APPENDIX A

Conceptual Model of Lake Okeechobee Internal Phosphorus Loading

1.1 Introduction to Internal Loading and Related Issues

This section presents a conceptual overview and model of internal loading in Lake Okeechobee, and how various processes may have influenced or could influence internal loading in the lake. The presentation of this model is motivated by the fact that internal loading is a rather complex phenomenon influenced by a variety of physical, chemical, and biological processes, and many readers may have difficulty understanding the selection of particular performance goals without further background. Thus, the objective of this conceptual model is to provide a simplified framework that (1) helps the reader understand how these various processes may function or interact specifically in Lake Okeechobee; and (2) establishes the basis for setting the goals and performance measures for the sediment management feasibility study. Note that the actual modeling of the various physical, chemical, and biological processes to evaluate how specific mitigative measures implemented in the lake will influence internal loading will involve a suite of far more detailed and complex mathematical models designed to address different aspects of the issue. The theoretical framework of the conceptual model is presented in Appendix III. Many of the conceptual issues presented in this model have been developed extensively by Havens et al. (2000) and Havens and Schelske (2000); rather than reproduce that work here, we have included both papers as appendices (Appendix I and II, respectively).

The basic objective of this study is to evaluate options to treat, remove, or manage the sediments in Lake Okeechobee in order to reduce internal loading fluxes of phosphorus and minimize the amount of time for the lake to respond to reductions in external loading. It is important to note that the only successful long-term strategy for lake restoration must include as its focal point reductions in the external loads of phosphorus to the lake. Without reductions in external inputs, mitigative measures to reduce internal fluxes of phosphorus will yield only short-term gains or improvements, and the lake ultimately will revert to its current eutrophied state. Indeed, mitigative measures to reduce internal loading in the absence of controlling external inputs may exacerbate the current trophic state of the lake. For example, Canfield and Hoyer (1988) observed that chlorophyll *a* and total phosphorus concentrations are uncorrelated, presumably because of light limitation imposed by high concentrations of resuspended sediment in the water column.

This role of light is supported both by work conducted by Havens (1994), who found that nutrients in Lake Okeechobee were not limiting to primary production during winter months when non-algal particles dominated light attenuation, and by irradiance growth studies conducted by Phlips et al. (1997) on waters collected from different regions in the lake. Thus, if corresponding reductions in external loading of phosphorus are not made concomitantly, mitigative measures such as dredging or capping that would reduce the flux of resuspended sediment in Lake Okeechobee may actually induce algal blooms that would be both more extensive and larger than in the past.

In general, internal loading refers to the resupply or recycling of phosphorus within the lake, principally from the sediments. Virtually all lakes function over long time scales as net sinks for phosphorus (i.e., lakes receive more phosphorus from external sources than they export). Depending on the form of the phosphorus entering the lake, it can initially be: (1) taken up directly by primary producers (soluble inorganic phosphorus); (2) metabolized in the water column by bacteria (labile organic phosphorus), and then taken up by primary producers; or (3) deposited in the sediments as organic and inorganic particulate phosphorus (see, for example, Rigler, 1975; Wetzel, 1975; Lampert and Sommer, 1997). Regardless of its initial fate, a significant fraction of the phosphorus entering the lake eventually is deposited in the sediments. This is because decomposition of organic matter is rarely wholly efficient or complete in mineralizing and releasing phosphorus. This deposited phosphorus continues to mineralize and, as a result, concentrations of dissolved inorganic phosphorus in the sediment porewaters can build up to concentrations several orders of magnitude in excess of dissolved inorganic phosphorus concentrations in the overlying water column. Internal loading results when phosphorus from this enriched pool is introduced into the water column, either through wind-wave induced resuspension of sediment particles containing comparatively high concentrations of exchangeable phosphorus, or through more passive exchange processes such as bioturbation (Figure 5; Appendix III).

Internal loading can be problematic if rates of resupply from the sediments are large relative to external inputs. In other words, the greater the relative degree of internal loading, the less efficient a lake is at trapping and permanently removing phosphorus from the water column. Thus, lakes with high relative rates of internal loading are comparatively more susceptible to eutrophication induced by a given phosphorus load than other lakes. Moreover, lakes with high internal loads also are less responsive to mitigative reductions in external inputs because the sediments serve as a large reservoir of phosphorus that

can continue to buffer and resupply phosphorus to the water column for many years (cf., Cooke et al., 1993; Rossi and Premazzi, 1990). This is often the case in lakes that are quite shallow, such as Lake Okeechobee. In shallow lakes, the sediments can often exert a more profound influence on water column phosphorus dynamics because wind-induced mixing and wave-induced sediment resuspension promote higher rates of exchange of phosphorus from sediments to the water column, and because the lower volume of water relative to sediment area within shallow lakes provides less capacity to buffer phosphorus fluxes from the sediments than do deeper lakes.

