

**BANANA LAKE SEDIMENT  
INACTIVATION PROJECT  
Polk County Contract #06-267**

**PRE- & POST-TREATMENT  
MONITORING PLAN**

**June 2007**

**Prepared For:**

**Polk County  
Natural Resources Division**

**Prepared By:**



**Environmental Research & Design, Inc.  
3419 Trentwood Blvd., Suite 102  
Orlando, FL 32812**

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## **1. Introduction**

### **1.1 Site History**

Banana Lake is a 242-acre waterbody located in unincorporated Polk County, south of the City of Lakeland and west of Lake Hancock. A location map for Banana Lake is given on Figure 1. Banana Lake outfalls to Banana Creek which discharges into Lake Hancock, Saddle Creek, and ultimately into the Peace River. The drainage basin for Banana Lake is largely urbanized and includes much of the City of Lakeland. Also included in this evaluation is Stahl Lake, a 30.6-acre waterbody located northwest of Banana Lake and connected to Banana Lake by a navigable channel.

During January 2006, a report was issued by Environmental Research & Design, Inc. (ERD) titled “Banana Lake Sediment Characterization and Inactivation Study” which summarized the results of field monitoring and laboratory analyses to evaluate sediment characteristics in Banana Lake and Stahl Lake. Sediment samples were collected at a total of 47 sites in Banana Lake and Stahl Lake, and the 0-10 cm layer was carefully sectioned off for further analyses. The physical and chemical characteristics of the collected sediment samples were quantified, and a speciation process was conducted to evaluate the potential for internal recycling of phosphorus from sediments into the overlying water column. This analysis indicated that approximately 39% of the existing total phosphorus within the sediments of Banana Lake and Stahl Lake is potentially available for release into the overlying water column. Based upon an aluminum:phosphorus (Al:P) ratio of 2:1, a total of 3,767,018 moles of aluminum is required for sediment inactivation in Banana Lake and Stahl Lake. This quantity of aluminum will be provided using a combination of alum and sodium aluminate to provide sediment inactivation and pH buffering within the water column.

