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Assessment of Estuarine Water and Sediment Quality at Timucuan Ecological and Historic Preserve, 2008

Natural Resource Data Series NPS/SECN/NRDS—2011/134

ON THE COVER
Great egret in the mudflats at Timucuan Ecological and Historic Preserve.
Photograph by National Park Service.

Assessment of Estuarine Water and Sediment Quality at Timucuan Ecological and Historic Preserve, 2008

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M. Brian Gregory and Joe DeVivo

National Park Service
Southeast Coast Inventory and Monitoring Network
160 Phoenix Road
Athens, GA 30605

Phillip H. Flournoy

University of Georgia
Marine Extension Service
0101 Fisheries Building
Brunswick, GA 31523

Katy Austin Smith

University of Georgia
Marine Extension Service
715 Bay Street
Brunswick, GA 31520

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The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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This report is a revision of and supercedes Natural Resource Report NPS/SECN/NRR—2009/108, "Assessment of coastal water quality at Timucuan Ecological and Historic Preserve." Comparisons of original and revised data values assessments can be found in Appendices A, B, and C of this report. Copies of this report and the presented data as well as other concurrently collected data including hydrographic profiles of temperature, pH, dissolved oxygen, and salinity; chlorophyll *a* and nutrient concentrations at middle and bottom depths; and sediment contaminants are available from the Southeast Coast Network and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

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Contents

Summary and Key Findings

1. In July 2008, the Southeast Coast Network and the University of Georgia conducted an assessment of water and sediment quality at Timucuan Ecological and Historic Preserve as a part of the NPS Vital Signs Monitoring Program.

2. Monitoring was conducted following methods developed by the U.S. Environmental Protection Agency as a part of the National Coastal Assessment Program and included laboratory analysis for chlorophyll *a*, total dissolved nitrogen and phosphorous concentrations and field measurements of water temperature, pH, dissolved oxygen, and salinity. Estimates of water clarity were made using secchi depth measurements and were adjusted for naturally occurring regional conditions.

3. Overall surface waters conditions at TIMU were predominately *fair* with 93% of sites rated as being in *fair* condition. Only two sites were assessed as having either *good* or *poor* surface water-quality conditions.

4. The majority of *poor* surface water ratings with respect to an individual parameter were due to elevated phosphorus concentrations, which were observed at 20% of sites.

5. Seven sites had individual parameters rated as *poor* due to either elevated levels of nitrogen or phosphorus or both. One site, TIMU-16, rated *poor* for nitrogen, phosphorus and chlorophyll *a* levels.

6. Elevated levels of both total dissolved phosphorus and nitrogen tended to be more common in the more upstream reaches of the Nassau and St. Johns River as well as inland areas along Clapboard Creek.

7. Overall sediment conditions in the assessed benthic areas were predominately *good* with 83% of sites rating as being in *good* condition.

8. *Fair* and *poor* sediment quality ratings observed at five sites were a result of elevated levels of total organic carbon (TOC) which were generally observed in more inland and riverine areas of TIMU.

9. No sites were observed to have sediment concentrations of contaminants frequently associated with detrimental effects to benthic communities although seven sites had at least one contaminant with concentrations detected at levels known to have occasional effects on benthic communities.

10. Findings suggest that continued surface-water monitoring especially for nutrients and chlorophyll would be prudent based on elevated levels found during this monitoring and the degree of development near TIMU.

11. This report is a revision of and supercedes Natural Resource Report NPS/SECN/NRR—2009/108, "Assessment of coastal water quality at Timucuan Ecological and Historic Preserve." Comparisons of original and revised data values assessments can be found in Appendices A, B, and C of this report.

Introduction

Estuaries are semi-enclosed coastal bodies of water that have free connection with the open sea and within which sea water mixes with fresh water. A key defining feature of an estuary is that it is an interface between sea water and fresh water and there is an influence of the ocean tide creating a dynamic relationship between the two waters. Estuaries contain critical habitat for a variety of fish and wildlife species. They serve as nursery habitats for fish, crustaceans, and shellfish and foraging habitat for birds and mammals. Additionally, they provide a multitude of recreational opportunities including boating, fishing, and bird watching. These are fragile ecosystems vulnerable to impacts caused by development and many other uses. Severe impacts including alterations to hydrodynamic processes, exposure to levels of chemical contaminants that cause mortality, altered growth, and reduced reproduction and exposure to more frequent and severe hypoxia have been shown in estuarine habitats due to urban and industrial development (Lerberg et al. 2000). However, some nutrient inputs to coastal waters are natural and necessary for a healthy, functioning estuarine ecosystem. When nutrients from various sources, such as sewage and fertilizers, are introduced into an estuary, the concentration of available nutrients will increase beyond natural background levels. This increase in the rate of supply of organic matter is called eutrophication, which may result in a host of undesirable water-quality conditions. Excess nutrients can lead to excess plant production, and thus, to increased chlorophyll, which can decrease water clarity and lower concentrations of dissolved oxygen. In addition, macrobenthic communities in impacted areas are often characterized by low diversity, low numbers of rare and pollution sensitive species, and low abundances (Lerberg et al. 2000). In areas with increased impervious cover, stormwater runoff is flashier and occurs in greater volumes than in undeveloped areas. This unnatural runoff can often be polluted with a wide variety of low-level contaminants that are released into estuaries and can accumulate in sediment (Holland et al. 2004).

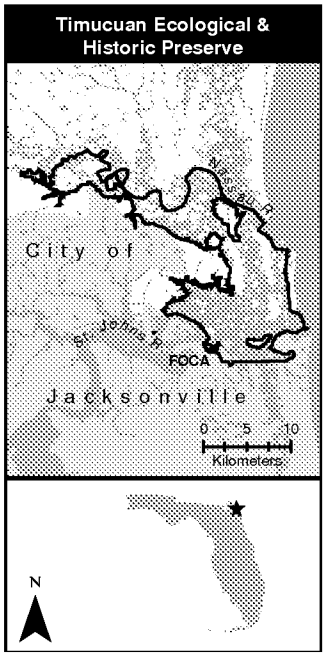

Figure 1. Location of Timucuan Ecological and Historic Preserve (TIMU) in Florida.

A wide variety of metals and organic substances, such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides, are discharged into estuaries from urban, agricultural, and industrial sources in the watershed. The contaminants adsorb onto suspended particles and eventually accumulate in depositional basins where they can disrupt the benthic community of invertebrates, shellfish, and crustaceans that live in or on the sediments. To the extent that the contaminants become concentrated in the organisms, they pose a risk to organisms throughout the food web—including humans.

Several factors that can vary significantly from park to park influence the extent and severity of sediment contamination. Fine-grained, organic-rich sediments are likely to become re-suspended and transported to distant locations and are also efficient at scavenging pollutants. Thus, silty sediments high in total organic carbon (TOC) are potential sources of contamination. Conversely, organic-rich particles bind some toxicants so strongly that the threat to organisms can be greatly reduced.

Timucuan Ecological and Historic Preserve (TIMU) is on the northeastern coast and inland area of Florida situated within Duval County and the city limits of Jacksonville, Florida, and encompasses approximately 46,000 acres between the St. Johns and Nassau rivers (Figure 1). The southern one-third of the preserve lies at the mouth of the extensive St. Johns River watershed, which includes parts of Duval and several other counties for approximately 300 miles to the south. The St. Johns River is heavily impacted by agricultural, industrial and urban pollution; however, marine tidal waters near its mouth serve to ameliorate pollution through dilution and flushing. The northern two-thirds of the preserve lie within the Nassau River drainage basin, a small watershed that covers parts of Duval and Nassau counties. The Nassau River watershed has not yet experienced the concentrated urban and industrial growth found along the St. Johns River; still, portions of the watershed exhibit poor water quality. The area surrounding the preserve to the west and north is predominantly marsh and low uplands utilized for timbering, residential and agricultural uses.

In July 2008, the Southeast Coast Network Inventory and Monitoring Network, in cooperation with the University of Georgia conducted an assessment of water and sediment quality at Timucuan as a part of the Network's Vital Signs Monitoring program (DeVivo et al. 2008). The purpose of this document is to report the most recently collected data from within the park as part of an ongoing long-term water-quality monitoring program. This report has been designed to provide the water-quality monitoring data to managers in a concise summary format in the context of applicable Federal Standards that were developed by the U.S. EPA. Other data collected during this survey are available at (http://www.nature.nps.gov/publications/NRPM).

Methods

Water quality assessment was conducted in estuarine and tidal creek waters following the methods developed by the Environmental Protection Agency's National Coastal Assessment Program (U.S. EPA 2001). Descriptions of the water-quality parameters and the assessment criteria are from EPA's National Coastal Assessment II Report (2005). Methods suggested for use in these protocols were adapted in part, and integrated into, protocols tailored specifically for parks in the Southeast Coast Network (Devivo and others *in review*). Site selection and sampling methodology are briefly outlined in the following sections.

Site Selection

Thirty sites within the boundaries of Timucuan Ecological and Historic Preserve were randomly selected for monitoring following methods developed by the U.S. EPA (Figure 2; Stevens 1997, Stevens and Olsen 1999, Stevens and Olsen 2004). A pool of alternate sites was also selected to use if any of the original sites were not accessible. This method of randomly selecting sites in a spatially balanced manner provides managers with a statistically valid estimate of the overall conditions of the assessed resource within or around the park.

