Appendix C. Lake George Sub-basin 2009 Land Uses

Blue Creek Sub-basin

Table C.1. Blue Creek 2009 Land Use Summary

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
1100	Residential, low density - less than 2 dwelling units/acre	96.19	0.84
1180	Rural residential	114.54	1.00
1200	Residential, medium density - 2-5 dwelling units/acre	418.39	3.64
1300	Residential, high density - 6 or more dwelling units/acre	9.70	0.08
1400	Commercial and services	58.86	0.51
1480	Cemeteries	7.60	0.07
1550	Other light industrial	7.47	0.07
1620	Sand and Gravel Pits	15.87	0.14
1650	Reclaimed lands	5.37	0.05
1660	Holding ponds	10.64	0.09
1700	Institutional	14.26	0.12
1730	Military	7.27	0.06
1840	Marinas & fish camps	2.93	0.03
1850	Parks and zoos	11.66	0.10
2110	Improved pastures (monocult, planted forage crops)	27.37	0.24
2120	Unimproved pastures	9.34	0.08
2130	Woodland pastures	15.57	0.14
2150	Field crops	47.22	0.41
2431	Shade ferns	9.78	0.09
2510	Horse farms	11.76	0.10
3100	Herbaceous upland nonforested	7.95	0.07
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	81.58	0.71
3300	Mixed upland nonforested/Mixed Rangeland	26.47	0.23
4110	Pine flatwoods	1296.07	11.29
4130	Sand pine	2432.95	21.19
4340	Upland mixed coniferous/hardwood	255.81	2.23
4410	Coniferous pine	685.88	5.97
4430	Forest regeneration areas	366.51	3.19
5100	Streams and waterways	112.59	0.98
5200	Lakes	379.12	3.30

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
5250	Open water within a freshwater marsh / Marshy Lakes	29.68	0.26
5300	Reservoirs - pits, retention ponds, dams	13.77	0.12
6110	Bay swamp (if distinct)	321.31	2.80
6170	Mixed wetland hardwoods	2972.12	25.89
6210	Cypress	2.24	0.02
6250	Hydric pine flatwoods	307.16	2.68
6300	Wetland forested mixed	924.06	8.05
6410	Freshwater marshes	166.65	1.45
6430	Wet prairies	8.31	0.07
6440	Emergent aquatic vegetation	103.05	0.90
6460	Treeless Hydric Savanna/Mixed scrub-shrub wetland	46.75	0.41
8200	Communications	2.63	0.02
8330	Water supply plants	2.84	0.02
8340	Sewage treatment	27.28	0.24
8350	Solid Waste Disposal	2.94	0.03
8370	Surface water collection basins	3.75	0.03
	SUM	**11481.25**	**100.00**

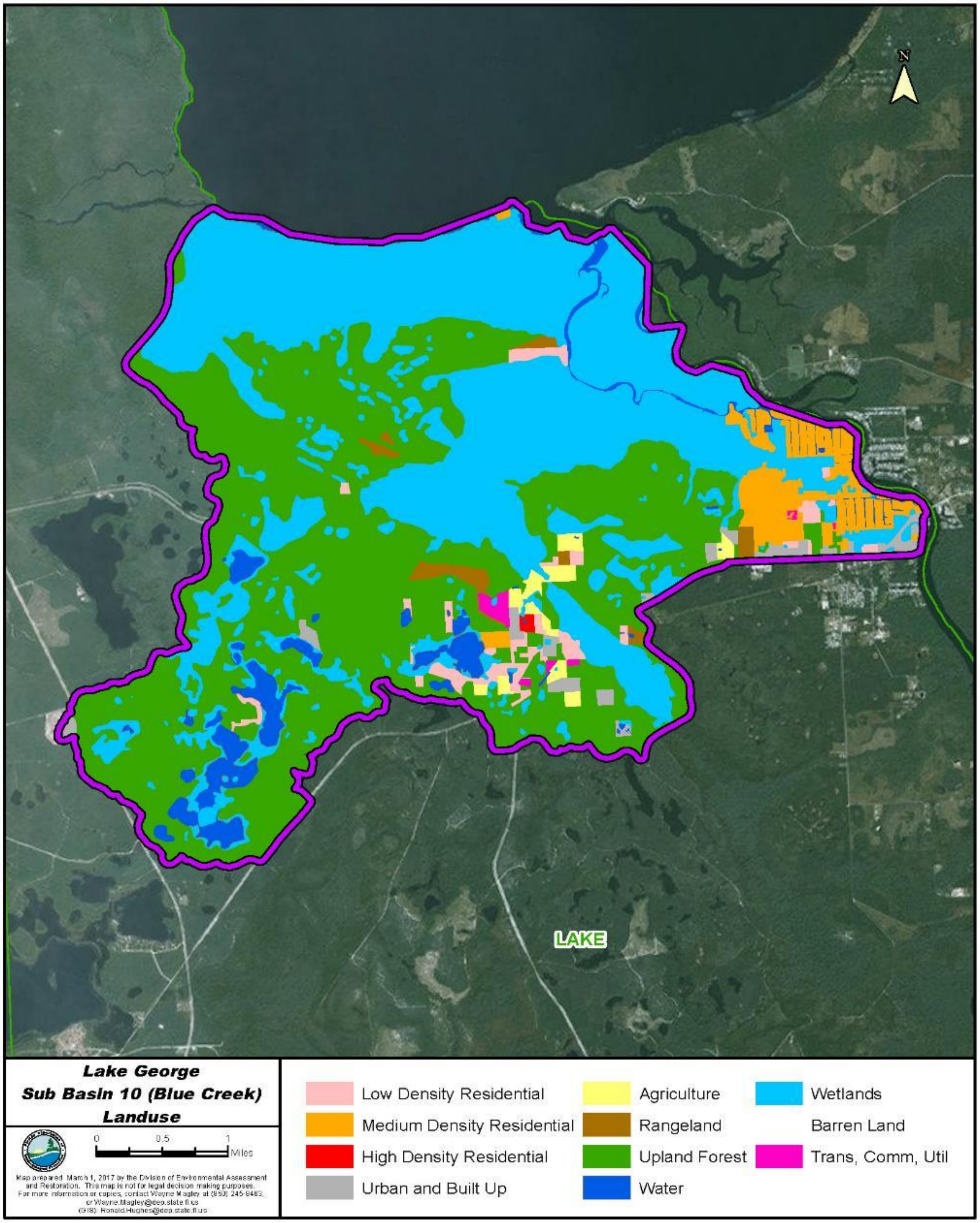
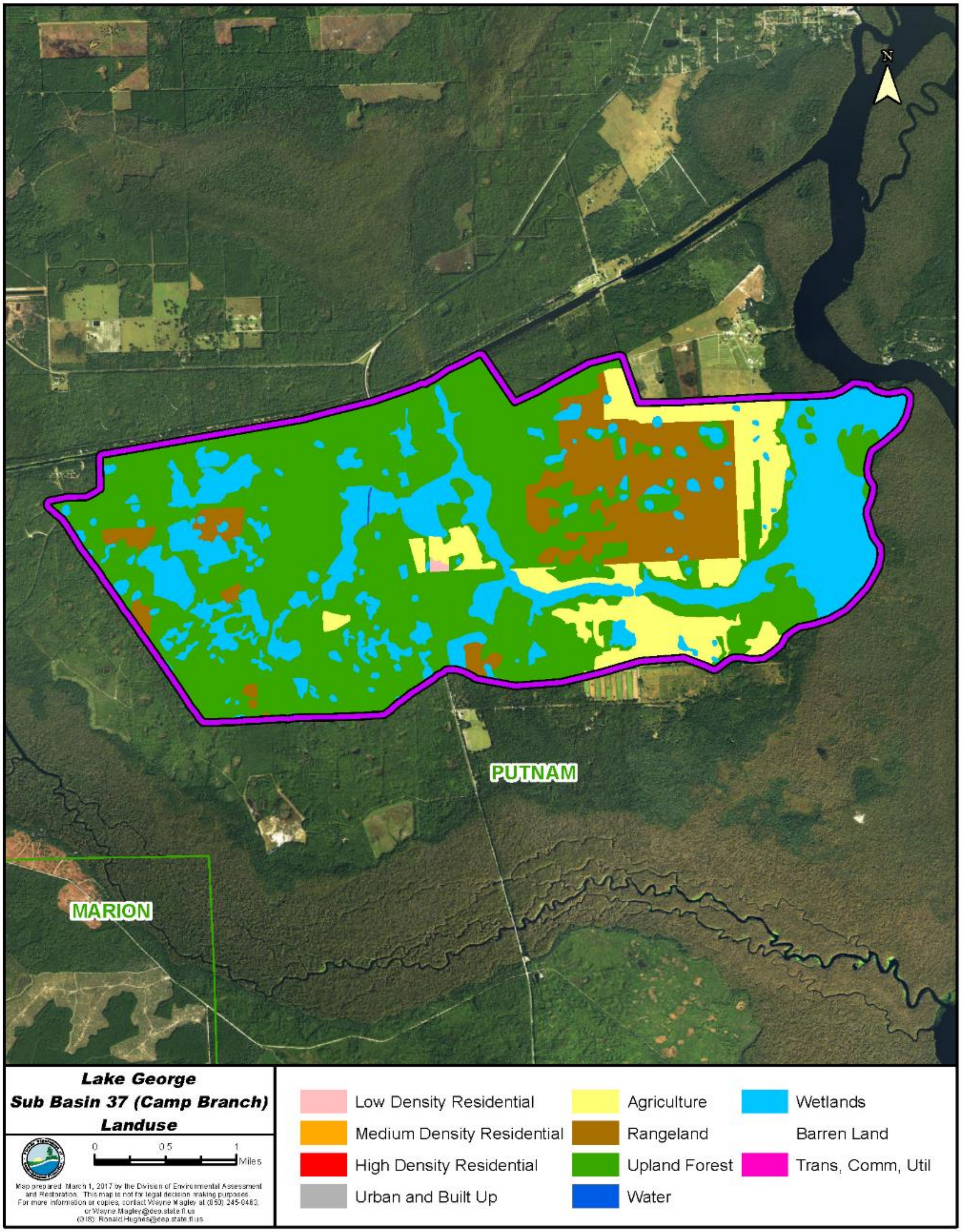


Figure C.1. Blue Creek Sub-basin

Camp Branch Sub-basin

Table C.2. Camp Branch 2009 Land Use Summary

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
1180	Rural residential	6.29	0.09
2110	Improved pastures (monocult, planted forage crops)	382.85	5.75
2120	Unimproved pastures	128.30	1.93
2130	Woodland pastures	35.43	0.53
2150	Field crops	11.85	0.18
2420	Sod farms	116.80	1.75
3100	Herbaceous upland nonforested	7.68	0.12
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	46.85	0.70
3300	Mixed upland nonforested/Mixed Rangeland	747.22	11.21
4110	Pine flatwoods	2438.28	36.59
4340	Upland mixed coniferous/hardwood	575.58	8.64
4410	Coniferous pine	497.28	7.46
4430	Forest regeneration areas	46.01	0.69
5100	Streams and waterways	3.80	0.06
6110	Bay Swamps	10.15	0.15
6170	Mixed wetland hardwoods	26.92	0.40
6210	Cypress	517.37	7.76
6250	Hydric pine flatwoods	275.72	4.14
6300	Wetland forested mixed	663.28	9.95
6410	Freshwater marshes	51.14	0.77
6430	Wet prairies	11.43	0.17
6440	Emergent aquatic vegetation	3.17	0.05
6460	Treeless Hydric Savanna/Mixed scrub-shrub wetland	60.28	0.90
	SUM	**6663.69**	**100.00**


N
PUTNAM
MARION
Lake George
Sub Basin 37 (Camp Branch)
Landuse
0
0.5
1
Miles
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For more information or copies, contact Wayne Magley at (850) 245-8463, or Wayne.Magley@dep.state.fl.us
(318): Ronald.Hughes@dep.state.fl.us
Low Density Residential
Medium Density Residential
High Density Residential
Urban and Built Up
Agriculture
Rangeland
Upland Forest
Water
Wetlands
Barren Land
Trans, Comm, Util

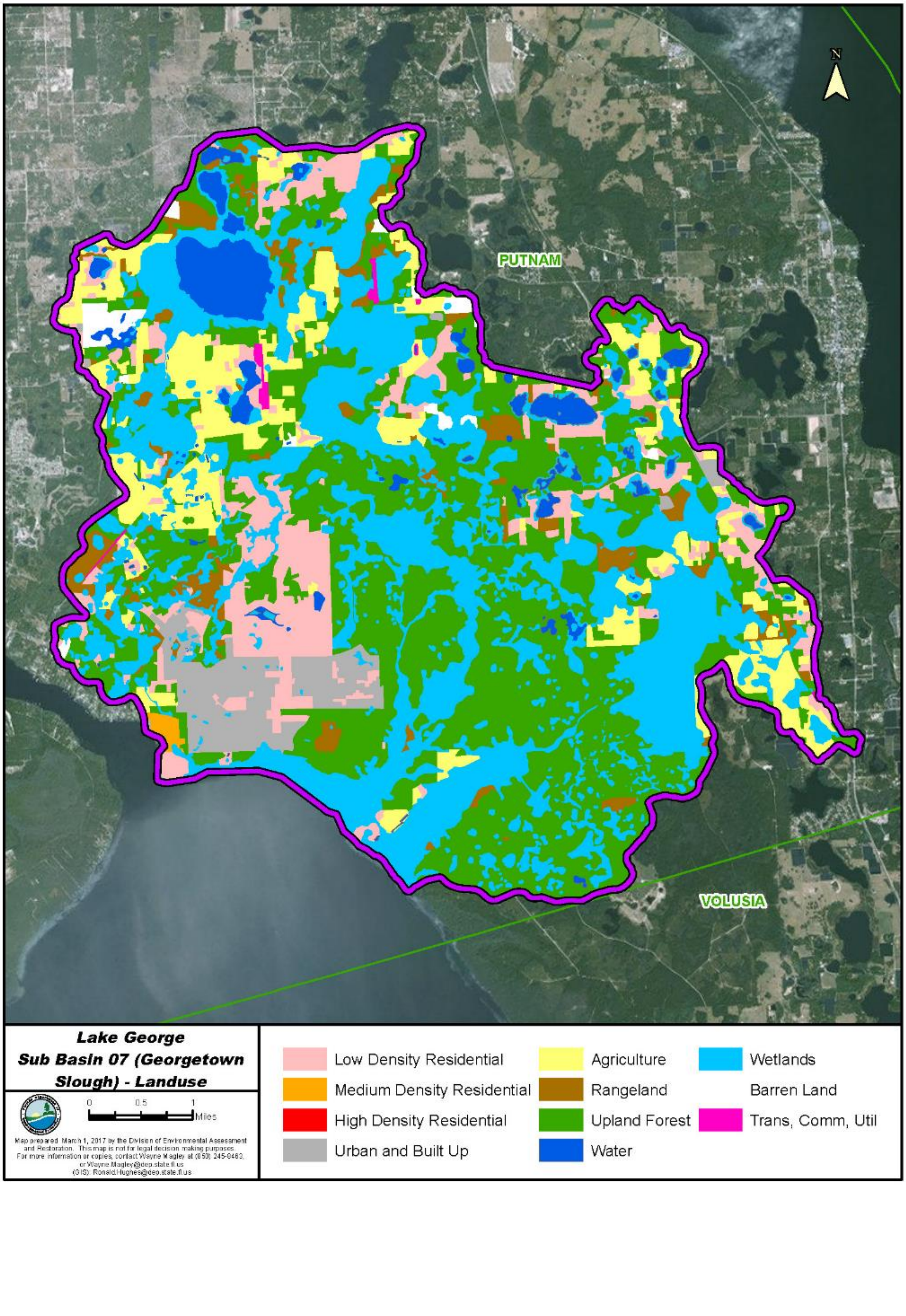
Figure C.2. Camp Brach Sub-basin

Georgetown Slough Sub-basin

Table C.3. Georgetown Slough Sub-basin 2009 Land Use Summary

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
1100	Residential, low density - less than 2 dwelling units/acre	974.75	4.46
1180	Rural residential	1085.75	4.97
1200	Residential, medium density - 2-5 dwelling units/acre	48.79	0.22
1400	Commercial and services	2.52	0.01
1550	Other light industrial	26.50	0.12
1620	Sand and Gravel Pits	10.29	0.05
1650	Reclaimed lands	5.02	0.02
1700	Institutional	5.67	0.03
1840	Marinas & fish camps	1.49	0.01
1920	Inactive land with street pattern but no structures	812.36	3.72
2110	Improved pastures (monocult, planted forage crops)	769.80	3.52
2120	Unimproved pastures	17.56	0.08
2130	Woodland pastures	152.99	0.70
2140	Row crops	42.45	0.19
2150	Field crops	87.50	0.40
2210	Citrus Groves <Orange, grapefruit, tangerines, etc.>	146.15	0.67
2240	Abandoned Groves	2.22	0.01
2400	Nurseries and vineyards	15.65	0.07
2410	Tree nurseries	7.75	0.04
2431	Shade ferns	421.38	1.93
2432	Hammock ferns	378.96	1.73
2510	Horse farms	122.55	0.56
2600	Other open lands - rural	0.72	0.00
3100	Herbaceous upland nonforested	118.10	0.54
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	561.87	2.57
3300	Mixed upland nonforested/Mixed Rangeland	176.69	0.81
4110	Pine flatwoods	1155.64	5.29
4120	Longleaf pine - xeric oak	524.91	2.40
4130	Sand pine	87.21	0.40