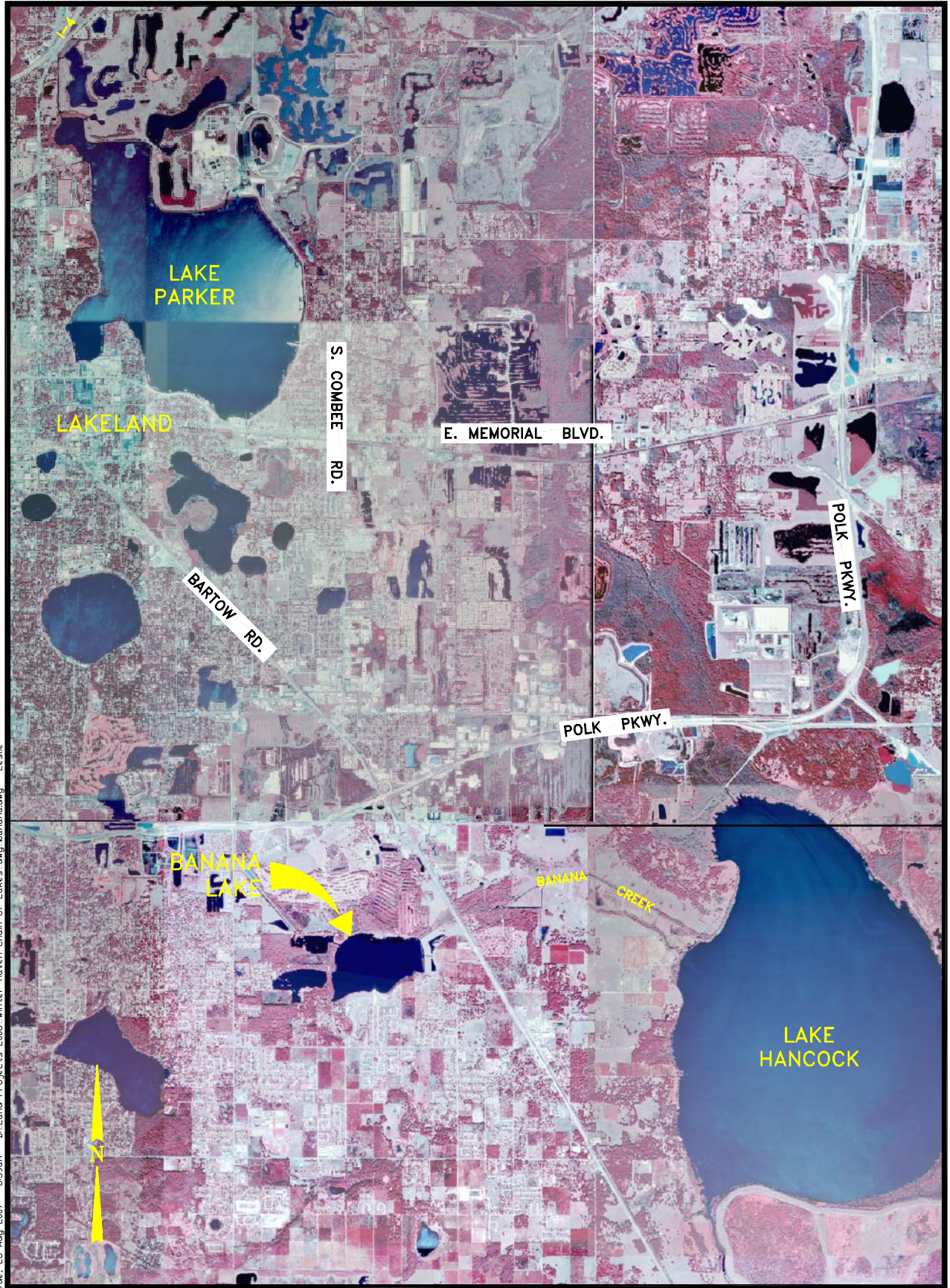
### **1.2 Summary of Historical Data**

Over the past several decades, Banana Lake has been characterized by elevated levels of total phosphorus, chlorophyll-a, and total nitrogen, combined with poor water column clarity. According to the Polk County Water Atlas, the historic average Trophic State Index (TSI) for Banana Lake from 1984-2005 is 83.7, indicating hypereutrophic conditions. Phosphorus release and recycling from nutrient-rich sediments is thought to be a contributing factor to the ongoing poor water quality characteristics within the lake. An aerial overview of Banana Lake and Stahl Lake is given in Figure 2.

### **1.3 Purpose of This Project**

The objective of this project is to reduce internal phosphorus loading to Banana Lake from existing sediments, improving water quality and reducing downstream loadings to Lake Hancock, Saddle Creek, and the Peace River. The appropriate alum dose has been determined by measuring the available phosphorus concentration in the upper 10 cm of the lake’s sediments. The required ratio of alum and sodium aluminate to maintain pH levels greater than 6.0 will be determined by jar testing. This reduction of internal phosphorus loading is being considered at this time because many other sources of phosphorus to the lake, including historical point source inputs, have been eliminated or treated in some way.





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Figure 1. Location Map for Banana Lake.



