DRAFT Implementation of the Turbidity Criterion for the Protection of Coral Reef and Hardbottom Communities

Division of Environmental Assessment and Restoration

Florida Department of Environmental Protection

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Contents

Section 1. Introduction

1.1 Purpose of Document

This document describes how the turbidity criterion for areas supporting coral reef and hardbottom communities will be implemented in Department permits. The criterion does not allow increases in turbidity above background levels but takes into account the variability in background levels. Key topics addressed in this document include how baseline (pre-project) levels will be established for permitted activities, how variability of baseline levels will be quantified, and how the variability will be used to assess compliance with the criterion.

1.2 Background Information

Florida is the only state in the continental United States with extensive shallow coral reef formations near its coasts. Coral reefs create specialized habitats that provide shelter, food, and breeding sites for numerous plants and animals. This includes species important to fishing like spiny lobster, snapper, and grouper. Coral reefs lay the foundation of a dynamic ecosystem with tremendous biodiversity. Most of Florida's corals occur in Florida's Coral Reef (FCR), which stretches approximately 360 linear miles from Dry Tortugas National Park west of the Florida Keys to the St. Lucie Inlet in Martin County (Figure 1). Roughly two-thirds of FCR lies within Biscayne National Park and the Florida Keys National Marine Sanctuary, a marine protected area that surrounds the Florida Keys island chain. The northern third of FCR (Miami-Dade to Martin County) was recently designated as the Southeast Florida Coral Reef Ecosystem Conservation Area (Coral ECA). Additionally, the state has extensive hardbottom habitats along its southeastern and southwestern coasts (Figure 2). Protection of these marine resources is critically important for preserving the State's marine biodiversity, protection of endangered or threatened species, and protection of fisheries, tourism, and coastal resiliency, including protection against the effects of sea level rise.

The implementation procedures presented in this document are intended to provide necessary protections to these critically important marine communities and help ensure that man-induced turbidity is not a limiting factor in the recovery of Florida's coral reefs. It is intended to help implement Executive Order 19-12 (Achieving More Now for Florida's Environment) by helping to ensure that Florida's valuable and vulnerable coastlines and natural resources are protected.

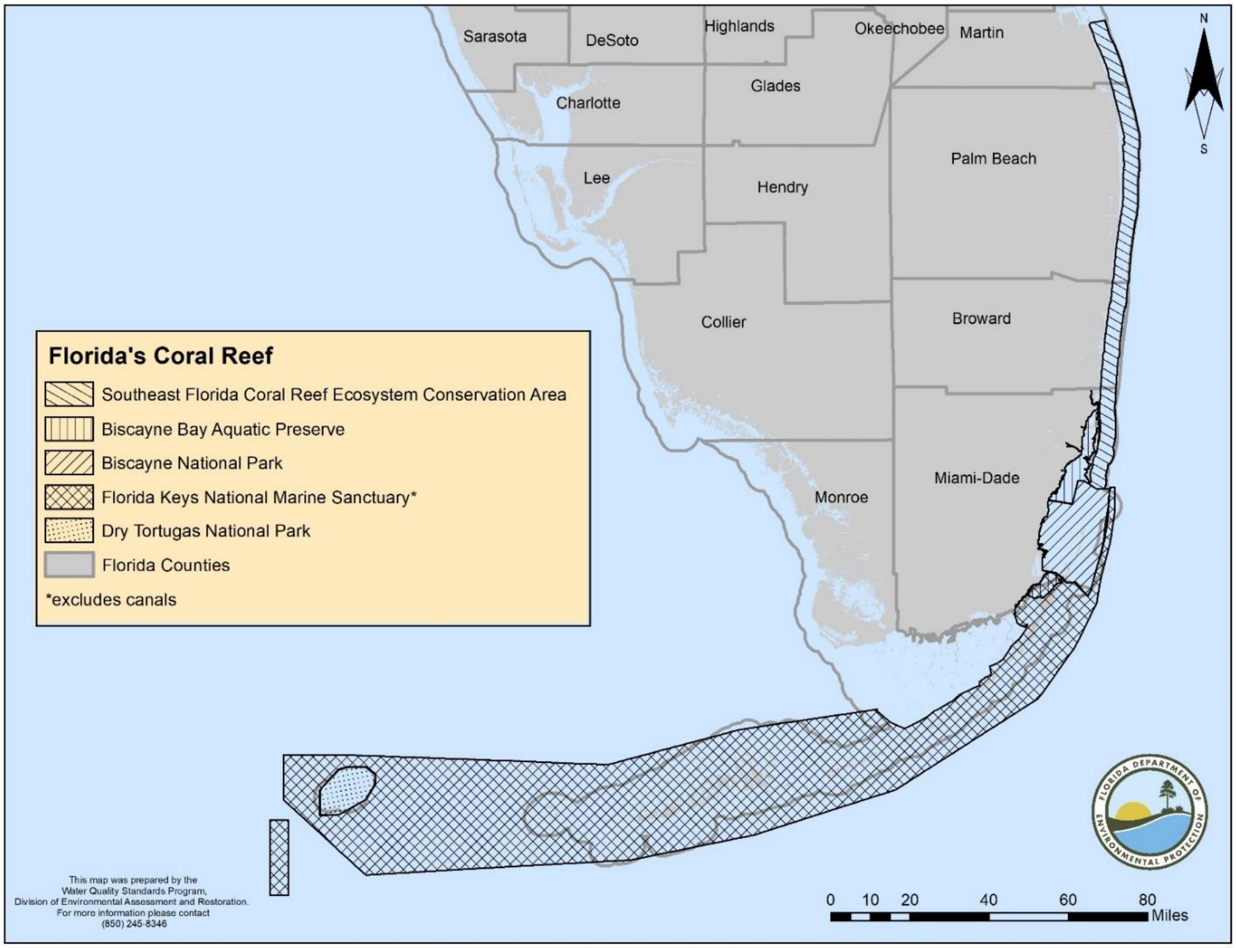

Figure 1. The location of Florida's Coral Reefs.

1.3 Proposed Criterion and Rule Language

As part of the Department's efforts to derive a turbidity water quality criterion that was specifically designed to be protective of coral reefs and hardbottom communities, Department staff conducted an extensive literature review of scientific studies addressing the effects of turbidity on coral reefs. During that literature review, the Department identified many different relevant studies and summarized the findings in a Technical Support Document (TSD) for *Turbidity Criterion to Protect Florida Coral and Hardbottom Communities*. While the data indicate that the current turbidity criterion (29 NTU above natural background) is not protective of corals and hardbottom communities, there are insufficient data to establish the magnitude of a specific numeric criterion that would be protective of all coral species.

