The Relationship between Jackson Turbidity Units and Nephelometric Turbidity Units, as Determined from Various Florida Sediment Samples

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INTRODUCTION

The Department of Environmental Regulation has proposed to change the turbidity standard in 17-3, F.A.C., from Jackson turbidity units (JTU) to nephelometric turbidity units (NTU). In early 1982, a preliminary study was undertaken based on 23 sediment samples taken from the eastern part of the Florida Panhandle. These sediment samples were visually selected to exemplify the fine-grained highly organic sediments expected to result in the greatest environmental damage; that is, those sediments of the greatest concern to the department in terms of turbidity regulation. Paired JTU/NTU data points were generated in that study based on artificially produced turbid water, and a linear regression indicated that the existing water quality standard of 50 JTU's corresponded to approximately 22 NTU's.

The present study is a considerable expansion of the earlier one, and was designed to utilize sediments taken from throughout the state in the documentation of the relationship between Jackson and nephelometric turbidity units. Further, this study includes analytical characterizations of the numerous types of sediments involved, and so certain conclusions can be drawn about the variation of the JTU/NTU ratio in relation to sediment characteristics (as well as to type and salinity of water body).

MATERIALS AND METHODS

Sediment Preparation and Sieving

Approximately thirty sediment samples were sent to Tallahassee immediately after collecting by each of the following district offices: Northwest, Northeast, St. Johns River, Southeast Florida, and South Florida. The samples arrived in a variety of containers but were always filled with at least 100g of wet sediment. Upon arrival at the Tallahassee biological laboratory, the samples were frozen until needed. As they were required, batches of samples were allowed to thaw overnight and then quantities of sediment were removed for further processing. A fairly large amount (i.e., enough to provide 25g of dried sediment) was placed in an aluminum foil tray for drying in a drying oven at 105°C for 24 hours. At the same time, smaller foil packets were made up containing about 5g of wet sediment, one for the Chemistry Section to use in making up slurries for JTU and NTU readings, and one for the Biology Section to use in determining the organic content of the sediment. The smaller packets were frozen until needed.

After a large packet of sediment had dried, it was broken up manually (this was particularly necessary with those sediments containing a large silt-clay fraction) and exactly 25g of the material were placed into a tared weight boat. The sediment was then placed into a 250ml Ehrleymeyer flask to which 10ml of Calgon™ solution (20g Calgon™ per liter of water) and 250ml of tap water was added. The material was stirred vigorously and then agitated mildly (on a shaker table) overnight. The wet sieving of the material follows the method of Buchanan and Kain (1971). Material larger than silt-clay size (i.e., larger than 62μm) was further sieved dry through a nested series of sieves and with the aid of a Ro-Tap machine. Each sample was Ro-Tapped for ten minutes. Each individual fraction was then weighed. The weight of the silt-clay fraction was then found by difference.

Organic Fraction

The percent of the organic fraction in a sample sediment was estimated by an ash-free dry weight method. Approximately 5 grams of sediment were placed in porcelain crucibles and dried at 105°C for 24 hours. After drying, the samples were cooled in a desiccator and weighed to the nearest 0.00001g. The sediment samples were then ignited at 550°C for one hour, cooled, and weighed again. The differences in weight were calculated, after blank corrections were run for each batch, for an estimate of the percent organic matter in each sample.

Turbidity Analyses

Samples were received frozen, wrapped in foil, and identified by the field sample ID#. They were logged in and given a Chemistry Section SPAN number. Bottles used for sample preparation were one-liter glass with teflon-lined caps. These bottles were washed with alconox and water, rinsed with tap water and triple rinsed with deionized water. Approximately 500ml of deionized water were then added to each bottle. The sediment samples were opened and small amounts of sediment were added to the deionized water and shaken vigorously. After settling for a minute, the turbidity was estimated by eye and more sediment was added if needed in order to achieve a turbidity between 20 and 75 NTU. The water was then decanted into another clean bottle and analyzed by the Jackson Candle Unit and by the HACH turbidimeter.

Standards were prepared according to Standard Methods, 15th Edition (1980). Working standards of 10, 20, 32, 40, 48, 80 and 120 NTU's were prepared every two to four days. A HACH model 18900 ratio turbidimeter was used for NTU measurements, and all of the above standards were read on this instrument. The turbidimeter was calibrated each day using HACH formazin turbidity standards of 18 and 180 NTU. A deionized water blank was also read each day on the HACH turbidimeter. All calibrations and adjustments were made following the directions in the instruction manual for the HACH ratio turbidimeter.

