CERP Guidance Memorandum

South Florida Water Management District – Jacksonville District, U.S. Army Corps Of Engineers

CGM NUMBER-REVISION: 42.01

EFFECTIVE DATE: July 21, 2010

CATEGORY: Water Quality

SUBJECT: Toxic Substances Screening Process - Mercury and Pesticides

DESCRIPTION:

This memorandum provides guidance to both Jacksonville District, U.S. Army Corps of Engineers (USACE) and South Florida Water Management District (SFWMD) staffs on screening for toxic substances, such as mercury and pesticides, in CERP projects.

The purpose of this CERP Guidance Memorandum is to provide project managers and teams with a uniform scheme for (1) screening project alternatives for the likelihood of unacceptable impacts from toxic substances; and (2) detecting project-related impacts of toxic substances and monitoring their mitigation. The scheme is adaptive and is intended to apply scarce resources where most needed.

It uses guidance developed by the SFWMD for District projects. This document is attached as Appendix A and, as guidance, can be used for projects co-sponsored by the USACE and SFWMD. It does not replace environmental site assessments that are usually the responsibility of the local sponsor nor does it imply USACE participation in any required remediation which is the responsibility of the local sponsor.

GUIDANCE:

Appendix A presents the details of the tiered process for screening each phase of a CERP project: Phase I addresses toxicant monitoring and assessment during the development of the Project Implementation Report (PIR), project design and construction; Phase II involves monitoring activities during project start-up or stabilization; and Phase III addresses activities during project operation. Each Phase has two or more tiers. Each tier begins with minimal sampling and testing. It progresses to more complex assessments as site conditions warrant.

For example, Phase I, Tier 1 assesses existing baseline data, requiring additional monitoring only if there is a gap in data needed to establish the baseline. Tier 2 consists of screening bulk sediment concentrations against basin-wide conditions and fish collection upstream, downstream and, where water bodies are found, within the project footprint. If Tier 1 baseline monitoring indicates that risk from mercury or other toxic substances is acceptable based on basin-wide conditions, the project remains in Tier 1 and only minimal monitoring is required upon start-up (Phase II).

Conversely, projects that exceed action levels in Tier 1 proceed to Tier 2, which requires additional monitoring to guide the development of alternatives. Projects in Tier 2 would require expanded monitoring at start-up. If, due to schedule or other considerations, the project proceeds to the operation phase without Tier 1 baseline monitoring, it does so at risk, automatically defaulting to a higher level of operational monitoring requirements.

The same approach, procedures, and decision logic are applied to the other phases of the project. If results from routine operational monitoring exceed a specified action level, follow-up tests are triggered to support further project decisions and adaptive management. Conversely, if the routine monitoring establishes the absence of a toxic substances problem over a specified time interval, the frequency of monitoring is first reduced and then eliminated altogether.

Federal government policies related to hazardous, toxic and radioactive wastes (HTRW) (RCRA, CERCLA and ER 1165-2-132) present issues involving the Corps participation in cost sharing and longevity of participation in monitoring. These issues need to be dealt with on a project by project basis, either within the Project Cooperation Agreement (PCA) or subsequently by project managers as the need arises. In some cases, HTRW issues will need to be resolved at a higher level.

APPLICATION:

Effective immediately the guidance provided in Appendix A of this CGM will be used to by USACE and SFWMD project managers and the staff of both agencies to screen projects for mercury and pesticide toxicity.

SFWMD contacts are listed at the end of Appendix A. The USACE contact for this CGM is Lisa Gued (904-232-1793, Lisa.R.Gued@usace.army.mil).

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This document provides working level guidance to assist project managers and teams in the implementation of the Comprehensive Everglades Restoration Plan (CERP) program executed between the South Florida Water Management District and the U.S. Army Corps of Engineers. The guidance does not constitute policy for either agency nor does it create authority beyond that granted to any agency member carrying out their duties. Guidance reflecting agency policy on subjects listed in the guidance memoranda section of the programmatic regulations for CERP will be issued when the final programmatic regulations are adopted, using the process stated in the regulations.

Appendix A

A Protocol for Monitoring Mercury and Other Toxicants

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INTRODUCTION

This document is intended to guide in the design of monitoring and assessment plans for mercury (Hg), pesticides, and other toxicants for South Florida Water Management District (District or SFWMD) projects. Because Hg is a regional problem in South Florida, it should be a consideration in all plans. As discussed below, although other toxicants are often found dispersed in various media throughout South Florida (e.g., water, sediment, biota), concentrations do not frequently exceed critical levels that are thought to result in toxicity. Therefore, risk from exposure to other toxicants tends to be a more localized concern than for mercury. More importantly in this context, the risk from changes related to the Comprehensive Everglades Restoration Plan (CERP) increasing the likelihood that wildlife will be exposed to these constituents, to a level that is toxic, also tends to be a localized concern. Accordingly, monitoring other toxicants should be considered on a case-by-case basis. It is not the intent of this plan to substitute for environmental site assessments (ESA) that are conducted on acquisition tracts. The District has an excellent record in conducting ESAs, site-specific environmental risk assessments (ERA), and implementation of corrective actions, where appropriate. This guidance has been prepared in consultation with and, where possible, will be implemented in coordination with the District's program for assessing the environmental liabilities associated with land transfer. However, the potential for anomalous methylmercury (MeHg) production is not considered during the ESA and thus must be assessed separately. With regard to other toxicants, the guidance provided here should prove useful in cases where:

- an ESA identified dispersed low-level contamination of toxicants and there is a need to reduce uncertainties, i.e., better define spatial or vertical distribution,
- where lands were purchased by other public/private entities, but may not have been subjected to the same level of ESA as current transfers,
- there has been a lengthy interval between the time of assessment and start of construction (with interim usage by a lessee), or
- where other toxicants have previously been identified as a concern on public lands (i.e., possibly as a result of stormwater runoff).