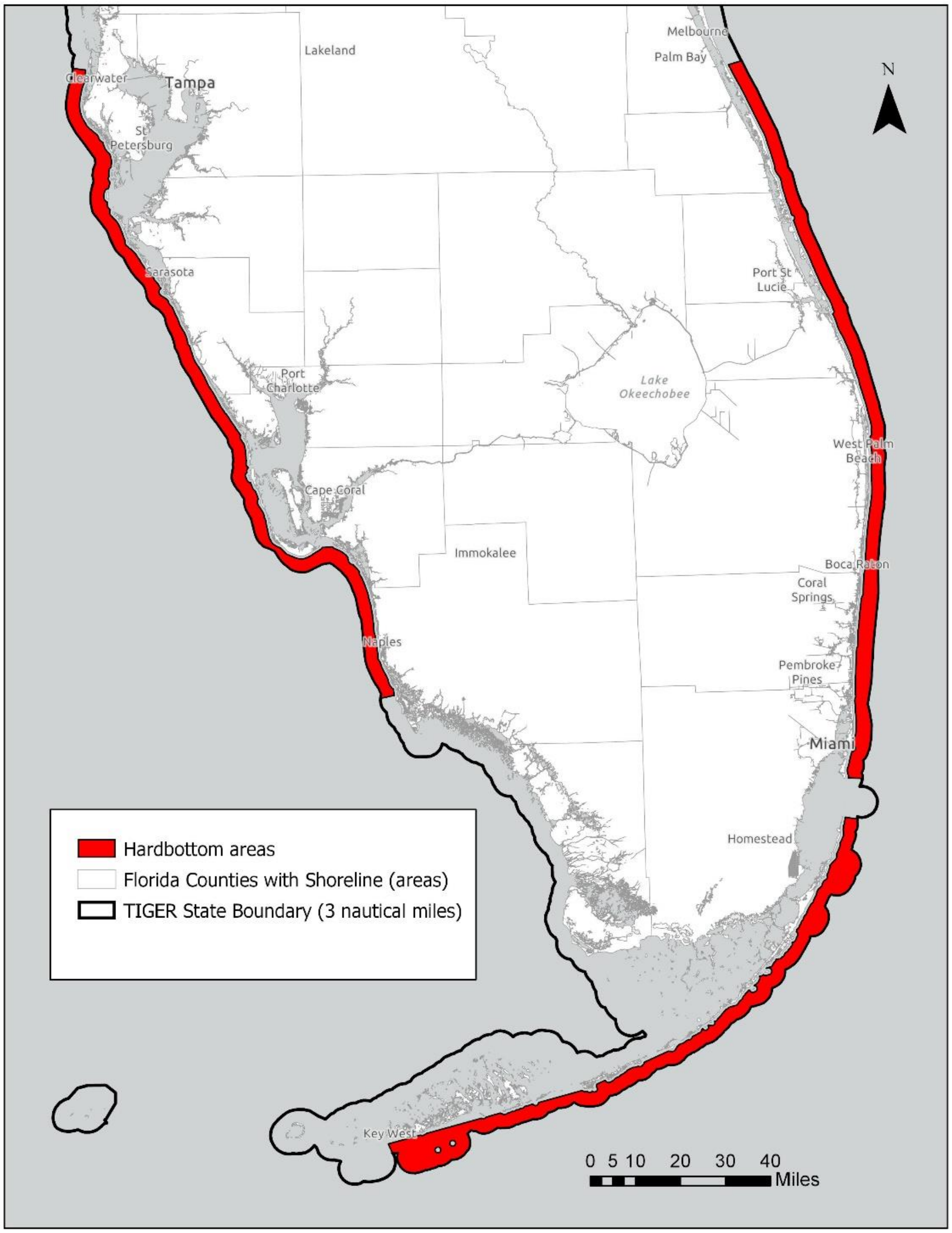

Figure 2: Distribution of Hardbottom areas within Florida's state waters.

However, the literature indicates that a) an appropriate magnitude of the criterion would likely fall between 3 and 7 NTU, depending on the species of coral, and b) the criterion would need to account for the natural variability in turbidity levels, which would need to be addressed in the duration and frequency component of the criterion. Given that the potential range of the magnitude of the criteria is generally similar to the range of the variability of natural background turbidity levels, the Department concluded that the best approach to establishing a turbidity criterion that is protective of corals is to adopt a criteria expressed and implemented in terms of maintaining turbidity levels within the range of background variability.

Paragraph 62-302.530(70)(b), Florida Administrative Code (F.A.C.), states:

b. Turbidity shall not be increased above background conditions within areas of the state where coral reef or hardbottom communities are currently found or have been demonstrated to have occurred since November 28, 1975. To evaluate this criterion, background conditions shall take into account the natural variability of turbidity levels and shall be established following the methods described in the document *Implementation of the Turbidity Criterion for the Protection of Coral Reef and Hardbottom Communities*, dated October 2020, which is incorporated by reference.

For the purposes of this criterion, “Coral Reef” shall mean a limestone structure composed wholly or partially of the living or dead skeletal remains of marine invertebrates in the Class Anthozoa and the Orders Scleractinia (stony corals), Stolonifera (organ-pipe corals), Antipatharia (black corals), and Hydrozoa (hydrocoral). “Hardbottom Coral Community” shall be defined as a consolidated hard structure with a living veneer of organisms characterized by the presence of corals, octocorals, and associated reef organisms. This definition of hardbottom does not include “worm reefs created by the *Phragmatopoma* species,” which is included in the definition of “hard-bottom” in 403.93345 of Florida Statues for Coral Reef Protection. However, worm reefs are not included in the definition applicable to the turbidity criterion because worm reefs typically occur in environments with highly dynamic natural turbidity conditions (FDEP, 2020).

The majority of coral reef and hardbottom communities are expected to occur within FCR. It contains waters currently or historically known to support extensive coral reefs and hardbottom coral communities. The historical presence of coral is of critical importance because corals have the potential to re-colonize areas where they have experienced significant losses due to bleaching events and disease. In addition, due to climate change, it is expected that corals will migrate as waters closer to the equator become too hot. Therefore, protecting areas where ever they occur , including outside of FCR, is also important. The turbidity criterion is intended to ensure that turbidity is not a limiting factor to their survival, recruitment, growth, or recovery, regardless of whether these species currently occur within an area.

