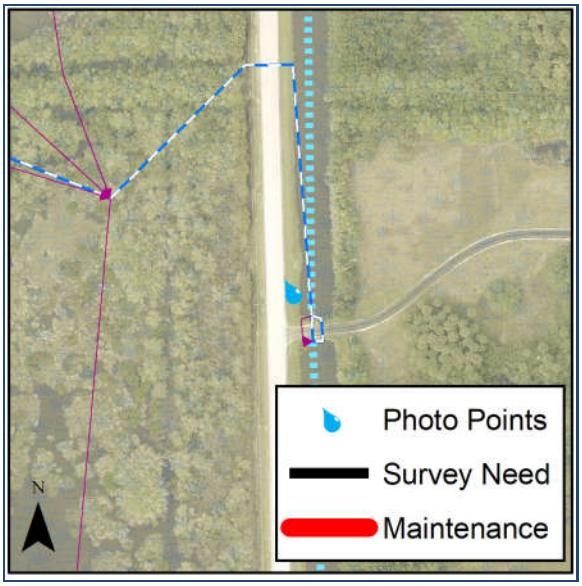
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PP2641_1

Lat: 28.455743972

SWAMPid: P024D626038037 Long: -80.70036797



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Confirmed different size pipes here

Drainage Pattern Verification:

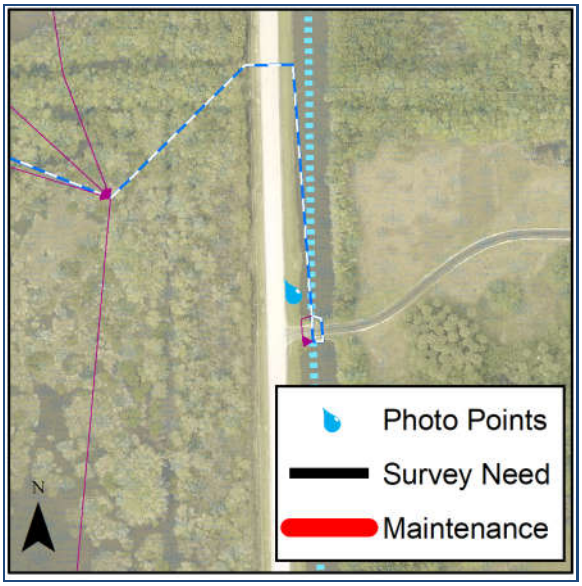
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PP2641_2

Lat: 28.455743972

SWAMPid: P023D626036039 Long: -80.70036797



Location

Field Photo 11/5/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Confirmed different size pipes here

Drainage Pattern Verification:

Drainage Pattern Comment:

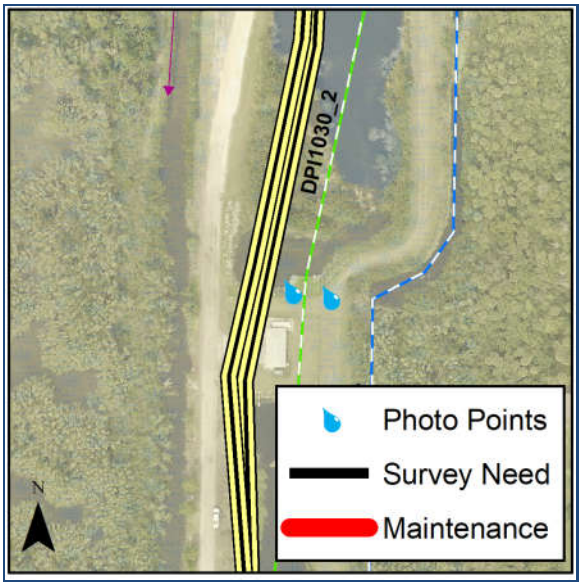
North Merritt Island Field Inspection Form

Link Name:DPI1030_2

Lat: 28.494029972

SWAMPid: BCE610CS011

Long: -80.72119997



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Outfall connection between Pine Island North pond and outfall channel. The structure includes 2 pipes and headwall weir structure. This validates the data in SWAMP and the construction plans

Drainage Pattern Verification:

Drainage Pattern Comment:

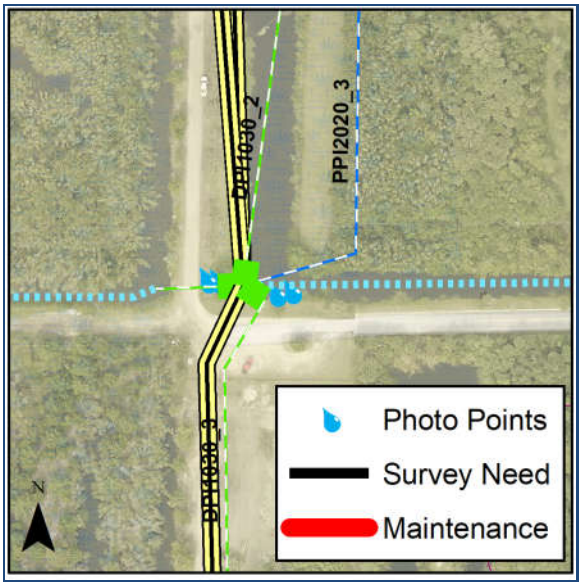
North Merritt Island Field Inspection Form

Link Name:DPI1030_3

Lat: 28.492736

SWAMPid: BCD610CS001

Long: -80.721162



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Because of the presence of the skimmer on this structure, it was assumed it was a drop structure, however the trash skimmer has no elevation control for the pipe connecting to the Pine Island South Pond.

Drainage Pattern Verification: Y

Drainage Pattern Comment: Confirmed, this provides a hydraulic connection between the ditch and Pine Island South Pond

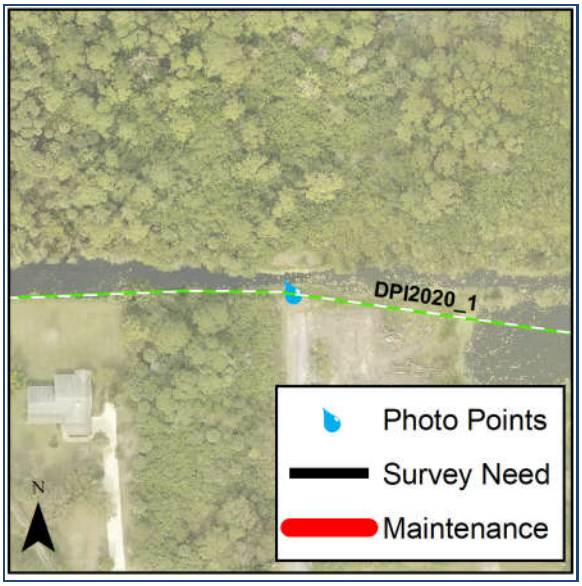
North Merritt Island Field Inspection Form

Link Name:DPI2020_1

Lat: 28.50008

SWAMPid: 0000CU000

Long: -80.71876



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: SWAMP data indicated the presence of a drop structure, however there is no structure visible in the field, just an open channel

Drainage Pattern Verification:

Drainage Pattern Comment:

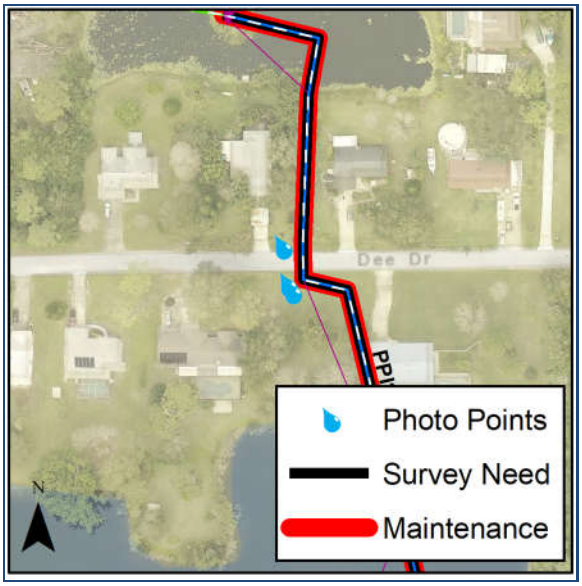
North Merritt Island Field Inspection Form

Link Name:PPI2010_1

Lat: 28.499110972

SWAMPid: 0000CU0000

Long: -80.717482



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Culvert inverts

Maintenance Need: Yes

Field Visit Notes: Culvert crossing Dee Dr. Partially Blocked. DEM Road. 4.0. Assume invert 1.0 NAVD88 until Survey updates