Results from the monitoring and assessment plan, in combination with information generated during land transfers, are intended to provide state and federal regulatory and trust oversight agencies with reasonable assurance that the project will not cause or contribute to an unacceptable increase in the risk of toxic effects to aquatic or terrestrial resources. As discussed below, the current numerical water quality standard (WQS) for total mercury (THg) is not protective of human or wildlife health. Consequently, assessments will need to place greater weight on protecting designated beneficial uses, i.e., recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. This will also be true for other toxicants that can be released suddenly from flooded soils and/or that have the potential to biomagnify. In addition to numerical water quality standards, assessments will need to consider Line 62 of chapter 62-302.530, Florida Administrative Code (F.A.C.), that states that substances in concentrations which injure, are chronically toxic to, or produce adverse physiological or behavioral response in humans, plants, or animals shall not be present. In addition to state requirements, federal legislation that may be pertinent include the Comprehensive Environmental Response, Compensation and Liability Act, the Endangered Species Act, and/or, the Migratory Bird Treaty Act. This guidance uses a phased, multi-tiered approach that is intended to commit information gathering, assessment and remedial resources in proportion to the likelihood of harm by following a logical and cost-effective procedure. The plan covers three phases of a project: (I) Baseline Collection and Assessment, (2) Monitoring during the Three Year Stabilization Period, and (3) Routine Operational Monitoring (Post-Stabilization). The plan includes decision criteria (i.e., if - then statements) and adaptive managements strategies to respond to a number different of scenarios. If an identified threshold of concern (i.e., action level) is crossed, then Tier 2 expanded monitoring and risk assessment would be triggered to determine the cause and guide appropriate adaptive management decision making regarding short-term corrective actions and long-term operational optimization. The intent of this approach is to allow monitoring efforts to smoothly ramp down or up, as appropriate.

This general plan is intended to accommodate diverse projects by providing a framework that can be tailored to a project's specific design. For example, a monitoring and assessment plan for a wetland restoration project would likely differ substantially from a plan for a Stormwater Treatment Area (STA) or reservoir. While it is anticipated that this guidance will serve as a frame of reference for future permit-mandated monitoring, incorporation of all, some, or none of its elements into a permit is at the discretion of the responsible authorities.

Mercury

Although atmospheric loading is often the dominant proximate source of inorganic mercury to many water bodies, the complication lies in the relationship between influx of inorganic mercury and the amount that"is methylated by sulfate-reducing bacteria (SRB) following deposition. The latter process is of fundamental concern because MeHg is the more toxic and bioaccumulative form that can build up in the food chain to levels harmful to" humans and other fish-eating animals, particularly in ecosystems with complex, lengthy food chains. Accordingly, a monitoring and assessment plan must be able to detect increased amounts of MeHg in the project area or downstream waters, either through sedimentary release of THg or MeHg, or through increased net Hg methylation. Although there are some constraints in predicting outcomes, the following factors are thought to be associated with increased MeHg production, particularly when in combination with certain site conditions (i.e., sediment biogeochemistry that is, as yet,
less well-defined):

- Increased proportion of source water from direct rainfall relative to surface water runoff (explanatory note: rain contains elevated levels of bioavailable inorganic Hg, particularly during summer; whereas, surface water runoff has already lost Hg through evasion back to atmosphere, sorption and deposition, and biological uptake);
- Elevated levels of oxidized sulfur compounds (e.g., sulfate, etc.) in inflows or sediments (explanatory note: used as electron acceptor by SRBs);
- Drawdown - drying followed by rewetting (explanatory note: allows constituents in the sediments/soils to oxidize); or
- Large bioavailable carbon source (explanatory note: feeds SRBs).

The goal is to prevent these factors from combining to produce a mercury methylation hot spot both in the short term (known as the "first-flush effect") and the long term (known as the "reservoir effect"). For additional details, see evolving conceptual model presented in the Fink et al., 1999; Stober et al., 2001; Harris et al., 2004; Atkeson and Axelrad, 2004.

The Florida Department of Environmental Protection (FDEP) has recognized that the current Florida numerical water quality criterion of 12 nanograms of total mercury (THg) per liter (ng/L) in water is of limited use, because fish consumption advisories have proven necessary for waters meeting the state criterion (Atkeson and Parks, 2002). Likewise, the U.S. Environmental Protection Agency (USEPA), also recognizing the limited utility of its recommended water quality criterion for the protection of human health, recently published guidance on a new criterion expressed not as a water-column concentration of mercury, but as a concentration of mercury in fish tissue (0.3 milligrams per kilogram (mg/kg) in fish tissue; USEPA, 2001). Biomonitoring mercury provides several advantages. First, MeHg occurs at much greater concentrations in fish tissues relative to surrounding water, making chemical analysis more accurate, precise, and cost effective.

Second, organisms integrate exposure to MeHg over space and time, while corresponding water concentrations may vary by a factor of two or more over a period of hours. Finally, the tissue Hg concentration in fish is a true measure of its bioavailability and provides a much better indicator of possible exposure to fish-eating wildlife and humans than the concentration in water. Because it is cost-effective, this generic plan has a biomonitoring program as a key component. The long-term goal is to reduce tissue Hg concentrations in predatory fish to levels that do not exceed USEPA guidance values for the protection of both human health and wildlife (for guidance values to protect wildlife, see USEPA, 1997). However, it should be recognized that the Everglades has a preexisting, widespread mercury problem (i.e., fish from most areas currently exceed one or more predatory protection criteria) and that many of the influential factors controlling MeHg production are beyond the scope of individual projects. Accordingly, use of USEPA's guidance criterion as a "risk-based" action level is not appropriate in the short term. Instead, monitoring and assessment plans will track the status and trends of mercury bioaccumulation to ensure that it does not significantly increase over baseline levels. This monitoring and assessment plan incorporates action levels or triggers for decision points based on existing reference or baseline conditions (i.e., annual basin-wide arithmetic average or percentile concentration for all basins pooled). For purposes of pooling related data, the basin will be operationally defined based on the physiography and land uses of the watershed, category of water body (e.g., wetland, slough, open lake, etc.), and the data set available at that time. Ideally, the data set would allow for comparisons between similar habitat or sediment types. However, near-term projects may not have this option and may need to collect reference samples (especially where data on similar sediment types are unavailable) or use surrogate data collected at Stormwater Treatment Areas or Water Conservation Areas under the Everglades Forever Act Permits for comparative purposes.