1.2 Conceptual Internal Loading Model of Phosphorus in Lake Okeechobee

As presented in Appendix III (cf., Equation [5]), the magnitude of the internal load is fundamentally dependent upon three variables:

1. The concentration of the mass of dissolved inorganic phosphorus in surficial sediment porewaters. This concentration in part establishes the magnitude of the concentration gradient across the sediment-water interface, $\P P/\P z$. It also is linked through adsorption-desorption kinetics to the magnitude of exchangeable phosphorus sorbed to sediment particles, thus directly influencing the effect of sediment-resuspension on phosphorus fluxes to the water column (both magnitude and direction of sorption – in other words, whether resuspended sediments behave as a source or a sink for phosphorus in the water column).
2. The rate of mass transfer of phosphorus across the sediment-water interface (e.g., via sediment resuspension, bioturbation, or diffusive exchange).
3. The areal extent of the sediments engaged in internal loading.

Thus, to the extent a process (e.g., physical, biological, or geochemical) occurring in the lake influences any or all of these variables, the internal load also is affected. These processes are described in detail in Table 1.

Processes that influence the concentration gradient relate primarily to those that influence the accretion of high concentrations of dissolved inorganic phosphorus in the sediment porewaters, including:

1. Increased rate of supply or deposition of organic matter to the sediments in response to increased total phosphorus loading to the lake. This increased rate of deposition directly results in higher porewater

phosphorus concentrations as the deposited organic matter decomposes and releases inorganic phosphorus into the porewater (Berner, 1980; Figure 6).

2. Changes in porewater chemical species such as calcium or iron that influence the solubility and/or sorption of inorganic phosphorus in the porewater. Within the sedimentary environment, a variety of competitive chemical reactions occur wherein other chemical species influence whether phosphorus is dissolved in porewaters or bound to solid phases (Stumm and Morgan, 1996; Olila and Reddy, 1997).
3. Increased saturation of sediment phosphorus sorption sites accompanying higher porewater concentrations (i.e., non-linear sorption such as Langmuir-type sorption [cf. Pollman, 1983]). Solid particles can only sorb a finite quantity of phosphorus, and once the sorption sites are occupied, dissolved phosphorus concentrations may increase significantly.
4. Changes in redox chemistry, in particular the presence of oxic versus anoxic conditions, accompanying increased organic matter deposition, resulting in solubilization of phosphorus previously bound to (in particular) iron precipitates (Moore and Reddy, 1994; Olila and Reddy, 1997; Moore et al., 1998; Figure 7).

   The redox cycle of iron in particular has long been recognized as playing a critical role on porewater phosphorus dynamics and the release of phosphorus from surficial sediments (Mortimer, 1941). Both iron and calcium concentrations are high in the calcareous sediments of Lake Okeechobee sediments. As a result, iron and manganese dissolution appears to release phosphorus during reducing conditions (Olila and Reddy, 1997), with calcium mineral formation governing the ultimate solubility of phosphorus (Moore and Reddy, 1994); during oxidizing conditions, iron phosphate mineral formation (Moore and Reddy, 1994) or sorption to ferric hydroxide may control phosphorus solubility.

Processes that influence the mass transfer coefficient are both physical and biological, and include:

1. Changes in the critical shear stress of the sediments, τ_c. Increased organic matter deposition likely will result in a reduction in the critical shear stress of the surficial sediments. Higher depositional rates typically cause a reduction in both the density of the sediment particles, and an increase in the water content of the sediments (cf. Håkanson and Jansson, 1983). Electrostatic interactions among sedimentary particles will likely change as well (i.e., due to lower clay content of the sediments), resulting in less cohesive sediments. These factors all promote sediment resuspension by wind-generated waves, effectively increasing the mass transfer coefficient.