Drainage Pattern Verification:

Drainage Pattern Comment:

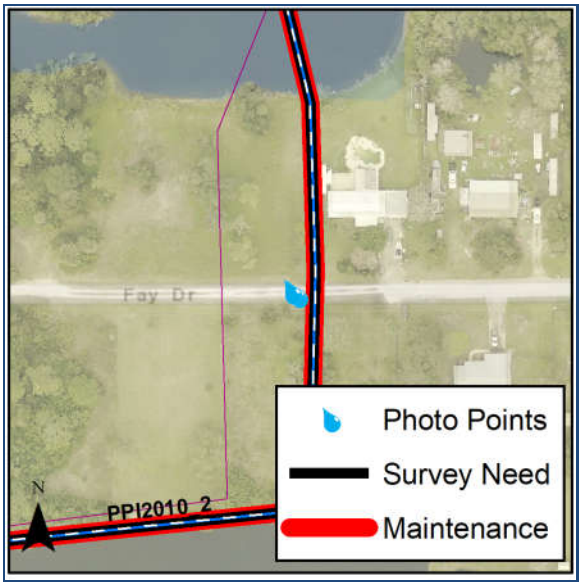
North Merritt Island Field Inspection Form

Link Name:PPI2010_2

Lat: 28.497479972

SWAMPid: 0000CU0000

Long: -80.717065



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Culvert inverts and inlet in Homeowners yard at the end of Fay St.

Maintenance Need: Yes

Field Visit Notes: Culvert from pond crossing dirt road portion of Fay Dr. Drainage path from lake is overgrown. Culvert silted. DEM overflow 3.5. Assume same inverts as outfall in other direction 1.0 NAVD88 until survey

Drainage Pattern Verification:

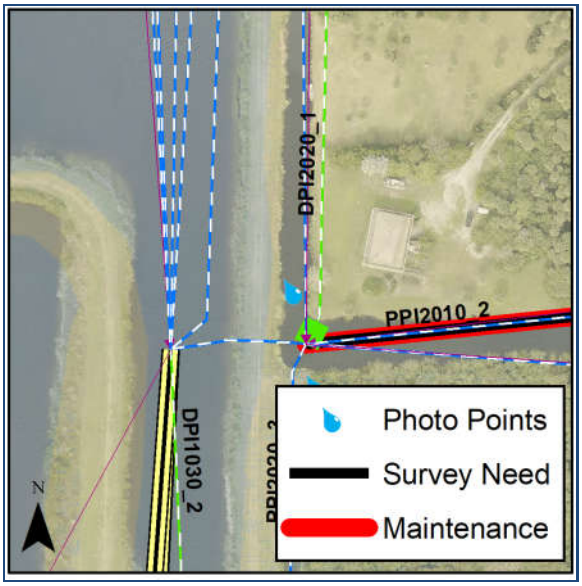
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:PPI2020_3

Lat: 28.496669

SWAMPid: P015D610016017 Long: -80.72060797



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Use inverts in SWAMP for inverts, culvert and headwall

Drainage Pattern Verification: Y

Drainage Pattern Comment: Confirmed drainage pattern discharges lake south through this link

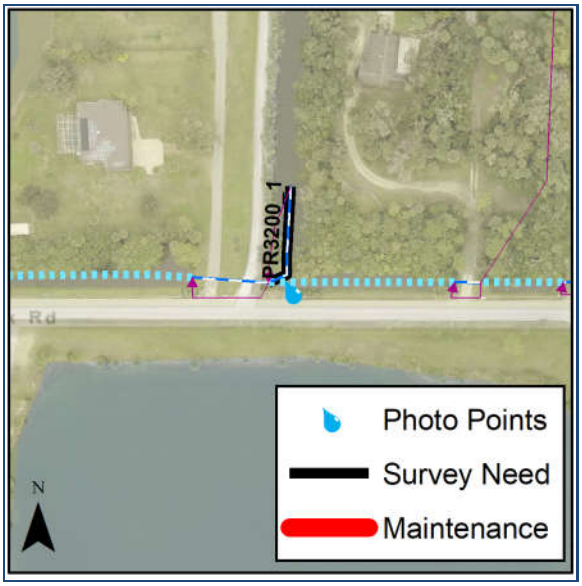
North Merritt Island Field Inspection Form