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
4200	Upland hardwood forests	72.35	0.33
4210	Xeric oak	227.44	1.04
4340	Upland mixed coniferous/hardwood	1484.49	6.79
4410	Coniferous pine	2886.00	13.20
4430	Forest regeneration areas	1026.96	4.70
5200	Lakes	870.89	3.98
5250	Open water within a freshwater marsh / Marshy Lakes	97.30	0.45
5300	Reservoirs - pits, retention ponds, dams	24.43	0.11
6110	Bay swamp (if distinct)	1000.50	4.58
6170	Mixed wetland hardwoods	798.33	3.65
6210	Cypress	176.33	0.81
6250	Hydric pine flatwoods	442.45	2.02
6300	Wetland forested mixed	2203.78	10.08
6410	Freshwater marshes	766.74	3.51
6430	Wet prairies	114.38	0.52
6440	Emergent aquatic vegetation	292.01	1.34
6460	Treeless Hydric Savanna/Mixed scrub-shrub wetland	1371.55	6.27
7400	Disturbed land	20.36	0.09
7410	Rural land in transition without positive indicators of intended activity	169.15	0.77
8110	Airports	37.91	0.17
8140	Airports	8.55	0.04
8310	Electrical power facilities	0.82	0.00
8320	Electrical power transmission lines	0.19	0.00
8350	Solid Waste Disposal	1.36	0.01
8370	Surface water collection basins	1.23	0.01
	SUM	**21858.74**	**100.00**


N
PUTNAM
VOLUSIA
Lake George
Sub Basin 07 (Georgetown Slough) - Landuse
0
0.5
1
Miles
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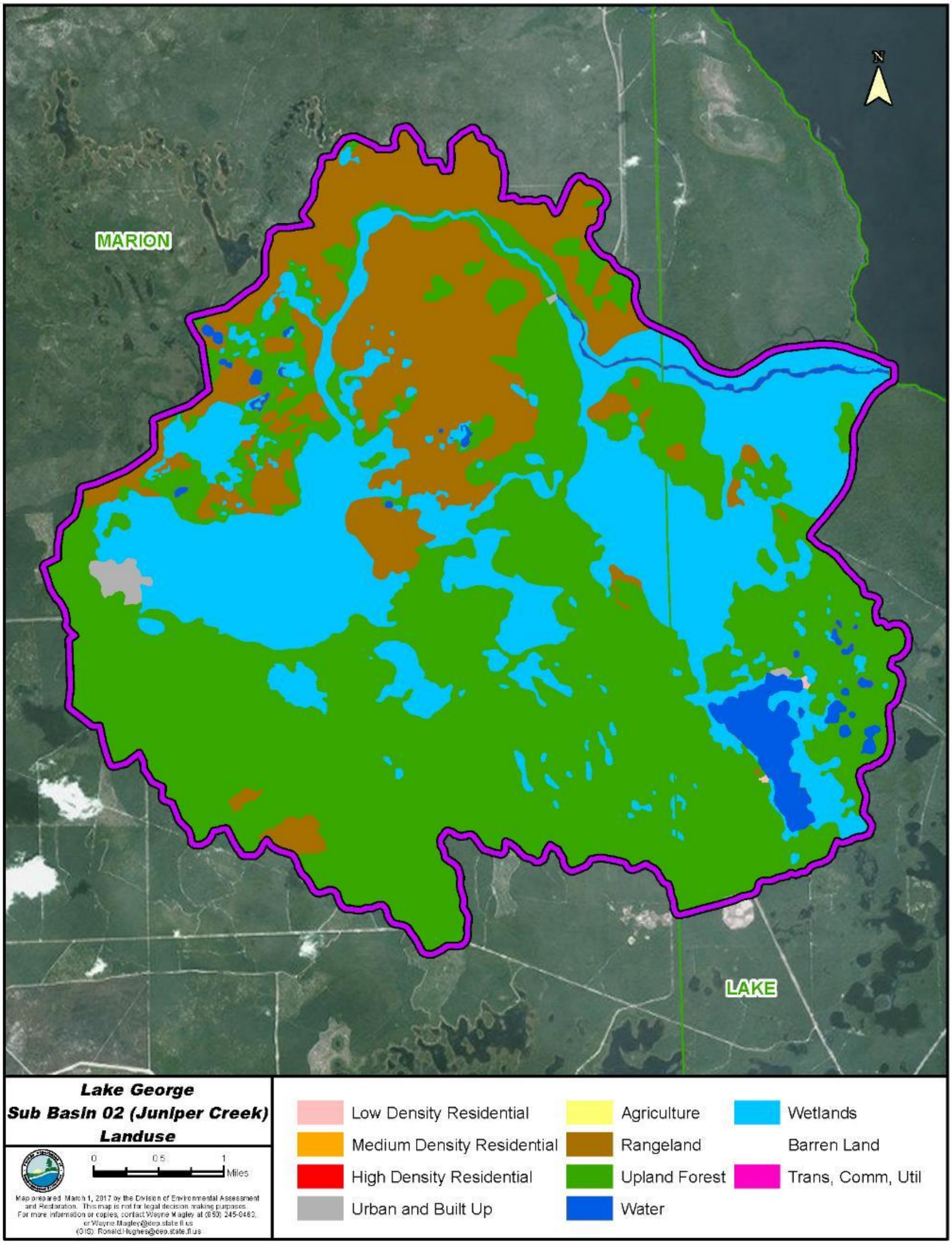
(GIS): Ronald.Hughes@dep.state.fl.us
Low Density Residential
Medium Density Residential
High Density Residential
Urban and Built Up
Agriculture
Rangeland
Upland Forest
Water
Wetlands
Barren Land
Trans, Comm, Util

Figure C.3. Georgetown Slough Sub-basin

Juniper Creek Sub-basin

Table C.4. Juniper Creek Sub-basin 2009 Land Use Summary

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
1180	Rural residential	4.86	0.03
1730	Military	1.04	0.01
1840	Marinas & fish camps	6.65	0.04
1850	Parks and zoos	63.79	0.38
3100	Herbaceous upland nonforested	1.48	0.01
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	3021.37	17.85
3300	Mixed upland nonforested/Mixed Rangeland	3.03	0.02
4110	Pine flatwoods	679.14	4.01
4130	Sand pine	6326.91	37.39
4340	Upland mixed coniferous/hardwood	420.12	2.48
4410	Coniferous pine	18.49	0.11
4430	Forest regeneration areas	1272.87	7.52
5100	Streams and waterways	53.05	0.31
5200	Lakes	358.24	2.12
6170	Mixed wetland hardwoods	3140.80	18.56
6210	Cypress	24.70	0.15
6220	Pond Pine	17.67	0.10
6250	Hydric pine flatwoods	512.66	3.03
6300	Wetland forested mixed	428.33	2.53
6410	Freshwater marshes	371.76	2.20
6430	Wet prairies	39.06	0.23
6440	Emergent aquatic vegetation	36.15	0.21
6460	Treeless Hydric Savanna/Mixed scrub-shrub wetland	120.02	0.71
	SUM	**16922.19**	**100.00**


N
MARION
LAKE
Lake George
Sub Basin 02 (Juniper Creek)
Landuse
0
0.5
1
Miles
Map prepared March 1, 2017 by the Division of Environmental Assessment and Restoration. This map is not for legal decision making purposes.
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(GIS): Ronald.Hughes@dep.state.fl.us
Low Density Residential
Medium Density Residential
High Density Residential
Urban and Built Up
Agriculture
Rangeland
Upland Forest
Water
Wetlands
Barren Land
Trans, Comm, Util

Figure C.4. Juniper Creek Sub-basin

Lake George Sub-basin 01

Table C.5. Lake George Sub-basin 01 2009 Land Use Summary

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
1100	Residential, low density - less than 2 dwelling units/acre	106.83	1.31
1180	Rural residential	160.48	1.96
1200	Residential, medium density - 2-5 dwelling units/acre	152.31	1.86
1700	Institutional	4.01	0.05
1840	Marinas & fish camps	9.00	0.11
1850	Parks and zoos	45.44	0.56
1890	Other Recreational <Riding stables, go-cart tracks, skeet ranges, etc.>	42.41	0.52
1900	Open land	12.40	0.15
1920	Inactive land with street pattern but no structures	58.56	0.72
2210	Citrus Groves <Orange, grapefruit, tangerines, etc.>	2.32	0.03
3100	Herbaceous upland nonforested	3.83	0.05
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	1214.28	14.85
4110	Pine flatwoods	54.99	0.67
4130	Sand pine	2580.15	31.55
4340	Upland mixed coniferous/hardwood	464.16	5.68
4410	Coniferous pine	115.71	1.41
4430	Forest regeneration areas	741.28	9.06
5100	Streams and waterways	14.43	0.18
5200	Lakes	34.80	0.43
5500	Major Springs	18.91	0.23
6110	Bay swamp (if distinct)	87.38	1.07
6170	Mixed wetland hardwoods	1125.75	13.77
6181	Cabbage palm hammock	1.87	0.02
6210	Cypress	22.57	0.28
6250	Hydric pine flatwoods	283.60	3.47
6300	Wetland forested mixed	441.03	5.39
6410	Freshwater marshes	2.60	0.03
6430	Wet prairies	8.00	0.10
6440	Emergent aquatic vegetation	61.62	0.75
6460	Treeless Hydric Savanna/Mixed scrub-shrub wetland	298.55	3.65
7410	Rural land in transition without positive indicators of intended activity	8.38	0.10
	SUM	**8177.67**	**100.00**

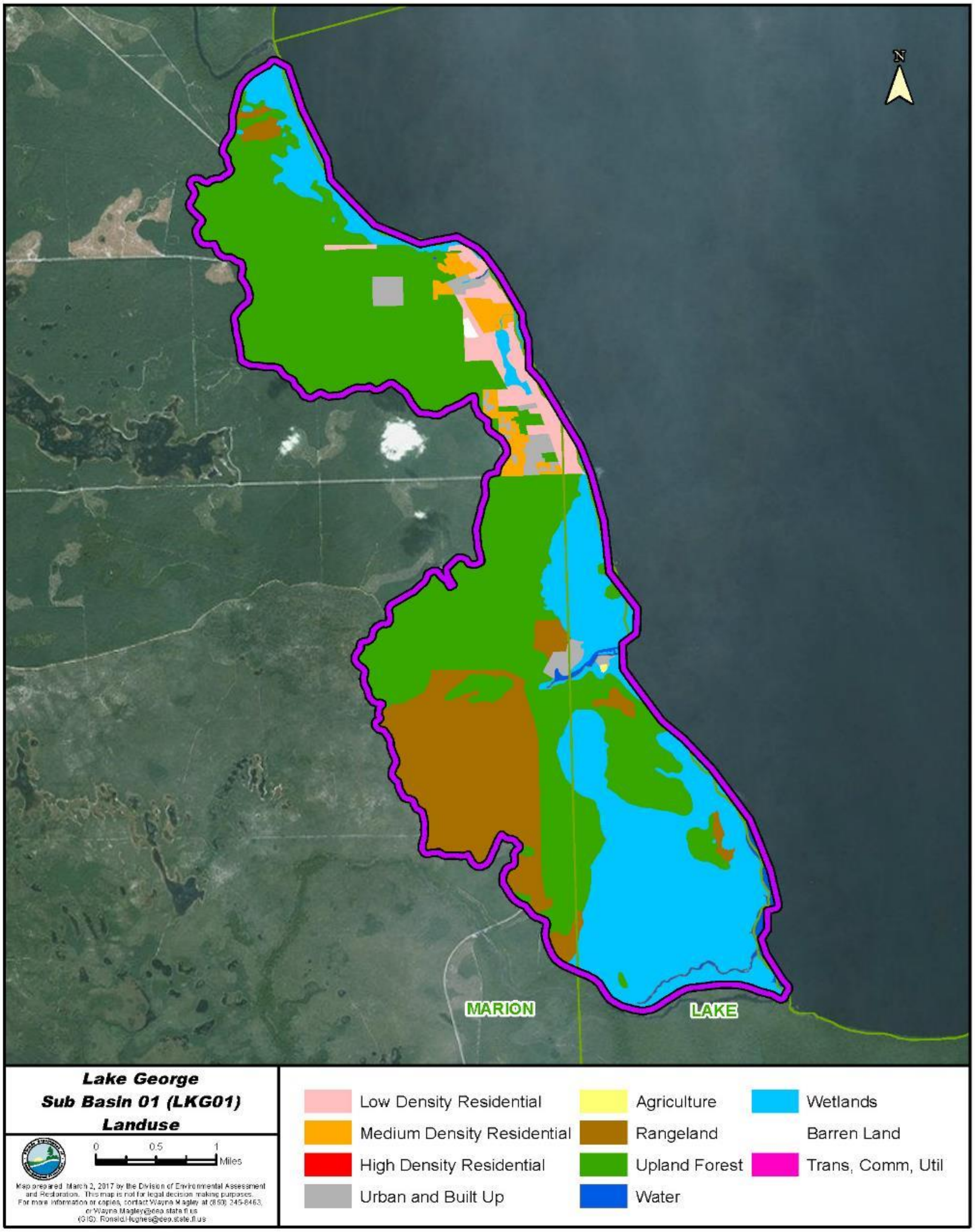


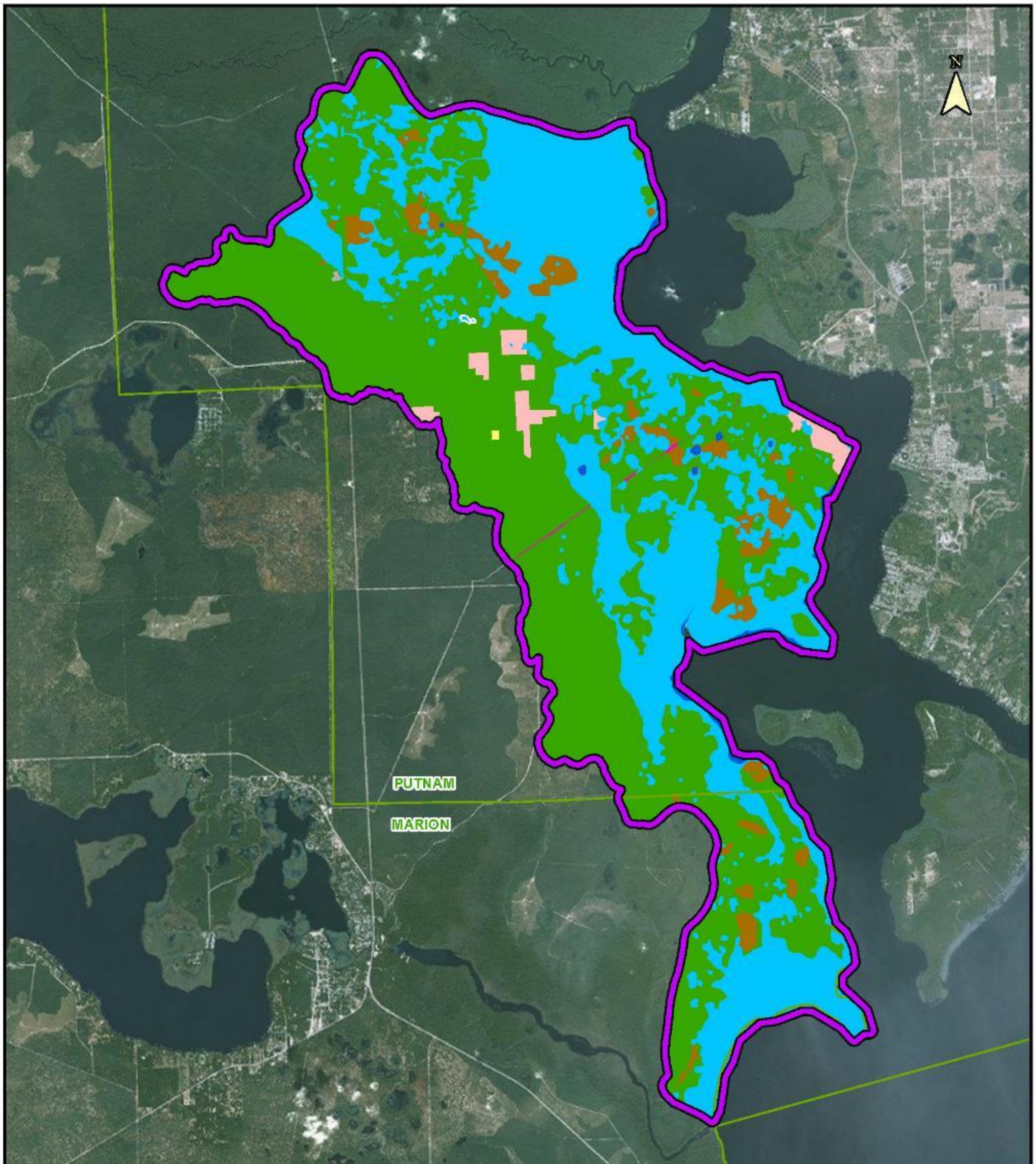
Figure C.5. Lake George Sub-basin 01

Lake George Sub-basin 05

Table C.6. Lake George Sub-basin 05 2009 Land Use Summary

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
1100	Residential, low density - less than 2 dwelling units/acre	76.55	0.51
1180	Rural residential	144.09	0.97
1890	Other Recreational <Riding stables, go-cart tracks, skeet ranges, etc.>	4.89	0.03
2110	Improved pastures (monocult, planted forage crops)	3.59	0.02
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	574.04	3.86
3300	Mixed upland nonforested/Mixed Rangeland	29.34	0.20
4110	Pine flatwoods	3802.68	25.57
4120	Longleaf pine - xeric oak	617.44	4.15
4130	Sand pine	1252.05	8.42
4210	Xeric oak	2.42	0.02
4340	Upland mixed coniferous/hardwood	310.53	2.09
4410	Coniferous pine	1364.66	9.17
4430	Forest regeneration areas	552.80	3.72
5100	Streams and waterways	71.60	0.48
5200	Lakes	16.26	0.11
5250	Open water within a freshwater marsh / Marshy Lakes	5.17	0.03
6110	Bay Swamps	479.71	3.23
6170	Mixed wetland hardwoods	1636.79	11.00
6181	Cabbage palm hammock	21.47	0.14
6210	Cypress	84.02	0.56
6220	Pond Pine	1.60	0.01
6250	Cypress	1853.54	12.46
6300	Pond Pine	1143.73	7.69
6410	Freshwater marshes	173.41	1.17
6430	Wet prairies	60.45	0.41
6440	Emergent aquatic vegetation	93.65	0.63
6460	Treeless Hydric Savanna/Mixed scrub-shrub wetland	475.08	3.19
7200	Sand Other Than Beaches	3.30	0.02
8320	Electrical power transmission lines	19.07	0.13