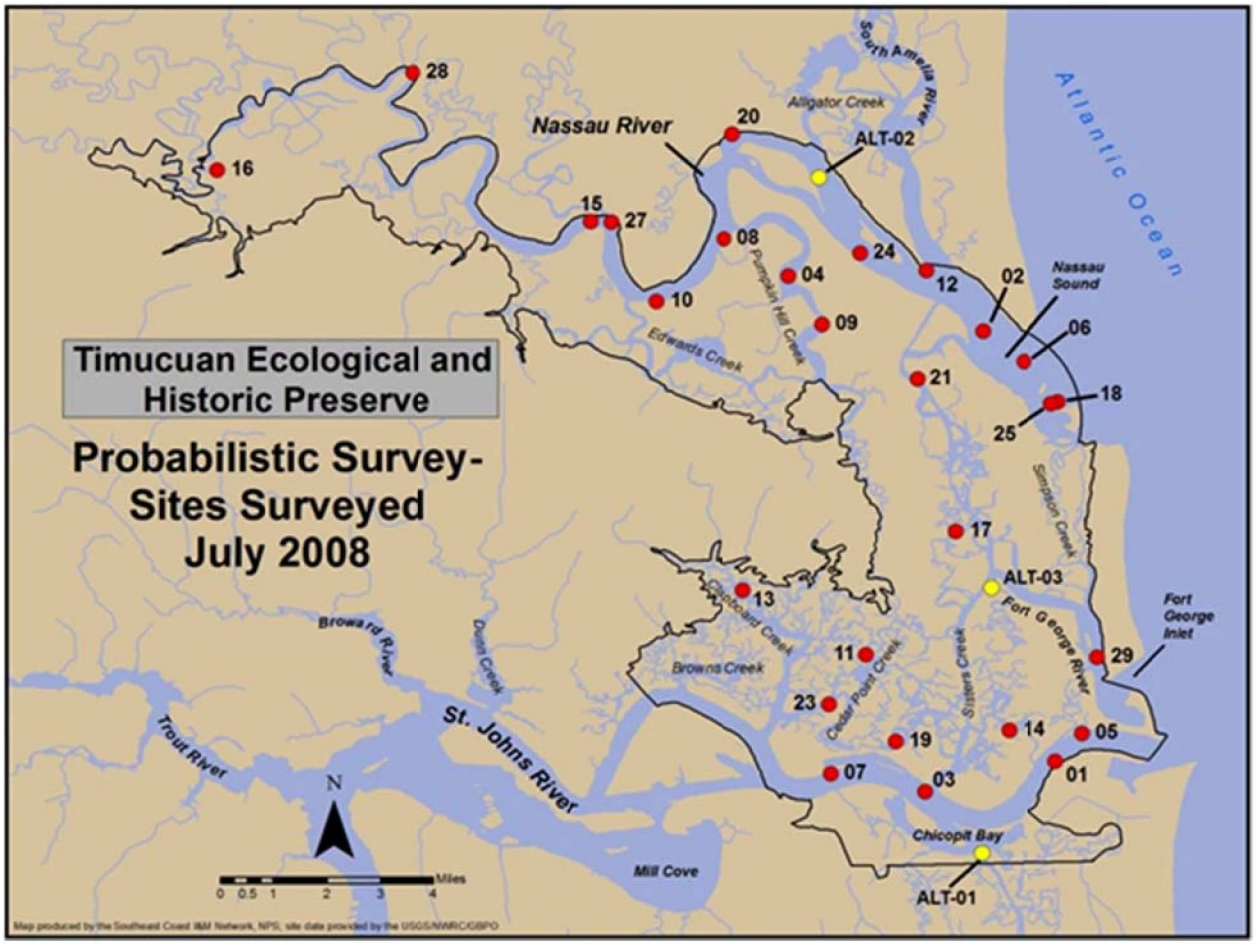

Figure 2. Location map showing sites sampled during July 2008 assessment of waters at Timucuan Ecological and Historic Preserve. Yellow symbols indicate locations where alternate sites were used.

Water-Quality Data Collection

The water-quality assessment conducted during this survey period included conducting hydrographic profiles at 0.5 to 1.0 m intervals at each site for temperature, pH, dissolved oxygen, and salinity. Concurrent measurements of chlorophyll *a* levels were made with nutrient samples at the surface, mid, and bottom depths depending on total water depths by filtering known volumes onto glass fiber filters. Filters and water samples were refrigerated and submitted for laboratory analysis. Sites collected in shallow water (<1 m) were assessed using only one surface sample. Estimates of water clarity were made at each site using a secchi disk to estimate light extinction depths which were converted to light attenuation coefficients corrected for naturally occurring turbidity conditions (Smith et al. 2006). Water clarity was not assessed at sites too shallow to ascertain an accurate secchi depth measurement. When sites were too shallow to access by boat, alternate sites were used.

Water-Quality Assessment Criteria

Water quality was assessed for each of the parameters following the East / Gulf Coast site criteria in EPA's National Coastal Assessment II Report (2005). The categorical assessments (e.g., *good*, *fair*, *poor*) use measurements of chlorophyll *a*, nutrients, dissolved oxygen and water clarity (Table 1) and are intended to characterize acutely degraded water-quality conditions and does not consistently identify sites experiencing occasional or infrequent hypoxia, nutrient enrichment, or decreased water clarity. As a result, a rating of *poor* for the water-quality index means that the site is likely to have consistently exhibited *poor* conditions before or after the assessment period. If a site is designated as *fair* or *good*, the site did not experience *poor* condition on the date sampled, but could be characterized by *poor* conditions for short time periods. In order to assess the level of variability in the index at a specific site, increased or supplemental sampling would be needed.

Table 1. Condition criteria applied to water-quality parameters collected by the Southeast Coast Network during Coastal Water Quality assessment.

Rating	Water Clarity Index (WCI)	Chlorophyll *a* (ug/L)	Total Dissolved Nitrogen (mg/L)	Total Dissolved Phosphorus (mg/L)	Dissolved Oxygen (mg/L)
Good	<2.3	<5	<0.1	<0.01	>5
Fair	2.3–2.99	5–20	0.1–0.5	0.01–0.05	2–5
Poor	>3.00	>20	>0.5	>0.05	<2
Missing					

Assessments were also made using an index that combines ratings given to each parameter into a site-specific Water-Quality Index Rating which allows general comparisons between sites within a park (Table 2). This rating allows general comparisons between parks using the percentage of sites that fall within the *good*, *fair* or *poor* categories.

Table 2. Condition criteria used for water-quality assessment summaries at individual sampling sites and the park.

Rating	Site Water Quality Index Rating	Park Water Quality Index Rating
Good	A maximum of one indicator is *fair*, and no indicators are *poor*.	<10% of sites are in *poor* condition and <50% of sites are in combined *poor* and *fair* condition.
Fair	One of the indicators is rated *poor*, or two or more indicators are rated *fair*.	10%–20% of sites are in *poor* condition, or >50% of sites are in combined *fair* and *poor* condition.
Poor	Two or more of the five indicators are rated *poor*.	>20% of sites are in *poor* condition.
Missing	Two components of the indicator are missing and the available indicators do not suggest a *fair* or *poor* rating.	

Sediment Data Collection

Assessments of sediment quality are used to indicate the potential for sediment contaminants to affect bottom-dwelling organisms. Sediment samples were collected using the protocol which involved taking multiple grabs at each site using a Van Veen sampler. The top 2–3 cm from each sample were composited and split into three separate subsamples that were analyzed for metals, organic contaminants, total organic carbon, and grain size.

Sediment Assessment Criteria

There are no absolute chemical concentrations that correspond to sediment toxicity, but Effects Range Low (ERL) and Effects Range Median (ERM) values are used as guidelines in assessing sediment contamination (Table 3; Long et al. 1995). ERM is the median concentration of a contaminant observed to have adverse biological effects in the literature studies examined. A more protective indicator of contaminant concentration is the ERL criteria, which is the 10th percentile concentration of a contaminant represented by studies demonstrating adverse biological effects in the literature. Ecological effects are not likely to occur at contaminant concentrations below the ERL criterion. The criteria for rating sediment contaminants at individual sampling sites are shown in Table 4.

Table 3. Sediment contaminant guidance values from Long et al. (1995). ERL (Effects Range Low) thresholds are determined for each chemical as the 10th percentile in a database of ascending concentrations associated with biological effects. ERM (Effects Range Median) thresholds are determined for each chemical as the 50th percentile (median) in a database of ascending concentrations associated with adverse biological effects.

Contaminant	ERL	ERM
Metals (ppm)[a]		
Arsenic	8.2	70
Cadmium	1.2	9.6
Chromium	81	370
Copper	37	270
Lead	46.7	218
Mercury	0.15	0.71
Nickel	20.9	51.6
Silver	1	3.7
Zinc	150	410
Organics (ppb)[b]		
Acenaphthene	16	500
Acenapthylene	44	640
Anthracene	85.3	1,100
Flourene	19	540
2-Methyl napthalene	70	670
Napthalene	160	2,100
Phenanthrene	240	1,500
Benz(a)anthracene	261	1,600
Benzo(a)pyrene	430	1,600
Chrysene	384	2,800
Dibenzo(a,h)anthracene	63.4	260
Fluoranthene	600	5,100
Pyrene	665	2,600
Low molecular weight PAH	552	3,160
High molecular weight PAH	1,700	9,600
Total PAHs	4,020	44,800
4,4'-DDE	2.2	27
Total DDT	1.6	46.1
Total PCBs	22.7	180

[a] Units are ug/g dry sediment, equivalent to ppm.

[b] Units are ng/g dry sediment, equivalent to ppb.

Sediment contaminant availability or organic enrichment can be altered in areas where there is considerable deposition of organic matter. Sediment toxicity potential from organic matter is assessed by measuring percent TOC in the sediment sample. The criteria for rating TOC for individual sampling sites are shown in Table 4.

After sediment contaminants and sediment TOC were assessed for a given site, the sediment quality index rating was calculated for the site and park based on these three indicators. The sediment quality index was rated *good* to *poor* for each site using the criteria shown in Table 4.

Table 4. Condition criteria for sediment contaminants.