Link Name:PR3200_1

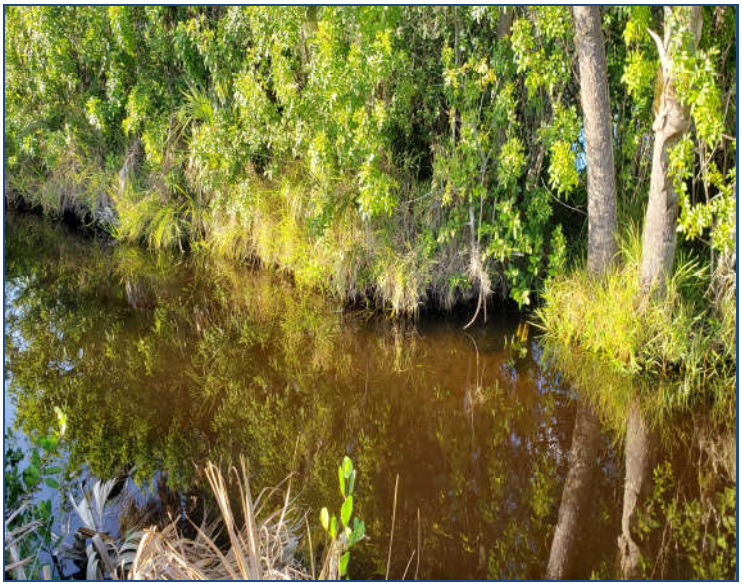
Lat: 28.449018972

SWAMPid: 0000CU0000

Long: -80.694974



Location



Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Culvert and inverts

Maintenance Need: No

Field Visit Notes: Couldn't see culvert clearly, but likely discharges depressional area north into canal. DEM El 3.0 of Berm. Assume Culvert invert 0 NAVD88 until survey confirmation.

Drainage Pattern Verification:

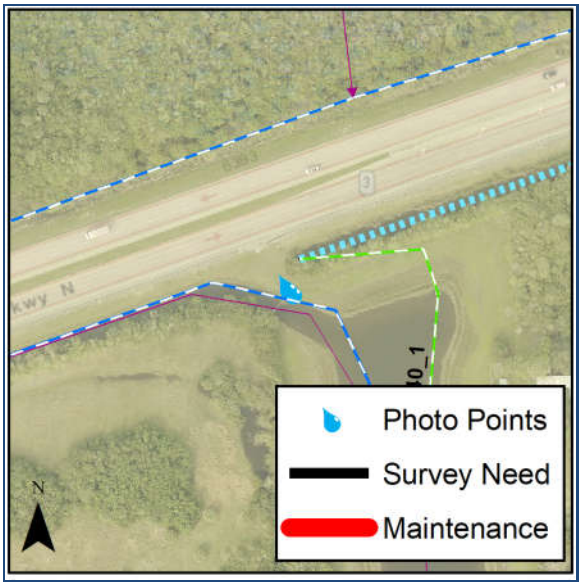
Drainage Pattern Comment:

North Merritt Island Field Inspection Form

Link Name:DS1140_1

Lat: 28.474769972

SWAMPid: 0000SC0000 Long: -80.70226397



Location

Field Photo 11/3/2020

Survey Need: Yes

SurveyDescription: Provide detailed sketch of structure to supplement SWAMP elevations.

Maintenance Need: No

Field Visit Notes: DOT pond 134. Could not gain access to the structure. SWAMP has elevations but not weir dimensions.

Drainage Pattern Verification:

Drainage Pattern Comment:

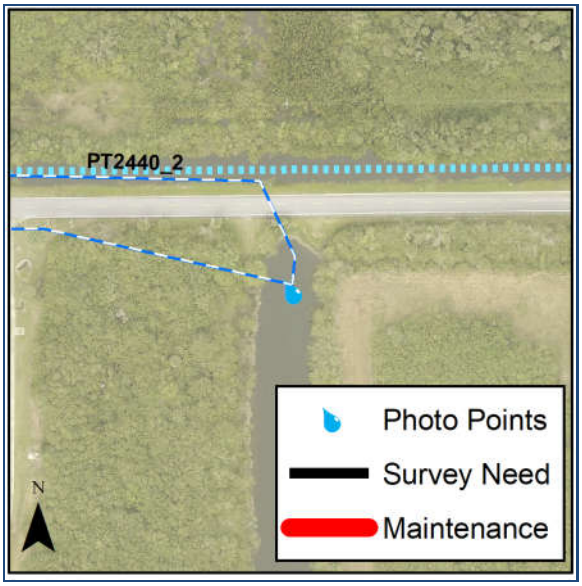
North Merritt Island Field Inspection Form

Link Name:PT2440_2

Lat: 28.492453

SWAMPid: 0000CU0000

Long: -80.71169997



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Old pump station without no culvert connection. Remove link from the model.