Standards of 32, 48, 80 and 120 NTU were read each day on the Jackson Candle Unit following the procedures in Standard Methods. Samples and standards were shaken vigorously and left to stand for one minute before taking readings on the Jackson Candle Unit or/and HACH turbidimeter. All calculations were made following procedures in Standard Methods.

RESULTS

The results obtained during this study are summarized in Tables 1-5. Samples for which the Jackson turbidity unit analyses resulted in values of "<25 JTU" are not included, since no relationship between JTU's and NTU's could be calculated. These samples were ones with little or no silt-clay component. Additionally, about six other sediment samples were not analyzed for a variety of reasons, including inadvertant sample loss and sample contamination.

DISCUSSION

Statistical analyses were performed using the variables listed in Tables 1-5: salinity, the five sediment size fractions, % organics, JTU turbidity, and NTU turbidity. Four water body types are listed in the tables, but insufficient numbers of samples were available for "freshwater lake" and for "marine" to allow analysis of these types. Instead, salinity is analyzed, and should adequately reflect any differences between freshwater and salt water habitats.

To characterize the relationship between NTU's and JTU's and to assess the importance of the other variables, a variety of linear, quadratic, cubic and natural logarithmic regressions were performed on the data. It was determined that in each case the constant term was not significantly different from zero, which was expected since theoretically zero NTU's should equal zero JTU's. Therefore, all subsequent regression runs were forced through the origin. An attempt was made to improve the accuracy of the estimates by limiting the data to only those cases in which the measured JTU's were less than or equal to 110. This attempt did not result in improved accuracy, and consequently all data were used.

CONCLUSIONS

The results of the analyses are that the most accuracte conversation, from JTU's and NTU's, was given by a logarithmic form, forcing the regression through the origin. The form of the equation is $NTU=(JTU)^b$ where b is the estimated term (see Figure 1). With this form the adjusted R^2 was .9949 which denotes the percent of explained variation about 0; not the variation about the mean as is done in usual regression with a constant term. The estimate for b is .85992697 with a 95% C.I. of (.8483, .8715). This gives the conversion of 50 JTU's to be 28.9 NTU's. Conversions from the other regressions were very close to this, ranging from 27 NTU's to 29 NTU's. However, the given equation is the most defensible from a statistical point of view.

Assessing the importance of particle size, organic content and salinity was not so clear cut. In all of the above mentioned regressions, all of these variables could not explain any more than an additional 1.6% of the variation from 0 or from the mean. This is in part due to the fact that there is a high correlation between these variables and both JTU and NTU measurements, so their effectiveness as predictors of one measurement relative to the other is lessened. However, we feel the main reason is that the types of sediment and water bodies measurements used in this analysis do not have pronounced effects on differences in the turbidity measurements in any predictable way.

Figure 1. Logarithmic Regression.