Rating	Sediment Contaminant Rating (SC)	% Total Organic Carbon (TOC)	Site Sediment Quality Index (SQI)	Park Sediment Quality Index
Good	No ERM concentrations are exceeded and less than five ERL concentrations are exceeded.	<2%	TOC is *good* and Sediment Contaminant Rating is *good*.	<5% of the sites are rated in *poor* condition and <50% of the sites are rated in combined *poor* and *fair* condition.
Fair	Five or more ERL concentrations are exceeded.	2%–5%	TOC is *fair* or Sediment Contaminant Rating is *fair*.	5%–15% of sites are in *poor* condition, or >50% of sites are in combined *poor* and *fair* condition.
Poor	An ERM concentration is exceeded for one or more contaminants.	>5%	TOC is *poor* or Sediment Contaminant Indicator is *poor*.	>15% of sites are in *poor* condition.

Water-Quality Condition Assessments

Figures 3 through 7 show maps illustrating the spatial distribution of sampling sites and the corresponding ratings for water clarity, chlorophyll *a*, total dissolved nitrogen, total dissolved phosphorus, and dissolved oxygen based on each parameter's corresponding condition category. Figure 8 shows the water-quality conditions summary for the park. Data used for condition assessments are shown in table 5.

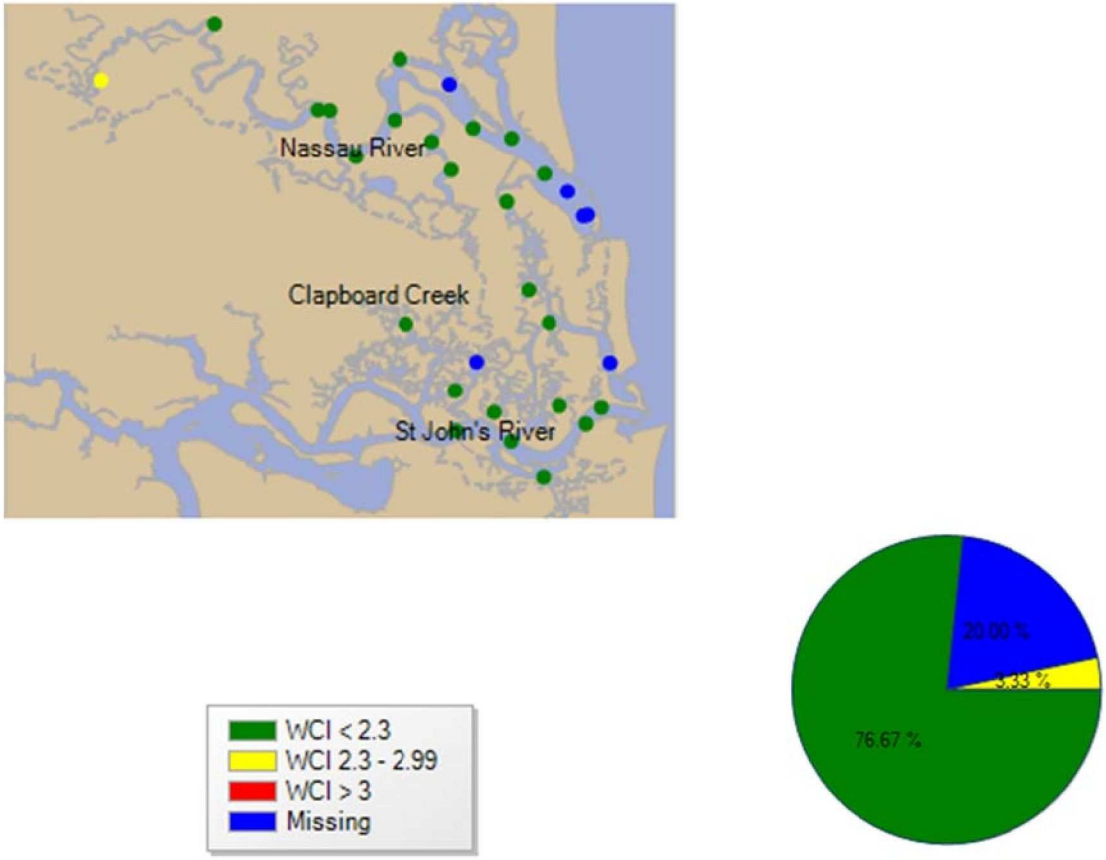

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Figure 3. Water clarity index (*k*) based on light attenuation estimates at sampling sites at Timucuan Ecological and Historic Preserve during July 2008. Graph shows the percentage of sites in each condition category.

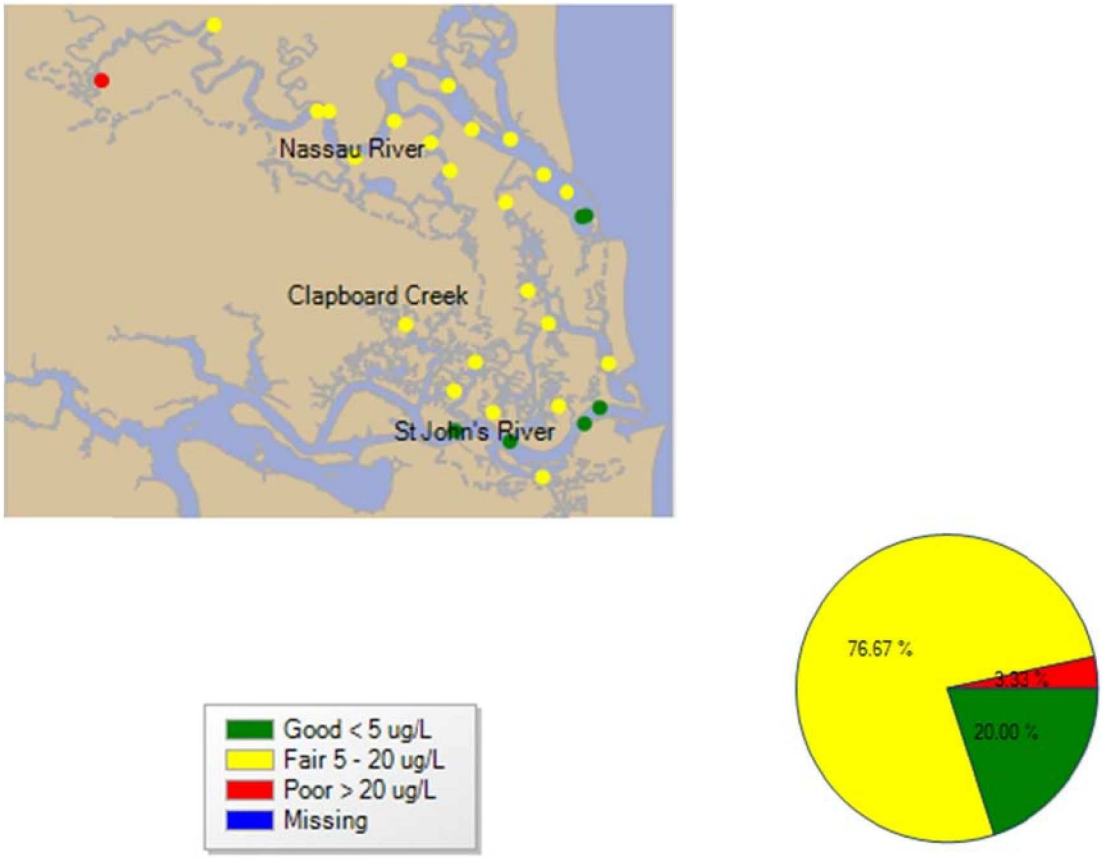

Figure 4. Chlorophyll *a* concentrations at sites within Timucuan Ecological and Historic Preserve during July 2008. Graph shows the percentage of sites in each condition category.

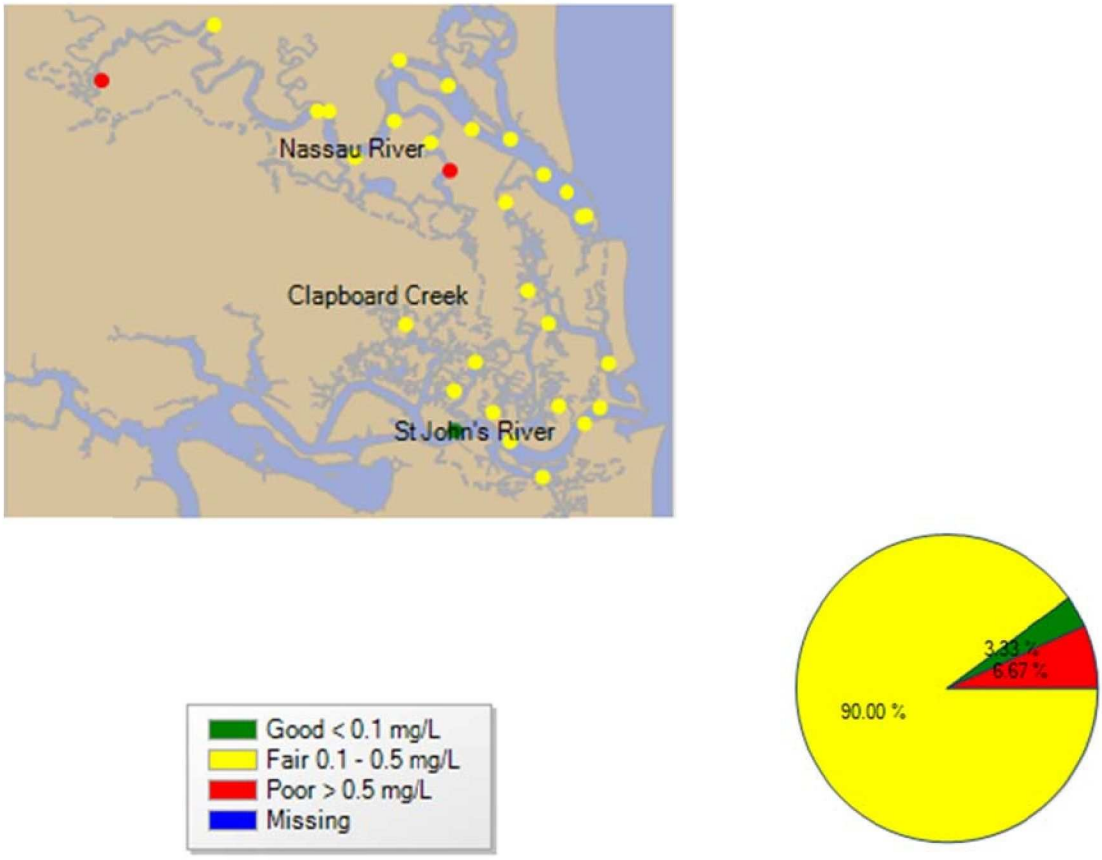

Figure 5. Total dissolved nitrogen (TDN) concentrations at sites within Timucuan Ecological and Historic Preserve in July 2008. Graph shows percentage of sites in each condition category.