Other Toxicants

Potential impacts to wildlife from exposure to toxicants other than mercury (e.g., organic pesticides or trace metals) continue to be a problem. This is of particular concern in Florida because of its complex stormwater management system from both urban (e.g., lawns, golf courses, "street dust") and agriculture, high groundwater table, and significant usage of a wide variety of pesticides and fertilizers. Fertilizers (including organic and biosolids) are a concern because several studies have measured heavy metals (e.g., cadmium, lead, nickel, and copper) in mineral ores and the resulting fertilizers (USEPA, 1999). Like mercury, many other toxicants, including relic (e.g., DDT, DDE, toxaphene, etc.) and new (e.g., atrazine, alachlor) pesticides, have been found to be atmospherically deposited from both local and global sources (for details, see Eisenreich et al., 1981; Goolsby et al., 1993). Consequently, source identification can be challenging.

Owing to their absorptive capacity, soils and sediments typically act as a sink for these contaminants. As long as these soils/sediments maintain the capacity to store and thus immobilize the potential toxicant, the effects are significantly reduced. However, any alteration in the environment (e.g., flooding, anoxia and redox, microbial processes, pH changes) can suddenly reduce the sediment's storage capacity, which in turn can result in serious environmental damage (see "Chemical Time Bomb" concept in Stigliani et al., 1991).

Pesticides have been detected in sediments and surface water at District structures at various times (Miles and Pfeuffer, 1997; Pfeuffer and Matson, 2003; Pfeuffer and Rand, 2004). Likewise, pesticide residues have been found in fish and wildlife from certain locations in the central and southern Everglades (USGS National Water Quality Assessment Program at http://fl.water.usgs.gov/Abstracts/fs110_97_haag.html; Rumbold et al. 1996, Spalding et al. 1997, Rodgers 1997, Fernandez et al. 2003). Recently, a bird kill in excess of 800 birds occurred on Lake Apopka, possibly as a result of pesticide poisoning, after former farmlands were flooded (http://floridaswater.com/lakeapopka/). The monitoring and assessment plan for other toxicants often takes advantage of the mercury monitoring program, as in many cases, additional work simply involves splitting samples.

MONITORING AND ASSESSMENT FRAMEWORK

1. Phase 1 - Baseline Collection and Assessment

This section describes activities conducted during the initial stages of a project. Phase 1 tests are meant to provide information regarding the likelihood that a given alternative may have a problem with mercury or other toxicants in the future, i.e., so that managers may avoid those sites or operational features. In other words, these tests are meant to control the risk to the District that the constructed facility will have negative consequences. In some cases, a Project Manager may opt to carry out these activities prior to site selection (i.e., on short-listed sites) to provide additional information to guide in the selection process. If site selection has already occurred, then a Project Manager may elect to carry out these tests to assist in selecting the final design (e.g., footprint or operational features). As previously stated, it is not the intent of this plan to substitute for ESAs that are conducted on acquisition tracts. Results of those assessments are routinely reviewed and receive necessary approvals from the U.S. Fish and Wildlife Service; and are provided to the FDEP. Accordingly, where an ESA has recently been completed, baseline collection and assessment of toxicants other than Hg is not a general recommendation beyond the Phase 1 - Tier 1 task of compiling and reviewing existing data. Although these tests are a general recommendation for mercury, it should be understood that due to current limitations in predicting methylation potential, results of these tests should not be the sole factor in making site or design selection. Nonetheless, information gathered during this phase of the project will be crucial in developing the final monitoring plan and as baseline for future, post-construction cause-and-effect assessments.

1.1 Phase 1 - Tier 1: Compilation and Review of Available Data

The first step in any project is to compile and review all available data (e.g., ESA, DBHYDRO - http://my.sfwmd.gov/dbhydroplsql/show_dbkey_info.main_menu, Battelle Monitoring Data

Inventory, results of the District's pesticide network (http://my.sfwmd.gov/portal/pls/portal/portal_apps.repository_lib_pkg.repository_browse?p_option=browse&p_perspectives=24896012&p_mode=all) collected from the project footprint and surrounding area. With regard to other toxicants, data should be reviewed to answer the following questions:

- If part of a land transfer, who was the responsible agency and what was the level of ESA performed (i.e., Phase I or 2)?
- Did the ESA identify contaminants of concern?
- Were any corrective actions taken and was there follow-up sampling?
- Was there dispersed low-level contamination of toxicants (i.e., that did not exceed the requirements for corrective action)?
- Has there been a lengthy interval between the time of assessment and start of construction (with interim usage by a lessee) and, if so, what chemicals may have been used in the interim?
- If public lands, have toxicants been previously identified based on surface water, sediment or fish monitoring?

Answers to these questions will guide in developing an abbreviated analyte list for subsequent monitoring.

In areas that have been extensively studied, projects may have adequate baseline datasets and may not require any additional data before developing the Phase 2 monitoring and assessment plan. Alternatively, where data gaps exist or where the preponderance of the baseline data demonstrate a potential problem, additional sampling (i.e., under Phase 1 - Tier 2 or Tier 3) may be necessary.

1.2 Phase 1 - Tier 2: Field Sampling

1. 2.a Soil/Sediment

To describe conditions within each project, it is recommended that soil/sediment cores be collected from five locations within each operable unit (i.e., OU - each independently operated treatment train of an STA or reservoir) or each 1,000-acre parcel, whichever is smaller. At each location or site, three cores from the 0-to-4 cm horizon are to be collected and composited as a single soil sample. To conserve resources at large projects, sub-samples or aliquots from each of the soil samples from the five different locations can be pooled to form a single supercomposite sample for each OU or 1,000 acres. In this two-staged sampling approach, the analyses of the supercomposite representing the entire OU or 1,000 acres can be used as a screening mechanism to identify if additional, individual analysis are need to be performed (on each of the individual soil/sediment samples). Accordingly, remaining material from each soil sample will be archived separately for up to one year to allow for possible future analysis.