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
	SUM	14873.93	100.00



Lake George
Sub Basin 05 (LKG05)
Landuse

0 0.5 1 Miles

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Low Density Residential
Medium Density Residential
High Density Residential
Urban and Built Up
Agriculture
Rangeland
Upland Forest
Water
Wetlands
Barren Land
Trans, Comm, Util

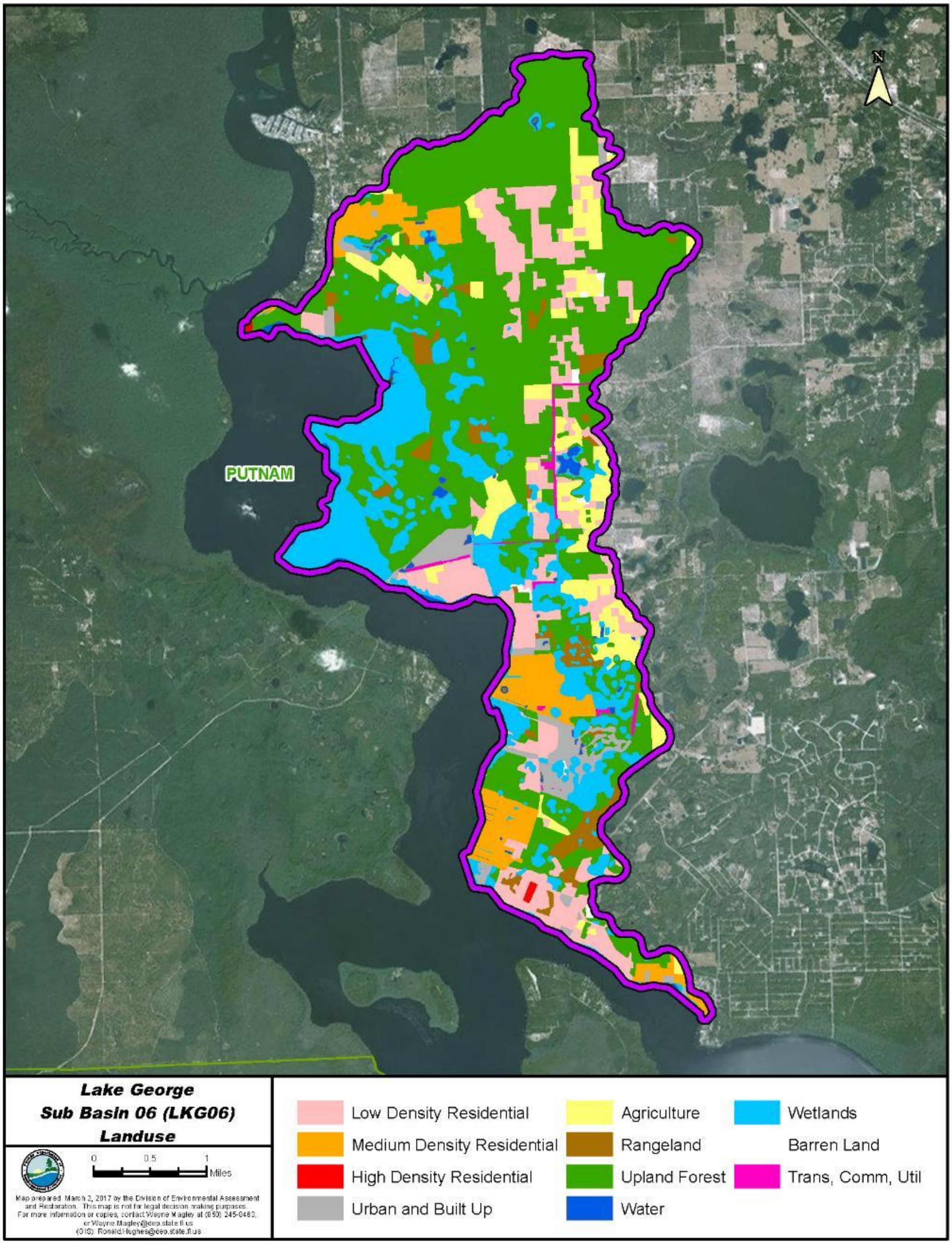
Figure C.6. Lake George Sub-basin 05

<u>Lake George Sub-basin 06</u>

Table C.7. Lake George Sub-basin 06 2009 Land Use Summary

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
1100	Residential, low density - less than 2 dwelling units/acre	700.18	7.89
1180	Rural residential	441.82	4.98
1200	Residential, medium density - 2-5 dwelling units/acre	507.81	5.72
1290	Medium Density Under Construction	57.99	0.65
1300	Residential, high density - 6 or more dwelling units/acre	11.59	0.13
1400	Commercial and services	18.17	0.20
1620	Sand and Gravel Pits	7.58	0.09
1650	Reclaimed lands	3.66	0.04
1700	Institutional	15.87	0.18
1820	Golf courses	92.66	1.04
1840	Marinas & fish camps	31.69	0.36
1850	Parks and zoos	12.00	0.14
1900	Open land	16.64	0.19
1920	Inactive land with street pattern but no structures	113.06	1.27
2110	Improved pastures (monocult, planted forage crops)	168.48	1.90
2120	Unimproved pastures	135.69	1.53
2130	Woodland pastures	43.26	0.49
2150	Field crops	35.81	0.40
2210	Citrus Groves <Orange, grapefruit, tangerines, etc.>	7.53	0.08
2430	Ornamentals	1.26	0.01
2431	Shade ferns	89.57	1.01
2432	Hammock ferns	59.03	0.66
2510	Horse farms	23.75	0.27
2540	Aquiculture	143.30	1.61
3100	Herbaceous upland nonforested	111.56	1.26
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	143.18	1.61
3300	Mixed upland nonforested/Mixed Rangeland	37.47	0.42
4110	Pine flatwoods	1400.60	15.78
4120	Longleaf pine - xeric oak	937.29	10.56
4200	Upland hardwood forests	13.18	0.15
4210	Xeric oak	214.61	2.42
4340	Upland mixed coniferous/hardwood	601.72	6.78
4410	Coniferous pine	481.36	5.42
4430	Forest regeneration areas	447.97	5.05
5100	Streams and waterways	45.78	0.52

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
5200	Lakes	13.26	0.15
5250	Open water within a freshwater marsh / Marshy Lakes	21.54	0.24
5300	Reservoirs - pits, retention ponds, dams	24.74	0.28
5500	Major Springs	1.25	0.01
6110	Bay swamp (if distinct)	10.95	0.12
6170	Mixed wetland hardwoods	555.79	6.26
6181	Cabbage palm hammock	54.46	0.61
6250	Hydric pine flatwoods	309.77	3.49
6300	Wetland forested mixed	273.73	3.08
6410	Freshwater marshes	160.50	1.81
6430	Wet prairies	35.64	0.40
6440	Emergent aquatic vegetation	74.38	0.84
6460	Treeless Hydric Savanna/Mixed scrub-shrub wetland	86.21	0.97
7400	Disturbed land	2.29	0.03
7410	Rural land in transition without positive indicators of intended activity	13.58	0.15
7430	Spoil areas	9.32	0.10
8110	Airports	9.47	0.11
8310	Electrical power facilities	4.02	0.05
8320	Electrical power transmission lines	35.37	0.40
8330	Water supply plants	5.19	0.06
8370	Surface water collection basins	2.71	0.03
	SUM	**8877.23**	**100.00**


PUTNAM
N
Lake George
Sub Basin 06 (LKG06)
Landuse
0 0.5 1 Miles
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(GIS): Ronald.Hughes@dep.state.fl.us
Low Density Residential
Medium Density Residential
High Density Residential
Urban and Built Up
Agriculture
Rangeland
Upland Forest
Water
Wetlands
Barren Land
Trans, Comm, Util

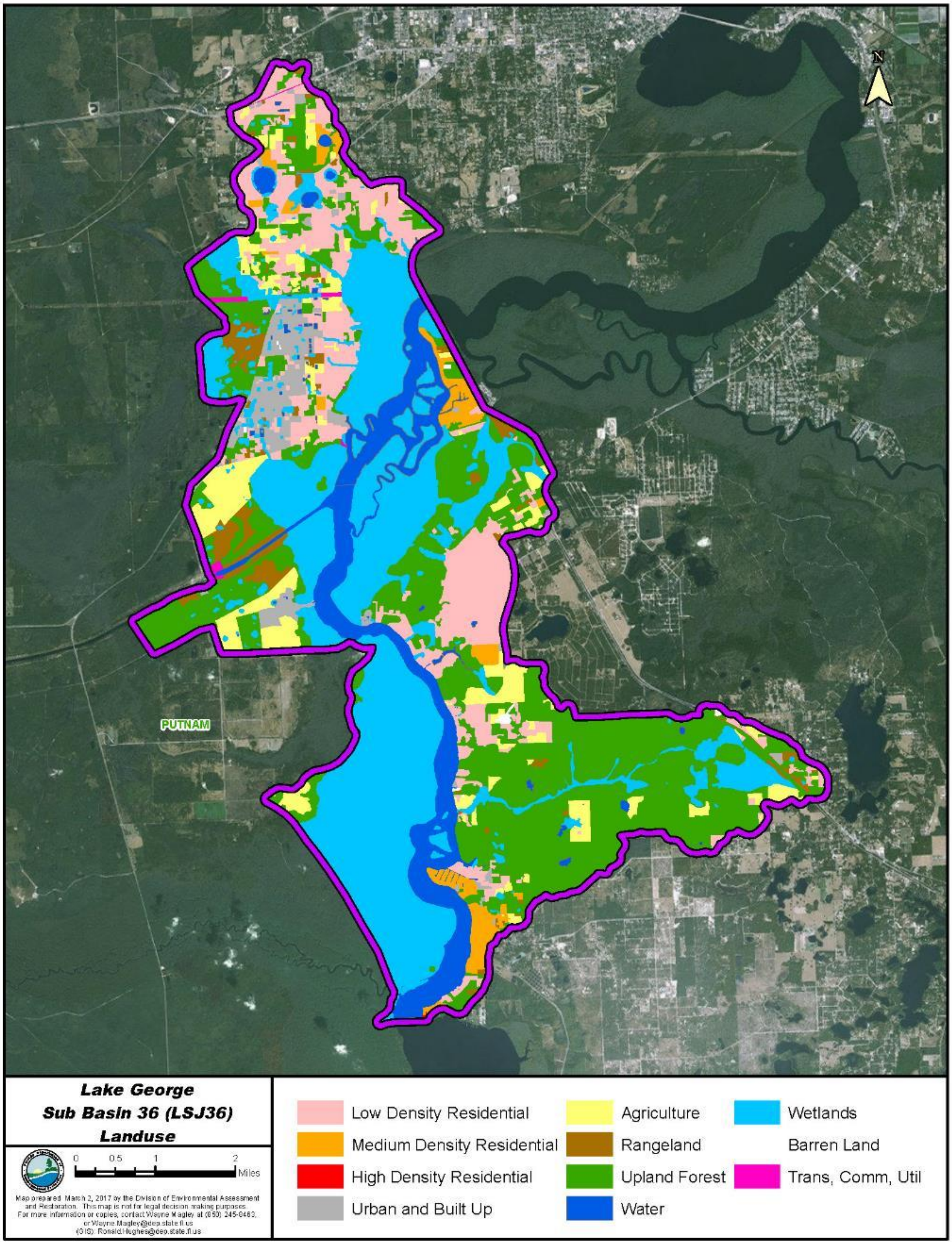
Figure C.7. Lake George Sub-basin 06

Lake George Sub-basin 36

Table C.8 Lake George Sub-basin 36 2009 Land Use Summary

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
1100	Residential, low density - less than 2 dwelling units/acre	2767.54	12.12
1180	Rural residential	159.18	0.70
1190	Low density under construction	4.43	0.02
1200	Residential, medium density - 2-5 dwelling units/acre	549.93	2.41
1300	Residential, high density - 6 or more dwelling units/acre	1.65	0.01
1400	Commercial and services	33.67	0.15
1480	Cemeteries	3.36	0.01
1561	Ship building & repair	27.73	0.12
1700	Institutional	129.43	0.57
1840	Marinas & fish camps	3.28	0.01
1850	Parks and zoos	3.80	0.02
1860	Community recreational facilities	3.77	0.02
1890	Other Recreational <Riding stables, go-cart tracks, skeet ranges, etc.>	4.54	0.02
1900	Open land	10.89	0.05
1920	Inactive land with street pattern but no structures	509.78	2.23
2110	Improved pastures (monocult, planted forage crops)	1018.56	4.46
2120	Unimproved pastures	68.29	0.30
2130	Woodland pastures	167.95	0.74
2140	Row crops	15.92	0.07
2150	Field crops	152.52	0.67
2200	Tree Crops	5.23	0.02
2210	Citrus Groves <Orange, grapefruit, tangerines, etc.>	10.50	0.05
2410	Tree nurseries	28.73	0.13
2420	Sod farms	0.21	0.00
2430	Ornamentals	20.47	0.09
2431	Shade ferns	2.17	0.01
2510	Horse farms	13.79	0.06
3100	Herbaceous upland nonforested	132.50	0.58
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	168.58	0.74
3300	Mixed upland nonforested/Mixed Rangeland	278.11	1.22
4110	Pine flatwoods	711.87	3.12
4120	Longleaf pine - xeric oak	50.51	0.22
4200	Upland hardwood forests	122.56	0.54

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
4210	Xeric oak	14.66	0.06
4340	Upland mixed coniferous/hardwood	2527.23	11.07
4410	Coniferous pine	2531.64	11.09
4430	Forest regeneration areas	951.64	4.17
5100	Streams and waterways	2061.94	9.03
5200	Lakes	135.56	0.59
5250	Open water within a freshwater marsh / Marshy Lakes	3.81	0.02
5300	Reservoirs - pits, retention ponds, dams	49.56	0.22
6110	Bay Swamps	177.99	0.78
6170	Mixed wetland hardwoods	2334.74	10.22
6181	Cabbage palm hammock	129.19	0.57
6210	Cypress	2944.81	12.89
6250	Hydric pine flatwoods	168.14	0.74
6300	Wetland forested mixed	947.87	4.15
6410	Freshwater marshes	76.36	0.33
6430	Wet prairies	160.50	0.70
6440	Emergent aquatic vegetation	95.76	0.42
6460	Treeless Hydric Savanna/Mixed scrub-shrub wetland	259.59	1.14
7400	Disturbed land	5.45	0.02
7410	Rural land in transition without positive indicators of intended activity	22.09	0.10
7430	Spoil areas	2.44	0.01
8140	Roads and highways (divided 4-lanes with medians)	11.57	0.05
8150	Port Facilities	2.49	0.01
8160	Canals and Locks	12.07	0.05
8200	Communications	0.64	0.00
8320	Electrical power transmission lines	27.30	0.12
8370	Surface water collection basins	0.82	0.00
	SUM	**22837.31**	**100.00**


N
PUTNAM
Lake George
Sub Basin 36 (LSJ36)
Landuse
0 0.5 1 2
Miles
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Low Density Residential
Medium Density Residential
High Density Residential
Urban and Built Up
Agriculture
Rangeland
Upland Forest
Water
Wetlands
Barren Land
Trans, Comm, Util