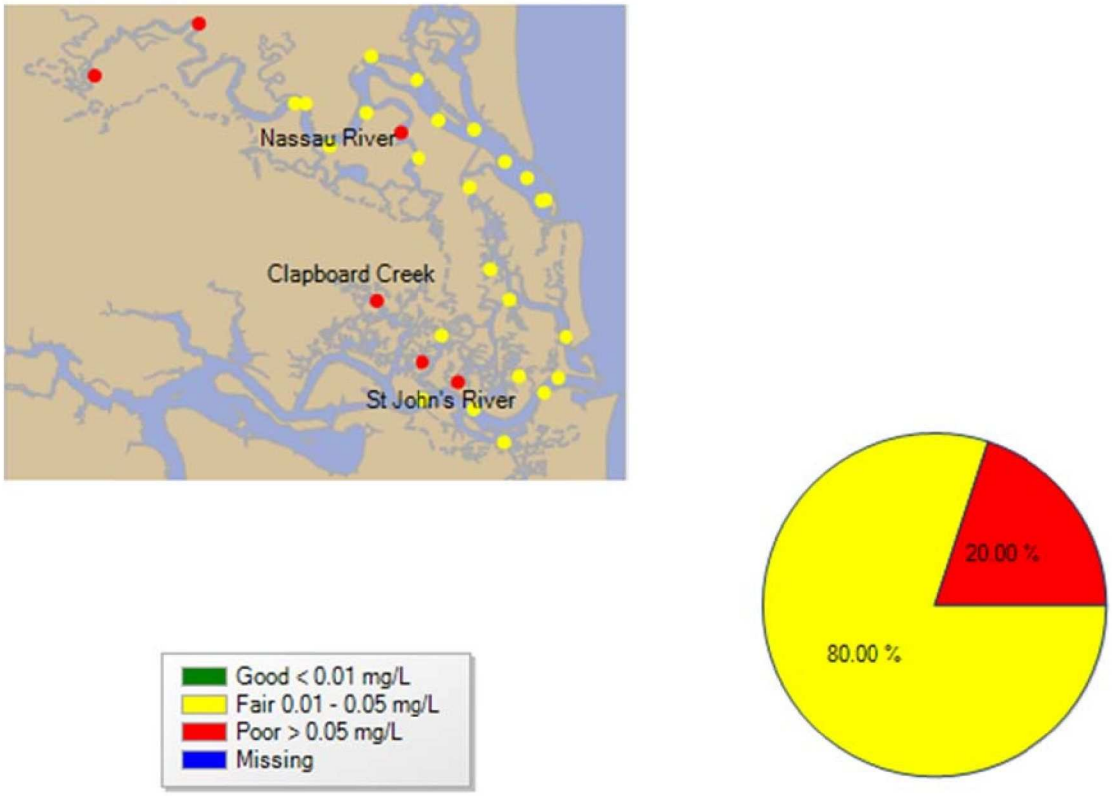

Figure 6. Total dissolved phosphorus (TDP) concentrations at sites within Timucuan Ecological and Historic Preserve during in July 2008. Graph shows percentage of sites in each condition category.

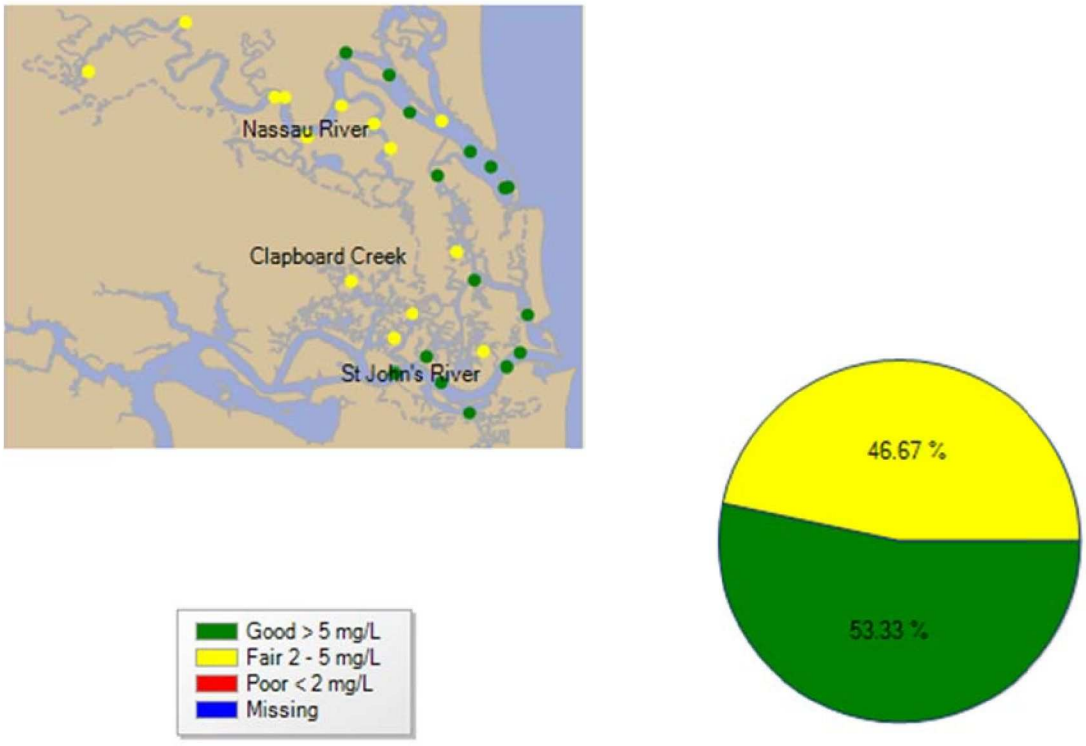

Figure 7. Dissolved oxygen (DO) concentrations at sites within Timucuan Ecological and Historic Preserve in July 2008. Graph shows percentage of sites in each condition category.

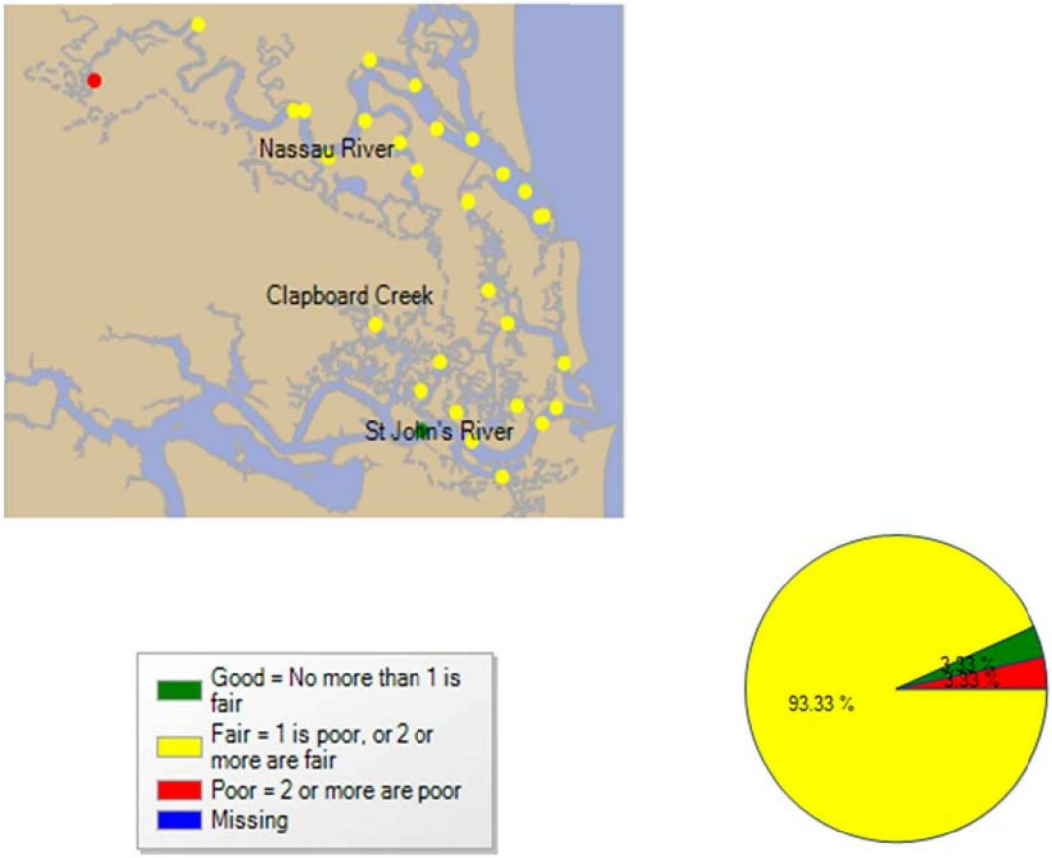

Figure 8. Park-wide water-quality conditions at Timucuan Ecological and Historic Preserve in July 2008. Assessment based on numbers of categorical ratings at each site for using the water clarity index (*k*), chlorophyll *a*, total dissolved nitrogen, total dissolved phosphorus and dissolved oxygen measurements. Graph shows percentage of sites in each condition category.