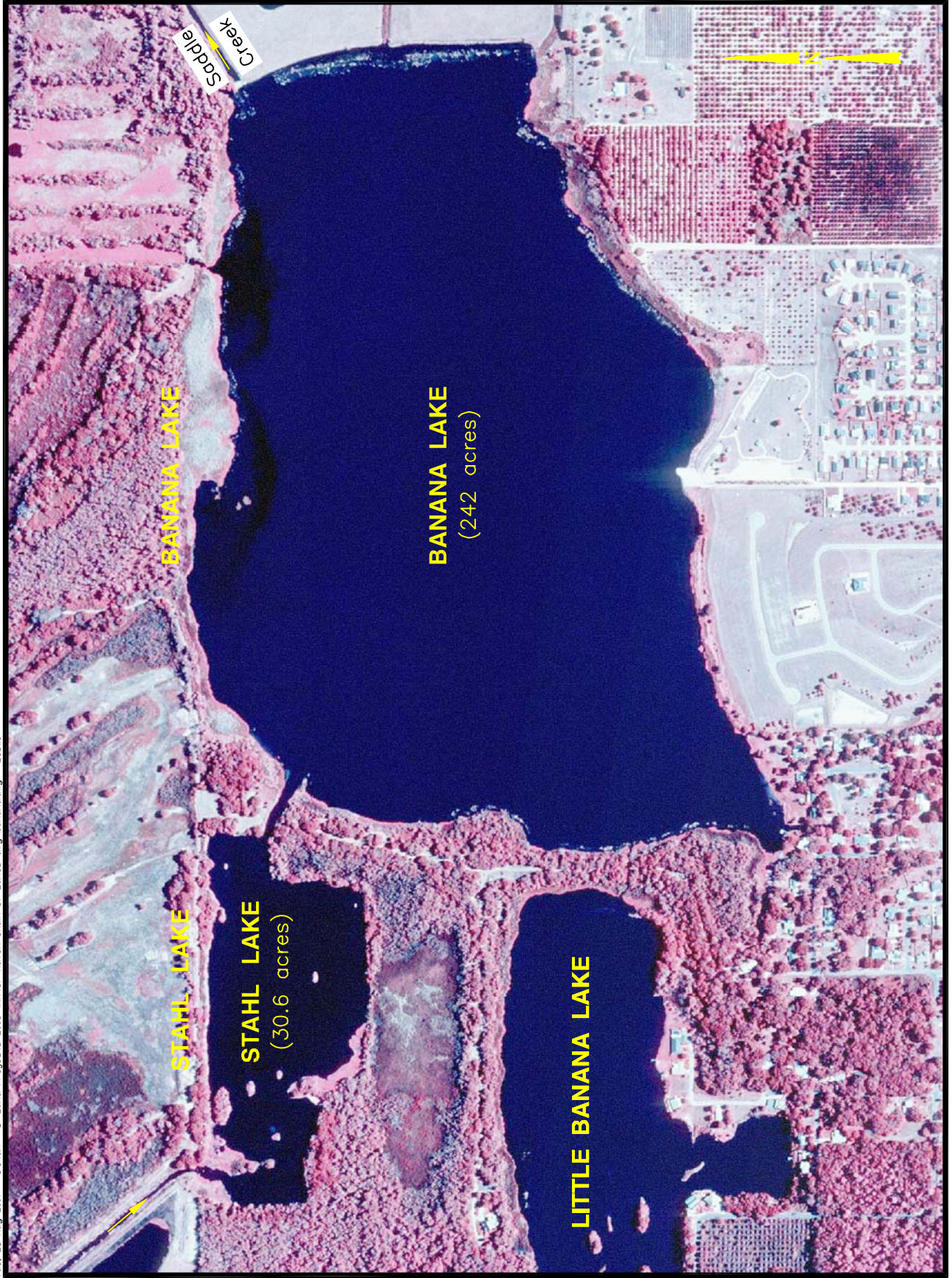


Figure 2. Overview of Banana Lake and Stahl Lake.

Aluminum sulfate ( $\text{Al}_2\text{SO}_4$ ), commonly referred to as alum, will be used to deactivate the phosphorus contained in the upper layers of the sediments in Banana Lake and Stahl Lake. Aluminum binds phosphorus very tightly under both aerobic and anaerobic conditions, and forms an inert floc that eventually becomes incorporated into the lake sediments. The appropriate alum dose will be determined by measuring the phosphorus concentration in the upper 10 cm of the lake's sediments.

This document provides details of pre- and post-treatment monitoring to be performed in Banana Lake by ERD as part of the Banana Lake Sediment Inactivation Project. The proposed monitoring includes surface water quality monitoring, benthic monitoring, and sediment sampling. All field monitoring activities will follow guidelines outlined in DEP-SOP-001/01, Standard Operating Procedures for Field Activities, dated February 1, 2004.

## **2. Project Schedule and Scope of Work**

The Scope of Work for this project provides a summary of pre- and post-treatment monitoring to be performed in Banana Lake by ERD as part of the Banana Lake Sediment Inactivation Project. The proposed monitoring activities include surface water quality monitoring and sediment sampling. Sediment sampling will be conducted at 47 sites within Banana Lake and Stahl Lake to establish pre-treatment sediment characteristics and to quantify the available phosphorus concentrations within the sediments of the lakes. This information will be used to determine the appropriate alum dose necessary for inactivation of sediment phosphorus release. The alum application will be divided into two separate treatments to minimize potential impacts. Pre- and post-treatment water quality monitoring will be conducted in Banana Lake and Stahl Lake for each of the two treatments. Measurements of field parameters and collection of surface water samples for laboratory analyses will be performed near the geographic center of each lake for both pre- and post-monitoring events. Each of the collected surface water samples will be analyzed for general parameters, nutrients, chlorophyll-a, and aluminum.

The beginning date for this project, based upon the contract executed between ERD and Polk County, is December 20, 2006. The projected ending date for this project is September 2007.