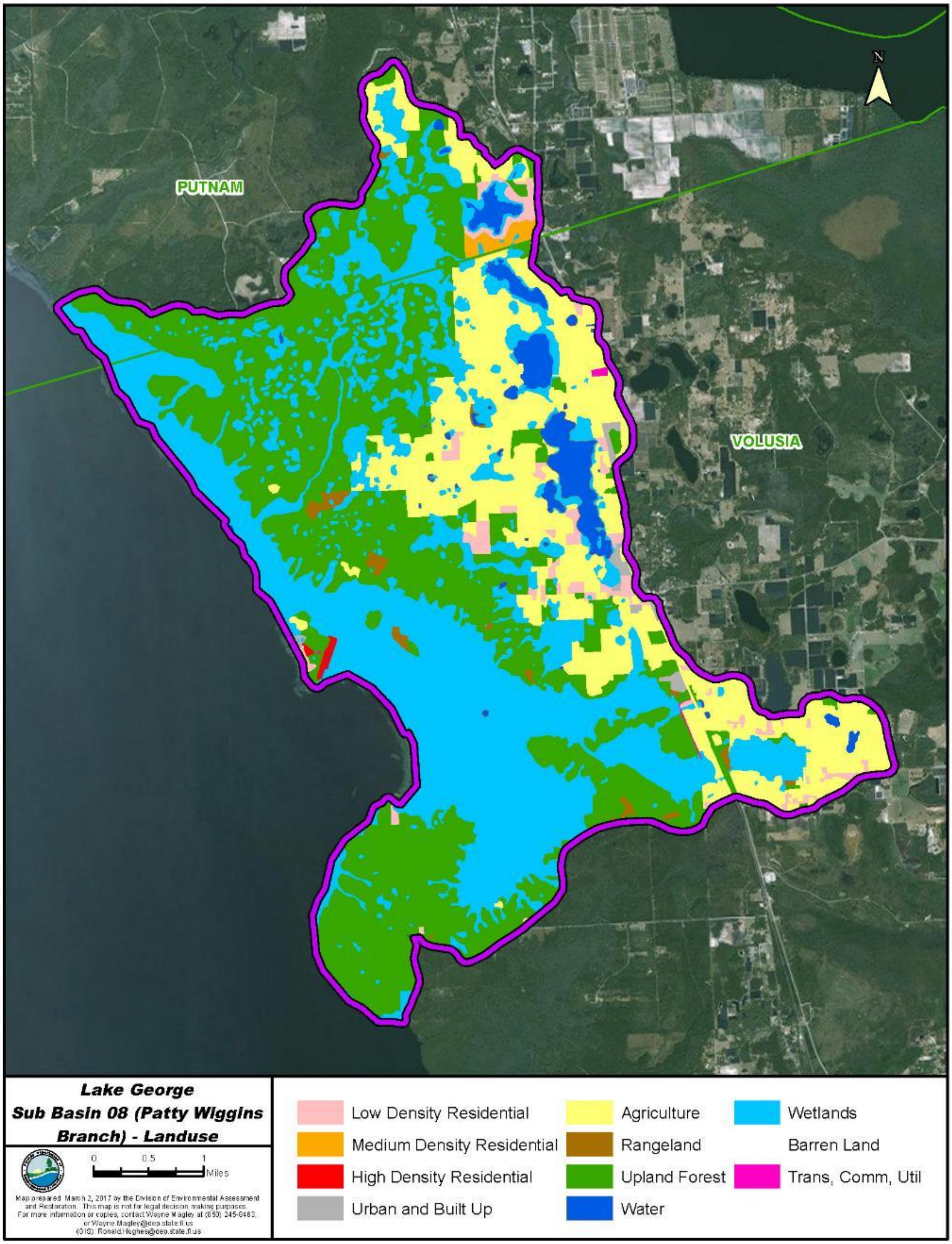
Figure C.8. Lake George Sub-basin 36

Lake George Patty Wiggins Branch Sub-basin

Table C.9 Patty Wiggins Branch Sub-basin 2009 Land Use Summary

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
1100	Residential, low density - less than 2 dwelling units/acre	173.04	1.13
1180	Rural residential	118.68	0.78
1200	Residential, medium density - 2-5 dwelling units/acre	69.47	0.45
1300	Residential, high density - 6 or more dwelling units/acre	21.71	0.14
1400	Commercial and services	20.14	0.13
1480	Cemeteries	8.33	0.05
1550	Other light industrial	16.75	0.11
1700	Institutional	10.58	0.07
1840	Marinas & fish camps	3.77	0.02
1850	Parks and zoos	2.99	0.02
1860	Community recreational facilities	3.92	0.03
2110	Improved pastures (monocult, planted forage crops)	1443.41	9.45
2120	Unimproved pastures	8.53	0.06
2130	Woodland pastures	156.68	1.03
2150	Field crops	320.82	2.10
2200	Tree Crops	4.81	0.03
2210	Citrus Groves <Orange, grapefruit, tangerines, etc.>	3.18	0.02
2400	Nurseries and vineyards	2.56	0.02
2410	Tree nurseries	13.09	0.09
2430	Ornamentals	35.30	0.23
2431	Shade ferns	387.81	2.54
2432	Hammock ferns	562.76	3.68
2510	Horse farms	49.11	0.32
2600	Other open lands - rural	30.63	0.20
3100	Herbaceous upland nonforested	24.26	0.16
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	56.54	0.37
3300	Herbaceous upland nonforested	19.86	0.13
4110	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	527.74	3.45
4120	Longleaf pine - xeric oak	19.14	0.13

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
4200	Upland hardwood forests	44.65	0.29
4340	Upland mixed coniferous/hardwood	690.76	4.52
4410	Coniferous pine	3962.52	25.94
4430	Forest regeneration areas	335.25	2.19
5100	Streams and waterways	2.10	0.01
5200	Lakes	474.31	3.10
5250	Open water within a freshwater marsh / Marshy Lakes	14.61	0.10
5300	Reservoirs - pits, retention ponds, dams	9.69	0.06
6110	Bay swamp (if distinct)	51.27	0.34
6170	Mixed wetland hardwoods	1861.35	12.18
6181	Cabbage palm hammock	50.83	0.33
6210	Cypress	146.85	0.96
6250	Hydric pine flatwoods	607.90	3.98
6300	Wetland forested mixed	1825.97	11.95
6410	Freshwater marshes	406.86	2.66
6420	Saltwater marshes	31.17	0.20
6430	Wet prairies	10.04	0.07
6440	Emergent aquatic vegetation	115.33	0.75
6460	Treeless Hydric Savanna/Mixed scrub-shrub wetland	509.11	3.33
8200	Communications	5.56	0.04
8320	Electrical power transmission lines	4.97	0.03
8350	Solid Waste Disposal	0.85	0.01
	SUM	**15277.57**	**100.00**



N
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VOLUSIA
Lake George
Sub Basin 08 (Patty Wiggins Branch) - Landuse
0
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1
Miles
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Low Density Residential
Medium Density Residential
High Density Residential
Urban and Built Up
Agriculture
Rangeland
Upland Forest
Water
Wetlands
Barren Land
Trans, Comm, Util

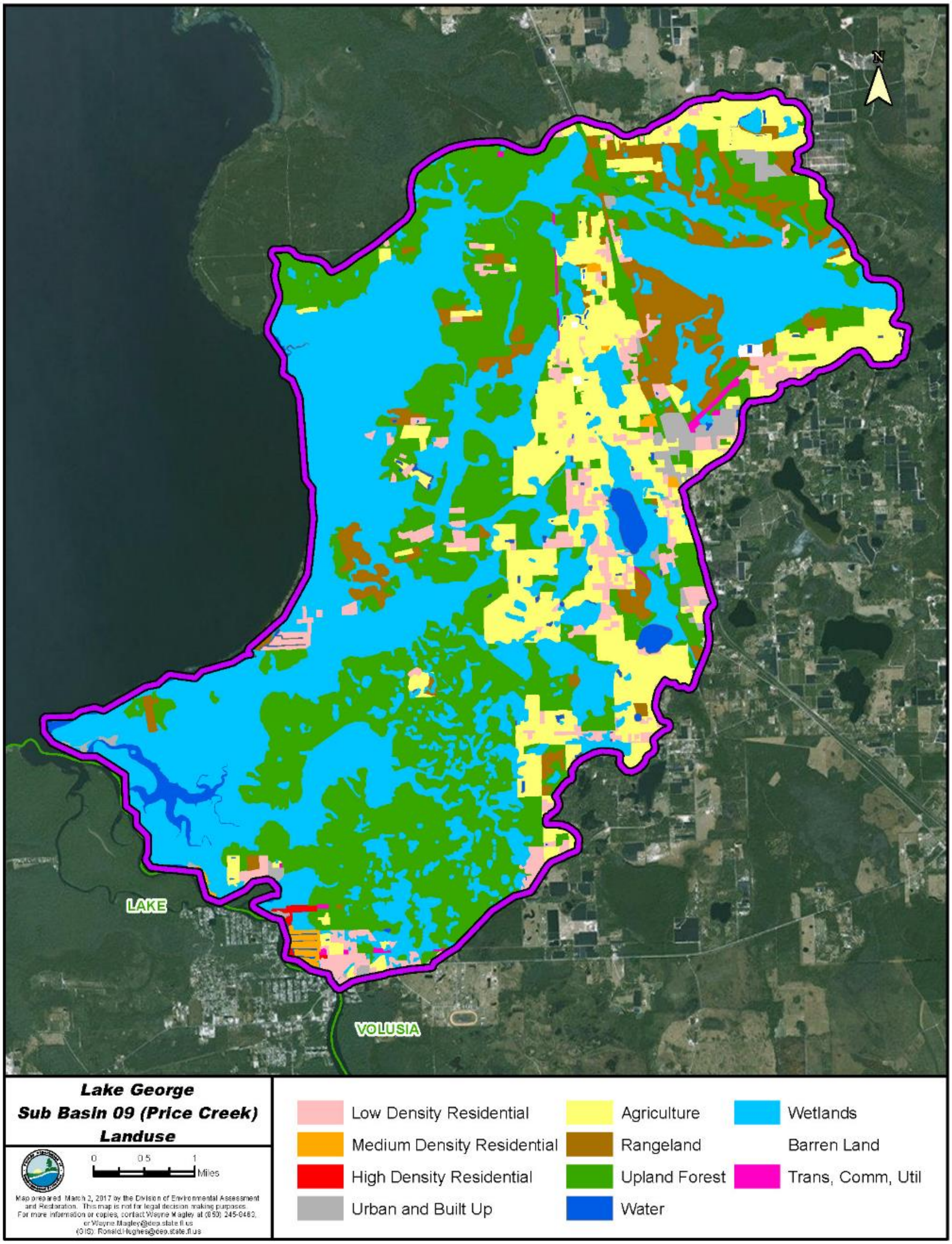
Figure C.9. Patty Wiggins Branch Sub-basin

Lake George Price Creek Sub-basin

Table C.10. Price Creek Sub-basin 2009 Land Use Summary

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
1100	Residential, low density - less than 2 dwelling units/acre	423.72	1.88
1180	Rural residential	489.71	2.18
1200	Residential, medium density - 2-5 dwelling units/acre	73.57	0.33
1300	Residential, high density - 6 or more dwelling units/acre	22.48	0.10
1400	Commercial and services	67.41	0.30
1550	Other light industrial	10.99	0.05
1700	Institutional	78.21	0.35
1840	Marinas & fish camps	33.33	0.15
1860	Community recreational facilities	44.11	0.20
1890	Other Recreational <Riding stables, go-cart tracks, skeet ranges, etc.>	49.32	0.22
2110	Improved pastures (monocult, planted forage crops)	864.57	3.84
2120	Unimproved pastures	26.10	0.12
2130	Woodland pastures	195.48	0.87
2150	Field crops	202.94	0.90
2200	Tree Crops	0.61	0.00
2210	Citrus Groves <Orange, grapefruit, tangerines, etc.>	17.36	0.08
2410	Tree nurseries	3.00	0.01
2430	Ornamentals	110.24	0.49
2431	Shade ferns	740.63	3.29
2432	Hammock ferns	724.27	3.22
2510	Horse farms	158.07	0.70
2540	Aquiculture	10.14	0.05
2600	Other open lands - rural	9.90	0.04
2610	Fallow cropland	18.57	0.08
3100	Herbaceous upland nonforested	73.48	0.33
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	986.05	4.38
3300	Mixed upland nonforested/Mixed Rangeland	259.66	1.15
4110	Pine flatwoods	1510.56	6.71
4120	Longleaf pine - xeric oak	67.95	0.30
4200	Upland hardwood forests	25.38	0.11
4340	Upland mixed coniferous/hardwood	761.92	3.39
4410	Coniferous pine	3762.98	16.72
4430	Forest regeneration areas	882.93	3.92

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
5100	Streams and waterways	194.80	0.87
5200	Lakes	160.86	0.71
5300	Reservoirs - pits, retention ponds, dams	74.91	0.33
6110	Bay swamp (if distinct)	227.26	1.01
6170	Mixed wetland hardwoods	2262.97	10.05
6181	Cabbage palm hammock	137.26	0.61
6210	Cypress	30.81	0.14
6220	Pond Pine	11.15	0.05
6250	Hydric pine flatwoods	472.75	2.10
6300	Wetland forested mixed	3780.12	16.80
6410	Freshwater marshes	315.32	1.40
6420	Saltwater marshes	4.34	0.02
6430	Wet prairies	65.44	0.29
6440	Emergent aquatic vegetation	15.65	0.07
6460	Treeless Hydric Savanna/Mixed scrub-shrub wetland	1966.33	8.74
7410	Rural land in transition without positive indicators of intended activity	25.99	0.12
7430	Spoil areas	1.29	0.01
8110	Airports	24.03	0.11
8200	Communications	1.45	0.01
8310	Electrical power facilities	3.37	0.01
8320	Electrical power transmission lines	14.31	0.06
8330	Water supply plants	1.07	0.00
8340	Sewage treatment	4.45	0.02
8370	Surface water collection basins	4.97	0.02
	SUM	**22506.55**	**100.00**


N
LAKE
VOLUSIA
Lake George
Sub Basin 09 (Price Creek)
Landuse
0 0.5 1
Miles
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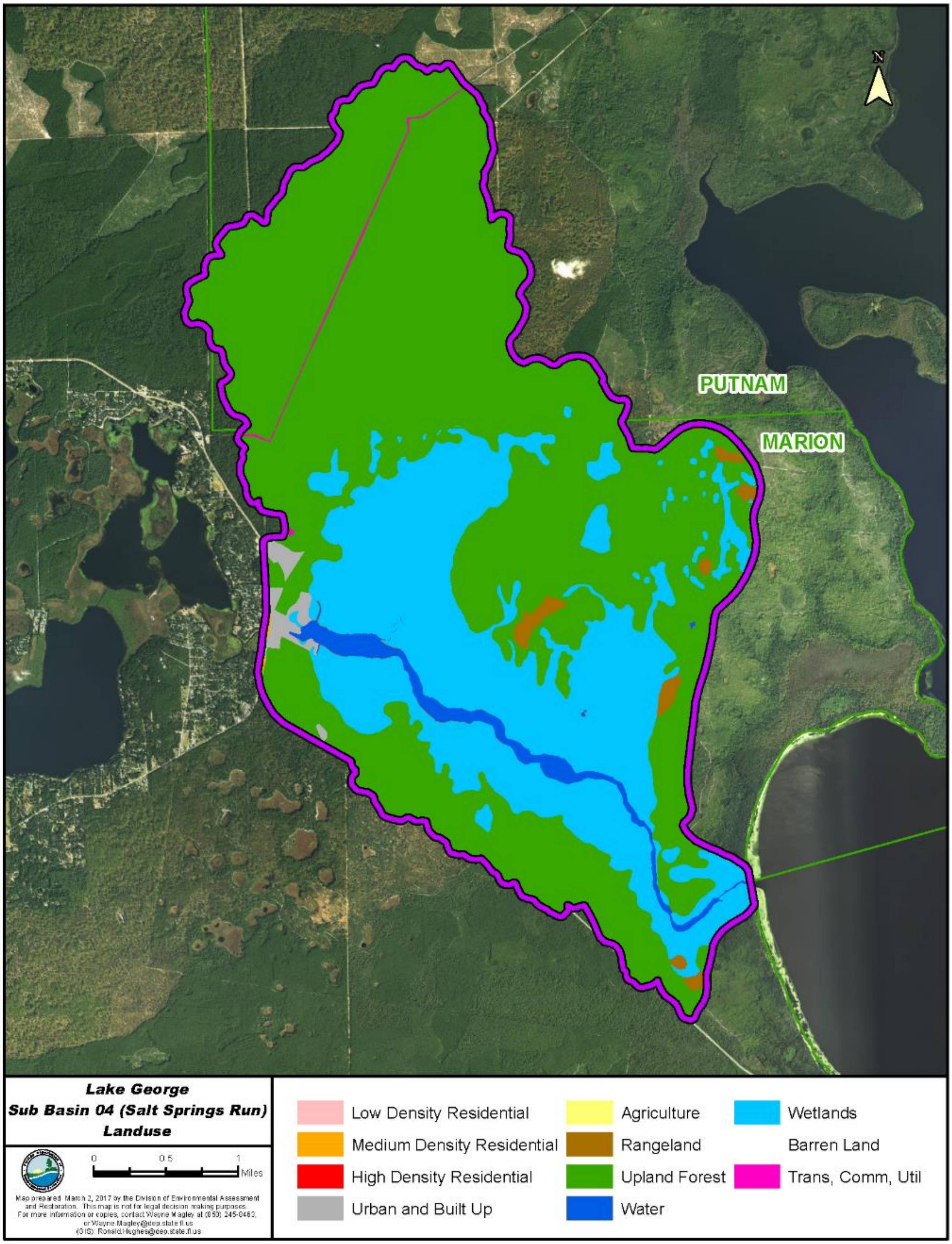
Medium Density Residential
High Density Residential
Urban and Built Up
Agriculture
Rangeland
Upland Forest
Water
Wetlands
Barren Land
Trans, Comm, Util

Figure C.10. Price Creek Sub-basin

Lake George Salt Springs Run Sub-basin

Table C.11 Salt Springs Run Sub-basin 2009 Land Use Summary

LUCODE	LAND USE CLASSIFICATION	ACRES	PERCENT
1200	Residential, medium density - 2-5 dwelling units/acre	2.09	0.02
1400	Commercial and services	27.70	0.31
1850	Parks and zoos	43.32	0.49
1890	Other Recreational <Riding stables, go-cart tracks, skeet ranges, etc.>	2.83	0.03
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub	80.20	0.91
4110	Pine flatwoods	598.13	6.80
4120	Longleaf pine - xeric oak	159.55	1.81
4130	Sand pine	3348.64	38.06
4200	Upland hardwood forests	9.70	0.11
4340	Upland mixed coniferous/hardwood	483.73	5.50
4410	Coniferous pine	483.34	5.49
4430	Forest regeneration areas	685.42	7.79
5200	Lakes	1.59	0.02
5500	Major Springs	204.78	2.33
6110	Bay swamp (if distinct)	335.06	3.81
6170	Mixed wetland hardwoods	1042.28	11.85
6181	Cabbage palm hammock	4.72	0.05
6220	Pond Pine	8.63	0.10
6250	Hydric pine flatwoods	364.65	4.14
6300	Wetland forested mixed	530.20	6.03
6410	Freshwater marshes	52.65	0.60
6430	Wet prairies	4.60	0.05
6440	Emergent aquatic vegetation	18.66	0.21
6460	Treeless Hydric Savanna/Mixed scrub-shrub wetland	272.31	3.10
8200	Communications	1.25	0.01
8320	Electrical power transmission lines	31.97	0.36
	SUM	**8798.00**	**100.00**



Lake George
Sub Basin 04 (Salt Springs Run)
Landuse

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Figure C.11. Salt Springs Run Sub-basin

Appendix D: Water Quality Stations Sampled for Nutrients in WBIDs 2893A, 2893A6, and 2213O over the 1980 – 2016 Period