Sediment Condition Assessments

Figures 9, 10, and 11 are maps which show the spatial distribution of sampling sites and the corresponding ratings for sediment contamination based on a summary of data collected at each site. Inset graphs on each figure show the percentage of sites in each rating category. Data used to make these graphs are found in tables 6, 7, and 8.

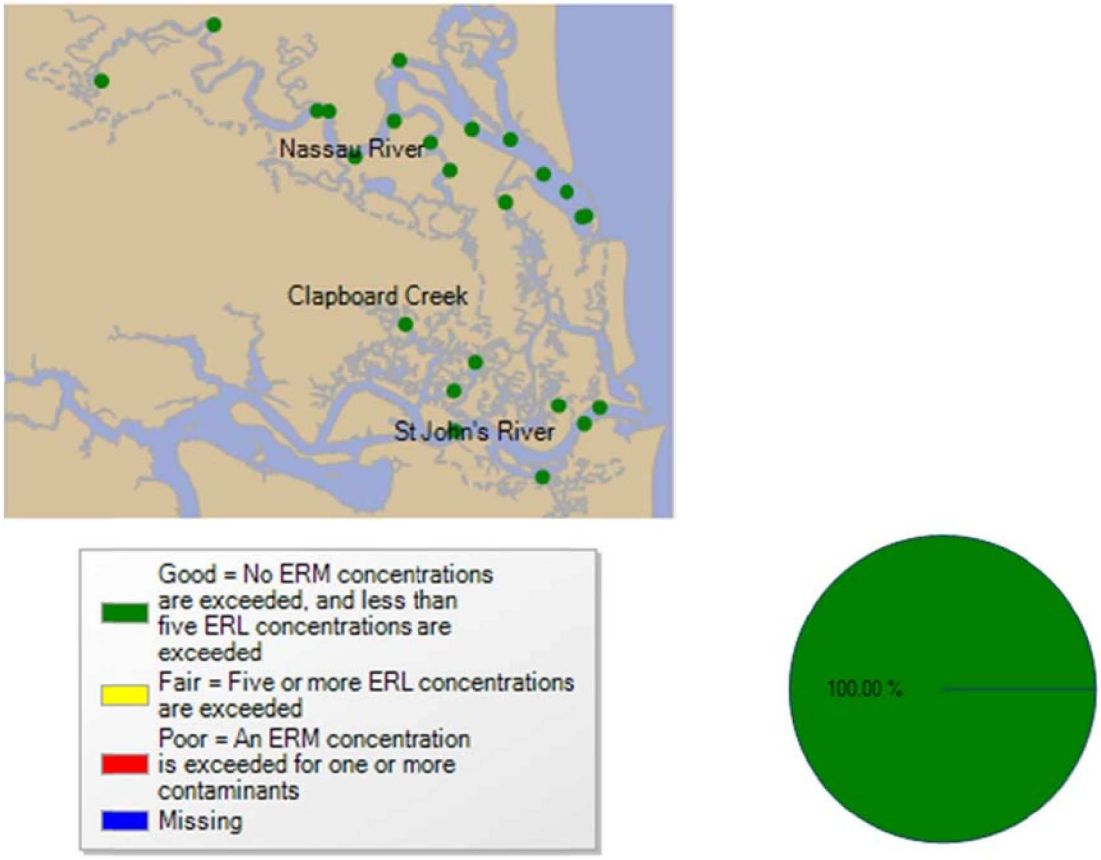

Figure 9. Sediment contaminant rating at Timucuan Ecological and Historic Preserve in July 2008. Assessment categories correspond to numbers of ERM and ERL concentrations exceeded at a site. Inset graph shows percentage of sites in each condition category.

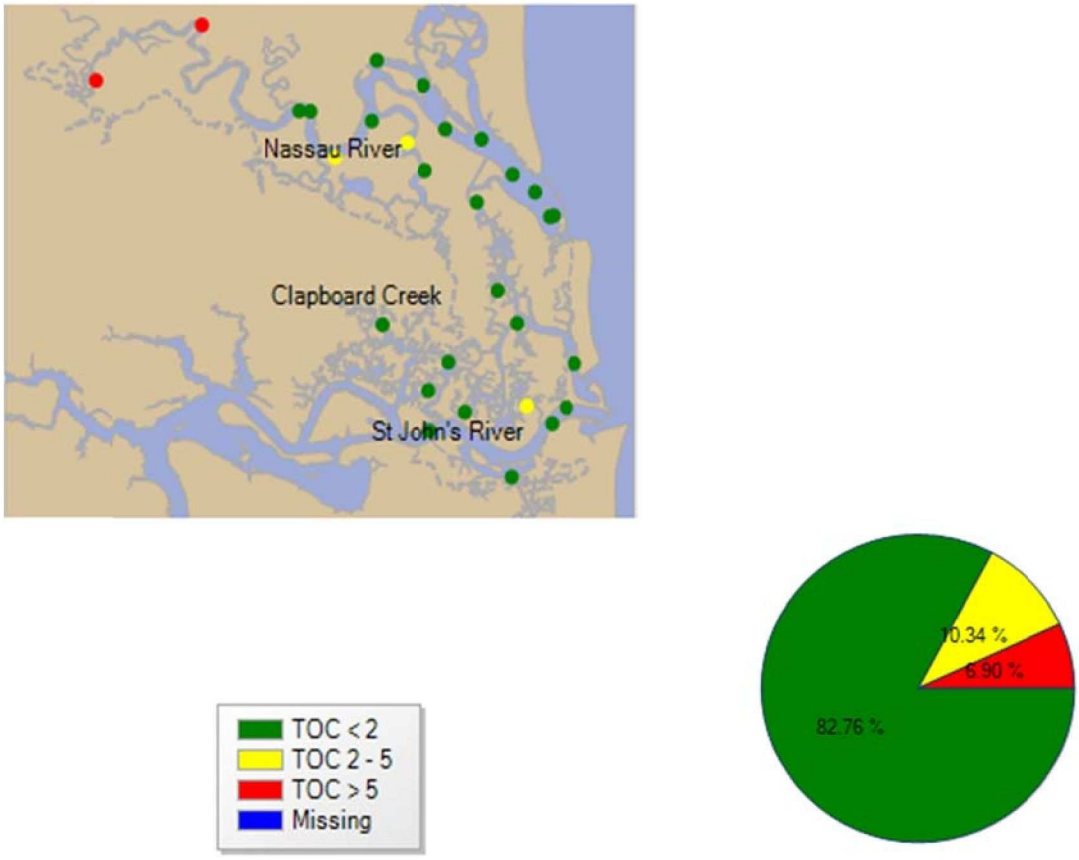

Figure 10. Total Organic Carbon (TOC) concentrations in sediments and condition ratings at Timucuan Ecological and Historic Preserve in July 2008. Inset graph shows percentage of sites in each condition category.

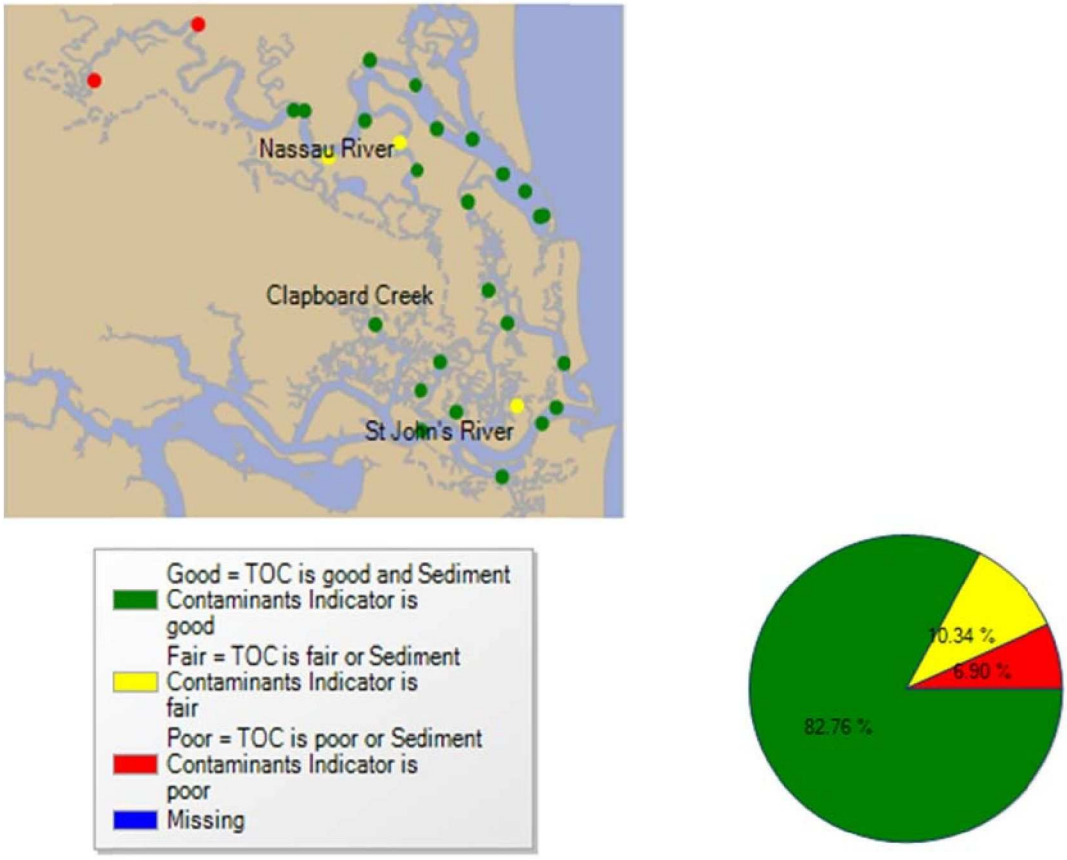

Figure 11. Sediment quality index ratings at Timucuan Ecological and Historic Preserve in July 2008. Inset graph shows percentage of sites in each condition category.