## **3. Project Organization**

Sample collection activities will be conducted by Environmental Research & Design, Inc. The laboratory analytical work will also be performed by Environmental Research & Design, Inc. An organizational chart for this project is given in Figure 3 which identifies responsible parties for field and analytical activities associated with this project.



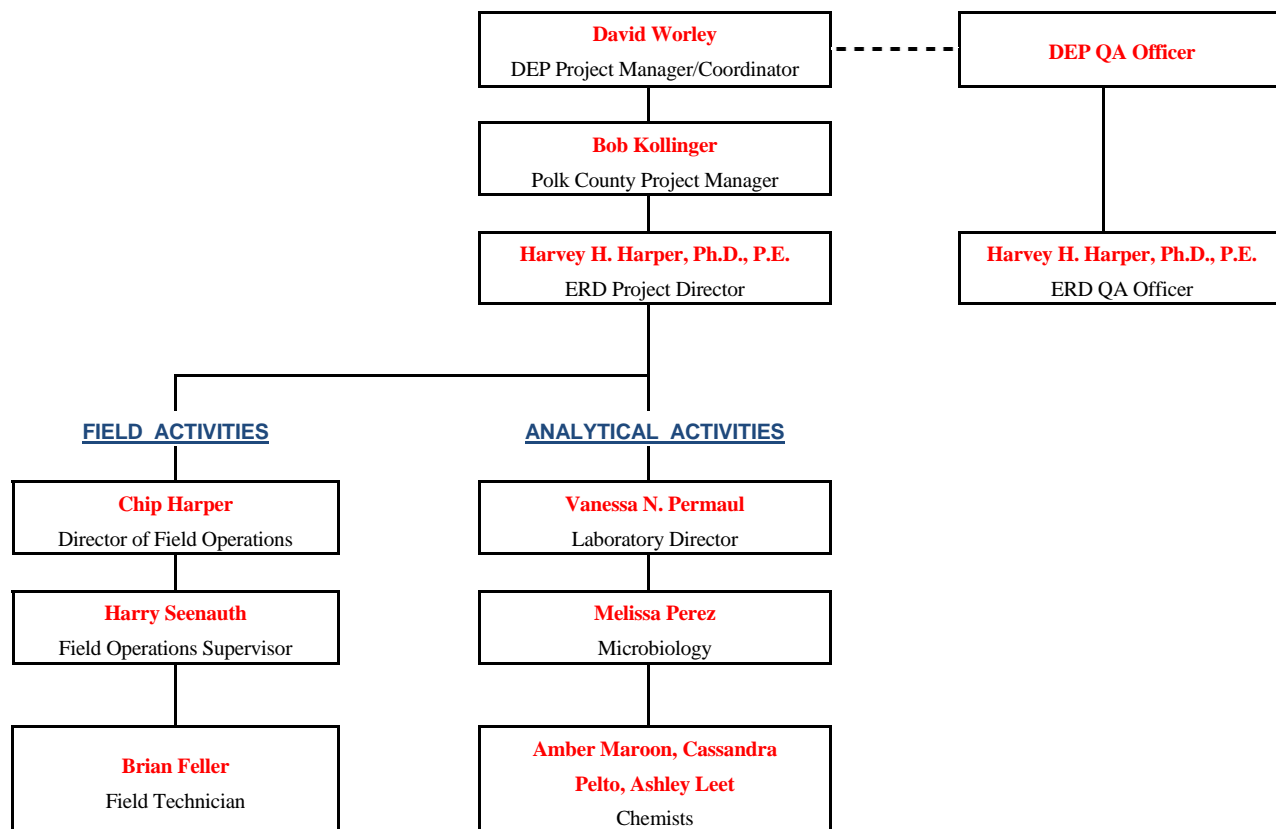


Figure 3. Project Organization.

## 4. Monitoring Methodology

### 4.1 Description of Field and Sample Collection Activities

#### 4.1.1 Surface Water

Pre- and post-treatment surface water samples will be collected near the geographic center of Banana Lake and Stahl Lake. A map showing the location of the monitoring sites in Banana Lake and Stahl Lake is given in Figure 4. Collection of surface water samples will be conducted by ERD. Sample acquisition will occur using a 12V portable peristaltic pump following procedures outlined in DEP-SOP, Section 4.2.3.3 – Sample Acquisition. One surface water sample will be collected at a water depth equal to one-half of the Secchi disk depth, and another at approximately 0.5 m from the lake bottom at each site. All samples will be placed in low-density polyethylene (LDPE) sample containers as appropriate for the parameters to be analyzed. Collected samples will be preserved in the field, placed on ice, and returned to the ERD laboratory where each of the samples will be analyzed for general parameters, nutrients, chlorophyll-a, and aluminum.