WBID	STATION	STATION OWNER	YEARS WITH DATA
2213O	112WRD 292600081405401	USGS	2001
2213O	112WRD 292751081411001	USGS	2001
2213O	21FLA 20030519	Department	1991
2213O	21FLA 20030520	Department	1991 - 1994
2213O	21FLA 20030521	Department	1991 - 1994
2213O	21FLCEN 20010167	Department	2002
2213O	21FLCEN 20010168	Department	2002
2213O	21FLCEN 20030519	Department	2002
2213O	21FLCEN 20030520	Department	2002
2213O	21FLGW 19127	Department	2003
2213O	21FLGW 26961	Department	2005
2213O	21FLGW 26969	Department	2005
2213O	21FLSJWMLGEO	SJRWMD	1990
2213O	21FLSJWMMSJFGF	SJRWMD	1997 - 2004
2213O	21FLSJWMSAVFRTFI	SJRWMD	1997
2213O	21FLSJWMSAVFRTFO	SJRWMD	1997
2213O	21FLSJWMSJ3	SJRWMD	2002
2893A	112WRD 02235500	USGS	1980 - 2013
2893A	21FLA 20010162	Department	1984 - 1987
2893A	21FLCEN 20010163	Department	2002
2893A	21FLCEN 20010164	Department	2002
2893A	21FLGFWFGFCCR0057	Florida Game and Freshwater Fish Commission	1987
2893A	21FLGFWFGFCCR0058	Florida Game and Freshwater Fish Commission	1987
2893A	21FLGFWFGFCCR0180	Florida Game and Freshwater Fish Commission	1980 - 1987
2893A	21FLGFWFGFCCR0181	Florida Game and Freshwater Fish Commission	1983 - 1990
2893A	21FLGW 20149	Department	2003

WBID	STATION	STATION OWNER	YEARS WITH DATA
2893A	21FLGW 20152	Department	2003
2893A	21FLGW 20154	Department	2003
2893A	21FLGW 20155	Department	2003
2893A	21FLGW 20157	Department	2003
2893A	21FLGW 20158	Department	2003
2893A	21FLGW 20159	Department	2003
2893A	21FLGW 20160	Department	2003
2893A	21FLGW 20162	Department	2003
2893A	21FLGW 20164	Department	2003
2893A	21FLGW 20165	Department	2003
2893A	21FLGW 20167	Department	2003
2893A	21FLGW 20170	Department	2003
2893A	21FLGW 20174	Department	2003
2893A	21FLGW 20178	Department	2003
2893A	21FLGW 28482	Department	2005
2893A	21FLGW 28483	Department	2005
2893A	21FLGW 28486	Department	2005
2893A	21FLGW 28488	Department	2005
2893A	21FLGW 28490	Department	2005
2893A	21FLGW 28492	Department	2005
2893A	21FLGW 28495	Department	2005
2893A	21FLGW 28497	Department	2005
2893A	21FLGW 28499	Department	2005
2893A	21FLGW 28500	Department	2005
2893A	21FLGW 28503	Department	2005
2893A	21FLGW 28504	Department	2005
2893A	21FLGW 28505	Department	2005
2893A	21FLGW 28507	Department	2005
2893A	21FLGW 28879	Department	2005
2893A	21FLGW 28881	Department	2005
2893A	21FLGW 36627	Department	2009
2893A	21FLGW 38206	Department	2009
2893A	21FLGW 38543	Department	2010
2893A	21FLGW 38548	Department	2010
2893A	21FLGW 39333	Department	2010
2893A	21FLGW 39338	Department	2010
2893A	21FLGW 40521	Department	2011
2893A	21FLGW 41182	Department	2011
2893A	21FLGW 41581	Department	2012
2893A	21FLGW 41585	Department	2012

WBID	STATION	STATION OWNER	YEARS WITH DATA
2893A	21FLGW 41593	Department	2012
2893A	21FLGW 43729	Department	2013
2893A	21FLGW 45064	Department	2014
2893A	21FLGW 45066	Department	2014
2893A	21FLGW 45070	Department	2014
2893A	21FLGW 45073	Department	2014
2893A	21FLKWATPUT-GEORGE-1	Florida Lakewatch	1995 - 2008
2893A	21FLKWATPUT-GEORGE-2	Florida Lakewatch	1995 - 2008
2893A	21FLKWATPUT-GEORGE-3	Florida Lakewatch	1990 - 1995
2893A	21FLKWATPUT-GEORGEEA-1	Florida Lakewatch	1990 - 2001
2893A	21FLKWATPUT-GEORGEEA-2	Florida Lakewatch	1990 - 2001
2893A	21FLKWATPUT-GEORGEEA-3	Florida Lakewatch	1998 - 2001
2893A	21FLKWATPUT-GEORGESO-1	Florida Lakewatch	1997 - 2013
2893A	21FLKWATPUT-GEORGESO-2	Florida Lakewatch	1997 - 2013
2893A	21FLKWATPUT-GEORGESO-3	Florida Lakewatch	1999 - 2013
2893A	21FLSJWMLAG	SJRWMD	1989 - 2014
2893A	21FLSJWMLEO	SJRWMD	1989 - 2016
2893A	21FLSJWMLGCE	SJRWMD	2008
2893A	21FLSJWMLGCW	SJRWMD	2008
2893A	21FLSJWMLGI	SJRWMD	1990 - 1991
2893A	21FLSJWMLGNE	SJRWMD	2008
2893A	21FLSJWMLGNW	SJRWMD	2008
2893A	21FLSJWMLGSE	SJRWMD	2008
2893A	21FLSJWMLGSW	SJRWMD	2008
2893A	21FLSJWMMSJLGM	SJRWMD	1998 - 2008
2893A	21FLSJWMMSJLGN	SJRWMD	1998 - 2008
2893A	21FLSJWMMSJLGS	SJRWMD	1998 - 1999
2893A	21FLSJWMSAVLKGRI	SJRWMD	2000 - 2003
2893A	21FLSJWMSAVLKGRO	SJRWMD	2000 - 2003
2893A	21FLSJWMSJ1	SJRWMD	2002
2893A	21FLSJWMSJ2	SJRWMD	2002
2893A	21FLVEMDSJ29	Volusia County	1991 - 1998
2893A	21FLVEMDVC-067	Volusia County	1999 - 2011
2893A	21FLVEMDVC-29A	Volusia County	2012 - 2013
2893A	21FLWQSPVOL334NL	Department	2005
2893A5	21FLA 20010165	Department	1984 - 1990
2893A5	21FLA 20030373	Department	1980 - 1995
2893A5	21FLCEN 20010165	Department	2015
2893A5	21FLCEN 20010166	Department	2015
2893A5	21FLGW 26979	Department	2005

WBID	STATION	STATION OWNER	YEARS WITH DATA
2893A5	21FLGW 26984	Department	2005
2893A5	21FLGW 36577	Department	2009
2893A5	21FLGW 38184	Department	2009
2893A5	21FLGW 43683	Department	2013
2893A5	21FLSJWM20030373	SJRWMD	1995 - 2016
2893A5	21FLSJWMLG11	SJRWMD	1993 - 1996
2893A5	21FLSJWMLG12	SJRWMD	1993 - 2011
2893A5	21FLSJWMLG13	SJRWMD	1993 - 1996

Appendix E: Lake George External Nutrient Loads Methodology

The Lake George External Nutrient Load – Methods
Provided for the Development of the L. George TMDL
John Hendrickson
2/20/17

Overview of the External Load

The Lake George WQ model simulations utilized several different data sources for the input load. An interpolated time series based on bimonthly measured data was used for the middle St. Johns River upstream boundary load.   Observed data from regional wet deposition stations were used for the atmospheric load, and measured concentrations and flows were used to calculate the artesian spring load. Due to the insufficiency of measured data, the local, adjacent watershed surface runoff loads were estimated with the seasonally-varying Pollution Load Screening Model (PLSM). The map of **Figure E.1** shows the extent of the adjacent watersheds to Lake George. Only three of these watersheds have visible flowing channels, due to the contribution of large artesian spring inputs: Juniper Creek, LKG01 (Silver Glen Spring), and Salt Run. For the remainder of the adjacent watersheds, nonpoint source input is conveyed in shallow groundwater seepage or ephemeral drains. The PLSM has been calibrated with a significant amount of observed data representative of a range of land development for the LSJR TMDL, so confidence exists with regard to the accuracy of its nutrient concentration predictions (Hendrickson et al, 2002). In the Lake George application, discharge for calculating loads were simulated with an application of HSPF (Cera et al., 2012).

A limited sampling effort of the three major tributaries discharging from adjacent basins on the western side of the lake indicate very low TN and TP concentrations (**Table E.1**), much lower than predicted from the PLSM, though it should be noted that these tributaries are dominated by artesian spring inputs. One of these tributaries, Juniper Creek, has a relatively large watershed area relative to its artesian inputs, and regressions relating specific conductance (used here as a proxy for artesian input) to TN and TP concentrations indicate that when surface runoff is relatively high (i.e., specific conductance is low), TN and TP concentrations are in the range predicted by the PLSM (**Figure E.2**).

Sucsy et al. (2016) provide an overview of the mean contributions to the external load to Lake George. From 2002 through 2013, the inflow from the middle St. Johns River represented the great majority of the total lake load, accounting for 94.4% and 95.9% of the total phosphorus and total nitrogen loading to the lake, respectively. The percent contribution of total phosphorus load from springs, local tributaries, and atmospheric deposition was 2.4%, 2.3% and 0.5%, respectively, while the percent contribution of total nitrogen load from these same sources was 0.3%, 0.9% and 2.9%, respectively (Sucsy et al., 2016).

Changes in Adjacent Watershed Land Development

Nutrient concentrations of the major springs discharging to the lake have remained stable over the past 15 years (Winkler, 2016) which includes the time interval utilized in this TMDL assessment, so constant values were used to calculate these loads.

The adjacent watershed PLSM-predicted loads for the assimilative capacity nutrient reduction simulations were based on the 2004 land cover. Because the TMDL simulations span relatively long time interval (2002-13), potential changes in land development would not represented in the model input loads, and might also not be representative of current land use upon which allocations may someday be based. To asses this possibility, the 4 land cover data layers available between 1995 to 2009 were examined over time. The changes over this time interval in aggregated land use categories are shown in **Figure E.3**. Most of the urban and residential development exists just downstream of the lake on the eastern banks, in the area encompassing the small towns of Welaka and Georgetown. The majority of this "urban" development is classified as low-density residential. In the most recent layers, there has been a slight shift of some of this toward medium density residential in the LKG06 basin (Welaka area). Much of the adjacent basin area is categorized as forested or silviculture, and all of the basins on the western banks, and also the southern half of the Georgetown basin are occupied by undeveloped public lands. The greatest relative change over time appears to have occurred in the Camp Branch watershed (LSJ37). The 1999 layer indicates a relatively large area of row crop, which does not appear in subsequent layers. This watershed also shows a decrease in areas dedicated to cattle ranching, from around 32 percent in 2000 to roughly 20 percent in subsequent layers. The 2009 land use indicates moderate increases in cattle and cropland in the watersheds draining to the n the southwestern portion of the lake.

Table E.1. Geometric Mean Chemical Constituent Concentrations for Tributaries Flowing to the Western Shore of Lake George, 2009-10.

Location	Chl-a Corr.	Cl	Color	Sp. Cond.	DOC	NOx	TKN-T	TN	TP-T	TSS	Turb	pH
Juniper Cr. At Hwy. 19	0.8	404.2	23	1710	2.1	0.023	0.141	0.174	0.030	1.9	1.3	7.75
Salt Run Near Mouth	1.3	1514.7	10	5478	0.5	0.048	0.072	0.128	0.028	1.8	0.7	7.97
Silver Glen R. nr. Mouth	0.8	437.3	10	1910	0.8	0.024	0.060	0.088	0.035	0.8	0.4	7.78

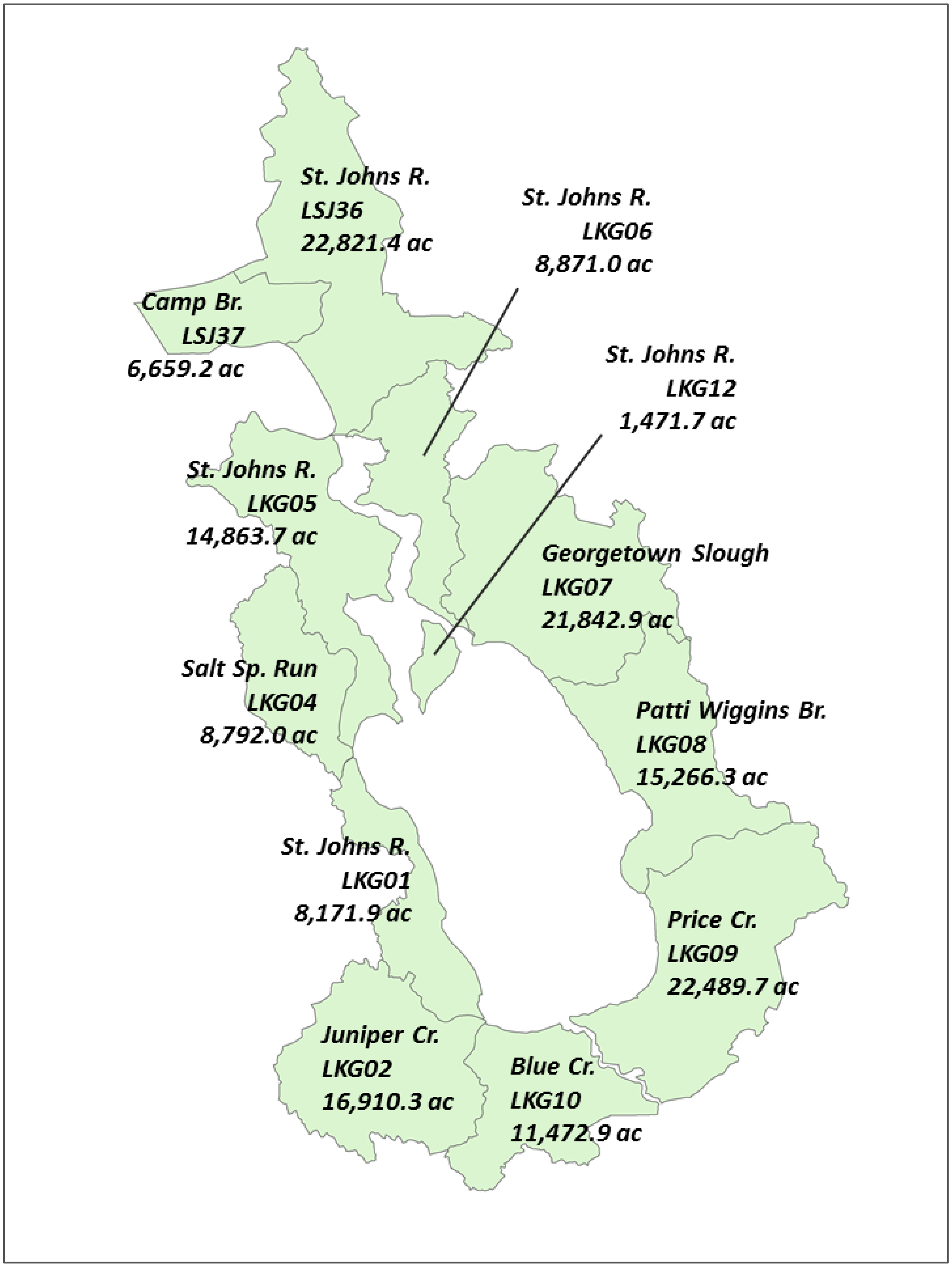

Figure E.1. Surface Water Adjacent to the Lake George Model Domain.

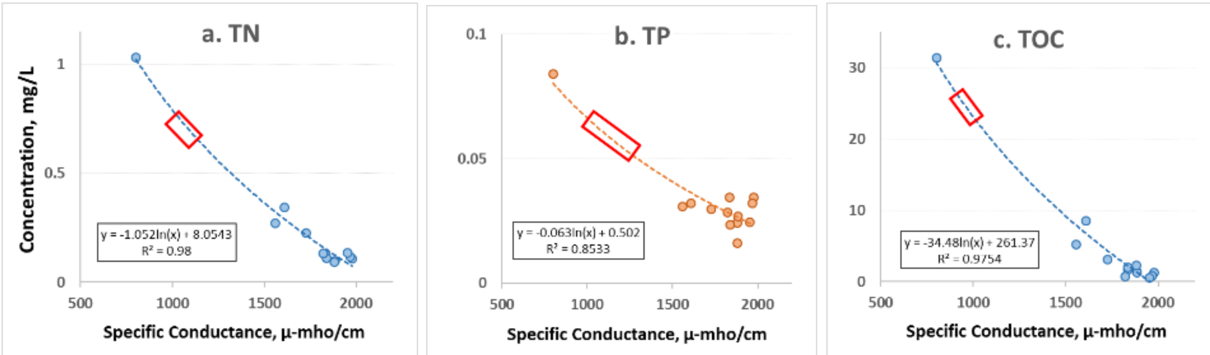

Figure E.2. Relationship between Specific Conductance and TN, TP and TOC Concentrations for Juniper Creek at Highway 19, May 2009 – August 2010. Red rectangles indicate the range for predicted PLSM concentrations.