2. Changes in the amount of wind-wave energy transmitted to the sediment-water interface. For example, Sheng (1993) demonstrated that resuspension flux of sediments is a function of the excess shearing stress generated by wind-wave induced currents; in other words, the resuspension flux can be calculated as an erosion constant times the difference between the bottom shear stress and the critical shear stress. Normally, when lake stage or depth increases, the amount of wind-wave energy transmitted to the sediment-water interface decreases, and less sediment resuspension occurs (Håkanson and Jansson, 1983). In Lake Okeechobee, however, one hypothesis holds that the extensive submerged aquatic macrophyte community that historically has occupied much of the western littoral zone of the lake has had an important role in stabilizing bottom sediments (by providing resistance to current velocities and shearing stresses), and that the integrity of this community is adversely impacted by high lake stage.
3. Changes in the benthic community. The activity of benthic invertebrates in surficial sediments has long been recognized as an important contributor to physical mixing and enhanced rates of exchange between porewater and the overlying water column (Figure 8). With increased deposition of organic matter, benthic invertebrate density generally increases. Changes in benthic invertebrate densities and the community structure both can alter the mass transfer coefficient.
4. Changes in the fish community with incipient eutrophication that lead to an increase in fish that consume the benthos. This predation is another form of physical mixing of the surficial sediments that can enhance the transfer of porewater phosphorus to the water column.

Processes that influence the areal extent of the sediments actively involved in internal loading include:

1. Changes in redox dynamics that could accompany changes in lake stage. Higher lake stages, theoretically at least, lead to the possibility of longer periods of stable thermal stratification, and a greater likelihood of sediments that normally would be oxic becoming anoxic, with concomitantly higher rates of sediment-water exchange. Whether this occurs in Lake Okeechobee and is significant has yet to be evaluated.
2. Increased loading of organic sediments, which contain higher concentrations of reactive phosphorus compared to inorganic sediments, and which promote higher concentrations of porewater phosphorus concentration.
3. An increase in the effective sediment deposition zone in the pelagic portion of the lake when lake stage is higher. As mentioned earlier, higher lake stage reduces the amount of wind-wave energy reaching

the bottom sediments. Thus greater areas in the pelagic zone of the lake become more favorable deposition areas compared to lake stage regimes when lake levels are lower. As a result, more of the lake area under high lake stage functions as a depositional zone for organic matter settling out of the water column, resulting in an increase in the internal load signal. During low lake stage regimes, these formerly "stable" depositional zones become erosional zones, the surficial organic matter is scoured, and deposition is focused in a smaller area.

Because of the nature and complexity of some of the process interactions, different models will be required to analyze different conceptual issues. For example, predictions on the effects of changing lake stage on sediment resuspension and particle transport into the littoral zone will require coupling two spatially complex models currently in use by the District, SWAN and the Lake Okeechobee Hydrodynamic and Transport Model (LOHTM, Figure 9). Likewise, evaluating the effect of changing calcium dynamics on porewater chemistry and dissolved inorganic phosphorus concentrations will require the application of a thermodynamic or chemical equilibrium model such as MINEQL+. Table 2 presents an overview and the relevant features of the various models that will be used in the analysis of sediment management alternatives. This information is provided to assist the reader in understanding how and why the models will be applied during the assessment of the goals and performance measures, which are presented in Section 3.

1.3 Application of Conceptual Model in Defining Performance Goals and Measures for Internal Phosphorus Loading

Performance goals and measures cannot be defined as a single number for reductions in internal loading (e.g., a 30 or 50% reduction) without specifying a reduction in the external load. This is because, without changing the fundamental morphometry of Lake Okeechobee, the rate of internal loading ultimately reflects the rate of external loading. For example, suppose a goal is set to reduce the internal load from 1.5 to 0.75 mg P/m^2-day. Assuming that the reduction in internal loading could indeed be achieved relatively rapidly, this desirable result or goal would not persist in the lake over the long-term without appropriate reductions in the areal external phosphorus loading rate ($J_{external}$), even if all the existing phosphorus in the sediment bed were completely removed. This is illustrated in Figures 10 and 11, which show predicted concentrations of total phosphorus in Lake Okeechobee under two different long-term loading regimes,

and how those time trajectories of predicted response vary if the initial sediment conditions are perturbed or altered as an instantaneous step function. Figure 10 shows the response for external loading conditions required (as estimated by the model used in the simulation) to produce a long-term concentration of phosphorus in the lake of 40 μg/L (an external load of 121 tonnes/year), while Figure 11 shows the response under the current estimated long-term loading rates (an external load of 496 tonnes/year). For both suites of simulations, the internal loading was effectively reduced by reducing the initial sedimentary total phosphorus concentration by varying degrees from 0 to 100%.