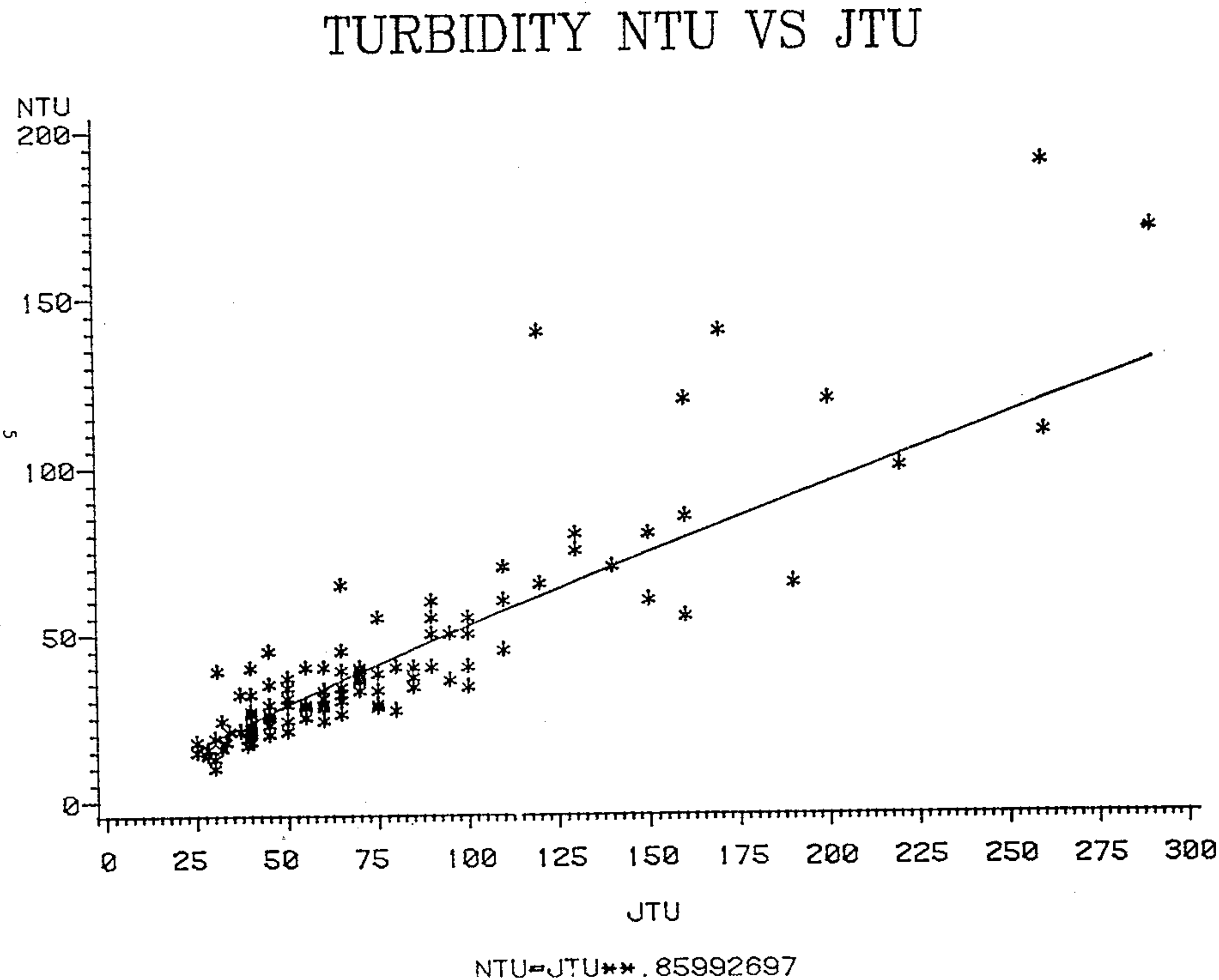

Table 1. Northwest District

Waterbody	Sample No.	Water-body Type *	Salin. (0/00)	%Silt-Clay (<63μm)	% V. Fine Sand (63μm -125μm)	% Fine-Med. Sand (125μm -500μm)	% Coarse Sand (500μm -2.0mm)	% Granules & larger (>2.0mm)	% Organics	Turbidity JTU	Turbidity NTU
Pine Bottom Creek	NW-1	F-S	0	3.44	5.68	43.88	22.76	24.24	0.52	40	32
Escambia River	NW-4	F-S	0	9.12	63.72	26.24	0.72	0.20	0.57	65	45
Escambia River	NW-5	F-S	0	3.56	46.48	49.92	0.04	0	0.18	25	18
Big Cold Water Creek	NW-6	F-S	0	1.52	2.16	25.92	30.84	39.56	0.47	40	32
Santa Rosa Sound, Navarre	NW-8	E	14	1.52	1.08	94.72	2.52	0.16	0.62	95	36
Choctawhatchee Bay	NW-9	E	2	1.96	6.44	81.96	9.60	0.04	0.52	55	28
Black Creek	NW-10	F-S	0	5.64	31.64	54.20	8.12	0.40	4.66	30	19
Choctawhatchee River	NW-11	F-S	0	5.60	35.88	57.72	0.64	0.16	0.75	45	35
Alaqua Creek	NW-12	F-S	0	27.92	27.88	36.68	7.36	0.16	14.55	90	55
Pensacola, auditorium	NW-13	E	15	3.64	6.24	62.92	14.52	12.68	1.76	65	32
Bayou Texar	NW-14	E	1	3.00	3.56	39.60	52.72	1.12	1.30	50	37
Carpenter Creek, Davis	NW-15	F-S	0	1.88	2.92	67.60	27.40	0.20	0.52	31	39
Bayou Chico, shipyard	NW-16	E	17	4.80	4.48	52.80	29.92	8.00	2.04	95	50
Bayou Chico	NW-17	E	17	0.76	2.44	77.00	18.84	0.96	0.41	75	33
Mullatt Bayou	NW-18	E	10	16.84	14.56	29.64	17.52	21.44	12.08	150	80
Escambia Bay	NW-19	E	15	26.00	21.16	47.84	5.00	0	2.36	120	65
Escambia Bay	NW-20	E	15	27.60	33.28	36.08	3.00	0.04	4.12	130	75
Escambia Bay	NW-21	E	13	86.00	5.16	8.48	0.36	0	7.97	110	70
Bass Hole Cove	NW-22	E	10	28.40	22.36	44.68	4.20	0.36	3.48	140	26
North Escambia Bay	NW-23	E	11	13.08	25.68	59.56	1.48	0.20	1.89	160	85
Escambia Bay Mouth	NW-24	E	18	93.72	3.96	2.12	0.16	0.04	7.73	65	65
Escambia Bay	NW-25	E	13.5	87.16	2.92	7.72	2.12	0.08	11.91	110	70
Escambia Bay	NW-26	E	8.5	1.36	3.36	88.88	6.40	0	0.47	100	50
Escambia River	NW-27	E	2	13.52	32.76	48.76	4.76	0.20	2.46	60	40
Smith Camp Creek	NW-28	E	3	84.00	4.84	7.20	3.64	0.32	20.13	160	120