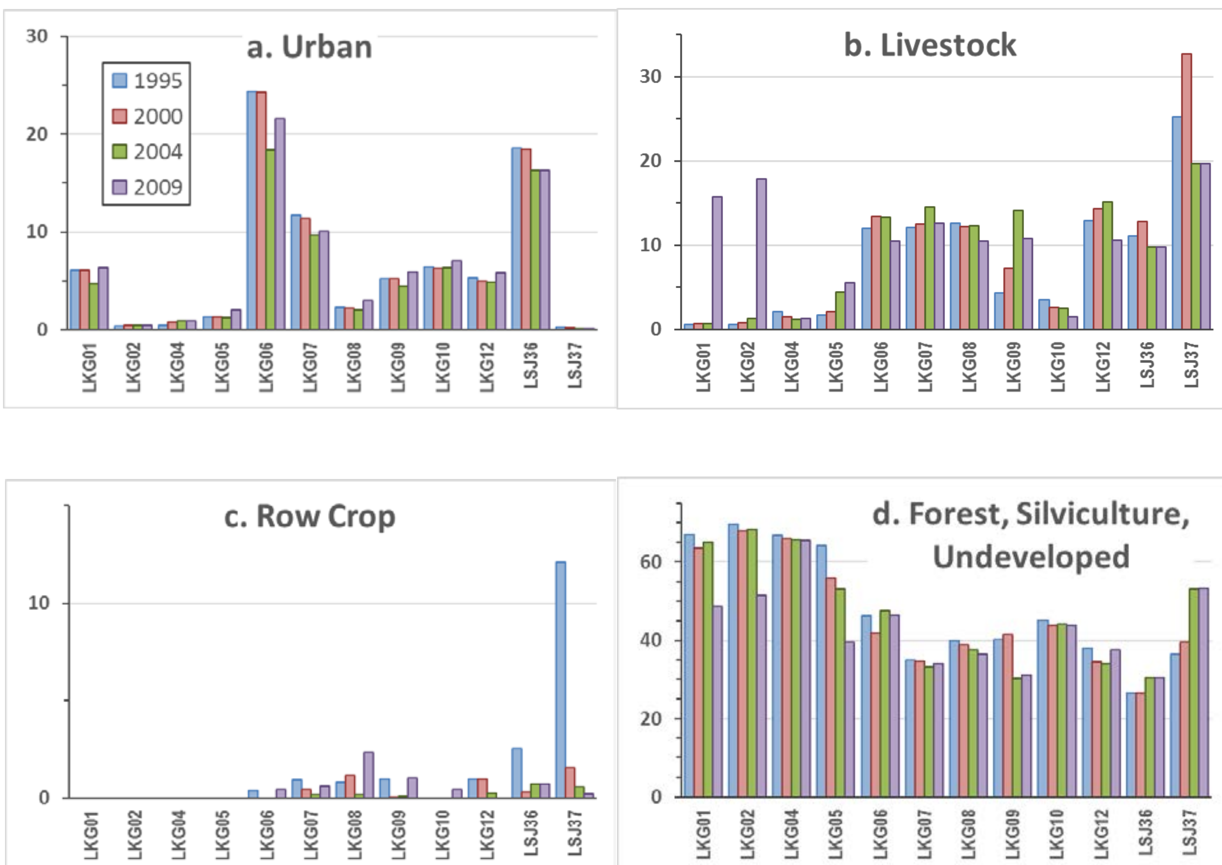

Figure E.3. Percent of Contributing Basin Area in Land Development Aggregates, 1995 – 2009. Note that vertical axes are not uniform scale.

Because of the generally low density of land development, the PLSM predicts low nitrogen concentrations for runoff from these adjacent basins for the most recent land use (2009). Annual mean predicted TN concentrations range between 0.66 and 0.89 mg/L, with an overall mean of 0.73 mg/L (**Figure E.4**). Predicted 2009 annual mean TP concentrations are also low for adjacent basins draining to the western side of the lake, ranging between 0.057 – 0.068 mg/L (**Figure E.5**). Increases in development and agriculture leads to predicted increases in TP for the eastern draining watersheds in the 2009 land use, relative to the 2004. For these four watersheds (LKG06-09), the predicted overall mean annual TP increases from 0.079 mg/L, to 0.097 mg/L. This concentration increase, when multiplied by the predicted annual discharge volume from these four watersheds, translates to a mean annual TP load increase of 1.3 MT/yr.

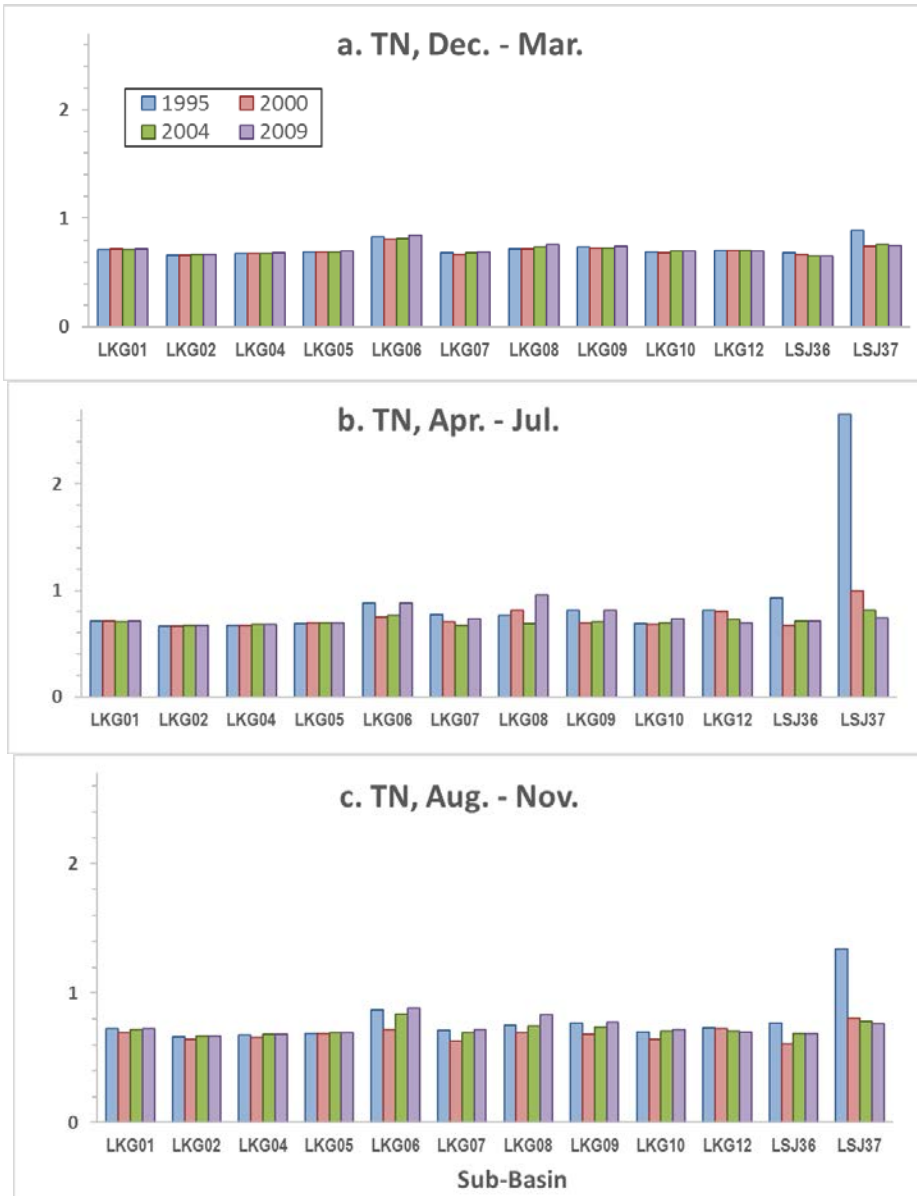

Figure E.4. Seasonal Predictions for TN Concentrations for Adjacent Watersheds to Lake George Based on Land Use from 1999 - 2009.

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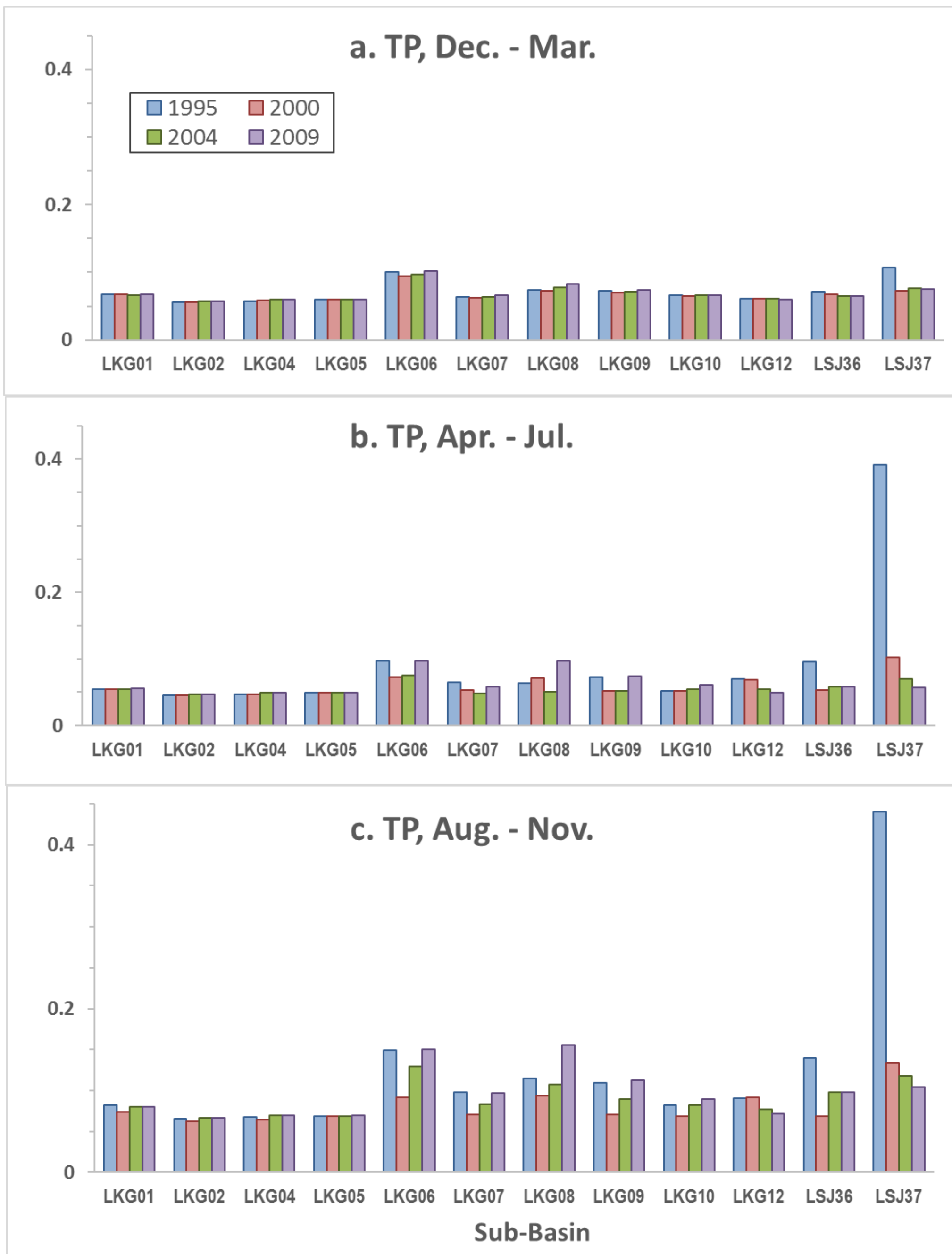
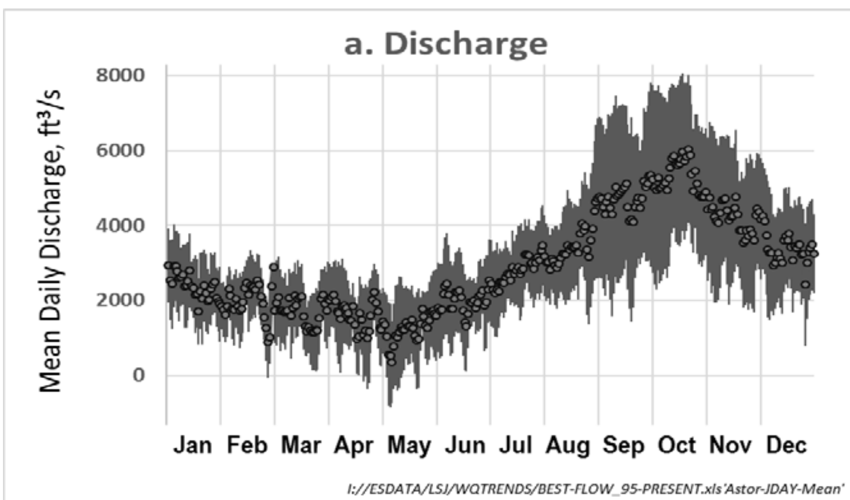


Figure E.5. Seasonal Predictions for TP Concentrations for Adjacent Watershed to Lake George Based on Land Use from 1999 - 2009

Middle St. Johns Inflow Patterns

The Middle St. Johns River inflow into Lake George exhibits a distinct seasonal pattern in discharge, with peak flow occurring in late summer and early fall, and an annual flow minimum occurring in spring (**Figure E.6a**). The annual pattern in TP concentration is strongly and positively correlated with discharge (**Figure E.6c**), with the result that the upstream load delivered to the lake in the three-month time span between mid-August and mid-November is equivalent to that provided the entire remainder of the year. The annual TN pattern is also correlated with discharge, but not as strongly as phosphorus (**Figure E.6b**). TN is for the most part present in the reduced organic form, measured as TKN, with nitrate+nitrite-N a small portion of the remaining fraction, and is essentially absent from April through July. A small increase in TN is distinguishable from mid-April through mid-June, which is likely attributable to internal loading from N-fixing cyanobacteria in upstream lakes.



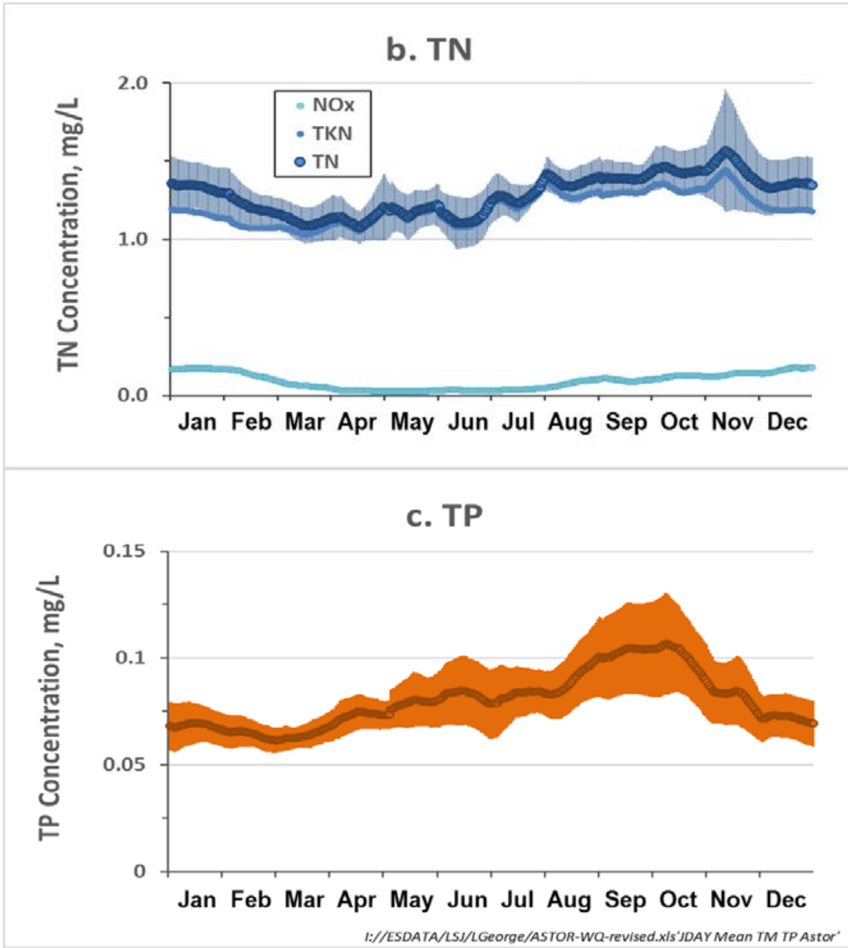


Figure E.6. Mean Discharge, TN and TP Observed at Astor from 2004 – 2015. Daily discharge values (a) calculated as the 12-year mean by Julian day, with vertical lines indicating the 90 percent confidence interval for the daily mean. Nitrogen (b) and phosphorus (c) concentrations for Julian day determined by interpolation from samples collected twice per month.

The process followed for compartmentalization of nutrient forms for the Astor boundary to the Lake George model is summarized in **Figure E.7**. Because of the substantial amount of refractory organic nutrients and carbon in the St. Johns River system, which are only minimally utilized for phytoplankton growth, the compartmentalization goes through a step to distinguish these forms. Color is relied upon in the Astor refractory organic carbon compartmentalization, as there are insufficient BOD and POC data, which are necessary to derive a relationship to based directly on bioavailability. An initial assumption is made in the compartmentalization that all colored dissolved organic matter is refractory. Relationships between laboratory color and Astor DOC, DON and DOP data were used for the refractory organic forms compartmentalization, and are shown in **Figure E.8**. These relationships were derived by selecting coefficients for the color versus DOC model that fit the bottom edge of the data, presumed to represent a condition in which all DOC is refractory (**Figure E.8a**). When compared to the color vs. RDOC relationship developed for the LSJR tributaries, the Astor data indicate a lower level of color for a given DOC concentration, a plausible condition if the CDOM has been resident in the river for a longer duration and undergone some degree of photo-decomposition. It also appears that part of the departure of the Astor relationship from the LSJR relationship may be due to the change in color determination in 2010 to a spectrophotometric method, which seems to provide higher color values at higher concentrations.

Along with the reliance on color, it is assumed that the total organic carbon (TOC) analysis provides a value that is somewhere in between DOC and the sum of DOC + POC, based on data collected previously from a wide range of systems, when POC is measured separately by filtration and combustion. To account for this, when DOC is unavailable in the data set, TOC has been substituted instead. POC is estimated from relationships between available POC and TSS or turbidity, and adjusted so that it is never less than the estimated POC based on chlorophyll *a*. Algal POC is estimated based on the relationships between phytoplankton biovolume and available POC data, with a concentration-variable model that attempts to account for the tendency for algal C:chlorophyll *a* to increase at higher concentration (Coveney et al, 2012(WSIS)).