Examination of the results illustrate several points. First, for a given loading scenario, the long-term response is predicted to be the same regardless of the change in the initial internal loading rate (note that in both Figures 10 and 11 all the response lines eventually come together). Second, the timing of response for achieving steady state is different for the two scenarios because the long-term sediment accretion rates and turnover rate of phosphorus in the sediments ultimately reflect the long-term loading rate, and it is the turnover rate of phosphorus in the sediments which exerts such a profound influence on the overall response time of the lake. The third point is that a performance measure *could be established* in terms of response time towards a certain fraction of the target concentration of phosphorus in the lake water goal defined by the areal external phosphorus loading rate. This is illustrated in Figure 12, which plots the time to reach 90% of the target concentration of 40 μg/L from a current concentration of 108 μg/L as a function of the amount of the stepped reduction in the current sedimentary total phosphorus concentration. (90% is shown simply for illustrative purposes; any other fraction could be selected for this analysis. As the choice of fraction of the target goal approaches 100%, the time of response will increase; note also that the steady state concentration will be approached asymptotically with time.) Interestingly enough, this analysis, which was produced using the internal phosphorus loading model recently developed for Lake Okeechobee by Pollman (2000), illustrates that a breakpoint in "sediment load" reduction occurs between approximately 35 to 45% (the shaded "Transition Zone") where further reductions are not particularly effective in reducing the time scale of response, and where reductions less than this range do not optimize the effective change in response time relative to the amount reduction in the internal load. Response time for internal load reductions resulting from lesser amounts of removal (higher initial fraction) is governed predominantly by internal loading; response time for internal load reductions resulting from greater amounts of removal (lower initial fraction) is governed predominantly by lake hydraulic residence time coupled with the gross settling velocity of phosphorus in the lake, u_{settle}.

LAKE OKEECHOBEE CONCEPTUAL ECOSYSTEM MODEL

Model Lead: Karl E. Havens
South Florida Water Management District
Email: khavens@sfwmd.gov

INTRODUCTION

Lake Okeechobee is a large (1,730 km^2) freshwater lake located at the center of the interconnected south Florida aquatic ecosystem. The lake is shallow (average depth <3 m), originated about 6,000 years ago during oceanic recession, and under natural conditions probably was a slightly eutrophic and had vast marshes to the west and south. The southern marsh was contiguous with the Florida Everglades, which received water as a broad sheet flow from the lake during periods of high rainfall (Gleason 1984).

Modern-day Lake Okeechobee differs in size, range of water depths, and connections with other parts of the regional ecosystem (Figure 1) (Havens et al. 1996). Construction of the Herbert Hoover Dike in the early to mid-1900s reduced the size of the lake's open-water zone by nearly 30%, resulted in a considerable reduction in average water levels, and produced a new littoral zone within the dike that is only a fraction of size of the natural one. The lake also has been impacted in recent decades by excessive inputs of nutrients from agricultural activities in the watershed (Flaig and Havens 1995). These nutrients have exerted the most dramatic impacts on the open-water region, where large algal blooms have occurred, along with accumulation of soft organic mud bottom sediments, which cause the lake water to become highly turbid when they are resuspended during windy periods (Maceina and Soballe 1990). The littoral zone has been invaded by 15 species of exotic plants, most notably *Melaleuca quinquenervia* and *Panicum repens* (torpedo grass), which have expanded over large areas, displacing native plants. Despite these human impacts, and a consensus that the lake's overall health has been greatly degraded by human actions, Lake Okeechobee continues to be a vital aquatic resource of south Florida, with irreplaceable natural and societal values. It is anticipated that the CERP, along with other local and regional restoration efforts, will improve hydrologic conditions in the lake (Figure 1), and that this will lead to improvements in the ecological attributes of the system.

An ecosystem conceptual model was developed for Lake Okeechobee restoration planning purposes. This model indicates, *via* a simple box-and-arrow diagram (Figure 2) how various cultural stressors affect attributes of the ecosystem that are of value to nature and society. The model is comprised of a top-to-bottom hierarchy of sources, stressors, ecosystem effects, attributes, and performance measures. For each performance measure there is a quantitative target (a desired endpoint of CERP and other local/regional restoration efforts) and a suite of monitoring parameters. The model for Lake Okeechobee is complex because the lake is comprised of three distinct components that have dramatically different

structure and function: a littoral marsh, a near-shore region, and an open water (pelagic) region. Stressors in one zone may have indirect effects that cross the boundary into another. The lake conceptual model was developed in the context of this heterogeneity. The model also reflects the lake's present spatial extent, rather than the larger historical boundaries.