Measurements of pH, dissolved oxygen, water temperature, specific conductivity, and oxidation/reduction potential (ORP) will be performed at each site using a Hydrolab Data Sonde 4a water quality monitor with measurements beginning 0.25 m and 0.5 m below the water surface and extending at 0.5 m intervals through the water column to the bottom. Measurements of Secchi disk depth (water column transparency) will also be conducted at each monitoring location. Pre- and post-calibration will be performed and documented on the Hydrolab unit for each day of use based on the manufacturer's instructions. Visual observations of water clarity, weather conditions and any noticeable water quality problems will be recorded for each site.

#### **4.1.2 Sediment Characterization and Speciation Sampling Procedures**

Sediment samples will be collected at 47 monitoring sites using a stainless steel split-spoon core device which will be penetrated into the sediments at each location to a minimum distance of approximately 0.5 m. After retrieval of the sediment sample, any overlying water will be carefully decanted before the split-spoon device is opened to expose the collected sample. Visual characteristics of each sediment core sample will be recorded, and the 0-10 cm layer will be carefully sectioned off and placed into a polyethylene container for transport to the ERD laboratory. Duplicate core samples will be collected at each site, and the 0-10 cm layers combined together to form a single composite sample for each of the 47 monitoring sites. The polyethylene containers utilized for storage of the collected samples will be filled completely so no air space is present in the storage container above the composite sediment sample. Each of the collected samples will be stored on ice and returned to the ERD laboratory for physical and chemical characterization. Approximate locations for the sediment collection sites are indicated on Figure 4. After return to the ERD Laboratory, each of the 47 collected sediment core samples will be analyzed for a variety of general parameters, including moisture content, organic content, sediment density, total nitrogen, and total phosphorus.

In addition to general sediment characterization, a fractionation procedure for inorganic soil phosphorus will be conducted on each of the 47 collected sediment samples. The modified Chang and Jackson Procedure, as proposed by Peterson and Corey (1966), will be used for phosphorus fractionation. The Chang and Jackson Procedure allows the speciation of sediment phosphorus into saloid-bound phosphorus (defined as the sum of soluble plus easily exchangeable sediment phosphorus), iron-bound phosphorus, and aluminum-bound phosphorus. Although not used in this project, subsequent extractions of the Chang and Jackson procedure also provide calcium-bound and residual fractions.

Saloid-bound phosphorus is considered to be available under all conditions at all times. Iron-bound phosphorus is relatively stable under aerobic environments, generally characterized by redox potentials greater than 200 mv ( $E_h$ ), while unstable under anoxic conditions, characterized by redox potential less than 200 mv. Aluminum-bound phosphorus is considered to be stable under all conditions of redox potential and natural pH conditions. A schematic of the Chang and Jackson Speciation Procedure for evaluating soil phosphorus bounding is given in Figure 5.