1.4 Threatened and Endangered Species Considerations

The criterion is also designed to protect threatened and endangered species of corals. The National Oceanographic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) currently lists *Acropora cervicornis* (staghorn coral), *Acropora palmata* (elkhorn coral), *Mycetophyllia ferox* (rough cactus coral), *Dendrogyra cylindrus* (pillar coral), *Orbicella annularis* (lobed star coral), *Orbicella faveolata* (mountainous star coral), and *Orbicella franksi* (boulder star coral) as threatened under the Endangered Species Act. All seven of these species occur within the waters of FCR. The NMFS has also designated most of FCR as critical habitat for staghorn coral and elkhorn coral. Given the presence of both critical habitat and threatened sensitive species, additional proactive protections are warranted.

1.5 Outstanding Florida Waters (OFW) Considerations

Large portions of the areas with coral reefs and/or hardbottom communities are designated as Outstanding Florida Waters (OFW). As of May 2019, there are 32 separate designated OFWs within FCR, including Florida Keys, Biscayne National Park, Great White Heron National Wildlife Refuge, John Pennekamp Coral Reef State Park, Biscayne Bay Aquatic Preserves, Key Largo National Marine Sanctuary, and St. Lucie Inlet Preserve State Park (see Rule 62-30.700, F.A.C.). Projects regulated by the Department or a Water Management District that are proposed within an OFW may not lower (degrade) existing water quality, which is defined as the water quality at the time of OFW designation or the year prior to the permit, whichever is better (see paragraph 62-4.242(2)(c), F.A.C.). For activities that increase turbidity, the OFW requirements have generally been interpreted to not allow any increase above natural background (defined below) levels. However, Department rules allow for temporary increases in turbidity in OFWs within a mixing zone for certain permitted activities provided that turbidity at the edge of the approved mixing zone does not exceed natural background levels by more than the range observed through a normal tidal cycle, as described in paragraph 62-4.242(2)(b), F.A.C., which states:

> *(b) The Department recognizes that it may be necessary to permit limited activities or discharges in Outstanding Florida Waters to allow for or enhance public use or to maintain facilities that existed prior to the effective date of the Outstanding Florida Water designation, or facilities permitted after adoption of the Outstanding Florida Water designation. However, such activities or discharges will only be permitted if:*

1. The discharge or activity is in compliance with the provisions specified in subparagraph (2)(a)2.[1]*, of this rule, or*

2. For dredging beach-quality sand from inlets and related channels, or restoration/nourishment of beaches and the use of offshore borrow areas, the applicant demonstrates that:

a. Turbidity has been minimized for both magnitude and duration to the maximum extent practicable,

b. Turbidity at the edge of the approved mixing zone does not exceed natural background levels by more than the range in natural background turbidity levels measured throughout a normal tidal cycle for the applicable sand dredging or beach restoration/nourishment site; and in no case shall it exceed 29 NTUs above natural background; and,

c. Turbidity levels, both inside and outside of the mixing zone, are not expected to have an adverse impact on marine resources, recreational value or public safety, or

3. Management practices and suitable technology approved by the Department are implemented for all stationary installations including those created for drainage, flood control, or by dredging or filling; and there is no alternative to the proposed activity, including the alternative of not undertaking any change, except at an unreasonably higher cost.

The application of the turbidity criterion for coral reef and hardbottom communities (paragraph 62-302.530(70)(b), F.A.C.) is similar to the implementation of antidegradation standards for turbidity within designated OFWs. Implementation of both standards requires characterization of background turbidity conditions and only allows deviation from that level within the range of background variability. However, this document establishes more extensive data requirements for establishing background turbidity conditions, including sampling over more background tidal cycles, and provides a different statistical approach for determining attainment of the criterion.

[1]Subparagraph 2(a)2., F.A.C., states:

2. The proposed activity of discharge is clearly in the public interest, and either:

a. A Department permit for the activity has been issued or an application for such permit was complete on the effective date of the Outstanding Florida Water designation, or

b. The existing ambient water quality within Outstanding Florida Waters will not be lowered as a result of the proposed activity or discharge, except on a temporary basis during construction for a period not to exceed thirty days; lowered water quality would occur only within a restricted mixing zone approved by the Department; and, water quality criteria would not be violated outside the restricted mixing zone. The Department may allow an extension of the thirty-day time limit on a construction-caused degradation for a period demonstrated by the applicant to be unavoidable and where suitable management practices and technology approved by the Department are employed to minimize any degradation of water quality.

Rule 62-302.200, F.A.C., defines the terms "background" and "natural background" differently. Background (subsection 62-302.200(3), F.A.C.) is defined as *the condition of waters in the absence of the activity or discharge under consideration, based on the best scientific information available to the Department*, while natural background (subsection 62-302.200(21), F.A.C.) is defined as *the condition of waters in the absence of man-induced alterations based on the best scientific information available to the Department. The establishment of natural background for an altered waterbody may be based upon a similar unaltered waterbody, historical pre-alteration data, paleolimnological examination of sediment cores, or examination of geology and soils* (note that additional language related to background in lakes is not shown). Although there is a difference between natural background and background conditions, in practice both the current turbidity criterion [*i.e.*, 29 NTU (Nephelometric Turbidity Unit) above natural background] and antidegradation requirements in paragraph 62-4.242(2)(b), F.A.C., are typically assessed using the best available background conditions because data that can be used to characterize true natural conditions are seldom available, especially for turbidity. For instance, offshore south Florida was historically known for "gin clear water." While offshore coral reef specific water quality monitoring in the Florida Keys goes back approximately 25 years and less than 5 years in the Coral ECA, only recently has turbidity been included in either program.

For implementation of this turbidity criterion, the Department will use the term "baseline," which is based on pre-project turbidity data, to acknowledge the difference between baseline and true natural background conditions. Baseline conditions represent minimally or least disturbed background conditions that serve as the best available <u>site-specific</u> estimate of turbidity levels under natural background conditions. The variability in site-specific turbidity levels under baseline conditions, which is key to implementing the criterion, is expected to be an even more accurate estimate of the variability under natural background conditions. However, if there are sufficient historical data for a given site to establish that natural background conditions previously exhibited lower variability than current data, that historical data should be used to establish baseline conditions.