Water-Quality Data

Table 5. Water-quality parameter values and assessment conditions for sites sampled at Timucuan Ecological and Historic Preserve in July 2008. Water Clarity Index (*k*) values were calculated using constant for estuarine water with naturally turbid conditions (Smith et al. 2006). Condition of assessed parameter from USEPA (2005). [Green, *good*; yellow, *fair;* red, *poor*; blue, missing data; *k*, light attenuation coefficient; ug/L, micrograms per liter; mg/l, milligrams per liter]

Station	Water Clarity Index (k)	Chlorophyll *a* (ug/L)	Total Dissolved Nitrogen (mg/L)	Total Dissolved Phosphorus (mg/L)	Dissolved Oxygen (mg/L)
TIMU-01	0.714	4.882	0.482	0.045	5.53
TIMU-02	0.813	9.344	0.147	0.028	5.86
TIMU-03	0.495	4.122	0.178	0.034	5.45
TIMU-04	1.538	15.57	0.422	0.055	4.54
TIMU-05	0.524	4.911	0.245	0.049	5.66
TIMU-06		8.722	0.203	0.026	7.01
TIMU-07	0.806	3.774	0.076	0.042	5.37
TIMU-08	1.299	14.323	0.376	0.049	4.79
TIMU-09	1.754	19.282	0.565	0.035	4.22
TIMU-10	2.128	12.89	0.456	0.05	4.86
TIMU-11	1.312	6.503	0.134	0.049	4.26
TIMU-12	1.351	9.839	0.282	0.034	4.94
TIMU-13	1.429	7.713	0.405	0.069	4.44
TIMU-14	1.136	5.807	0.249	0.037	4.87
TIMU-15	1.266	11.096	0.425	0.048	4.72
TIMU-16	2.326	27.583	0.526	0.077	4.83
TIMU-17	1.408	8.41	0.139	0.045	3.94
TIMU-18		1.962	0.161	0.023	6.92
TIMU-19	0.971	8.542	0.358	0.06	5.42
TIMU-20	1.156	9.871	0.207	0.037	5.22
TIMU-21	1.031	6.465	0.245	0.032	5.18
TIMU-23	1.299	7.665	0.282	0.056	4.74
TIMU-24	1.036	9.6	0.287	0.032	5.51
TIMU-25		2.476	0.161	0.023	6.94
TIMU-27	1.111	10.955	0.398	0.048	4.74
TIMU-28	1.786	19.678	0.472	0.054	4.38
TIMU-29		6.452	0.072	0.026	5.69
TIMU-ALT-01	1.266	5.458	0.263	0.044	5.11
TIMU-ALT-02		8.594	0.385	0.033	5.41
TIMU-ALT-03	0.758	10.781	0.26	0.034	5.62

Sediment-Quality Data

Table 6. Concentrations of select metals (in ppm) for sites sampled at Timucuan Ecological and Historic Preserve in July 2008. Condition of assessed constituent from Long et al. (1995). [Green, *good*; yellow, *fair*; red, *poor*; blue, missing; —, value not reported, below the detection limit; *, value estimated, used in condition assessment summaries]

Station	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
TIMU-01	*4.6	-	*9.7	*7.4	11.9	*0.016	*4.8	-	*21.5
TIMU-02	-	-	-	*1.4	*3.2	-	-	-	*17.7
TIMU-04	*0.18	-	47.9	*0.2	0.36	0.042	0.32	-	1
TIMU-05	-	-	-	*1.6	*5.6	-	*1.7	-	*7.8
TIMU-06	-	-	-	*0.81	*1.7	-	-	-	*2.1
TIMU-07	*4.1	-	*3.2	*4.4	*9.0	-	*2.6	-	*13.3
TIMU-08	-	-	*1.6	*1.3	*3.3	-	-	-	*3.6
TIMU-09	-	-	-	*3.3	*6.9	*0.011	5.1	-	15.7
TIMU-10	*13.9	-	56.3	*7.3	16.1	*0.012	14.2	-	*45.6
TIMU-11	-	-	-	*2.5	*5.6	*0.0095	*2.3	-	*10.2
TIMU-12	-	-	-	*0.96	*2.0	-	-	-	12.9
TIMU-13	-	-	-	*2.0	*3.9	-	-	-	*5.9
TIMU-14	*6.7	-	*10.7	12.8	21.1	*0.023	10.9	-	55.5
TIMU-15	-	*2.2	-	*4.2	*5.4	-	5.8	2.7	18.1
TIMU-16	*8.5	2.8	29.2	*8.2	18.4	0.043	14.7	2.9	*48.7
TIMU-17		-	*5.4	*4.4	10.1	*0.021	5.5	-	*21.1
TIMU-18	-	-	-	0.94	*2.7	-	-	-	*10.4
TIMU-19		-	*7.3	*6.2	14.1	*0.016	*4.8	-	*28
TIMU-20	*4.4	*2.3	-	*4.9	*9.9	-	7.2	2.8	22.6
TIMU-21	-	-	-	*3.1	*6.6	-	*2.2	-	*18
TIMU-23	-	-	-	*2.8	*5.6	-	*2.0	-	*14
TIMU-24	-	-	-	*1.1	*1.9	-	-	-	*4.2
TIMU-25	-	-	-	0.78	*2.6	-	-	-	*13.7
TIMU-27	-	2.6	-	*4.1	*4.9	-	5.6	2.8	*19.1
TIMU-28	*9.2	*2.4	29.7	*9.1	21.1	0.046	16.1	2.9	52.4
TIMU-29		-	*1.4	*4.7	-		*1.3	-	*4.2
TIMU-ALT-01	-	-	13.3	*5.0	*7.3	*0.018	*3.4	-	*19.4
TIMU-ALT-02		-	-	*2.8	10.2	-	*3.5	-	*13.3
TIMU-ALT-03		-	-	-	*2.5	*0.019	-	-	-

Table 7. Concentrations of select organic compounds (in ppb) and totals for select classes of compounds for sites sampled at Timucuan Ecological and Historic Preserve, July 2008. Assessment criteria from Long et al. (1995). [Green, *good*; yellow, *fair*; and red, *poor*; —, value not reported, below the detection limit; * , value estimated , used in condition assessment summaries]

Station	2-Methylnaphthalene	4,4'-DDE	Acenaphthene	Acenaphthylene	Anthracene	Benz[a]anthracene	Benzo[a]pyrene	Chrysene	Dibenz[a,h]anthracene	Fluoranthene	Fluorene	Naphthalene
TIMU-01	-	-	-	-	*0.99	*4.2	*0.99	*3.2	-	*5	-	-
TIMU-02	*1	-	-	-	-	-	-	-	-	-	-	*1
TIMU-04	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-05	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-06	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-07	-	-	-	-	*0.56	*2.2	*1.4	*3.1	-	*3.1	-	-
TIMU-08	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-09	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-10	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-11	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-12	*2	-	-	*1.5	*1.5	*2.5	*2	*2.5	-	*2.5	*1.5	*2
TIMU-13	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-14	-	-	-	-	-	*1.2	*0.78	*1.1	-	*2.3	-	-
TIMU-15	-	-	-	-	-	-	-	-	-	-	-	*1
TIMU-16	*1	-	-	-	-	-	-	-	-	-	-	*1
TIMU-17	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-18	*1	-	-	-	-	-	-	-	-	-	-	*1
TIMU-19	-	-	-	-	-	*2.5	*1.5	*3	-	*5.5	-	-
TIMU-20	*1	-	-	-	-	-	-	-	-	-	-	*1
TIMU-21	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-23	-	-	-	-	-	-	-	-	-	*1.5	-	-
TIMU-24	*1	-	-	-	-	-	-	-	-	-	-	*1
TIMU-25	-	-	-	-	-	-	-	-	-	*1	-	*1
TIMU-27	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-28	*1	-	-	-	-	-	-	*1.5	-	*2	-	*1
TIMU-29	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-ALT-01	-	-	-	-	-	-	-	-	-	*1.5	-	-
TIMU-ALT-02	-	-	-	-	-	-	-	-	-	-	-	-
TIMU-ALT-03	-	-	-	-	-	-	-	-	-	-	-	-

Table 7. (Continued).

Station	Phenanthrene	Pyrene	Total DDT	High molecular weight PAH	Low molecular weight PAH	Total PAHs	Total PCBs
TIMU-01	*1.7	*3.7	0	20.8	3.43	24.2	0
TIMU-02	*1	-	0	0	3	3	0
TIMU-04	-	-	0	0	0	0	0
TIMU-05	-	-	0	0	0	0	0
TIMU-06	-	-	0	0	0	0	0
TIMU-07	*1.7	*3.4	0	17.1	2.26	19.4	0
TIMU-08	-	-	0	0	0	0	0
TIMU-09	-	-	0	0	0	0	0
TIMU-10	-	-	0	0	0	0	0
TIMU-11	-	-	0	0	0	0	0
TIMU-12	*2	*2	0	20.5	20	40.5	0
TIMU-13	-	-	0	0	0	0	0
TIMU-14	*1.1	*1.9	0	9.92	1.1	11	0
TIMU-15	-	-	0	0	1	1	0
TIMU-16	-	-	0	0	2	2	0
TIMU-17	-	-	0	0	0	0	0.9
TIMU-18	-	-	3.6	0	2	2	0
TIMU-19	*2	*5.5	0	23.5	2	25.5	0
TIMU-20	*1	-	0	0	3	3	0
TIMU-21	-	-	0	0	0	0	0
TIMU-23	-	*1.5	0	3	0	3	0
TIMU-24	-	-	0	0	2	2	0
TIMU-25	-	-	0	1	1	2	0
TIMU-27	-	-	3	0	0	0	0
TIMU-28	*1	-	0	3.5	3	6.5	0
TIMU-29	-	-	0	0	0	0	0
TIMU-ALT-01	*0.9	*1.2	0	2.7	0.9	3.6	0
TIMU-ALT-02	-	-	0	0	0	0	0
TIMU-ALT-03	-	-	0	0	0	0	0

Table 8. Sediment contaminant rating (SC), percent total organic carbon (TOC), and Sediment Quality Index (SQI) rating for sites sampled at Timucuan Ecological and Historic Preserve July 2008.