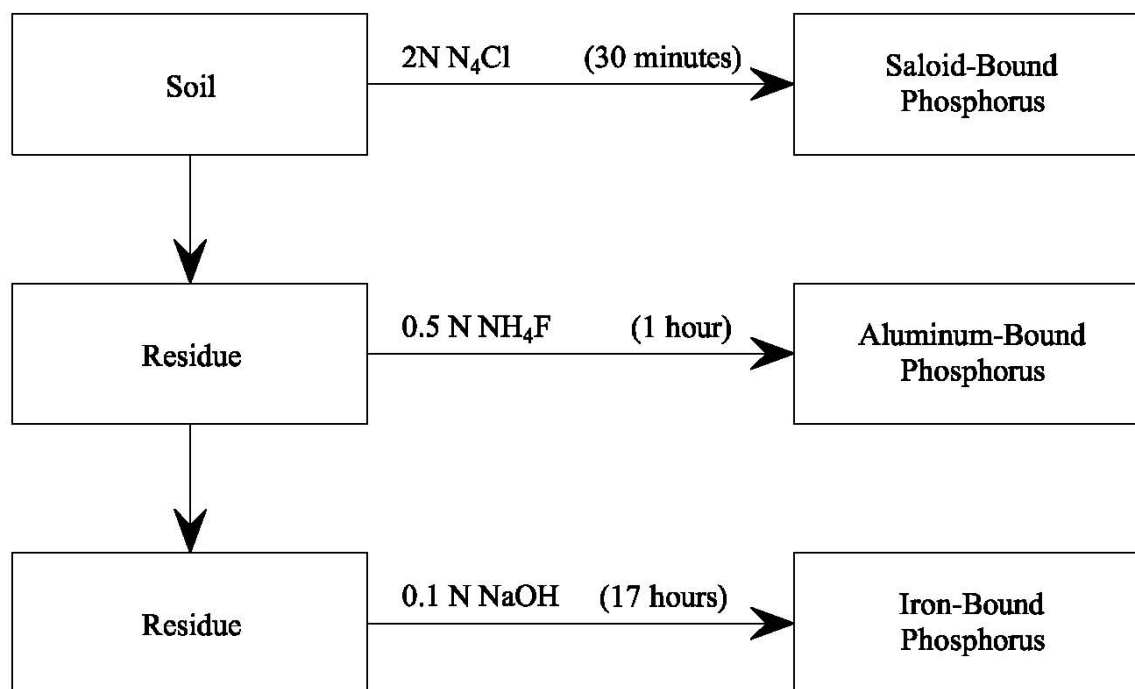


Figure 5. Schematic of Chang and Jackson Speciation Procedure for Evaluating Soil Phosphorus Bonding.

For purposes of evaluating release potential, ERD typically assumes that potentially available inorganic phosphorus in soils/sediments, particularly those which exhibit a significant potential to develop highly reduced conditions below the sediment-water interface, is represented by the sum of the soluble inorganic phosphorus and easily exchangeable phosphorus fractions (collectively termed saloid-bound phosphorus), plus iron-bound phosphorus, which can become solubilized under reduced conditions. Aluminum-bound phosphorus is generally considered to be unavailable in the pH range of approximately 5.5-7.5 under a wide range of redox conditions.

The results of the sediment speciation will be used to develop an isopleth map of available sediment phosphorus in Banana Lake and Stahl Lake. Areas within each of the isopleths will be integrated to generate an estimate of the total available phosphorus in the 0-10 cm sediment layer. Using an Al:P ratio of 2:1, the amount of alum required for inactivation of sediment phosphorus release will be calculated, and the alum volume will be divided by the lake volume to estimate the whole-lake water column dose of aluminum resulting from addition of the required alum volume.



Using the dose of alum calculated from the sediment sampling, laboratory jar testing will be conducted on a composite lake water sample to ensure that the lake water pH does not depress below a value of approximately 6.0 following alum addition. A composite lake water sample will be generated by collecting and combining composite lake water samples collected at three separate locations in Banana Lake and one location in Stahl Lake. Each composite lake water sample will be collected as a vertical depth composites with sub-samples collected at 0.5 m intervals to form the single composite samples for use in laboratory testing. Alum will be added to the composite lake water sample at three separate alum doses which bracket the dose calculated (75% of dose, 100% of dose, and 125% of dose), with the pH being measured at 1 minute, 1 hour, and 24 hours (4 samples total, including 1 raw and 3 treated). This testing will be used to establish the appropriate ratio for alum and sodium aluminate during the treatment.

#### 4.2 Field Collection Methods and References

All operating procedures for field activities will adhere to standard operating procedures outlined in *DEP-SOP-001/01, Standard Operating Procedures for Field Activities*, dated February 1, 2004. These activities will include procedures for equipment cleaning/decontamination, collection methods and references, and analytical methods and detection limits for field measurements.

A summary of field equipment cleaning/decontamination procedures is given in Table 1. All proposed field monitoring activities and equipment used for this project are listed, along with construction materials and cleaning methods referenced from Section FC1000. Cleaning and construction references are provided for peristaltic sampling pumps, analyte-free water containers, ice chests, Hydrolab data sondes, split-spoon sampler, and Secchi disk. All field equipment shall be pre-cleaned prior to on-site arrival at the monitoring location.