*E=estuarine, F-S=freshwater stream

Table 2. Northeast District

Waterbody	Sample No.	Water-body Type*	Salin. (0/00)	%Silt-Clay (<63μm)	% V. Fine Sand (63μm -125μm)	% Fine-Med. Sand (125μm -500μm)	% Coarse Sand (500μm -2.0mm)	% Granules & larger (>2.0mm)	% Organics	Turbidity	
										JTU	NTU
St. Marys River	Jax 805	F-S	0	84.64	0.96	11.76	1.56	1.08	10.50	120	140
Rice Creek	Jax 807	F-S	0	12.04	37.12	49.36	1.28	0.20	3.34	85	40
Simms Creek	Jax 808	F-S	0	1.44	14.80	82.96	0.64	0.16	0.58	70	40
Lake Butler	Jax 809	F-L	0	33.32	39.88	24.84	1.72	0.24	11.47	260	190
Price Creek	Jax 811	F-S	0	0.64	11.40	79.80	7.96	0.20	0.28	32	24
Olustee Creek	Jax 812	F-S	0	16.28	33.80	40.60	7.84	1.48	14.70	70	39
New River	Jax 813	F-S	0	4.80	27.64	63.00	4.48	0.08	1.66	50	29
Matanzas River	Jax 814	E	23	8.04	24.44	66.04	1.48	0	1.08	110	60
ICW, Flagler Beach	Jax 815	E	20	1.52	19.84	76.84	1.44	0.36	0.75	55	25
Governors Creek	Jax 817	E	1	0.28	7.20	87.96	3.00	1.56	0.34	45	23
Alligator Creek	Jax 818	F-S	0	5.44	26.48	67.84	0.16	0.08	2.41	45	25
Oil Pit Tributary	Jax 819	F-L	0	5.00	11.00	82.72	1.08	0.20	1.06	90	60
Wire Mill Ditch	Jax 820	F-S	0	1.72	22.12	75.76	0.24	0.16	0.50	60	33
Effluent Ditch Culvert	Jax 822	F-S	0	4.56	42.76	51.56	0.96	0.16	1.12	55	29
Boggy Branch	Jax 823	F-S	0	1.64	5.16	85.64	7.56	0	0.83	40	32
Clarkes Creek	Jax 825	F-S	0	2.08	10.80	86.60	0.48	0.04	2.03	70	37
Cormorant Branch	Jax 826	F-S	0	3.52	22.44	68.40	2.04	3.60	3.39	80	40
Simms Creek	Jax 827	F-S	0	25.92	8.24	63.80	1.84	0.20	5.90	90	60
Effluent Creek	Jax 828	F-S	0	1.20	49.32	48.16	1.32	0	1.14	37	32
Effluent Culvert	Jax 829	F-S	0	1.72	7.36	89.76	1.16	0	0.83	100	55