If the site was flooded and sediments had been saturated for some period of time (i.e., in excess of a month) with water comparable to future source water, then sediments may be immediately analyzed for THg, MeHg, moisture content, total organic carbon (TOC), total sulfur (TS), and total iron (TFe). Alternatively, if soils were collected from a dry site (i.e., orange grove, range land, etc.), then baseline concentrations will not reflect future flooded conditions (i.e., potential for MeHg production or first flush). Accordingly, soil/sediment must first be incubated with source water (i.e., surface water containing ambient concentrations of sulfate and dissolved organic carbon mixed with rainwater containing bioavailable inorganic Hg) for a period to evaluate this potential for first flush and future MeHg production. This test (i.e., beaker-scale microcosm test) will use fresh soils (i.e., the supercomposite from above) and ambient water from the anticipated inflows (i.e., appropriate mixture of surface water and rainfall, which have been subsampled for analysis for THg and MeHg), and will be run under static conditions, with frequent renewal. Upon completion of the test, sediments will be collected and analyzed for THg, MeHg, moisture content, TOC, TS, and TFe.

If deemed necessary, based on the discussion above, soil/sediment samples (wet or dry) could also be split and analyzed for toxicants of concern identified either through an ESA, available water quality (WQ) database or, if these were unavailable, previous land uses (both upstream and within the footprint). Although this coarse sampling would likely miss possible "hot spots" (e.g., fuel loading or pesticide mixing zones), which should have been detected during the ESA (when cores were collected from 5-acre subparcels and composited for randomly selected 50-acre parcels), this level of detail should be sufficient to characterize dispersed contaminants.

The objectives of screening for toxicants are (1) to prevent direct toxicity, either acute or chronic, and (2) to prevent the biomagnification of toxicants from reaching unacceptable levels that would pose a threat to upper trophic level wildlife. To achieve the first objective, toxicants would be evaluated against effects-based, numerical sediment quality assessment guidelines (SQAGs for sediment dwelling organisms, MacDonald Environmental Sciences Ltd. and United States Geological Survey, 2003). In cases where the effects-based SQAG did not assess the potential for adverse effects on aquatic organisms due to the resuspension of sediments or partitioning of contaminants into water (i.e., using elutriates or pore water), soils may be subjected to a synthetic precipitate leaching procedure (SPLP; USEPA Method 1312; also see Brannon et al., 1994) using ambient source water to elute the column and the resulting elutriate assessed based on Chapter 62-302, F.A.C. (and other references contained in Pfeuffer and Matson, 2003); exceedances would trigger Tier 3 assessments. To achieve the second objective, bioaccumulative toxicants would also be evaluated against established bioaccumulative-based SQAGs, if available (MacDonald Environmental Sciences Ltd. and United States Geological Survey, 2003).

A project would stop and reevaluate the ESA (if completed) and/or proceed to Phase 1 – Tier 3 Bioaccumulation Tests and Dynamic Modeling if:

- concentrations in sediments exceeded the appropriate SQAG,
- concentrations in sediments exceeded a value reported in the ESA or a level that was determined to be critical in a site-specific risk assessment, or
- the concentration in the elutriate exceeded a WQS in Chapter 62-302, F.A.C.

Although bioaccumulation-based SQAGs have been developed for a limited number of toxicants, there is no chemical-specific SQAG for mercury. Consequently, there is no screening-level benchmark sediment THg or MeHg concentration that can be used to confidently predict whether a site will become a "MeHg hotspot". However, data collected over the last nine years by various agencies working in the Everglades offer some limited capability as a reference (or baseline) to predict the potential for excessive MeHg production. Accordingly, as one of several potential tools for alternatives analysis, it is recommended that soil/sediment conditions of the site be assessed for MeHg production potential through comparisons with this reference database. If absolute concentrations of MeHg, or %MeHg (i.e., percentage of THg that is in the MeHg form) in soils/sediment from an OU exceeds the 90% upper confidence interval for within basin sediments or, if not available, the 75th percentile concentration (or %MeHg) for all basins, then the potential exists for excessive MeHg production and, accordingly, it is recommended that the project proceed to Phase 1 - Tier 3.

As previously discussed, a great deal of uncertainty remains surrounding the use of soil/sediment concentrations as a predictive tool to forecast future MeHg potential. Accordingly, as discussed in the following section, it is recommended that resident fish also be collected to assess current MeHg production and bioaccumulation.

1. 2.b Fish Tissues

At a minimum, fish samples from multiple trophic levels should be collected upstream and downstream of each project. Specifically, a sample of at least 100 mosquitofish *(Gambusia spp.)* should be collected from each location and composited into a single sample for THg analysis. Additionally, individual sunfish [sample size (n) should be greater than or equal to 5; whole-body] should be collected from each location and analyzed for THg. Where habitat will support largemouth bass *(Micropterus salmoides)* and there is a possibility of future recreational harvesting, bass should also be collected and individually analyzed for THg (n should be greater than or equal to 5; fillets). Because virtually all (> 85 %) of the mercury in fish muscle tissues is in the methylated form (Grieb et al., 1990; Bloom, 1992; SFWMD, unpublished data), the analysis of fish tissue for THg, which is a more straightforward and less-costly procedure than for MeHg, can be interpreted as being equivalent to the analysis of MeHg.

To reduce variance (i.e., due to species related differences in diet, ontological shifts in diet, exposure duration) and improve spatial and temporal comparisons of tissue levels within trophic levels, collections should target bluegill *(Lepomis macrochirus)* ranging in size from 102 to 178 mm (i.e., 4 to 7 inches) and largemouth bass ranging in size from 307 to 385 mm (i.e., 12 to 15 inches); however, other lepomids (first priority being given to spotted sunfish, *L. punctatus,* due to similar trophic status) or sizes are to be collected if efforts fail to locate targeted fish. If neither sunfish nor bass are present, then consideration should be given to sampling other species.