**TABLE 1**

#### **FIELD EQUIPMENT CLEANING / DECONTAMINATION PROCEDURES**

| <b>MONITORING ACTIVITY</b>                            | <b>EQUIPMENT USED</b>         | <b>CONSTRUCTION MATERIAL</b>          | <b>CLEANING METHOD<sup>1</sup></b> |
|-------------------------------------------------------|-------------------------------|---------------------------------------|------------------------------------|
| Surface Water Sample Collection                       | 12V portable peristaltic pump | Pump: SS and plastic<br>Tubing: Tygon | Pump: FC 1132<br>Tubing: FC 1160   |
| Analyte-Free Water for Equipment Blanks               | LDPE container                | LDPE                                  | FC 1180                            |
| Sample Transport                                      | Plastic ice chest             | Plastic                               | FC 1190                            |
| Field Measurements of pH, D.O., Cond., Temp., and ORP | Hydrolab Data Sonde           | HDPE, SS                              | Per Manufacturer's Specifications  |
| Collection of Sediment Samples                        | Split-spoon sampler           | SS                                    | FC 1131                            |
| Water Column Transparency                             | Secchi Disk                   | Plastic with fiberglass tape          | FC 1132                            |
| Field Filtration (SRP)                                | Plastic syringe               | HDPE                                  | FC 1132                            |

1. Based on protocol outlined in *DEP-SOP-001/01, Standard Operating Procedures for Field Activities*, dated February 1, 2004.

A summary of field collection methods and references for proposed field monitoring activities is given in Table 2. Specific references for collection/sampling are provided for surface water sample collection, sediment cores, measurements of Secchi disk depth, and collection of in-situ measurements of pH, temperature, dissolved oxygen, conductivity, and ORP. A summary of analytical methods and detection limits for field analyses is given in Table 3.

**TABLE 2**  
**FIELD COLLECTION METHODS AND REFERENCES**

| MONITORING ACTIVITY             | EQUIPMENT USED                | COLLECTION/SAMPLING REFERENCE <sup>1</sup> |
|---------------------------------|-------------------------------|--------------------------------------------|
| Surface Water Sample Collection | 12V portable peristaltic pump | FS 2100, par. 1.2.3                        |
| Sediment Core Samples           | Split-spoon core sampler      | FS 4000, par. 3.7                          |
| pH                              | Hydrolab Data Sonde           | FT 1000 (General Requirements)<br>FT 1100  |
| Temperature                     | Hydrolab Data Sonde           | FT 1000 (General Requirements)<br>FT 1400  |
| Dissolved Oxygen                | Hydrolab Data Sonde           | FT 1000 (General Requirements)<br>FT 1500  |
| Conductivity                    | Hydrolab Data Sonde           | FT 1000 (General Requirements)<br>FT 1200  |
| ORP                             | Hydrolab Data Sonde           | FT 1000 (General Requirements)<br>FT 2100  |
| Field Filtration                | Acrylic syringe filter        | FS 2000, par. 1.3                          |

1. Based on protocol outlined in *DEP-SOP-001/01, Standard Operating Procedures for Field Activities*, dated February 1, 2004.

**TABLE 3**  
**ANALYTICAL METHODS AND DETECTION LIMITS FOR FIELD ANALYSES**

| MEASUREMENT PARAMETER               | METHOD                                                    | LOCATION | METHOD DETECTION LIMITS (MDLs) <sup>1</sup> |
|-------------------------------------|-----------------------------------------------------------|----------|---------------------------------------------|
| Hydrogen Ion (pH)                   | EPA-83 <sup>2</sup> , Sec. 150.1/Manf. Spec. <sup>3</sup> | Field    | N/A                                         |
| Temperature                         | EPA-83, Sec. 170.1/Manf. Spec.                            | Field    | N/A                                         |
| Dissolved Oxygen                    | SM-19 <sup>4</sup> Sec. 4500-O G.                         | Field    | 0.2 mg/l                                    |
| Specific Conductivity               | EPA-83, Sec. 120.1/Manf. Spec.                            | Field    | 0.3 µmho/cm                                 |
| Oxidation/Reduction Potential (ORP) | Manf. Spec.                                               | Field    | N/A                                         |

1. MDLs are calculated based on the EPA method of determining detection limits.
2. *Methods for Chemical Analysis of Water and Wastes*, EPA 600/4-79-020, Revised March 1983.
3. Subject to manufacturer's specifications for test equipment used.
4. *Standard Methods for the Examination of Water and Wastewater*, 19th Ed., 1995.

Details concerning allowable materials for collection containers, field preservation techniques, and sample holding times are included in the attached Quality Management Plan for ERD (Section 6.5). Procedures for handling wastes from equipment cleaning and from sampling are also discussed in the above-referenced Plan (Section 6.8).