*E=estuarine, F-L=freshwater lake, F-S=freshwater stream

Table 3. St. Johns River District

Waterbody	Sample No.	Water-body Type*	Salin. (0/00)	%Silt-Clay (<63μm)	% V. Fine Sand (63μm -125μm)	% Fine-Med. Sand (125μm -500μm)	% Coarse Sand (500μm -2.0mm)	% Granules & larger (>2.0mm)	% Organics	Turbidity JTU	Turbidity NTU
Indian River	SJR 4489-1	E	21.5	3.72	6.32	82.04	6.44	1.48	2.17	150	60
Banana River	SJR 4486-2	E	24	11.52	18.60	49.00	16.00	4.88	3.84	220	100
Sykes Creek	SJR 4487-3	E	7.8	3.16	28.20	59.56	6.36	2.72	0.66	40	23
Sykes Creek	SJR 4488-4	E	21	5.00	11.12	60.28	12.44	11.16	3.21	100	34
Sebastian Inlet	SJR 4495-5	M	30	1.88	36.96	58.76	2.32	0.08	0.91	40	22
Sebastian Creek	SJR 4494-6	E	19	67.80	9.76	20.00	1.84	0.60	13.27	190	65
St. Johns River	SJR 4493-7	F-S	0	32.12	17.60	42.72	7.28	0.28	11.88	70	36
Taylor Creek	SJR 4492-8	F-S	0	6.72	27.36	59.04	5.96	0.92	7.68	65	30
Big Econ River	SJR 4490-10	F-S	0	3.92	17.24	67.08	2.92	8.84	4.05	55	40
Shingle Creek	SJR 4511-11	F-S	0	2.76	43.24	51.00	2.04	0.96	3.03	130	80
Palatlakaha River	SJR 4515-15	F-S	0	0.88	4.36	55.08	25.44	14.24	2.43	50	34
Dora Canal	SJR 4497-17	F-S	0	0	3.36	68.16	22.88	5.88	10.76	30	10
Dead River	SJR 4498-18	F-S	0	0.20	2.52	84.76	9.04	3.40	1.53	40	18
Oklawaha River	SJR 4501-21	F-S	0	5.88	12.32	74.32	6.40	1.08	10.28	45	26
Silver River	SJR 4502-22	F-S	0	3.08	1.92	58.20	25.04	11.76	2.76	170	140
Silver River	SJR 4503-23	F-S	0	7.96	35.60	55.20	1.12	0.12	2.05	75	55
St. Johns River	SJR 4509-26	F-S	0	0	19.12	78.36	0.60	2.12	0.66	30	13
Lake Underhill	SJR 4506-27	F-L	0	0.92	5.20	85.44	8.24	0.20	2.35	37	21
Lake Jessup	SJR 4510-28	F-L	0	65.88	7.94	24.16	1.94	0.05	27.47	110	45
Little Wekiva River	SJR 4507-30	F-S	0	34.72	42.60	21.44	1.08	0.16	1.11	45	29

*E=estuarine, F-L=freshwater lake, F-S=freshwater stream, M=marine

Table 4. Southeast Florida District

Waterbody	Sample No.	Water-body Type*	Salin. (0/00)	%Silt-Clay (<63µm)	% V. Fine Sand (63µm -125µm)	% Fine-Med. Sand (125µm -500µm)	% Coarse Sand (500µm -2.0mm)	% Granules & larger (>2.0mm)	% Organics	Turbidity JTU	Turbidity NTU
St. Lucie River	WP-3	E	6	2.72	2.12	88.64	5.88	0.64	1.12	75	28
St. Lucie River	WP-4	E	4	66.64	1.24	2.16	6.48	23.48	15.09	60	29
St. Lucie River	WP-5	E	2	11.52	26.00	48.44	10.80	3.24	5.74	75	38
N. Fork, St. Lucie River	WP-6	E	1	88.88	4.48	3.56	1.92	1.16	16.38	60	28
N. Fork, St. Lucie River	WP-7	E	1	3.56	21.68	66.92	6.76	1.08	1.83	25	15
C-24 Canal	WP-8	F-S	0	8.20	62.08	28.68	0.88	0.16	1.83	140	70
N. Fork, St. Lucie River	WP-9	F-S	0	7.04	53.92	30.08	7.04	1.92	6.26	60	31
N. Fork, St. Lucie River	WP-10	F-S	0	4.08	25.92	67.60	2.00	0.40	2.64	75	29
N. Fork, St. Lucie River	WP-11	F-S	0	44.20	14.12	32.52	6.68	2.48	9.28	28	14
N. Fork, St. Lucie River	WP-12	F-S	0	18.20	51.88	27.40	1.96	0.56	6.22	34	21
N. Fork, St. Lucie River	WP-13	F-S	0	4.88	32.52	61.40	0.96	0.24	1.29	55	29
St. Lucie Riv, Sandpiper Bay	WP-14	F-S	0	46.08	25.40	24.28	3.96	0.28	15.62	50	21
St. Lucie Riv, Sandpiper Bay	WP-15	F-S	0	24.24	36.00	33.52	4.32	1.92	4.89	90	50
West Lake	WP-17	E	15	28.16	7.00	23.12	19.04	22.68	4.12	45	45
Dania Cutoff Canal Basin	WP-18	E	3	28.36	10.76	52.44	3.96	4.48	7.94	45	45
Port Everglades	WP-19	M	36	79.00	4.24	6.40	3.92	6.44	10.55	40	40
S. Fork, New River	WP-20	E	4	10.16	7.84	74.08	5.36	2.56	16.20	28	16
Marina Basin, ICWW	WP-22	E	29	27.52	27.52	44.04	0.68	0.04	8.55	70	33
Soveral Finger Canal	WP-23	E	16	7.20	3.48	81.68	7.60	0.04	2.99	39	17
N. Fork, Loxahatchee Riv.	WP-25	E	22	86.56	8.52	4.60	0.16	0.16	12.57	39	19
Canal C-51	WP-27	F-S	0	20.40	15.84	58.12	5.20	0.44	6.38	40	26
Canal C-51	WP-28	F-S	0	6.76	14.96	70.48	4.56	3.24	2.96	50	31
Shingle Creek	WP-31	F-S	0	13.84	30.04	47.96	6.80	1.36	30.39	32	16
Shingle Creek	WP-32	F-S	0	8.68	69.16	20.52	0.96	0.68	2.41	60	24
Riverside Marina	WP-33	M	30	74.84	6.80	15.48	1.96	0.92	16.35	65	32