Drainage Pattern Verification:

Drainage Pattern Comment:

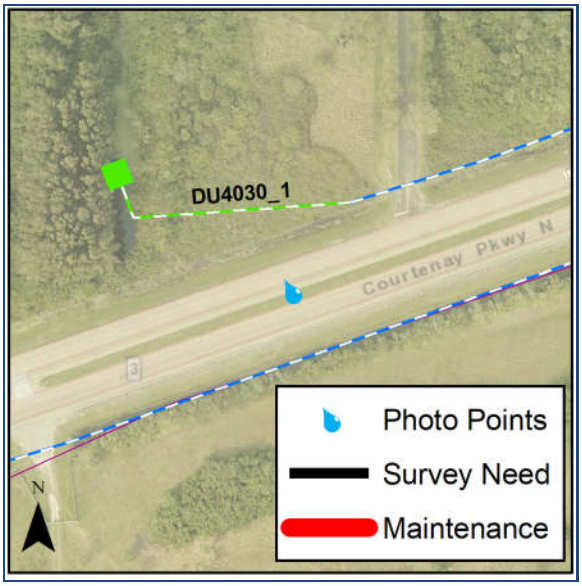
North Merritt Island Field Inspection Form

Link Name:DU4030_1

Lat: 28.474586776

Long: -80.70389571

SWAMPid: Not in SWAMP



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Outfall structure appears overgrown yet consistent with development plans from church. Rely upon construction plans for structure information.

Drainage Pattern Verification:

Drainage Pattern Comment:

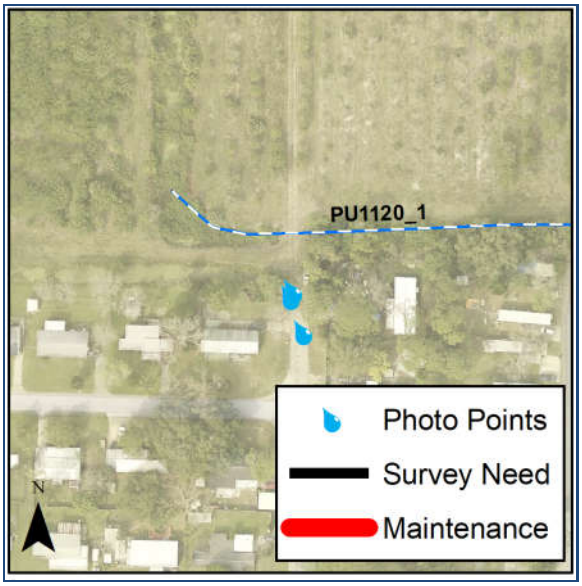
North Merritt Island Field Inspection Form

Link Name:PU1120_1

Lat: 28.481733972

Long: -80.70872597

SWAMPid: Not in SWAMP



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: Rural connection across access road. 24 inch pipe submerged at normal water level. Per DEM 3.74 NAVD88 is the elevation of the roadway. Approximate Invert 0.5 NAVD88.

Drainage Pattern Verification:

Drainage Pattern Comment:

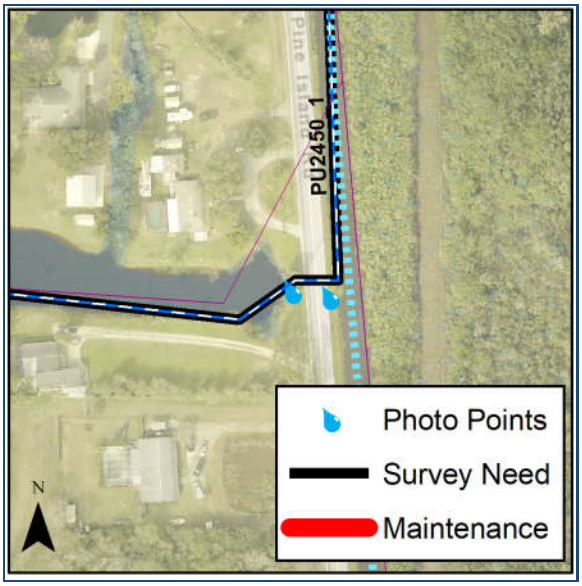
North Merritt Island Field Inspection Form