In addition, if possible (i.e., if flooded), mosquitofish should also be collected randomly from multiple locations from each OU or 1,000 acres (total should exceed 100 mosquitofish) and physically composited to from a single mosquitofish sample representative of the entire OU.

Body burdens in upstream and downstream fish do not provide predictive capabilities for alternatives analysis; however, this data set will be a crucial baseline for trend analyses following initiation of flow-through operation. Alternatively, ambient fish from the interior or footprint do provide some predictive capabilities for alternatives analysis. If these mosquitofish demonstrate excessive levels of MeHg bioaccumulation that exceed the 90% upper confidence level of the basin-wide annual average (reference basin will be defined for each specific project) or the 75th percentile concentration for the period of record for all basins, then it is recommended that the project proceed to Phase 1 - Tier 3: Bioaccumulation Tests and Dynamic Modeling.

If deemed necessary, based on the discussion above, fish samples could also be split and analyzed for bioaccumulative toxicants identified either through an ESA, available WQ database or, if these were unavailable, previous land uses (both upstream and within the footprint). Although it is recognized that under certain circumstances a taxa other than fish may be more appropriate biological sentinels depending on toxicant and risk assessment endpoint, this will require a thorough justification.

If levels of other toxicants in tissues exceed recognized background tissue concentrations (USGS National Water Quality Assessment Program, etc.) or benchmarks established in ecological risk assessments completed as part of the ESA, then the project would stop and reevaluate the ESA or proceed to Tier 3 Bioaccumulation Tests and Dynamic Modeling.

1. 3. Phase 1 - Tier 3: Bioaccumulation Tests and Dynamic Modeling

Tier 3 assessments during Phase I Baseline Collection and Assessment are triggered if one of the following action levels is exceeded:

- If absolute concentrations of MeHg, or average %MeHg (i.e., percentage of THg that is in the MeHg form) in soils/sediments from an OU exceeds the 90% upper confidence level of within the basin average, or if not available, the 75th percentile concentration (or %MeHg) for all basins;
- If concentrations of other toxicants in soils/sediments exceeded benchmarks established in ecological risk assessments completed as part of the ESA, or exceeded an appropriate SQAG, or the concentrations in the elutriate exceeds Chapter 62-302, F.A.C.; or
- If ambient fish collected within the project boundary demonstrate excessive bioaccumulation that exceeds: 1) the critical tissue benchmark used to establish SQAGs or in site-specific risk assessments or, 2) 90% upper confidence level of the basin-wide annual average, or if not available, the 75th percentile concentration for all basins.

Before proceeding to full Tier 3 sampling or modeling, the following steps are recommended to better define spatial extent of problem (i.e., to focus future efforts and thus conserve resources).

Step 1. Run analytical chemistry on the five individual soil samples that comprise the supercomposite that exceeded the trigger.

Step 2. Resample mosquitofish at a finer scale (i.e., 1 sample per 200 acres) within the OU or 1,000 acres for which the Tier 1 composite sample exceeded the trigger.

1.3.a Bioaccumulation Tests

As previously discussed, uncertainties remain surrounding the use of soil/sediment concentrations as a predictive tool to forecast future MeHg potential. Depending on soil conditions (e.g., concentration of TOC, TS, or TFe) bulk concentrations could substantially overestimate the fraction of MeHg actually bioavailable to aquatic animals living on or in surficial soils and thus the short-term MeHg bioaccumulation potential.

To reduce this uncertainty, a standardized laboratory determination of MeHg bioaccumulation (ASTM 1688-00a, EI706-00el, or equivalent; also see Ingersoll et al., 1998; Nuutinen and Kukkonen, 1998) may be carried out using soils collected from multiple locations within the footprint of the proposed component; supercomposite from above or individual composites (if area has been defined by sediment concentrations). Because most of the cost of this test is associated with the collection of soil/sediments, a Project Manager may opt to collect sufficient soil/sediments for this test during Tier 1 sampling.

The bioaccumulation test will use soils/sediments and ambient water from the anticipated inflows (i.e., appropriate mixture of surface water and rainfall, which have been subsampled for analysis for THg and MeHg) and will be run under static conditions with frequent renewal. Current standard protocols utilize infaunal invertebrates (e.g., *Lumbriculus variegatus,* a freshwater benthic worm) and are non-feeding exposures. Therefore, assessment of food chain transfers (biomagnification) require modeling (i.e., in this case to mosquitofish or sunfish) using biomagnification factors (BMFs) from the peer-reviewed literature, if basin-specific data are unavailable. A probabilistic bioenergetics-based food chain model may be used if a valid, applicable BMF cannot be obtained (e.g., Norstrom et al., 1976; Rodgers, 1994; Korhonen et al., 1995; Schultz et al., 1995).

If Tier 3 Bioaccumulation Tests and Modeling is triggered by toxicants other than Hg on a site that has recently undergone an ESA or ERA, then the Project Manager should reevaluate early model runs and rerun with additional data. Where a SQAG (either effects-based or bioaccumulation-based) has not been identified, or in cases where an exceeded SQAG is thought to be overly conservative, it is recommended that a standardized laboratory bioaccumulation test be performed (ASTM 1997a, 1997b, or equivalent; also see Ingersoll et al., 1998).

1.3.b Modeling

If Phase 1 - Tier 2 evaluations or Tier 3 bioaccumulation tests demonstrate the potential for excessive MeHg production and bioaccumulation over a substantial portion of the project footprint (hence, the need to define spatial extent, as discussed above), then it is recommended that the Everglades Mercury Cycling Model (E-MCM) or comparable model be used during alternatives analysis. Preferably, model output should be considered both in terms of site selection and operational design. However, due to the current limitations in the predictive strength of the E-MCM, results of the management scenarios simulated must be considered as possible, rather than probable outcomes (Harris et al., 2004), and should not be the sole factor in site selection.