## **5. Laboratory Procedures and Quality Control**

### **5.1 Laboratory Activities**

All laboratory analyses associated with this project will be performed by Environmental Research & Design, Inc. The ERD Laboratory is certified by the Florida Department of Health, Bureau of Laboratories (E93351).

A listing of proposed samples, matrices, and analytical methods for this project is given in Table 4. This table provides a summary of the frequency of sample collection, the number of samples to be collected, quality control summary, analytical methods, and quality assurance targets, based upon information contained in the ERD Quality Management Plan.

A summary of analytical methods for sediment analyses is given in Table 5, based upon information contained in the ERD Quality Management Plan.

### **5.2 Quality Control**

A discussion of routine quality control checks utilized by ERD is given in Section 11 of the attached Quality Management Plan. The specific types of laboratory control checks that will be used when analyzing samples for this project are summarized in Table 6.

### **5.3 Quality Assurance Management**

#### **5.3.1 Corrective Actions**

In addition to corrective actions cited in the attached Quality Management Plan, all involved parties will initiate any corrective action deemed necessary by DEP.

#### **5.3.2 Performance and Systems Audits**

##### **5.3.2.1 Field Activities**

Specific audits planned for this project are:

| <u>Audit Type</u> | <u>Frequency/Date</u> | <u>Description</u>                                                                                  |
|-------------------|-----------------------|-----------------------------------------------------------------------------------------------------|
| 1. System         | Initially             | Evaluate system components for proper selection and use                                             |
| 2. Performance    | Quarterly             | Evaluate field operations, field decontamination, documentation, field measurements, log-in, blanks |





**TABLE 5**  
**ANALYTICAL METHODS**  
**FOR SEDIMENT ANALYSES**

| MEASUREMENT PARAMETER             | SAMPLE PREPARATION            | ANALYSIS REFERENCE | REFERENCE PREP./ANAL. | METHOD DETECTION LIMITS (MDLs) |
|-----------------------------------|-------------------------------|--------------------|-----------------------|--------------------------------|
| pH                                | EPA 9045                      | EPA 9045           | 3 / 3                 | 0.01 pH units                  |
| Moisture Content                  | p. 3-54                       | p. 3-58            | 1 / 1                 | 0.1%                           |
| Organic Content (Volatile Solids) | p. 3-52                       | pp. 3-59 to 3-60   | 1/ 1                  | 0.1%                           |
| Total Phosphorus                  | pp. 3-227 to 3-228 (Method C) | EPA 365.4          | 1/ 2                  | 0.005 mg/kg                    |
| Organic Nitrogen                  | p. 3-201                      | pp. 3-201 to 3-204 | 1/ 1                  | 0.010 mg/kg                    |
| Specific Gravity (Density)        | p. 3-61                       | pp. 3-61 to 3-62   | 1/ 1                  | NA                             |

References:

1. *Procedures for Handling and Chemical Analysis of Sediments and Water Samples*, EPA/Corps of Engineers, EPA/CE-81-1, 1981.
2. *Methods for Chemical Analysis of Water and Wastes*, EPA 600/4-79-020, Revised March 1983.
3. *Test Methods for Evaluating Solid Wastes, Physical-Chemical Methods*, Third Edition, EPA-SW-846, Updated November 1990.

**TABLE 6**  
**LABORATORY QUALITY CONTROL CHECKS**

| AREA                          | QUALITY CONTROL CHECKS TO BE PERFORMED | FREQUENCY                     |
|-------------------------------|----------------------------------------|-------------------------------|
| General Parameters, Nutrients | Reagent Blanks                         | 1/sample run                  |
|                               | Duplicate Samples                      | 1/10 samples                  |
|                               | Continuing Calibration Standards       | 1/sample run                  |
|                               | Matrix Spikes                          | 1/20 samples                  |
|                               | QC Check Samples                       | 2 times/year                  |
|                               | QC Check Standards                     | Beginning and end of each run |
| Microbiology (chlorophyll-a)  | Duplicates                             | 1/10 samples                  |

### 5.3.2.2 Laboratory Activities

Specific audits planned for this project are:

| <u>Audit Type</u> | <u>Frequency/Date</u> | <u>Description</u>                                                 |
|-------------------|-----------------------|--------------------------------------------------------------------|
| 1. System         | Initially             | Evaluate measurement systems to determine proper selection and use |
| 2. Performance    | Each application      | Evaluate data for standards, spikes, duplicates and audit samples  |

### 5.4 Quality Assurance Reports

Project-specific QA Reports will be submitted to Polk County at the completion of the project.