Link Name:PU2450_1

Lat: 28.491672972

SWAMPid: 0000CU0000

Long: -80.70057797



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription: JEA RTK NASA Model

Maintenance Need: No

Field Visit Notes: DEM roadway 2.4 NAVD88. Field measure 2 ft from crown of pipe to top of road, which yields a structure invert of -1.0 NAVD88.

Drainage Pattern Verification:

Drainage Pattern Comment:

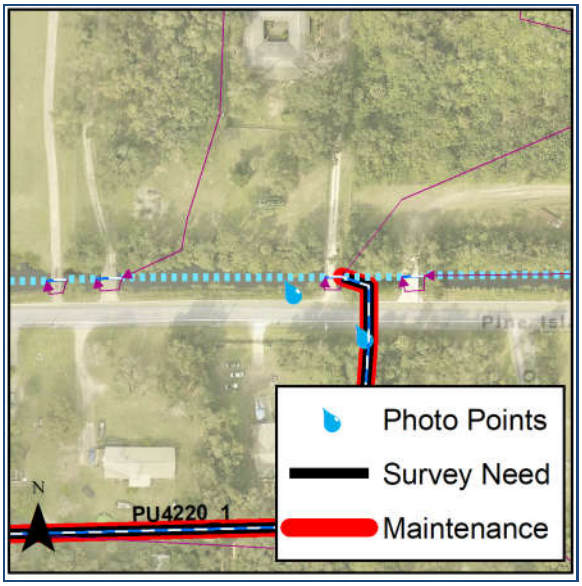
North Merritt Island Field Inspection Form

Link Name:PU4220_1

Lat: 28.492806972

SWAMPid: 0000CU0000

Long: -80.70472497



Location

Field Photo

11/3/2020

Survey Need: Yes

SurveyDescription: Culvert inverts

Maintenance Need: Yes

Field Visit Notes: 36 inch culvert. 7.5 ft from road to flow line. Culvert partially silted in need of maintenance to function optimally. DEM roadway 4.1 NAVD88. invert -3.4 NAVD88.

Drainage Pattern Verification:

Drainage Pattern Comment:

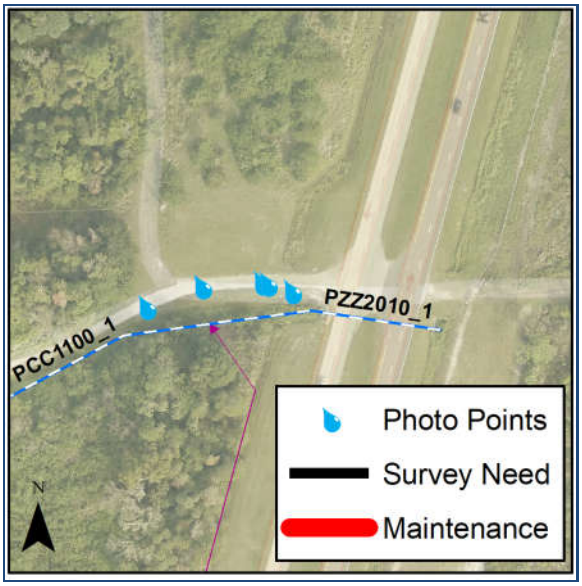
North Merritt Island Field Inspection Form

Link Name:PZZ2010_1

Lat: 28.492927972

Long: -80.67485397

SWAMPid: Not in SWAMP



Location

Field Photo 11/3/2020

Survey Need: No

SurveyDescription:

Maintenance Need: No

Field Visit Notes: 3 x 30 inch CMPs. These structures are part of the NASA model under development at the time of this field work. Incorporate data from the NASA model when it is available for this location.

Drainage Pattern Verification: Y

Drainage Pattern Comment: Connects Drainage across SR3