Station	Sediment Contaminant Rating	Total Organic Carbon (%)	Sediment Quality Index
TIMU-01	Good	1.4	Good
TIMU-02	Good	0.32	Good
TIMU-04	Good	5	Fair
TIMU-05	Good	0.49	Good
TIMU-06	Good	0.41	Good
TIMU-07	Good	1.2	Good
TIMU-08	Good	0.36	Good
TIMU-09	Good	1.6	Good
TIMU-10	Good	3.9	Fair
TIMU-11	Good	0.82	Good
TIMU-12	Good	0.42	Good
TIMU-13	Good	0.64	Good
TIMU-14	Good	2.8	Fair
TIMU-15	Good	0.59	Good
TIMU-16	Good	5.6	Poor
TIMU-17	Good	1.4	Good
TIMU-18	Good	0.28	Good
TIMU-19	Good	0.91	Good
TIMU-20	Good	0.98	Good
TIMU-21	Good	0.6	Good
TIMU-23	Good	0.63	Good
TIMU-24	Good	0.29	Good
TIMU-25	Good	0.28	Good
TIMU-27	Good	0.74	Good
TIMU-28	Good	5.7	Poor
TIMU-29	Good	0.7	Good
TIMU-ALT-01	Good	0.41	Good
TIMU-ALT-02	Good	1.2	Good
TIMU-ALT-03	Good	0.3	Good

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Appendix A. Water-quality values and parameter-based condition assessments made in original and revised report.

Table A-1. Comparison of water-quality parameter values reported in original version of the report and revised values reported for sites sampled at Timucuan Ecological and Historic Preserve, July 2008. Water Clarity Index (*k*) values were calculated using a constant for estuarine water with naturally turbid conditions (Smith et al. 2006); condition of assessed parameter from USEPA (2005). [Green, *good*; yellow, *fair*; and red, *poor*; blue, missing data; *k*, light attenuation coefficient; ug/L, micrograms per liter; mg/L, milligrams per liter]

Station	Water Clarity Index (k)		Chlorophyll *a* (ug/L)		Total Dissolved Nitrogen (mg/L)		Total Dissolved Phosphorus (mg/L)		Dissolved Oxygen (mg/L)	
	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised
TIMU-01	0.715	0.714	4.45	4.882	0.177	0.482	0.038	0.045	5.6	5.530
TIMU-02	1.022	0.813	8.914	9.344	0.11	0.147	0.028	0.028	5.95	5.860
TIMU-03	0.629	0.495	3.311	4.122	0.086	0.178	0.031	0.034	5.78	5.450
TIMU-04	1.022	1.538	7.372	15.570	0.214	0.422	0.049	0.055	4.77	4.540
TIMU-05	0.463	0.524	5.17	4.911	0.128	0.245	0.046	0.049	5.97	5.660
TIMU-06	2		8.722	8.722	0.102	0.203	0.026	0.026	7.01	7.010
TIMU-07	0.397	0.806	3.07	3.774	0.069	0.076	0.037	0.042	5.78	5.370
TIMU-08	0.85	1.299	6.125	14.323	0.199	0.376	0.048	0.049	5.01	4.790
TIMU-09	1.222	1.754	17.55	19.282	0.255	0.565	0.041	0.035	5.46	4.220
TIMU-10	2	2.128	12.842	12.890	0.214	0.456	0.046	0.050	4.86	4.860
TIMU-11	1.5		6.523	6.503	0.095	0.134	0.047	0.049	4.33	4.260
TIMU-12	0.85	1.351	9.745	9.839	0.155	0.282	0.032	0.034	5.33	4.940
TIMU-13	1.5	1.429	6.489	7.713	0.175	0.405	0.066	0.069	4.44	4.440
TIMU-14	1.222	1.136	5.516	5.807	0.133	0.249	0.041	0.037	4.91	4.870
TIMU-15	0.427	1.266	12.672	11.096	0.171	0.425	0.044	0.048	5.37	4.720
TIMU-16	2	2.326	27.583	27.583	0.263	0.526	0.077	0.077	4.83	4.830
TIMU-17	1.042	1.408	8.41	8.41	0.139	0.139	0.045	0.045	4.42	3.940
TIMU-18	2		2.118	1.962	0.092	0.161	0.023	0.023	6.92	6.920
TIMU-19	1.5	0.971	8.542	8.542	0.179	0.358	0.06	0.060	5.42	5.420
TIMU-20	0.626	1.156	13.183	9.871	0.126	0.207	0.034	0.037	5.3	5.220
TIMU-21	0.838	1.031	6.62	6.465	0.113	0.245	0.033	0.032	5.69	5.180
TIMU-23	0.85	1.299	8.039	7.665	0.154	0.282	0.053	0.056	5.01	4.740
TIMU-24	0.462	1.036	10.429	9.600	0.14	0.287	0.033	0.032	6.03	5.510

Table A-1. (Continued).

Station	Water Clarity Index (k)		Chlorophyll *a* (ug/L)		Total Dissolved Nitrogen (mg/L)		Total Dissolved Phosphorus (mg/L)		Dissolved Oxygen (mg/L)	
	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised
TIMU-25	2		2.476	2.476	0.081	0.161	0.023	0.023	6.94	6.940
TIMU-27	0.626	1.111	13.596	10.955	0.147	0.398	0.043	0.048	5.04	4.740
TIMU-28	0.85	1.786	16.793	19.678	0.305	0.472	0.061	0.054	4.66	4.380
TIMU-29	2		6.452	6.452	0.072	0.072	0.026	.026	5.69	5.690
TIMU-ALT-01	1.5	1.266	5.458	5.458	0.131	0.263	0.044	0.044	5.11	5.110
TIMU-ALT-02	5		8.594	8.594	0.192	0.385	0.033	0.033	5.41	5.410
TIMU-ALT-03	1.022	0.758	8.828	10.781	0.114	0.260	0.036	0.034	5.87	5.620

Appendix B. Sediment metal concentrations and condition assessments made in original and revised report.

Table B-1. Comparison of sediment metal concentrations (in ppm) reported in original version of the report and revised values reported for sites sampled at Timucuan Ecological and Historic Preserve, July 2008. Cell colors indicate condition of assessed parameter (Long et al. 1995). [Green, *good*; yellow, *fair*; red, *poor*; blue, missing data; —, value not reported, below the detection limit; *, value estimated, used in condition assessment summaries]

Station	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	
	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised
TIMU-01	4.6	*4.6	0.26	-	9.7	*9.7	7.4	*7.4	11.9	11.9	0.016	*0.016
TIMU-02	4	-	0.26	-	1.6	-	1.4	*1.4	3.2	*3.2	0.0063	-
TIMU-04	0.18	*0.18	0.0051	-	47.9	47.9	0.2	*0.2	0.36	0.36	0.042	0.042
TIMU-05	3.9	-	0.25	-	0.8	-	1.6	*1.6	5.6	*5.6	0.0063	-
TIMU-06	3.9	-	0.25	-	1.6	-	0.81	*0.81	1.7	*1.7	0.0063	-
TIMU-07	4.1	*4.1	0.25	-	3.2	*3.2	4.4	*4.4	9	*9	0.0063	-
TIMU-08	3.9	-	0.25	-	1.6	*1.6	1.3	*1.3	3.3	*3.3	0.0063	-
TIMU-09	4	-	0.26	-	0.8	-	3.3	*3.3	6.9	*6.9	0.011	*0.011
TIMU-10	12.55	*13.9	0.255	-	55.45	56.3	7	*7.3	15.85	16.1	0.0175	*0.012
TIMU-11	5.95	-	0.385	-	1.2	-	2	*2.5	6.3	*5.6	0.0094	*0.0095
TIMU-12	4	-	0.26	-	1.6	-	0.96	*0.96	2	*2	0.0063	-
TIMU-13	4	-	0.26	-	0.8	-	2	*2	3.9	*3.9	0.0063	-
TIMU-14	6.7	*6.7	0.25	-	10.7	*10.7	12.8	12.8	21.1	21.1	0.023	*0.023
TIMU-15	3.9	-	2.2	*2.2	1.6	-	4.2	*4.2	5.4	*5.4	0.0063	-
TIMU-16	8.5	*8.5	2.8	2.8	29.2	*29.2	8.2	*8.2	18.4	18.4	0.043	0.043
TIMU-17			0.25	-	5.4	*5.4	4.4	*4.4	10.1	10.1	0.021	*0.021
TIMU-18	3.95	-	0.255	-	1.6	-	0.935	*0.94	2.9	*2.7	0.0063	-
TIMU-19			0.25	-	7.3	*7.3	6.2	*6..2	14.1	14.1	0.016	*0.016
TIMU-20	4.4	*4.4	2.3	*2.3	1.6	-	4.9	*4.9	9.9	*9.9	0.0063	-
TIMU-21	3.9	-	0.25	-	1.6	-	3.1	*3.1	6.6	*6.6	0.0063	-
TIMU-23	4	-	0.26	-	0.8	-	2.8	*2.8	5.6	*5.6	0.0063	-
TIMU-24	3.9	-	0.25	-	1.6	-	1.1	*1.1	1.9	*1.9	0.0063	-
TIMU-25	4	-	0.26	-	1.6	-	0.78	*0.78	2.6	*2.6	0.0063	-
TIMU-27	3.9	-	2.6	2.6	1.6	-	4.1	*4.1	4.9	*4.9	0.0063	-
TIMU-28	9.2	*9.2	2.4	*2.4	29.7	*29.7	9.1	*9.1	21.1	21.1	0.046	0.046
TIMU-29			0.25	-	0.79	-	1.4	*1.4	4.7	*4.7	0.0062	-
TIMU-ALT-01	3.9	-	0.25	-	13.3	*13.3	5	*5	7.3	*7.3	0.018	*0.018
TIMU-ALT-02			0.26	-	0.81	-	2.8	*2.8	10.2	10.2	0.0063	-
TIMU-ALT-03			0.25	-	0.8	-	0.75	-	2.5	*2.5	0.019	*0.019

Table B-1. (Continued).