Consultants under contract to the District's Land Acquisition Department have developed and routinely use several different models for evaluating biomagnification and ecological risk from exposure to other toxicants. If resulting risk estimates (either based on uptake or critical tissue concentrations) are deemed acceptable, the project would proceed and initiate Phase 2 - Tier 1 monitoring. On the other hand, if risk is deemed to be unacceptable, then the Project Manager would proceed to determine potential remedial actions/alternatives to reduce exposure and risk.

2. Phase 2 - Monitoring During Three-Year Stabilization Period

This section describes a general monitoring and assessment plan to be conducted on projects after initial flooding and through the first three years of operation.

2.1 Phase 2 - Tier 1: Routine Monitoring During Stabilization Period

2.1.a Water

Until a new criterion is promulgated, monitoring THg (and MeHg) in surface water will likely be required by permit to demonstrate compliance with Chapter 62-302, F.A.C. Accordingly, for components that are expected to require a permit, an unfiltered surface water sample ($n = 1$) should be collected in accordance with Chapter 62-160, F.A.C., at the inflows and immediately upstream of the outflows of each project on a quarterly basis and analyzed for THg, MeHg, and if not included under routine WQ monitoring, sulfate. In addition, flow will be monitored at the inflow and outflow to allow for load estimation to and from the project (it should be recognized that quarterly sampling would allow for only rough estimation of loads).

This data set will provide crucial information regarding assessment measures (i.e., annual outflow loads of THg and MeHg should not be significantly greater than inflow loads), including atmospheric loading; load estimates should include confidence intervals that describe uncertainty in measures of flow and concentration (e.g., field and analytical precision) and resulting from interpolation (note: assessment protocol to be negotiated with permitting authority). Failure to satisfy this assessment measure would trigger Tier 2 Expanded Monitoring and Risk Assessment.

It is recommended that other toxicants identified during Phase 1 - Tier 1 data review (i.e., based on ESA, DBHYDRO, Pesticide Network, and Battelle Monitoring Data Inventory) be included on the analyte list for quarterly water-column sampling. Because of the concern for potential acute toxicity, the initial sample collection should occur prior to flow through operation. Subsequent sampling would occur at the same frequency as mercury monitoring and be assessed using a similar performance measure (i.e., outflow load should not be significantly > inflow load, including atmospheric load). Because of differences in the anticipated time frames under which sedimentary release are thought to occur (i.e., relative to MeHg that may have time lag associated with changes in biogeochemistry and microbial methylation driven by water quality, especially in sandy soils), monitoring for other toxicants would cease after one year if action levels are not exceeded within that time. Exceedance of WQS in Chapter 62-302 F.A.C. would trigger Tier 2 Expanded Monitoring and Risk Assessment.

2. 1.b Soil / Sediment

Soil / sediments will not be collected under Phase 2 - Tier 1 monitoring.

2.1.c Fish Tissues

At a minimum, samples of fish from multiple trophic levels should be collected from each OU and from a single downstream site for each project. Specifically, within one month following initial flooding and quarterly thereafter, mosquitofish should be collected from multiple locations (at least 100 fish) within each OU and physically composited into one (spatially-averaged) sample and analyzed for THg (note, a single aliquot should be analyzed per composite). Mosquitofish were selected as a primary sentinel species because of their widespread occurrence in the Everglades, ability to invade newly flooded areas, and because of their relatively small home range and short life span. Mosquitofish are known to bioaccumulate MeHg, metals, such as lead, zinc, selenium and cadmium, and pesticides including but not limited to DDT, endosulfan, and toxaphene (Schaper and Crowder, 1976; Williams and Giesy, 1978; Denison et al., 1985; Nowak and Sunderam, 1991; Kumar and Chapman, 2001; Sepulveda et al. 2003; Wu, 2004).These characteristics make the mosquitofish a potentially excellent indicator of short-term, localized changes in a toxicant's bioavailablity.

On an annual basis, sunfish (n should be greater than or equal to 5) should be collected and individually analyzed (whole-fish) for THg. Sunfish were selected because of their widespread occurrence (especially bluegill) and because they are a preferred prey for a number of fish-eating species. Where habitat supports largemouth bass and there is a possibility of future recreational harvesting, bass should also be collected (n should be greater than or equal to 5) and individually analyzed (fillets) for THg. Largemouth bass can be used as an indicator of potential human exposure to mercury. To reduce variance (i.e., due to species differences in diet, ontological shifts in diet, exposure duration) and improve spatial and temporal comparisons of tissue levels within trophic levels, collections should target bluegill ranging in size from 102 to 178 mm (i.e., 4 to 7 inches) and largemouth bass ranging in size from 307 to 385 mm (i.e., 12 to 15 inches); however, other lepomids (due to similar trophic status, first priority being given to spotted sunfish) or sizes are to be collected if efforts fail to locate targeted fish.

Due to their relatively longer life spans and larger home ranges, sunfish and largemouth bass integrate their exposure over a larger spatial area and longer time frame. Accordingly, caution should be exercised when assessing levels in these fish in recently flooded (or intermittingly flooded) marshes. Under those circumstances, more weight should be placed on levels in mosquitofish which, as stated previously, integrate exposure over a shorter period of time.

If after one year of monitoring, sufficient data are collected to demonstrate that conditions within the different OUs are equivalent, collection of large-bodied fish can be reduced to one OU and one downstream site. Alternatively, if OUs are shown to differ in terms of average concentration in mosquitofish, project managers may elect to sample large-bodied fish from the OU with the highest observed concentration and assess results as "worst case". However, in either case, mosquitofish collections would continue from all OUs.