1.6 Natural Factors Influencing Background Turbidity Levels

Turbidity in coastal waters can be generated and influenced by natural events such as wind patterns, wave height and frequency, water currents, and land runoff. Sediments can be naturally resuspended in a system when exposed to wind-driven waves. The amount of sediment that is picked up varies based on the strength and duration of the wind creating the waves. Storms can also influence the amount of suspended sediment within the water column. As storms pass through an area, they block the normal wind patterns of an area and may result in alternating periods of low winds with small waves followed by large waves, which creates a highly variable amount of turbidity in different locations (Storlazzi and Jaffe 2008). The duration and severity of the storm are integral factors in the amount of suspended sediment introduced into the water column.

Tidal cycles can be another strong influencer of natural turbidity. Experiments performed in estuaries showed that turbidity was highest at or near low tide when the more turbid, lower salinity water from the upper estuary extended seaward (Ward 2004). The magnitude of the tidal range also impacts the amount of sediments suspended in the water column. Larger spring tides can cause higher amounts of sediment to be picked up during the low tide, subsequently making the water more turbid when the tide rises (Ward 2004). Tidal Stage can be very important near inlets as well.

Section 2. Implementation in Permitting

2.1 Permitting Information

The turbidity criterion for corals (paragraph 62-302.530(70)(b), F.A.C.) will affect dredging, beach nourishment, and other projects that may generate turbidity in coastal waters where coral and/or hardbottom communities are present. Documentation supporting the presence or absence of corals or hardbottom shall be based on current site-specific evaluation of the habitat, substrate, and epifaunal species present, which is required as part of the permit application process. The evaluation must be based on benthic surveys within the area affected by the project or construction area. If corals and hardbottom are present, the turbidity criterion could affect the boundaries (size) of allowable turbidity mixing zones, limits applied to permits, and associated water quality monitoring requirements for Joint Coastal Permits (JCP) and Environmental Resource Permits (ERP) in these areas whenever there is an expectation that the project will generate turbidity above the existing background.

Neither the criterion in paragraph 62-302.530(70)(b), F.A.C., nor this Implementation Document alter the opportunities or requirements for permittees to obtain mixing zones available under Rule 62-4.244, F.A.C., or variances. This document only affects how background is defined and determined. Compliance is still intended to be determined at the edge of an authorized mixing zone. However, turbidity levels, both inside and outside of the mixing zone, must not have an adverse or acute impact on marine resources, recreational value or public safety.

Activities that require a JCP include beach restoration or nourishment; construction of erosion control structures, such as groins and breakwaters; construction of public fishing piers; maintenance of inlets and inlet-related structures; and dredging of navigation channels that include disposal of dredged material onto the beach or in the nearshore area. Beach restoration and nourishment have been the main methods of managing beach erosion and maintaining beach habitat. Key rules and statutes that govern JCPs include: Chapter 161 Florida Statutes (F.S.), Chapter 62B-41, F.A.C., Chapter 62B-49, F.A.C., Chapter

18-20, F.A.C., Chapter 18-21, F.A.C., Chapter 62-4, F.A.C., Chapter 62-302, F.A.C., Chapter 62-330, F.A.C., Chapter 253, F.S., Chapter 258, F.S., part IV Chapter 373, F.S., and Chapter 403, F.S.

The ERP Program regulates activities in, on or over surface waters or wetlands, as well as any activity involving the alteration of surface water flows. The Program regulates almost any change to the landscape, including all tidal and freshwater wetlands and other surface waters (including isolated wetlands) and uplands. The ERP program deals with dredging and filling in wetlands and other surface waters (including ports and navigational channels), as well as stormwater runoff quality and quantity. The ERP Program is implemented jointly by the Department and four of the WMDs (all except the Northwest WMD). This program ensures that water quality is not degraded, and that wetlands and other surface waters continue to provide a productive habitat for fish and wildlife. Key rules and statutes that govern ERPs include Chapter 18-20, F.A.C., Chapter 18-21, F.A.C., Chapter 62-4, F.A.C., Chapter 62-302, F.A.C., Chapter 62-330, F.A.C., Chapter 253, F.S., Chapter 258, F.S., part IV Chapter 373, F.S., and Chapter 403, F.S.

2.2 Establishing Baseline (Pre-project) Levels

Permit applicants have the ultimate responsibility to provide the information needed to establish the baseline turbidity, including the natural variability in baseline turbidity levels, for the area where the permitted activity will take place. However, permittees have the options of a) using the interquartile range of values of existing available turbidity data for the area where the project is located (see Table A-1 in the appendix), b) using the interquartile range of baseline/background data from previously permitted projects in the area (see Section 2.4), or c) establishing natural baseline variability based on pre-project turbidity data collected specifically for the project at "baseline" stations. While this approach provides flexibility on how to establish baseline turbidity, applicants should be aware that the resultant permit limits will be more conservative if an applicant relies on existing turbidity data to establish baseline turbidity variability because a) the available historical data may not incorporate the full range of site-specific variability in turbidity levels as they are dominated by open water sites that generally have low turbidity levels, and b) the statistical methods used to establish baseline variability were specifically selected to be more conservative when relying on historical data.

Regardless of the option selected, pre-project baseline turbidity variability must be established for each project sub-area (*e.g.*, offshore borrow areas, nearshore placement stations, nearshore dredging areas, offshore dredging areas). Permit applicants have the option of choosing different methods to establish the baseline variability for different sites. All turbidity data and calculations (described below) provided by applicants will be reviewed by the Department and used to develop permit-required turbidity limits for use throughout the duration of the project. Compliance with these permit-required turbidity limits will constitute attainment of the turbidity criterion.

Also regardless of the option selected, turbidity data used to establish background variability must be taken using a hand-held Nephelometric Turbidity Meter in accordance with standard protocols (*i.e*., DEP-SOP-001/01 FT 1600 Field Measurements of Turbidity) or data sonde meeting all applicable QA/QC requirements under Chapter 62-160, F.A.C. If the applicant uses data from a continuous monitoring sampling unit (sonde), the applicant must also meet the minimum calibration and quantitative or chronological bracketing requirements for continuous samples in the department document Continuous Monitoring SOP for Environmental Field Deployments.

2.3 Measuring Baseline (Pre-project) Levels

To qualify for the statistical methods for deriving the pre-project baseline turbidity variability using site-specific data as described in Section 2.2, the sampling must meet all of the requirements of this section.