*E=estuarine, F-S=freshwater stream, M=marine

Table 5. South Florida District

Waterbody	Sample No.	Water-body Type*	Salin. (0/00)	%Silt-Clay (<63μm)	% V. Fine Sand (63μm -125μm)	% Fine-Med. Sand (125μm -500μm)	% Coarse Sand (500μm -2.0mm)	% Granules & larger (>2.0mm)	% Organics	Turbidity ITU	Turbidity NTU
Lake Istokpoga	C060882-601	F-L	0	2.84	35.52	59.40	2.24	0	0.75	50	24
Arbuckle Creek	C060882-602	F-S	0	11.00	13.36	69.32	5.84	0.48	2.87	290	170
Kissimmee River	C060882-603	F-S	0	1.12	19.64	72.92	5.64	0.68	1.54	40	21
Broad Creek	C060882-21	F-S	0	3.16	32.32	62.12	2.04	0.36	1.09	65	34
Myrtle Creek	C060882-22	F-S	0	2.48	42.28	50.88	3.24	1.12	0.54	40	27
Shell Creek	C060882-23	F-S	0	2.40	28.96	65.28	1.64	1.72	1.45	70	37
Prairie Creek	C060882-24	F-S	0	2.08	32.68	58.56	3.92	2.76	4.57	55	25
Peace River	C060882-26	F-S	0	2.84	27.16	69.04	0.88	0.08	0.33	65	39
Creek, De Soto Co (C-761)	C060882-27	F-S	0	4.32	61.24	33.20	0.84	0.40	1.90	45	20
Cr., De Soto Co (Barrow Rd)	C060882-31	F-S	0	3.08	37.72	58.96	0.20	0.04	0.26	45	25
Horse Creek	C060882-32	F-S	0	0.52	5.52	84.44	9.48	.04	0.28	40	20
Hawthorne Creek	C060882-35	F-S	0	7.49	18.41	67.81	4.37	1.92	2.94	200	120
Shell Creek	C060882-36	F-S	0	3.44	20.28	74.20	1.52	0.56	1.11	65	26
Alligator Creek	B060982-40	F-S	0	2.00	6.24	36.52	22.36	32.88	2.70	33	18
Alligator Creek	B060982-41	F-S	0	2.80	21.08	67.92	7.08	1.12	1.18	90	40
Oyster Creek	B060982-42	F-S	0	3.76	19.84	70.52	5.24	0.64	0.83	100	40
Peace River	B060982-43	E	7	6.52	1.92	6.24	12.72	72.60	1.62	80	27
Elkcam Waterway	B060982-44	E	11	1.24	6.92	71.40	14.28	6.16	0.78	85	34
Tarpon Waterway	B060982-46	E	11	2.48	8.72	81.08	7.20	0.52	1.12	85	37
Tarpon Inlet	B060982-47	E	23	3.08	33.64	55.24	1.72	6.32	0.92	160	55
Colony Point	B060982-49	M	30	6.48	33.92	52.36	4.72	2.52	2.14	260	110

*E=estuarine, F-L=freshwater lake, F-S=freshwater stream, M=marine

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