This data will then be used to evaluate the following assessment measures: 1) Hg in any (quarterly) mosquitofish composite should not exceed the 90% upper confidence level of the basin-wide average or, if basin-specific data are lacking, exceed the 75th percentile concentration for the period of record for all basins; 2) annual average THg levels in fishes should not increase progressively over time or become elevated to the point of exceeding the 90% upper confidence level of the annual basin-wide average, or if basin specific data are lacking, exceeding the 75th percentile concentration for the period of record for all basins. Exceedance of any of these action levels would trigger Phase 2 - Tier 2 Expanded Monitoring and Risk Assessment.

It is recommended that bioaccumulative toxicants identified during the Phase I - Tier I data review (i.e., based on information contained in the ESA, available WQ database, or previous land uses) be included on the analyte list for fish tissues collected during the first year of the stabilization period, if analytical procedures exist (for list of possible analytes by matrix, see Table 1). For toxicants other than mercury, more weight may need to be placed on whole-body residues in mosquitofish and sunfish (that will include organs that may preferentially accumulate other toxicants) to assess ecological risk than levels in fillets of largemouth bass. Furthermore, it should also be recognized that under certain circumstances taxa other than fish may be more appropriate biological sentinels depending on the toxicant and the risk assessment endpoint. For example, preliminary discussions have taken place regarding the possible use of the apple snail *(Pomacea paludosa)* to biomonitor potential copper exposure to the endangered snail kite*(Rostrhamus sociabilis plumbeus)*. However, a thorough justification will be required in any plan that targets species other than mosquitofish, sunfish, or bass.

Tissue levels of other toxicants should not increase significantly over time or become elevated to the point of exceeding: 1) the critical tissue benchmark used to establish SQAGs or developed during site-specific risk assessments; 2) the 90% upper confidence level of the annual basin-wide average, or if not available, exceeding the 75th percentile concentration for all basins. Exceedance of these action levels would trigger Phase 2 – Tier 2 Expanded Monitoring and Risk Assessment.

Table 1. List of pesticides with currently available analytical methods (for the specified matrix) for possible inclusion in Phase 1 - 3.

pesticide	surface water	sediment	fish
chlorinated (phenoxy acid) herbicides			
2,4-D	X	X	-
2,4,5-T	X	X	-
2,4,5-TP (silvex)	X	X	-
urea herbicides and imidacloprid			
diuron	X	X	-
linuron	X	X	-
imidacloprid	X	-	-
organophosphorus and nitrogen pesticides			
alachlor	X	X	-
ametryn	X	X	-
atrazine	X	X	X
atrazine desethyl	X	-	-
atrazine desisopropyl	X	-	-
azinphos methyl (guthion)	X	X	-
bromacil	X	X	-
butylate	X	-	-
chlorpyrifos ethyl	X	X	X
chlorpyrifos methyl	X	X	-
demeton	X	X	-
diazinon	X	X	-
disulfoton	X	X	X
ethion	X	X	X
ethoprop	X	X	X
fenamiphos	X	X	-
fonophos	X	X	-
hexazinone	X	X	-
malathion	X	X	-
metalaxyl	X	-	-
methamidophos	-	X	-
metolachlor	X	X	-
metribuzin	X	X	X
mevinphos	X	X	-
monocrotophos	-	X	-
naled	X	X	-
norflurazon	X	X	X
parathion ethyl	X	X	-
parathion methyl	X	X	-
phorate	X	X	X
prometryn	X	X	-
simazine	X	X	X

pesticide	surface water	sediment	fish
organochlorine pesticides			
aldrin	X	X	X
alpha BHC	X	X	X
beta BHC	X	X	X
delta BHC	X	X	X
gamma BHC (lindane)	X	X	X
carbophenothion (trithion)	X	X	-
chlordane	X	X	-
cis-chlordane	-	-	X
trans-chlordane	-	-	X
chlorothalonil	X	X	-
cypermethrin	X	-	-
o,p'-DDD	-	-	X
p,p'-DDD	X	X	X
o,p'-DDE	-	-	X
p,p'-DDE	X	X	X
o,p'-DDT	-	-	X
p,p'-DDT	X	X	X
dicofol (kelthane)	X	X	-
dieldrin	X	X	X
alpha endosulfan	X	X	X
beta endosulfan	X	X	X
endosulfan sulfate	X	X	X
endrin	X	X	X
endrin aldehyde	X	X	-
heptachlor	X	X	X
heptachlor epoxide	X	X	X
methoxychlor	X	X	X
mirex	X	X	X
permethrin	X	X	-
toxaphene	X	X	X
PCB-1016	X	X	-
PCB-1221	X	X	-
PCB-1232	X	X	-
PCB-1242	X	X	-
PCB-1248	X	X	-
PCB-1254	X	X	-
PCB-1260	X	X	-
trifluralin	X	X	-
cis-nonachlor	-	-	X
trans-nonachlor	-	-	X

- not analyzed

Compounds in italics have** **a Surface** ***Water Quality Class I or III criterion (FAC 62-302)

2.2 Phase 2 - Tier 2: Expanded Monitoring and Risk Assessment

Phase 2 - Tier 2 is triggered if one of the following action levels is exceeded:

- If a WQS (in Chapter 62-302, F.A.C.) is exceeded; or
- If annual outflow loads of THg or MeHg are determined to be significantly greater than inflow loads (based on an uncertainty analysis of loading estimates, e.g., precision in measuring analytes and flow, interpolation over quarter); or
- If Hg in any (quarterly) mosquitofish composite exceeds the 90% upper confidence level of the basin-wide average or, if basin-specific data are lacking, exceeds the 75th percentile concentration for the period of record for all basins; or
- If annual average Hg levels in a given fish species become elevated to the point of exceeding the 90% upper confidence level of the basin-wide average, or if basin-specific data are lacking, exceeding the 75th percentile concentration for the period of record for all basins; or
- If annual average levels of a residue in a given fish species increase progressively over time (i.e., two or more years) ($p < 0.1$); or
- If residue levels of other toxicants in fish become elevated to the point of exceeding the critical tissue benchmark used to establish SQAGs or developed in risk assessments.