1) If any living coral or hardbottom communities are within the area where the project has a reasonable potential to increase turbidity levels above the criterion, at least one of the pre-project baseline stations must be located above the living coral or hardbottom community. If coral or hardbottom communities are present at distinctly different areas within the overall project area, multiple baseline stations may be needed to address the different background conditions.

2) Projects expected to last longer than three months must provide data for the seasons in which the permitting activity is projected to occur and may have season-specific turbidity limits. Applicants are encouraged to have a pre-application meeting so that DEP permitting staff can provide site-specific guidance on the appropriate siting of pre-project baseline stations and seasonal requirements (if any).

3) The minimum duration over which background turbidity variation must be assessed to qualify for the measured turbidity option is four tidal cycles at each pre-project baseline station. The tidal cycles do not have to be consecutive; however, care must be taken to ensure that background turbidity data are collected at the same location for each tidal cycle. GPS coordinates must be provided to verify the baseline station location, and the location of each baseline station shall not differ by more than 10 meters between tidal cycle events.

4) Turbidity measurements must be collected at the surface (0.5 – 1 meter below surface) and bottom (0.5 – 1 meter off bottom) at a minimum of one representative baseline station for each project area. Total depths must also be recorded for checks in consistency and total depth must be recorded for each sample. For example, borrow areas and beach placement areas must each have representative baseline stations. In some cases, there may be more than one borrow area or placement area, and each of these areas must have at least one baseline station. Turbidity samples must be collected at a frequency of no greater than 4 hours apart throughout each tidal cycle, and applicants must report turbidity at the peak of each tidal stage. Pre-project turbidity samples may be collected more frequently (e.g., hourly) at the applicant's discretion to help ensure a more accurate and complete representation of the range of background variability. The measurement of turbidity may be started at any point in the tidal cycle and must end at the same point in the next cycle, such as from high to low to high, or from low to high to low.

5) The applicant must provide the Department with reasonable assurance that the collected turbidity data are representative of the natural variation in turbidity over a typical tidal cycle. This demonstration must include 1) tidal data (*i.e.,* tide charts, observed water levels) and other meteorological data (*i.e.*, current direction, wave height, wind speed and direction, precipitation) for the period over which baseline samples were collected; and, 2) longer-term tide and weather data for the project area. "Typical" shall mean that the height of the low and high tide are within the range of the 5^{th} and 95^{th} percentiles, respectively, of the historic data.

6) Because the pre-project data set requirements are relatively small in terms of sample size, the results are prone to undue influence from statistical outliers. Therefore, the turbidity results must be screened for outliers and any outliers shall be flagged for potential removal from the dataset before the calculation of background variability and calculation of permit-required turbidity limits. These outliers may be retained if the Department agrees that the values are representative of background conditions. For purposes of this analysis, an outlier shall mean any turbidity value that is greater than the mean of the data set plus three times the standard deviation, and the outlier analysis shall be conducted for each station and depth independently.

2.4 Calculation of Baseline Variability

The turbidity criterion in paragraph 62-302.530(70)(b), F.A.C., is intended to protect coral and hardbottom communities from deleterious effects associated with elevated turbidity levels. It is assumed that any sessile benthic organisms present within an area are adapted to the background turbidity in that area, including natural variability in background levels. However, increases in the magnitude, duration or frequency (*i.e.*, increased variability) of turbidity above background conditions have deleterious effects on the resident coral and hardbottom. Thus, the turbidity criterion is designed to maintain the pre-project background turbidity magnitude, frequency, and duration. Permits for dredging or other activities that may increase turbidity in waters subject to paragraph 62-302.530(70)(b), F.A.C., will be subject to permit-required turbidity limits based on pre-project variability. These permit-required turbidity limits will be established based on the observed turbidity range at the representative pre-project baseline station(s) and will be expressed as the allowable increase in turbidity between the project background and compliance stations.

If turbidity data from previously permitted projects are used to calculate the baseline variability, the applicant has the option of calculating the allowable increase in turbidity over background levels by a) calculating the interquartile range of all available baseline and background data from the project(s) or, b) if sufficient data are available to meet the tidal cycle requirement of Section 2.3, calculating the upper 90% confidence interval of the range over the tidal cycles, as described below.

When using data collected at project-specific baseline station(s), the allowable increase in turbidity over pre-project background levels and associated permit-required turbidity limit shall be calculated as an upper confidence interval of the mean difference between minimum and maximum turbidity over a typical tidal cycle. The allowable increase in turbidity shall be calculated using an upper 95% confidence based on a minimum of 4 pre-project tidal cycles and shall be calculated using the follow equation:

Allowable increase over Background Station = Upper 95% confidence interval =$\bar{X} + 1.96 \times \frac{S}{\sqrt{n}}$, where

(Equation 2)

$\bar{X}$= Mean of differences between minimum and maximum turbidity over each baseline tidal cycle

S = Standard deviation of the differences between minimum and maximum turbidity over all baseline tidal cycles

n = the number of baseline tidal cycles

Allowable increase over Background Station = Upper 95% confidence interval =exp $(\bar{y} + 1.96 \times \frac{S_y}{\sqrt{n}})$, where (Equation 2)

$\bar{y}$= Mean of logarithms of differences between minimum and maximum turbidity over each baseline tidal cycle

Sy = Standard deviation of the logartihms of the differences between minimum and maximum turbidity over all baseline tidal cycles
n = the number of baseline tidal cycles

The applicant must report and use all collected pre-project baseline turbidity data collected during l tidal cycles that passed applicable quality assurance requirements of Chapter 62-160, F.A.C., in the calculation of the confidence interval and cannot pick a sub-set of the pre-project baseline tidal cycles that provides the highest possible confidence interval. The calculated upper confidence intervals shall be applied in the determination of permit-required turbidity limits, as described in Section 2.5.

2.5 Assessment of Turbidity Levels During Construction Operations

To assess compliance with the turbidity criterion during construction, permittees must sample turbidity at both representative background and compliance stations. The background data collected during construction should be collected at station(s) located in an area clearly outside of the influence of any construction activities and may not necessarily be at the same location(s) as the pre-project baseline station(s). The locations of these compliance and background stations will generally not be fixed, but rather will change between monitoring events in response to changes in the plume direction as the work area (portion of the project area that is being dredged or filled) shifts or in response to changing tidal conditions over the course of the construction. Individual permits will specify the number of required stations, sampling frequency (minimum of 3 per day collected 4 hours apart), and specific conditions for siting compliance and background stations. However, there must be at least one background station and one compliance station at the edge of each authorized mixing zone, with turbidity samples collected at surface (0.5 to 1 m) and 0.5 to 1 m above the bottom at both locations unless the depth is less than 5 m, in which case only one mid-depth sample is needed. Individual permits will specify a minimum distance between the work zone and background station.