In the LSJR TMDL model application, refractory organic N and P (the portion of P not measured as PO4 plus estimated to be within phytoplankton is referred to in this assessment as organic P, although likely much of it is adsorbed or contained in mineral particulates) were split out by stoichiometric proportioning. In this analysis, individual models have been developed for these fractions, and are shown in **Figure E.8b&c**. This was done due to the concern that the heterogeneity of organic matter sources, and how the degree of decomposition would affect the C:N and C:P ratios. This change seems to produce a predicted color vs. RDON relationship that is higher for N, and lower for P. With regard to P, this results in a greater proportion of TP placed into the labile fraction, which can be thought of as a conservative assumption in that most of the phosphorus in the system is available for phytoplankton incorporation. This is supported by the observed ratios of estimated phytoplankton C:TP in Lake George, which at bloom peak, usually exceed the Redfield ratios, suggesting most if not all P in the system can be utilized by phytoplankton.

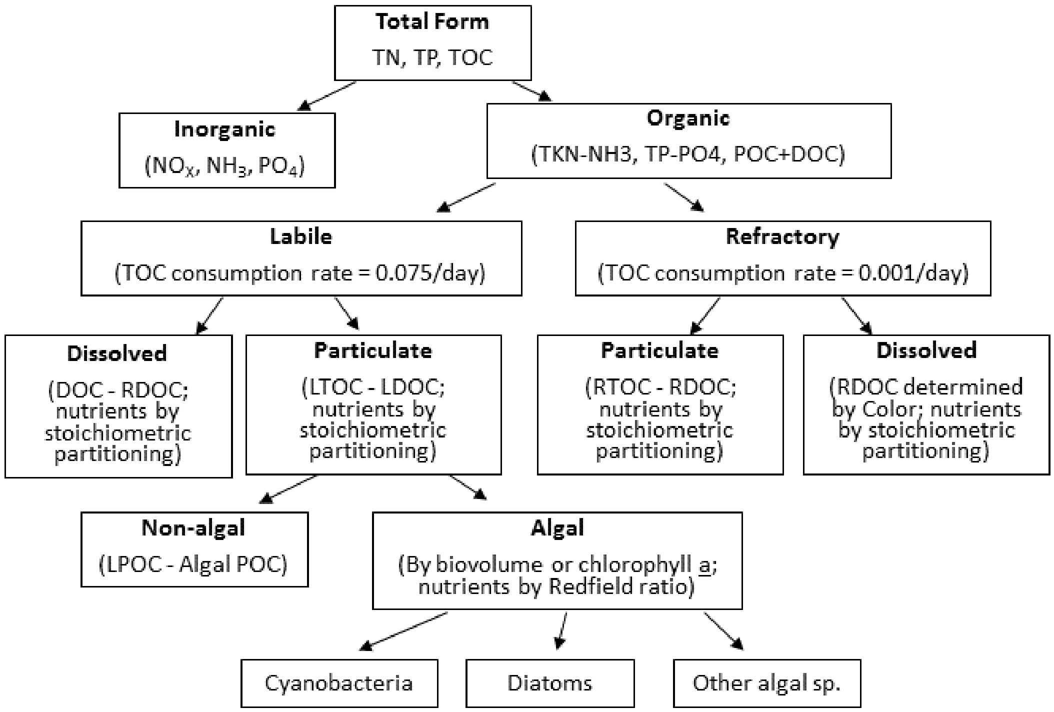


Figure E.7. General Procedure for Compartmentalizing C, N and P forms in the Astor Inflow Chemistry Data.

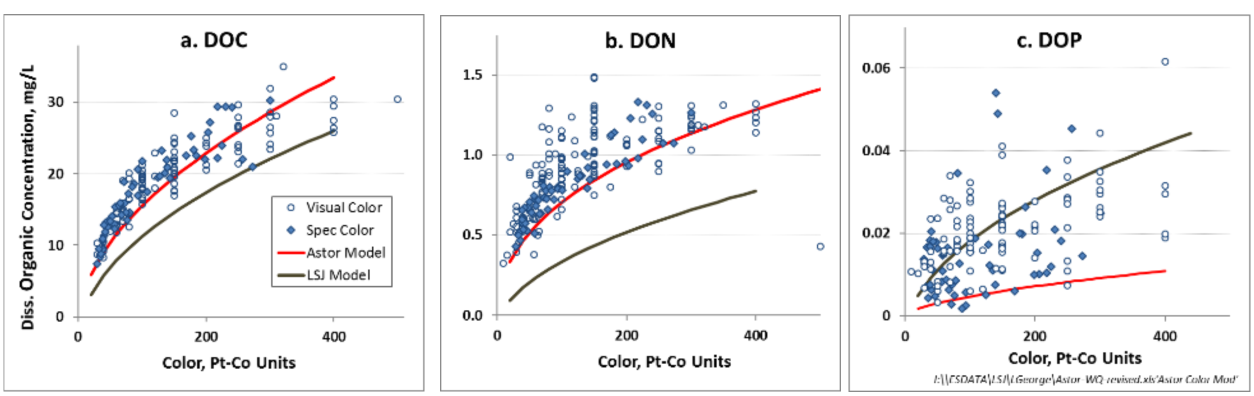


Figure E.8. Relationships Between Laboratory Color and Astor DOC, DON, and DOP

Estimated Natural Background Loads

In its pre-development condition, by all historic accounts the St. Johns River was a very productive aquatic ecosystem. It is useful to understand the growth resources and productivity potential of the system in its natural state, so that nutrient load reductions can be expressed as percent reductions of the anthropogenic load.

In order to reconstruct the natural background N and P profile, several sources of historic data were combined with present-day annual patterns to create a time series reflecting the hydrologic conditions of the TMDL study period, but with average N and P concentrations that existed prior to significant development in the watershed. The one-year study by Pierce (1947) from 1939-40 in Little Lake George provides the most detailed characterization of pre-development water quality. This study conducted monthly sampling, with measurements of Secchi depth, nitrogen forms, algal species identification and abundance, dissolved solids, chloride, pH and alkalinity. The data from this study indicate that the TN concentration in this reach of the St. Johns is much lower than that presently observed, with a study mean of 0.43 mg/L, compared to the 2002-15 Lake George outlet annual geometric mean of 1.43 mg/L. Secchi depth was approximately twice that currently observed, and chlorophyll *a* (converted from study biovolume estimates) was one eighth of that measured today. Secchi depth in the Pierce study is correlated with discharge (**Figure E.9**), suggesting that the import of colored dissolved organic matter (CDOM) was, as it is today, the predominant driver of underwater light conditions, and the similar correlation with TN suggests that the majority of nitrogen was compartmentalized within CDOM.

Figure E.10 displays the relationship between the current, calculated North L. George RDON concentration, the non-algal TON concentration for the Little Lake George site in the Pierce study, and the TON concentrations for the two other Pierce study sites in the Ocklawaha and St. Johns at Buffalo Bluff, versus their simultaneously measured Secchi depth. The solid dark grey line indicates the relationship between Secchi depth, converted from light attenuation coefficient by the simple 1.7/Kd conversion, and RDON, converted from RDOC, which in turn was converted form color measurements. The Kd values were derived from the color partial light extinction term of the Gallegos underwater light model. The Gallegos model-predicted Secchi vs. RDON relationship adheres closely to the upper bound of present-day calculated Lake George RDON, consistent with the condition that would exist when the control of underwater light is due solely to CDOM, without the attenuation of phytoplankton and its detritus, and the only organic N in the system was that contained within CDOM. It appears that the Pierce data also follow this relationship, though shifted to the right, reflecting a realm where particulate attenuation is far less than current levels. The Pierce data appears to reside farther below the theoretical line that the current data, with a possible explanation for this being the inability of the analytical method used in the Pierce study, the Nessler titration for ammonia liberated after the addition of alkaline potassium permanganate (albuminoid N), to liberate all of this recalcitrant organic N form.

The earliest known data on phosphorus concentrations in the Middle St. Johns River are contained in the 1952 State-wide survey by Professor Howard Odum. Results of this sampling effort for waters in the St. Johns River Basin are listed in Table 1. In August of 1952, Odum measured a total phosphorus concentration in Lake George in the vicinity of Silver Glen Springs of 0.044 mg/L. This is roughly half of the present day mean concentration of 0.081 mg/L observed at the inlet to the Lake at Astor. It should be noted that present day and presumably also historic TP concentrations are positively correlated with discharge, and the Odum survey occurred at a time of relatively low flow, so may be lower that an estimate derived from the central tendency of a numbers of samples collected over a range of flow conditions. Odum (1952) indicates that some of the study sites in the St. Johns River were influenced by a combination of sewage discharge and agricultural runoff. Sites that he concluded were affected by waste discharges included Lake Monroe, Lake Jesup, and the Econlochatchee River. Though upstream, these locations are distant from Lake George, and several other sites in his survey in the St. Johns or in other representative blackwater stream or river environments had low TP concentrations, ranging from 0.007 – 0.04 (**Table E.2**).

In order to provide a second representative value, a prediction of the natural background TP concentration was derived with the morpho-edaphic index (MEI) model of Vighi, and Chaudani (1985). This model incorporates alkalinity and lake mean depth to predict the natural background TP concentration. Lowe and Hendrickson (2012, draft) adapted the MEI to Florida lake data for the Numeric Nutrient Criteria development process, with the inclusion of a second term for color to account for the reduction in lake productivity relative to phosphorus, arising in dystrophic lakes from either the attenuation of water column light from colored dissolved organic matter, or reduced bioavailability of P. Applying this empirical model to the St. Johns River at Astor predicts a mean natural background TP concentration of 48.6 µg/L.

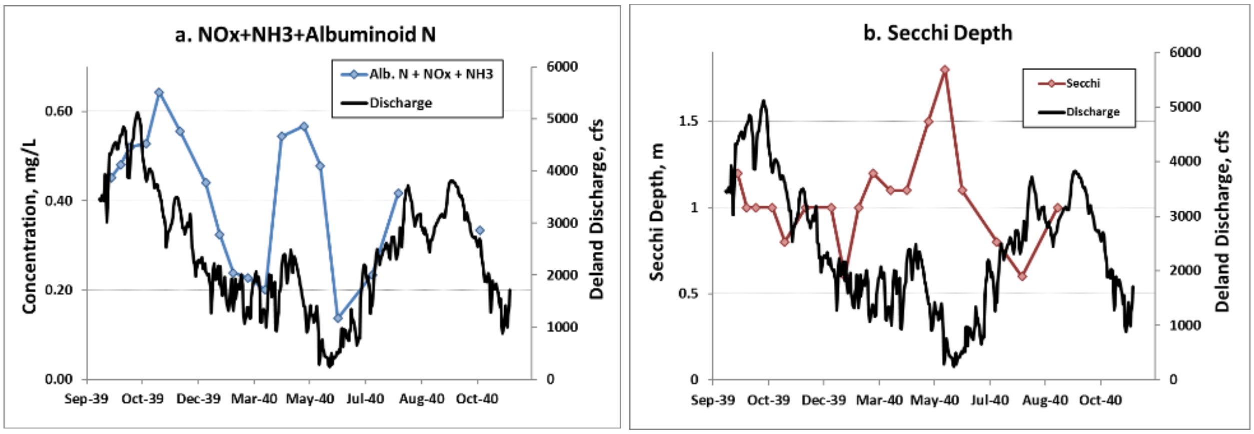


Figure E.9. TN and Secchi Depth Time Series for the Pierce Study, from September 1939 – November 1940. Discharge was recorded at the long-term USGS site in the St. Johns River near Deland, upstream of L. George at Hwy. 44.

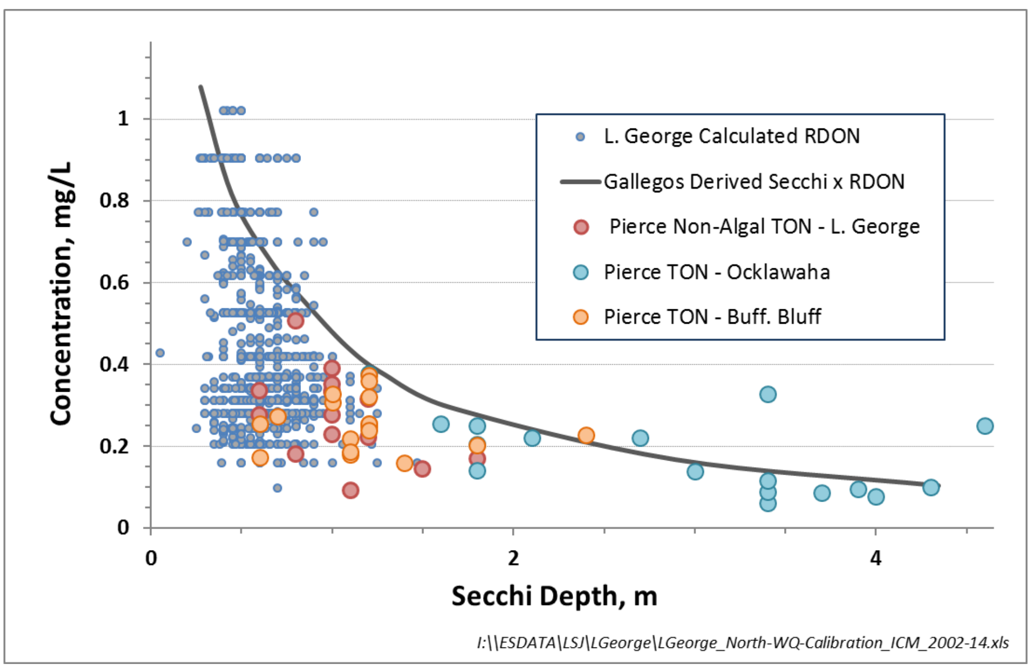


Figure E.10. Current and 1939-40 Relationship Between Secchi Depth and Organic N For the St. Johns River In and Below Lake George. Blue "+" symbols indicate the current relationship between Secchi depth and calculated RDON. Circles indicate the relationship at various locations between Secchi depth and total non-algal ON from Pierce (1947).

Table E.2. Total Phosphorus Concentrations Determined for Selected Locations in St. Johns River Basin in 1952. Data from Odum (1953).

Location	*Date*	*Total P, mg/L*
Black Creek, Route 17	Aug. 9, 1952	0.04
Deep Creek, Hastings, Route 207	Jul. 14, 1952	0.54
Crescent Lake, Andalusia	Jul. 19, 1952	0.033
Doctor's Lake, Route 17	Aug. 9, 1952	0.065
Lake George at Silver Glen Springs	**Aug. 14, 1952**	**0.044**
Lake Monroe, Sanford	Jun. 23, 1952	0.18
Ortega River, Route 21	Aug. 9, 1952	0.044
St. Johns R., Crows Bluff, Volusia Co.	Sep. 3, 1952	0.117
St. Johns R., Palatka	Jul 19, 1952	0.061
St. Johns R., Route 192 (Brevard Co.)	Jun. 23, 1952	0.007
St. Johns R., Route 50 (Orange Co.)	Jun. 23, 1952	0.015
St. Johns R., Green Cove Springs	Jul. 16, 1952	0.119

These pre-development measurements of N and P were used as the foundation of a concentration time series for Astor that presents a reasonable characterization of the pre-development nutrient conditions. This time series was further partitioned into the state variables necessary for simulations with the CE-QUAL-ICM WQ model. Based on the apparent adherence between the Pierce data and present day organic N and Sturb.ecchi depth, and with no reason to suspect that this constituent, the presence of which is driven by natural processes, would have changed over time, an assumption is made here that the present day RDON reflects that which would have existed in the pre-development condition. The current calculated mean concentration of RDON + RPON at Astor is 0.76 mg/L (2002 – 2014), greater than the mean albuminoid – ammonia calculated concentration of 0.279 for the Pierce study. Several factors could account for this lower value, such as the inflow of several large artesian springs between Astor and the Pierce site, an under-reporting of organic N derived from the albuminoid method, photodecomposition in Lake George, incorporation by water hyacinth, or the moderately lower flow conditions occurring in 1940. The pre-development labile N determined from the Pierce study, calculated as the sum of NH4, NO2+3, and estimated algal ON, is 0.144 mg/L. This is considered to be a minimum value, as it does not explicitly include non-algal particulate organic N and dissolved organic N. To account for this potential underestimate, and with the lack of other information on which to judge this nitrogen fraction, this value was doubled to a mean concentration of 0.288 mg/L. By comparison, the present day total labile N derived from the Astor WQ data is 0.548 mg/L.

The sum of the estimated total labile and refractory N forms, at 1.05 mg/L, was taken to represent the overall mean pre-development TN concentration at Astor. In order to impart temporal changes in this TN concentration, the daily percent deviation from the present day mean, determined from a daily interpolated data series, was calculated and then multiplied by this pre-development mean to derive a pre-development, time varying TN concentration. As indicated above, the existing RDON is considered to be equivalent to the pre-development concentration, so all labile N (NH4, NOx, algal ON, LDON and non-algal LPON) were partitioned from the difference between TN and RDON + RPON. Because the phytoplankton biomass is considered to be driven primarily by the available TP, pre-development algal organic carbon was determined by stoichiometric mass ratios (41:1) from the algal-incorporated P, determined from the product of the current proportion of TP calculated to be within the phytoplankton (group-specific algal P/TP) and the pre-development TP. Algal ON was then determined by standard Redfield stoichiometric ratios (5.68:1) from the pre-development algal OC. The remaining respective inorganic and organic N forms were fractionated based on their present-day proportions. The resulting current condition and natural background TN time series are shown in **Figure E.11**. While the time series do not appear to be greatly different, it should be kept in mind that all of the differences are in labile N forms.