The following steps will be taken if any action level in Phase 2 - Tier 2 is triggered:

Step 1: Notify permitting authority;
Step 2: Resample media (e.g., water or fish) that triggered Tier 2;

If results of Step 2 (i.e., re-sampling of media that triggered Tier 2) demonstrate that the anomalous condition was an isolated event, the permitting authority will be notified that the project will revert back and continue with Phase 2 - Tier 1 monitoring. Alternatively, if results of Step 2 reveal the anomalous condition was not an isolated event, proceed to Step 3.

Step 3: Expanding monitoring program as follows:

- Increase frequency of mosquitofish collection from quarterly to monthly.
- If Tier 2 was triggered by excessive loading or exceedance of a WQS at common outflow, then begin sampling discharges at outflows of each OU or independent treatment train to better define spatial extent of problem. If necessary (i.e., if loading uncertainty is high), increase frequency of surface water collection to monthly (reducing temporal interpolation), or as appropriate for hydraulic retention time (HRT).
- To further define spatial extent of problem, collect multiple mosquitofish composites from within the OU or treatment train exhibiting anomalous conditions.
- If Tier 2 was triggered by tissue levels in large-bodied fish, increase sample size of large-bodied fish to n = 20, i.e., 20 each of sunfish (collect various species and sizes) and/or bass (collect various sizes and extract otolith from bass for age determination).
- To evaluate possible trends in methylation rates in sediments (i.e., to determine if problem is improving or worsening), replicate sediment cores (0-4 cm) can be collected from the suspected methylation "hot spot" and reference locations within the component (for THg, MeHg, moisture content, TOC, TS, and TFe) over a given period of time (e.g., 2 to 4 months). At these same locations and times, collect pore water samples and analyze for THg, MeHg, and

sulfides, or if no acceptable pore water protocol has been developed, acid-volatile sulfide (AVS) on solids.

Projects shown to have (spatially) large or multiple MeHg "hotspots" should consider use of the E-MCM or comparable model as an assessment tool (i.e., to synthesize results of expanded monitoring).

Step 3 will also include the notification of the permitting authority that anomalous conditions are continuing. The permitting authority and the permittee may then develop an adaptive management plan using the data generated from the expanded monitoring program. This plan will evaluate the potential risks from continued operation under existing conditions (i.e., through a risk assessment for appropriate ecological receptors). If risk under existing operational conditions is deemed acceptable, then project monitoring would continue under a modified Tier 2 scheme to monitor exposure. On the other hand, if risk under existing operational conditions is deemed unacceptable, then the adaptive management plan would then proceed to determine potential remedial actions to (1) reduce exposure and risk (e.g., signage for human health concerns, reduce fish populations, reduce forage habitat suitability); if risk of acute toxicity – immediate drawdown of an OU and reevaluation of ESA [Note that assessment of potential human health impacts and corrective actions (i.e., signage) will require the involvement of the Florida Department of Health]; and (2) affect mercury biogeochemistry to reduce net methylation (e.g., modify hydroperiod or stage, water quality).

In developing this adaptive management plan, the permitting authority may conduct a publicly noticed workshop to solicit comments from the permittee, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, the National Park Service, the Florida Fish and Wildlife Conservation Commission, and other interested persons.

The next step would then be to carry out such remedial or corrective action. If the remedial or corrective action is demonstrated to be successful, then the project would revert back to Phase 2 - Tier 1 monitoring. Alternatively, if monitoring data indicate that the remedial action was unsuccessful in reducing fish tissue concentrations or downstream loading, the permitting authority and the permittee would then initiate a peer-reviewed, scientific assessment of the benefits and risks of the project.

3. Phase 3 - Operational Monitoring

3.1 Phase 3 - Tier 1: Routine Operational Monitoring from Year 4 to Year 9

If after the first three years of monitoring neither downstream loading nor residue levels in fishes exceed action levels in the preceding two years, then (1) surface water sampling would be discontinued, (2) frequency of mosquitofish collection would be reduced to semiannually, and (3) frequency of large-bodied fish collection would be reduced to one collection event every three years. If not met within the first three years, criteria would be re-evaluated annually based on preceding two-year period.

3.2 Phase 3 - Tier 2: Expanded Monitoring and Risk Assessment

Phase 3-Tier 2 is triggered if one of the following action levels is exceeded during operation:

- If annual average THg levels in mosquitofish progressively increased over time (i.e., two or more years) or any (semi-annual) mosquitofish composite exceeds the 90% upper confidence level of the basin-wide annual average or, if basin-specific data are lacking, exceeds the 75th percentile concentration for the period of record for all basins; or
- If triennial monitoring of large-bodied fish (i.e., in years 6 and 9) reveals tissue Hg levels in fishes have statistically increased progressively over time (i.e., two or more years) or have become elevated to the point of exceeding the 90% upper confidence level of the basin-wide annual average or, if basin-specific data are lacking, exceeded the 75th percentile concentration for the period of record for all basins.

3.3 Phase 3 - Tier 3: Routine Operational Monitoring After Year 9

On the other hand, if fishes collected under Phase 3 Operational Monitoring have not exceeded action levels by year 9, project-specific monitoring would be discontinued; future assessments would be based on regional monitoring under RECOVER. However, Project Managers are cautioned that action levels may be revised at a future date.

CONTRACTOR SELECTION CRITERIA

Given the inherent difficulties of ultra-trace monitoring, it is crucial that any contractor selected to carry out field collection has demonstrated prior performance or be trained by District staff and has a stringent quality assurance/quality control (QA/QC) program in place. Likewise, the analytical lab must also demonstrate prior performance in ultra-trace analysis, have a stringent QA/QC program (including inter-laboratory comparisons) and be capable of achieving desired method detection limits.

REPORTING REQUIREMENTS

The District shall submit an annual report to the permitting authority that summarizes the most recent data and compares them with the cumulative results from previous years. This report shall also evaluate assessment performance measures (i.e., action levels) outlined above.

CONTACTS

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