Typically, permittees are required to collect turbidity samples 3 times per day, 4 hours apart, during daylight hours only. The permittee shall report all turbidity data (*i.e.*, raw field sheets and processed data in an electronic database), and shall also report the following information:

a. Time of day samples were taken;
b. Dates of sampling and analysis;
c. GPS location of sample;
d. Depth of water body;
e. Depth of each sample;

f. Weather conditions, including wind direction and velocity;
g. Tidal stage and direction of flow;
h. Water temperature;
i. A map, overlaid on the most recent generally available aerial photograph, indicating the sampling locations, dredging and discharge locations, direction of flow, boundaries of natural resources (e.g., coral reefs, hardbottom, worm reefs, seagrass beds) and GPS coordinates for all vessels operating during the monitoring period.
j. A statement describing the methods used in collection, handling, storage and analysis of the samples; and
k. A statement by the individual responsible for implementation of the sampling program concerning the authenticity, precision, limits of detection, calibration of the meter, accuracy of the data and precision of the GPS measurements.

Each compliance sample shall be independently compared to the corresponding depth-specific background turbidity value, and any increase in turbidity at the compliance station above the background station must be equal to or less than the allowable increase in turbidity (*i.e.*, permit-required turbidity limit), as calculated using Equation 1 or 2. Dredging projects lasting longer than three months may have season-specific permit-required turbidity limits. The turbidity increase between the two stations shall be calculated as the measured compliance station turbidity minus the measured background station turbidity.

2.6 Example Application of the Permit Required Turbidity Limit

Table 1 provides an example calculation of the permit-required turbidity limit for a hypothetical dredging project. The hypothetical applicant collected turbidity measurements at a representative pre-project baseline station through five typical tidal cycles. No outliers were identified in the data set. The applicant tabulated the differences between maximum and minimum turbidity for each tidal cycle at both depths (*i.e.*, independently for samples collected at each the surface and bottom depth), calculated the mean and standard deviation of the difference independently for each depth, and then used Equation *2* to calculate the upper 95% confidence interval for each depth. The calculated upper 95 percent confidence intervals (*i.e.*, 2.1 and 2.6 NTU) will serve as maximum allowed increase between the background and compliance stations, and the permit shall specify permit limits for both surface (0.5 – 1 m) and bottom (0.5 - 1 m above bottom) depth samples.

Table 1. Pre-project baseline turbidity measurements collected to calculate the surface and bottom depth permit-required turbidity limits for a hypothetical dredging project within the Southeast Florida Coral

Reef Ecosystem Conservation Area. The baseline data were used to calculate upper 95% confidence intervals, which will serve as the applicable permit-required turbidity limits for the project.

Tidal Cycle	Surface Minimum Turbidity (NTU)	Surface Maximum Turbidity (NTU	Bottom Minimum Turbidity (NTU)	Bottom Maximum Turbidity (NTU)	Turbidity Difference Surface	Turbidity Difference Bottom
1	1.5	2.8	1.2	2.6	1.3	1.4
2	3.1	3.5	2.9	4.1	0.4	1.2
3	1.1	2.7	1.1	2.5	1.6	1.4
4	3.5	3.8	2.5	4.4	0.3	1.9
5	2.4	5.1	2.3	5.6	2.7	3.3
				Mean Difference	1.26	1.84
				Standard Deviation	0.981	0.856
				Sample size (n)	5	5
				Upper 95% C.I.	2.1	2.6

During construction, the permittee conducted the permit-required compliance and background station turbidity monitoring throughout the duration of the project. Turbidity measurements were collected at all monitoring stations three times per day at a frequency of every four hours at both surface and bottom depth at the background and compliance stations. **Table 2** provides an example background and compliance turbidity dataset collected over four days of the project. The pre-project baseline values calculated in **Table 1** (i.e., 2.1 and 2.6 NTU for the surface and bottom depth background measurement, respectively) were added to the turbidity values at the background (BG) sampling locations during construction to determine whether any of the samples taken at compliance stations during construction were out of compliance with the permit-required turbidity limits. In this example, one of the surface or bottom depth compliance measurements exceeded the applicable turbidity limits (see yellow highlighting).

Table 2. Hypothetical dredging project turbidity compliance data reported in NTU (Nephelometric Turbidity Unit). Turbidity measurements were collected at background and compliance stations at surface and bottom depth. Allowable increases in turbidity of 2.1 and 2.6 were added to the surface (BG_s) and

bottom depth (BG_b) background turbidity values, respectively, for each time and depth used to evaluate compliance with the permit-required turbidity limits.

Date	Time (HH:MM)	Surface Background Turbidity (NTU, BG_s)	Surface Turbidity Limit (NTU, BG_s + 2.1)	Surface Compliance Turbidity (NTU)	Bottom Background Turbidity (NTU, BG_b)	Bottom Turbidity Limit (NTU, BG_b + 2.6)	Bottom Compliance Turbidity (NTU)
5/27/2019	7:00	3.9	6.0	5.6	3.4	6.0	5.4
5/27/2019	11:00	3.2	5.3	4.1	3.3	5.9	4.9
5/27/2019	15:00	2.1	4.2	4.4	2.3	4.9	4.3
5/28/2019	7:00	3.7	5.8	5.5	4.0	6.6	6.0
5/28/2019	11:00	4.7	6.8	4.8	3.7	6.3	5.3
5/28/2019	15:00	2.5	4.6	4.2	2.5	5.1	4.5
5/29/2019	7:00	3.6	5.7	4.9	4.4	7.0	6.4
5/29/2019	11:00	2.9	5.0	5.0	2.1	4.7	4.7
5/29/2019	15:00	5.1	7.2	3.2	2.1	4.7	4.1
5/30/2019	7:00	4.7	6.8	4.1	5.0	7.6	7.3
5/30/2019	11:00	4.0	6.1	5.9	3.8	6.4	6.2
5/30/2019	15:00	3.9	6.0	5.7	4.1	6.7	6.7

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Appendix A

Purpose

This appendix provides summary statistics for baseline turbidity data that can be used to establish permit limits for dredging activities that have a reasonable potential to cause or contribute to violations of the coral turbidity criterion. It provides area-specific turbidity interquartile ranges for areas that have known coral or hard-bottom communities. Data were aggregated based on **w**ater**b**ody **id**entification (WBID) units used by the Department for impaired waters assessments. It should be emphasized that coral and hard-bottom communities do not occur throughout the entirety of these areas. Instead, they have been documented to have occurred somewhere within the area, and a permit applicant has the option of using these values to determine applicable permit limits for projects within these areas if they decide not to use site-specific data.