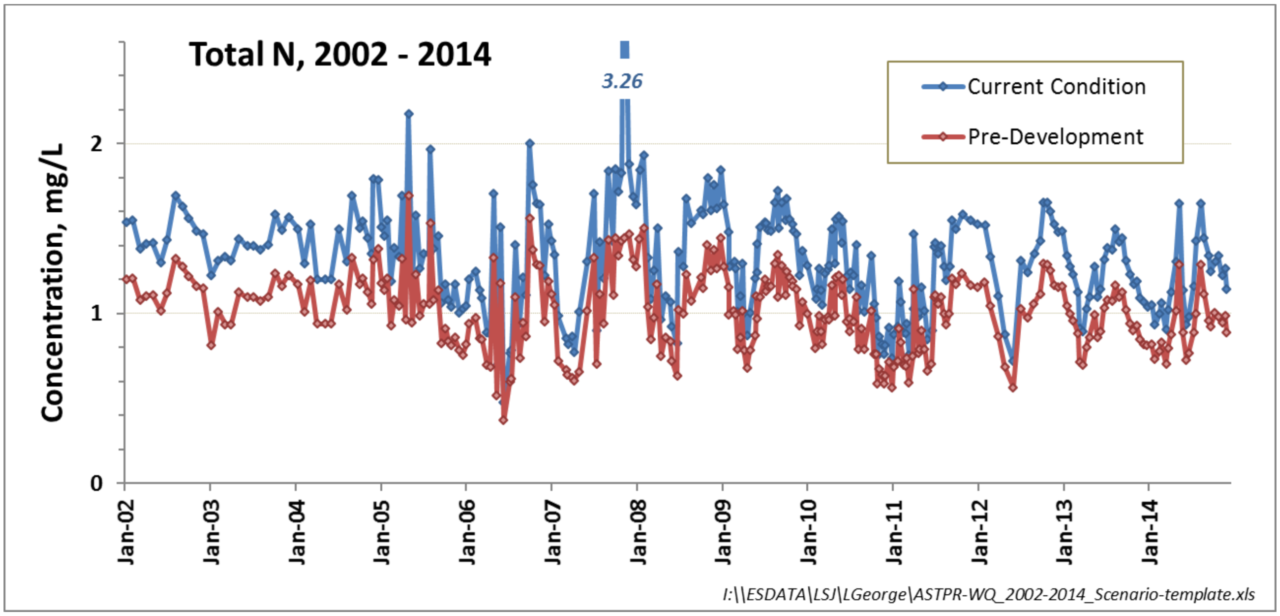


Figure E.11. Astor 2002 – 2014 TN Concentration Time Series, and the Estimated Pre-Development Time Series for the Same Interval.

The midpoint of the two available estimates for pre-development TP concentration, 0.044 mg/L from the Odum (1952) survey, and 0.048 mg/L from the MEI model (Lowe and Hendrickson, 2012) prediction, or 0.046, was selected as a reasonable representative value of the pre-development mean TP concentration of the St. Johns River flowing into Lake George. The time series distribution of this mean TP concentration was done similar to the method for TN, by multiplying the percent of the present-day mean of the interpolated daily concentration by this pre-development value to get a similarly-proportioned TP for each day. The present-day RDOP was then subtracted from this daily value, to get a total labile P concentration remaining. This total labile P was partitioned into PO4, LPOP and LDOP, and phytoplankton OP based on the present day proportions of these variables in of the total labile fraction. The resulting pre-development TP time series is shown in **Figure E.12**.

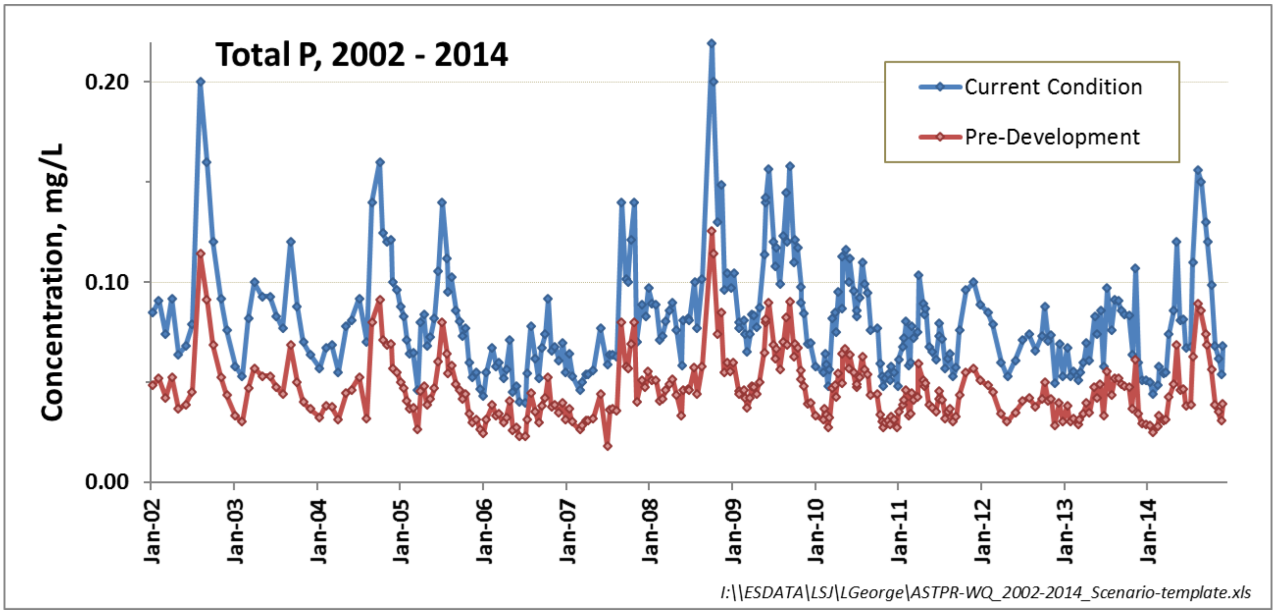


Figure E.12. Astor 2002 – 2014 TP Concentration Time Series, and the Estimated Pre-Development Time Series for the Same Interval.

Appendix F: External Loads under Existing, TMDL, and Natural Background Conditions and the NNC Criteria Calculations

Table F.1. Annual External TN loads to Lake George Under Existing Conditions

Annual Loads Expressed as Kg/yr

Sub-Basin	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Annual Average
1-ASTOR	5,087,002	5,792,926	5,613,918	2,025,721	1,836,194	6,203,863	3,443,885	2,518,151	2,907,467	2,857,324	2,689,222	**3,725,061**
2-Juniper	1,062	1,074	1,175	1,025	904	970	1,074	972	847	813	792	**973**
3-Silver Glen	5,450	5,335	4,373	4,610	4,221	5,167	4,846	4,542	3,556	3,499	3,486	**4,462**
4-Salt	7,333	7,386	7,758	7,164	6,775	6,993	7,128	6,950	6,478	6,423	6,546	**6,994**
12-Glen Surface	4,542	3,985	4,370	1,254	2,668	5,207	5,053	3,076	3,866	3,147	3,745	**3,719**
13-Juniper Surface	7,357	7,616	6,010	1,622	5,358	6,275	9,463	5,878	6,400	6,075	6,914	**6,270**
14-Jumping Gully	9,980	8,571	11,148	1,449	4,100	10,601	13,790	4,873	8,289	7,323	7,594	**7,974**
15-Hitchens	1,984	1,335	1,503	577	324	1,518	2,056	1,343	962	1,189	773	**1,233**
16-Willow	6,136	3,661	5,079	1,001	1,884	6,360	4,909	2,559	3,278	2,846	4,539	**3,841**
17-Tiger	15,280	15,817	15,105	2,945	4,071	12,514	12,435	8,207	8,979	9,943	9,965	**10,478**
21-Salt Surface	4,156	3,601	4,080	990	2,164	4,490	4,400	2,675	3,032	3,291	3,105	**3,271**
26-Juniper Pick-Up	778	785	860	750	655	707	740	697	614	608	589	**707**
Atmospheric	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	**115,784**
TOTAL (KG)	5,266,845	5,967,874	5,791,161	2,164,893	1,985,102	6,380,449	3,625,563	2,675,707	3,069,551	3,018,265	2,853,054	**3,890,769**

Table F.2. Annual External TP loads to Lake George Under Existing Conditions

Annual Loads Expressed as Kg/yr

Sub-Basin	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Annual Average
1-ASTOR	290,105	440,410	357,725	99,232	93,393	493,739	269,979	161,561	173,515	144,910	161,175	**244,159**
2-Juniper	1,062	1,074	1,175	1,025	904	970	1,074	972	847	813	792	**973**
3-Silver Glen	2,516	2,462	2,019	2,128	1,948	2,385	2,237	2,096	1,641	1,615	1,609	**2,060**
4-Salt	3,259	3,283	3,448	3,184	3,011	3,108	3,168	3,089	2,879	2,855	2,909	**3,108**
12-Glen Surface	931	861	888	281	567	1,117	960	648	811	601	717	**762**
13-Juniper Surface	1,515	1,515	1,071	326	1,142	1,286	1,652	1,133	1,270	1,071	1,230	**1,201**
14-Jumping Gully	2,076	1,847	2,211	328	842	2,188	2,457	976	1,686	1,380	1,359	**1,577**
15-Hitchens	429	304	327	128	73	362	422	277	207	253	165	**268**
16-Willow	1,300	829	1,081	231	427	1,464	892	496	707	584	905	**811**
17-Tiger	3,239	3,596	3,147	624	912	2,856	2,210	1,605	1,953	1,955	1,979	**2,189**
21-Salt Surface	800	734	773	222	433	900	773	510	602	585	561	**627**
26-Juniper Pick-Up	778	785	860	750	655	707	740	697	614	608	589	**707**
Atmospheric	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	**1,370**
TOTAL (KG)	309,380	459,070	376,094	109,830	105,678	512,450	287,933	175,431	188,102	158,600	175,362	**259,812**

Table F.3. Annual External TN loads to Lake George Under 30%TN70%TP Scenario

Annual Loads Expressed as Kg/yr

Sub-Basin	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Annual Average
1-ASTOR	4,704,527	5,364,863	5,263,488	1,868,554	1,730,511	5,633,739	3,198,824	2,309,602	2,663,014	2,632,421	2,484,773	**3,441,301**
2-Juniper	1,062	1,074	1,175	1,025	904	970	1,074	972	847	813	792	**973**
3-Silver Glen	5,450	5,335	4,373	4,610	4,221	5,167	4,846	4,542	3,556	3,499	3,486	**4,462**
4-Salt	7,333	7,386	7,758	7,164	6,775	6,993	7,128	6,950	6,478	6,423	6,546	**6,994**
12-Glen Surface	4,257	3,731	4,094	1,175	2,499	4,875	4,737	2,883	3,622	2,950	3,510	**3,485**
13-Juniper Surface	7,021	7,257	5,722	1,547	5,111	5,981	9,006	5,604	6,101	5,782	6,581	**5,974**
14-Jumping Gully	9,327	8,010	10,426	1,352	3,834	9,915	12,911	4,556	7,750	6,853	7,110	**7,459**
15-Hitchens	1,867	1,257	1,414	544	305	1,427	1,934	1,264	905	1,119	727	**1,160**
16-Willow	5,790	3,450	4,790	946	1,775	5,991	4,636	2,417	3,092	2,685	4,282	**3,623**
17-Tiger	15,171	15,685	14,996	2,926	4,036	12,403	12,372	8,157	8,908	9,879	9,899	**10,403**
21-Salt Surface	3,656	3,140	3,541	909	1,888	3,871	3,808	2,358	2,649	2,852	2,700	**2,852**
26-Juniper Pick-Up	778	785	860	750	655	707	740	697	614	608	589	**707**
Atmospheric	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	**115,784**
TOTAL (KG)	4,882,024	5,537,756	5,438,422	2,007,286	1,878,299	5,807,821	3,377,800	2,465,785	2,823,320	2,791,669	2,646,782	**3,605,179**

Table F.4. Annual External TP loads to Lake George Under 30%TN70%TP Scenario

Annual Loads Expressed as Kg/yr

Sub-Basin	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Annual Average
1-ASTOR	203,610	306,619	242,831	69,469	67,585	345,910	188,972	113,295	121,505	101,258	112,791	**170,349**
2-Juniper	1,062	1,074	1,175	1,025	904	970	1,074	972	847	813	792	**973**
3-Silver Glen	2,516	2,462	2,019	2,128	1,948	2,385	2,237	2,096	1,641	1,615	1,609	**2,060**
4-Salt	3,259	3,283	3,448	3,184	3,011	3,108	3,168	3,089	2,879	2,855	2,909	**3,108**
12-Glen Surface	808	769	771	252	503	998	806	568	714	506	604	**664**
13-Juniper Surface	1,397	1,402	938	298	1,081	1,203	1,436	1,019	1,166	935	1,081	**1,087**
14-Jumping Gully	1,854	1,709	1,945	301	760	1,995	2,019	850	1,501	1,184	1,122	**1,385**
15-Hitchens	384	275	293	117	65	328	372	246	185	226	148	**240**
16-Willow	1,179	769	982	216	397	1,365	760	435	646	524	802	**734**
17-Tiger	2,938	3,333	2,832	568	839	2,642	1,869	1,414	1,783	1,721	1,749	**1,972**
21-Salt Surface	718	682	694	208	399	836	669	454	551	508	491	**565**
26-Juniper Pick-Up	778	785	860	750	655	707	740	697	614	608	589	**707**
Atmospheric	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	**1,370**
TOTAL (KG)	221,872	324,532	260,158	79,886	79,517	363,816	205,490	126,504	135,402	114,122	126,057	**185,214**

Table F.5. Annual External TN loads to Lake George Under Natural Background Loading Scenario

Annual Loads Expressed as Kg/yr

Sub-Basin	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Annual Average
1-ASTOR	3,974,468	4,538,080	4,534,939	1,574,915	1,571,525	4,433,056	2,703,883	1,978,786	2,243,403	2,243,518	2,114,924	**2,901,045**
2-Juniper	1,062	1,074	1,175	1,025	904	970	1,074	972	847	813	792	**973**
3-Silver Glen	5,450	5,335	4,373	4,610	4,221	5,167	4,846	4,542	3,556	3,499	3,486	**4,462**
4-Salt	7,333	7,386	7,758	7,164	6,775	6,993	7,128	6,950	6,478	6,423	6,546	**6,994**
12-Glen Surface	3,592	3,141	3,452	991	2,105	4,100	4,000	2,433	3,052	2,491	2,964	**2,938**
13-Juniper Surface	6,235	6,419	5,049	1,372	4,534	5,296	7,939	4,964	5,402	5,099	5,804	**5,283**
14-Jumping Gully	7,804	6,703	8,744	1,126	3,213	8,312	10,859	3,815	6,494	5,758	5,979	**6,255**
15-Hitchens	1,596	1,073	1,207	467	260	1,214	1,651	1,081	773	956	621	**991**
16-Willow	4,983	2,958	4,115	816	1,522	5,129	3,998	2,085	2,658	2,309	3,683	**3,114**
17-Tiger	14,918	15,376	14,744	2,882	3,956	12,143	12,226	8,040	8,745	9,729	9,746	**10,228**
21-Salt Surface	2,489	2,064	2,285	718	1,246	2,426	2,426	1,616	1,757	1,828	1,756	**1,874**
26-Juniper Pick-Up	778	785	860	750	655	707	740	697	614	608	589	**707**
Atmospheric	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	115,784	**115,784**
TOTAL (KG)	4,146,492	4,706,178	4,704,484	1,712,621	1,716,699	4,601,297	2,876,553	2,131,766	2,399,562	2,398,814	2,272,677	**3,060,649**

Table F.6. Annual External TP loads to Lake George Under Natural Background Loading Scenario

Annual Loads Expressed as Kg/yr

Sub-Basin	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Annual Average
1-ASTOR	166,541	249,286	193,593	56,713	56,527	282,560	154,256	92,612	99,205	82,543	92,055	**138,717**
2-Juniper	1,062	1,074	1,175	1,025	904	970	1,074	972	847	813	792	**973**
3-Silver Glen	2,516	2,462	2,019	2,128	1,948	2,385	2,237	2,096	1,641	1,615	1,609	**2,060**
4-Salt	3,259	3,283	3,448	3,184	3,011	3,108	3,168	3,089	2,879	2,855	2,909	**3,108**
12-Glen Surface	755	729	721	240	475	947	739	534	673	465	555	**621**
13-Juniper Surface	1,346	1,353	881	287	1,055	1,167	1,344	970	1,121	876	1,017	**1,038**
14-Jumping Gully	1,759	1,650	1,832	289	725	1,912	1,831	796	1,422	1,100	1,020	**1,303**
15-Hitchens	365	263	278	112	62	313	350	232	176	214	140	**228**
16-Willow	1,127	744	939	209	384	1,322	703	408	619	498	757	**701**
17-Tiger	2,809	3,220	2,696	545	808	2,551	1,723	1,331	1,710	1,621	1,650	**1,879**

21-Salt Surface	683	660	661	202	384	809	624	430	530	475	461	**538**
26-Juniper Pick-Up	778	785	860	750	655	707	740	697	614	608	589	**707**
Atmospheric	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	**1,370**
TOTAL (KG)	184,370	266,878	210,473	67,054	68,307	300,121	170,159	105,538	112,806	95,053	104,925	**153,244**

Table F.7. Lake George Rolling 7-year Averages Under 30%TN70%TP Scenario Used to Calculate the NNC

Averaging Period	**Chla AGM average (7 years) (µg/L)**	AverageTN Load (7 years) (kg)	Average TP Load (7 years) (kg)
2013-2007	20	3,113,068	164,415
2012 - 2006	20	3,021,711	157,820
2011 - 2005	20	3,399,819	178,682
2010 - 2004	20	3,787,596	205,700
2009 - 2003	19	4,132,773	219,324
AVERAGE	20	3,490,993	185,188
MAXIUM	20	4,132,773	219,324