Station	Nickel		Silver		Zinc	
	originally reported	revised	originally reported	revised	originally reported	revised
TIMU-01	4.8	*4.8	0.49	-	21.5	*21.5
TIMU-02	1.3	-	0.49	-	17.7	*17.7
TIMU-04	0.32	0.32	0.0097	-	1	1
TIMU-05	1.7	*1.7	0.48	-	7.8	*7.8
TIMU-06	1.2	-	0.48	-	2.1	*2.1
TIMU-07	2.6	*2.6	0.48	-	13.3	*13.3
TIMU-08	1.2	-	0.48	-	3.6	*3.6
TIMU-09	5.1	5.1	0.49	-	15.7	*15.7
TIMU-10	14.25	14.2	0.485	-	43.15	*45.6
TIMU-11	2.95	*2.3	0.73	-	15.7	*10.2
TIMU-12	1.3	-	0.49	-	12.9	*12.9
TIMU-13	1.3	-	0.49	-	5.9	*5.9
TIMU-14	10.9	10.9	0.48	-	55.5	55.5
TIMU-15	5.8	5.8	2.7	2.7	18.1	*18.1
TIMU-16	14.7	14.7	2.9	2.9	48.7	*48.7
TIMU-17	5.5	5.5	0.48	-	21.1	*21.1
TIMU-18	1.25	-	0.485	-	11.5	*10.4
TIMU-19	4.8	*4.8	0.48	-	28	*28
TIMU-20	7.2	7.2	2.8	2.8	22.6	*22.6
TIMU-21	2.2	*2.2	0.48	-	18	*18
TIMU-23	2	*2	0.49	-	14	*14
TIMU-24	1.2	-	0.48	-	4.2	*4.2
TIMU-25	1.3	-	0.49	-	13.7	*13.7
TIMU-27	5.6	5.6	2.8	2.8	19.1	*19.1
TIMU-28	16.1	16.1	2.9	2.9	52.4	52.4
TIMU-29	1.3	*1.3	0.48	-	4.2	*4.2
TIMU-ALT-01	3.4	*3.4	0.48	-	19.4	*19.4
TIMU-ALT-02	3.5	*3.5	0.49	-	13.3	*13.3
TIMU-ALT-03	1.2	-	0.48	-	2	-

Appendix C. Sediment organic compound concentrations and condition assessments made in original and revised report.

Table C-1. Comparison of organic sediment contaminant concentrations (in ppb) values reported in original version of the report and revised values reported for sites sampled at Timucuan Ecological and Historic Preserve, July 2008. Cell colors indicate condition of assessed parameter (Long et al. 1995). [Green, *good*; yellow, *fair*; red, *poor;* blue, missing data; —, value not reported, below the detection limit; *, value estimated, used in condition assessment summaries]

Station	2-Methylnaphthalene		4,4'-DDE		Acenaphthene		Acenaphthylene		Anthracene		Benz[a]anthracene	
	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised
TIMU-01	5	-	0.5	-	5	-	5	-	0.99	*0.99	4.2	*4.2
TIMU-02	1	*1	0.5	-	10	-	10	-	10	-	10	-
TIMU-04	1.9	-	0.5	-	1.9	-	1.9	-	1.9	-	1.9	-
TIMU-05	5.3	-	0.5	-	5.3	-	5.3	-	5.3	-	5.3	-
TIMU-06	10	-	0.5	-	10	-	10	-	10	-	10	-
TIMU-07	5.6	-	0.5	-	5.6	-	5.6	-	0.56	*0.56	2.2	*2.2
TIMU-08	6.3	-	0.5	-	6.3	-	6.3	-	6.3	-	6.3	-
TIMU-09	4.1	-	0.5	-	4.1	-	4.1	-	4.1	-	4.1	-
TIMU-10	3	-	0.5	-	3	-	3	-	3	-	3	-
TIMU-11	5.6	-	0.5	-	5.6	-	5.6	-	5.6	-	5.6	-
TIMU-12	2	*2	0.5	-	10	-	1.5	*1.5	1.5	*1.5	2.5	*2.5
TIMU-13	6	-	0.5	-	6	-	6	-	6	-	6	-
TIMU-14	3.1	-	0.5	-	3.1	-	3.1	-	3.1	-	1.2	*1.2
TIMU-15	10	-	0.5	-	10	-	10	-	10	-	10	-
TIMU-16	1	*1	0.5	-	10	-	10	-	10	-	10	-
TIMU-17	10	-	0.5	-	10	-	10	-	10	-	10	-
TIMU-18	1	*1	0.5	-	6.25	-	10	-	10	-	27	-
TIMU-19	10	--	0.5	-	10	-	10	-	10	-	2.5	*2.5
TIMU-20	1	*1	0.5	-	10	-	10	-	10	-	10	-
TIMU-21	10	-	0.5	-	10	-	10	-	10	-	10	-
TIMU-23	5.9	-	0.5	-	5.9	-	5.9	-	5.9	-	5.9	-
TIMU-24	1	*1	0.5	-	10	-	10	-	10	-	10	-
TIMU-25	10	-	0.5	-	10	-	10	-	10	-	10	-
TIMU-27	10	-	0.5	-	10	-	10	-	10	-	10	-
TIMU-28	1	*1	0.5	-	10	-	10	-	10	-	10	-
TIMU-29	10	-	0.5	-	10	-	10	-	10	-	10	-
TIMU-ALT-01	6	-	0.5	-	6	-	6	-	6	-	6	-
TIMU-ALT-02	10	-	0.5	-	10	-	10	-	10	-	10	-
TIMU-ALT-03	10	-	0.5	-	10	-	10	-	10	-	10	-

Table C-1. (Continued).

	Phenanthrene		Pyrene		Total DDT		High molecular weight PAH		Low molecular weight PAH		Total PAHs		Total PCBs	
Station	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised	originally reported	revised
TIMU-01	1.7	*1.7	3.7	*3.7	1	0	40.77	20.77	58.43	3.43	99.2	24.2	21	0
TIMU-02	1	*1	10	-	1	0	120	0	113	3	233	3	21	0
TIMU-04	1.9	-	1.9	-	1	0	22.8	0	26.6	0	49.4	0	21	0
TIMU-05	5.3	-	5.3	-	1	0	63.6	0	74.2	0	137.8	0	21	0
TIMU-06	10	-	10	-	1	0	120	0	140	0	260	0	21	0
TIMU-07	1.7	*1.7	3.4	*3.4	1	0	45.1	17.1	69.46	2.26	114.56	19.36	21	0
TIMU-08	6.3	-	6.3	-	1	0	75.6	0	88.2	0	163.8	0	21	0
TIMU-09	4.1	-	4.1	-	1	0	49.2	0	57.4	0	106.6	0	21	0
TIMU-10	3	-	3	-	1	0	36	0	42	0	78	0	21	0
TIMU-11	5.6	-	3.35	-	1	0	64.95	0	78.4	0	143.35	0	21	0
TIMU-12	2	*2	2	*2	1	0	50.5	20.5	30	20	80.5	40.5	21	0
TIMU-13	6	-	6	-	1	0	72	0	84	0	156	0	21	0
TIMU-14	1.1	*1.1	1.9	*1.9	1	0	22.32	9.92	41.4	1.1	63.72	11.02	21	0
TIMU-15	10	-	10	-	1	0	120	0	131	1	251	1	21	0
TIMU-16	10	-	10	-	1	0	120	0	122	2	242	2	21	0
TIMU-17	10	-	10	-	1	0	120	0	140	0	260	0	20.92	0.92
TIMU-18	5.5	-	22	-	2.55	3.6	201.75	0	115.75	2	317.5	2	21.8	0
TIMU-19	2	*2	5.5	*5.5	1	0	73.5	23.5	132	2	205.5	25.2	21	0
TIMU-20	1	*1	10	-	1	0	120	0	113	3	233	3	21	0
TIMU-21	10	-	10	-	1	0	120	0	140	0	260	0	21	0
TIMU-23	5.9	-	1.5	*1.5	1	0	62	3	82.6	0	144.6	3	21	0
TIMU-24	10	-	10	-	1	0	120	0	122	2	242	2	21	0
TIMU-25	10	-	10	-	1	0	111	1	131	1	242	2	21	0
TIMU-27	10	-	10	-	3.5	3	120	0	140	0	260	0	21	0
TIMU-28	1	*1	10	-	1	0	103.5	3.5	113	3	216.5	6.5	21	0
TIMU-29	10	-	10	-	1	0	120	0	140	0	260	0	21	0
TIMU-ALT-01	0.9	*0.9	1.2	*1.2	1	0	62.7	2.7	78.9	0.9	141.6	3.6	21	0
TIMU-ALT-02	10	-	10	-	1	0	120	0	140	0	260	0	21	0
TIMU-ALT-03	10		10	-	1	0	120	0	140	0	260	0	21	0