Data Processing

Data were obtained from the Department's IWR Run 57 database and DEP's Florida Reef Tract Nutrient Water Quality Assessment project for the Coral ECA[2]. Data were processed and analyzed in Excel and Systat 13. All turbidity data that passed quality assurance checks were included in the calculations, with the exception of data from stations within canals or within 200 meters of shore, which were excluded from the analysis to avoid biasing the results. Summary statistics (arithmetic mean. 10th, 25th, 75th and 90th percentiles, and the interquartile range) were calculated for each WBID with at least 20 turbidity measurements. In some cases, neighboring WBIDs were combined to attain the 20-measurements minimum. WBIDs 8077 and 8078 were split between waters within the Florida Keys National Marine Sanctuary (FKNMS) and outside the FKNMS (*i.e.*, Florida Bay portion of the WBIDs) to create homogenous (relative to turbidity) water segments. Sufficient turbidity data were available for most WBIDs in the area of interest with the exception of open ocean WBIDs along the Atlantic Coast north of Martin County.

Results

The mean, 10th, 25th, 75th, 90th percentile, and the interquartile range turbidity values for each WBID are summarized in Table A-1 and shown in Figure A-1. The table also provides the period or record used for each WBID. The periods of record are provided as a minimum date (earliest record) and maximum date (most recent record).

[2] The Florida Reef Tract Nutrient Water Quality Assessment is managed by the Office of Resilience and Coastal Protection. The data from this project were not loaded into WIN or the IWR database at the time of report preparation.

Table A-1. Summary of existing background turbidity (NTU) within WBIDs within FCR and open coastal WBIDs within Manatee, Sarasota, Charlotte, Lee, Collier, Monroe, Miami-Dade, Broward, Palm Beach, Martin, St. Lucie, Indian River, and Brevard (to Cape Canaveral) counties. The listed 90th percentile values shall be used for IWR assessments and listing decisions. The spatial extent of WBIDs was based on IWR Run 60.

WBID	Area	POR Start	POR End	Sample Size (N)[1]	Mean	10th Percentile	25th Percentile	75th Percentile	90th Percentile	Interquartile Range
8065	10,000 Islands	10/19/92	9/23/19	131	4.9	0.7	1.4	5.3	8.6	3.9
8066	10,000 Islands	7/31/96	3/12/20	267	5.8	2.4	3.3	6.2	8.0	2.9
8067	10,000 Islands	2/25/15	10/21/19	15	5.4	1.6	2.0	3.9	6.0	1.9
8068	10,000 Islands	2/25/15	10/21/19	19	4.1	1.6	2.1	4.9	7.7	2.8
8069	10,000 Islands	9/15/92	3/3/20	202	4.4	1.4	2.0	5.3	8.6	3.3
8070	10,000 Islands	3/9/15	10/21/19	20	7.5	2.6	3.2	9.1	16.0	5.9
8103	Atlantic Coast			ID						
8104	Atlantic Coast			ID						
8105	Atlantic Coast			ID						
8106	Atlantic Coast			ID						
8107	Atlantic Coast			ID						
8108	Atlantic Coast			ID						
8109	Atlantic Coast			ID						
8110	Atlantic Coast			ID						
8111	Atlantic Coast			ID						
6001	Biscayne Bay	5/6/70	1/9/20	9701	1.3	0.3	0.4	1.6	2.9	1.2
8088	Biscayne Bay	3/28/95	8/21/19	345	1.3	0.2	0.3	1.1	1.8	0.8
8089	Biscayne Bay	5/6/70	11/13/19	322	1.7	0.2	0.3	1.2	2.6	0.9
8090	Biscayne Bay	9/30/93	11/13/19	210	2.0	0.1	0.3	1.0	1.9	0.7
3226H	Biscayne Bay	8/14/74	1/9/20	4102	2.4	0.4	0.7	3.1	5.2	2.4
3226H1	Biscayne Bay	3/19/79	1/6/20	496	1.2	0.4	0.6	1.6	2.2	1.0
3226H2[2]	Biscayne Bay	3/19/79	3/4/20	2111	2.5	0.5	0.7	3.1	4.6	2.4
3226H3[2]	Biscayne Bay	3/19/79	3/4/20	2111	2.5	0.5	0.7	3.1	4.6	2.4
6001C	Card Sound	5/6/70	1/8/20	2174	0.9	0.3	0.4	1.1	1.8	0.7
8091[3]	Coral ECA	5/6/70	3/5/20	275	0.6	0.2	0.3	0.7	1.2	0.4
8092[3]	Coral ECA	5/6/70	3/5/20	275	0.6	0.2	0.3	0.7	1.2	0.4
8093	Coral ECA	9/25/17	3/12/20	422	0.6	0.2	0.3	0.7	1.3	0.4
8094	Coral ECA	8/8/00	3/12/20	307	0.5	0.2	0.3	0.6	1.0	0.3
8095	Coral ECA	9/27/17	3/12/20	217	0.4	0.2	0.3	0.5	0.7	0.2
8096	Coral ECA	8/4/00	3/11/20	1430	0.4	0.2	0.3	0.5	0.8	0.3

WBID	Area	POR Start	POR End	Sample Size (N)[1]	Mean	10th Percentile	25th Percentile	75th Percentile	90th Percentile	Interquartile Range
8097	Coral ECA	9/28/17	3/23/20	93	0.2	0.2	0.2	0.3	0.3	0.1
8098	Coral ECA	9/28/17	3/23/20	279	0.5	0.2	0.2	0.5	1.0	0.3
8099	Coral ECA	9/21/17	3/23/20	180	0.8	0.2	0.3	0.5	1.5	0.3
8100	Coral ECA	9/21/17	3/23/20	120	1.0	0.2	0.3	0.5	2.0	0.3
8101	Coral ECA	9/20/17	3/18/20	278	1.4	0.2	0.3	1.3	2.9	1.0
8102	Coral ECA	1/18/19	3/17/20	135	3.3	0.4	0.7	3.8	10.7	3.1
8072	Dry Tortugas	5/26/95	10/5/11	363	1.3	0.2	0.3	0.8	1.2	0.5
8071	Florida Bay	7/15/92	4/1/20	377	11.6	2.4	3.8	12.7	25.6	8.9
6009	Florida Keys			ID						
6010	Florida Keys			ID						
6016	Florida Keys			ID						
6017	Florida Keys			ID						
6018	Florida Keys	3/23/95	6/24/13	132	1.5	0.3	0.5	1.2	1.8	0.7
6019	Florida Keys			ID						
8073	Florida Keys	3/22/95	12/17/19	904	2.1	0.3	0.5	1.8	3.3	1.2
8074	Florida Keys	4/5/95	5/3/13	425	2.5	0.5	0.8	2.1	3.6	1.3
8075	Florida Keys	3/26/95	5/3/13	684	2.3	0.5	0.7	1.8	3.3	1.1
8076	Florida Keys	3/26/95	4/10/13	470	1.7	0.5	0.7	1.4	2.1	0.7
8079	Florida Keys	3/22/95	12/17/19	739	1.6	0.2	0.4	1.4	2.2	1.0
8080	Florida Keys	3/23/95	12/16/19	297	1.6	0.3	0.5	1.4	2.3	0.9
8081	Florida Keys	1/17/89	6/24/13	272	1.5	0.3	0.4	1.4	2.4	1.0
8082	Florida Keys	3/24/95	1/23/13	60	1.1	0.1	0.2	0.6	1.4	0.4
8083	Florida Keys	3/24/95	1/23/13	264	1.8	0.3	0.5	1.4	2.6	0.9
8084	Florida Keys	3/24/95	1/22/13	257	1.6	0.2	0.3	1.4	2.8	1.1
8085	Florida Keys	3/27/95	1/22/13	367	1.5	0.1	0.2	1.1	2.1	0.9
8086	Florida Keys	3/28/95	4/9/13	264	1.5	0.2	0.3	1.1	2.2	0.8
8087	Florida Keys	3/28/95	1/17/13	324	1.5	0.3	0.5	1.2	1.9	0.7
6005A	Florida Keys	12/5/85	4/6/20	308	4.6	1.2	1.8	5.8	9.9	4.0
6005B	Florida Keys	10/19/89	4/6/20	215	1.2	0.3	0.5	1.4	2.1	0.9
6006A	Florida Keys			ID						
6006B	Florida Keys			ID						
6011A	Florida Keys			ID						
6011B	Florida Keys			ID						
6011C	Florida Keys			ID						
6012A	Florida Keys	12/29/82	2/27/20	101	1.7	0.5	0.7	1.8	2.4	1.1

WBID	Area	POR Start	POR End	Sample Size (N)[1]	Mean	10th Percentile	25th Percentile	75th Percentile	90th Percentile	Interquartile Range
6012C	Florida Keys			ID						
6012D	Florida Keys			ID						
6012E	Florida Keys			ID						
6013A	Florida Keys			ID						
6013B	Florida Keys			ID						
6013C	Florida Keys			ID						
6013D	Florida Keys			ID						
6014A	Florida Keys			ID						
6014B	Florida Keys			ID						
6014C	Florida Keys	4/5/95	10/5/11	60	2.1	0.8	0.9	1.9	2.2	1.0
8077 + 8078 Within FKNMS[4]	Florida Keys	6/7/78	4/10/13	277	1.9	0.4	0.7	1.7	2.7	1.0
8077 Outside FKNMS	Florida Keys	12/2/81	4/7/20	1952	7.3	0.7	1.2	7.8	16.6	6.6
8078 Outside FKNMS	Florida Keys	12/2/81	4/7/20	1029	7.2	1.1	1.8	6.8	15.8	5.0
8050	Gulf of Mexico	8/8/90	12/16/14	91	2.8	0.5	0.9	3.2	6.1	2.3
8051	Gulf of Mexico	8/8/90	12/16/14	364	2.7	0.8	1.1	2.9	5.8	1.8
8052	Gulf of Mexico	8/8/90	12/16/14	214	3.2	0.7	1.1	2.8	6.9	1.7
8053	Gulf of Mexico	8/8/90	12/16/14	152	3.0	0.7	1.1	3.2	6.9	2.0
8054	Gulf of Mexico	1/14/11	12/16/14	92	3.0	0.7	1.1	3.4	5.2	2.3
8055	Gulf of Mexico			ID						
8056	Gulf of Mexico	1/22/96	12/13/00	63	2.8	0.6	1.0	3.4	6.5	2.4
8057	Gulf of Mexico			ID						
8058	Gulf of Mexico	5/25/04	9/13/11	38	2.8	0.6	1.0	2.9	7.7	1.9
8059	Gulf of Mexico	9/22/83	12/17/18	27	3.4	0.3	1.0	3.4	11.5	2.4
8060	Gulf of Mexico			ID						
8061	Gulf of Mexico			ID						
8062	Gulf of Mexico	2/21/06	10/25/06	34	2.6	0.2	2.0	3.7	4.5	1.7
8063	Gulf of Mexico	1/26/99	3/17/20	92	2.6	0.7	1.1	3.1	4.8	2.0
6002	Manatee Bay – Barnes Sound	12/5/85	1/8/20	717	1.1	0.4	0.5	1.4	2.3	0.9
6003	Manatee Bay – Barnes Sound	1/9/86	1/8/20	1329	1.7	0.4	0.5	1.6	2.9	1.1

[1] Entries of "ID" in the Sample Size (N) column indicate that there were insufficient data to calculate the summary statistics.

[2] Values were based on the neighboring WBID 3226H3 due to insufficient data in WBID 3226H2.

[3] Calculated based on combined WBIDs 8091 and 8092

[4] Values were based on combined WBID 8077 and 8078 stations within the FKNMS. These are displayed as WBID 8077K and 8078K on the maps..

1. Calculated based on combined WBIDs 8091 and 8092
2. Values were based on the neighboring WBID 3226H3 due to insufficient data in WBID 3226H2.
3. Values were based on combined WBID 8077 and 8078 stations within the FKNM.

Figure A-1. Map Displaying Interquartile Ranges from Table A-1.