EXTERNAL DRIVERS AND ECOLOGICAL STRESSORS

Seven in-lake stressors that have strong impacts on the lake's natural and societal values originate from five distinct external sources (Figure 2). Elevated concentrations of **nitrogen and class I/III chemical contaminants**, including chloride (Cl^-) certain pesticides, and total dissolved solids (TDS), are by-products of agriculture or other human activities in the watershed. These contaminants may have detrimental effects in the ecosystem, but in general, are focused in particular locations (e.g., near input sources). A much greater concern, from the standpoint of ecosystem effects is the elevated level of **phosphorus**. High concentrations of this nutrient, which are largely responsible for the rapid eutrophication of the lake in the last two decades, are a result of excessive inputs from the watershed. The primary source of phosphorus pollution is agriculture, with lesser contributions from urban and other sources (Flaig and Havens 1995). As a result of decades of high inputs, the soils in the watershed, the sediments of tributaries, and the lake's bottom sediments now contain large quantities of phosphorus (Olila and Reddy 1993, Flaig and Reddy 1995). These soils and sediments represent large secondary sources of phosphorus loading to the lake. The deep canals of the C&SF Project facilitate delivery of phosphorus and other chemical stressors to the lake.

The pelagic region of Lake Okeechobee experiences elevated concentrations of **resuspended sediments**, whose source is a region of soft organic mud that covers about 50% of the central lake bottom. When wind mixes the shallow water column, the upper few cm of mud are resuspended. The spatial extent, depth, and phosphorus content of this mud have increased rapidly in the last 100 years, coincident with agricultural development and increased nutrient inputs from the watershed (Brezonik and Engstrom 1999). The Herbert Hoover Dike may facilitate sediment accumulation by preventing natural flushing that once may have occurred during high water events.

Variations in rainfall, evapotranspiration, water supply deliveries from the lake, and operation of the C&SF Project (including the regulation schedule, supply side management, and compliance with any Minimum Water Level criteria) have the potential to affect water levels (stage) in the lake. This becomes stressful to the ecosystem when there is **prolonged or extreme high or low lake stage**. The impacts of high and low stage are more severe than they would have been when the dike did not encircle the lake. Under natural conditions, water was able to expand and recede over a large low-gradient marsh to the west and south. Today, when lake stage exceeds 15 ft NGVD, water simply stacks up over the small littoral zone, flooding it to a greater depth. When lake stage falls below 11 ft, the entire littoral zone is dry, and lateral expansion is constrained to the east due to a relatively steep drop off in the lakes bottom contours. Hence, extreme high or low lake levels of any duration, or moderate high or low lake levels of prolonged (>12 months) duration, can cause significant harm to the ecosystem, as described below in greater detail. In contrast to the harmful effects of extremes, a certain degree of natural variation in lake stage, between 12 and 15 ft NGVD,

has been shown to be benefit the ecosystem (Smith et al. 1995; Smith 1997) and is a desired hydrologic result of the CERP.

In recent decades, Lake Okeechobee has experienced a rapid expansion of **exotic and nuisance plants** and the introduction and expansion of certain **exotic animals**. The plants have been the greatest concern to date. There now are 15 species of exotic plants in the lake's littoral zone. Species that have caused the most substantial harm are *Melaleuca* and torpedo grass (*Panicum repens*), which were purposely introduced to the region, for dike stabilization and cattle forage, respectively. Other exotic plants that have stressed the lake's values include *Hydrilla* sp., water hyacinth (*Eichhornia crassipes*), and water lettuce (*Pistia stratiotes*). Exotic animals in the lake now include fish (*Tilapia aurea)*, mollusks (*Corbicula fluminea*), and microinvertebrates (*Daphnia lumholtzii*). Each of these species exerts different impacts on the ecosystem, as discussed below. Many of these species have been accidentally introduced to the lake, and this situation is likely to continue, as new species are introduced to the United States and subsequently spread by boats and other mechanisms into Florida waters. Certain species known to have dramatic ecological and the ability to tolerate conditions in the lake impacts (e.g., the zebra mussel) should be monitored for presence / absence on a regular basis.

ECOLOGICAL ATTRIBUTES

The Conceptual Model working group identified four major attributes associated with the Lake Okeechobee ecosystem (Figure 2). The attributes encompass the overall ecological health of the lake, and they also reflect the quality of several societal uses of the resource, including fishing, drinking water quality, hunting, wildlife observation, and recreational boating. Two non-ecological attributes that are strongly linked with the lake, water supply and flood control, are not included as attributes in the conceptual ecosystem conceptual model. Those cultural attributes are reflected in models of the Lake Okeechobee Service Area and the Lower East Coast; both have their own set of performance measures, some of which reflect water supply from the lake and flood protection. In the Lake Okeechobee ecosystem conceptual model, they represent sources of high and low lake stage (ecological stressors) and are indicated as such.

The first attribute is **lake water quality**, which directly affects the quality of the habitat for vegetation, fish, and other wildlife. Poor water quality in the last two decades can be linked with reduced overall health of the biotic components of the ecosystem (Havens et al. 1996). Water quality in the lake also affects drinking water quality, and it can affect the health of downstream ecosystems (the St. Lucie and Caloosahatchee Estuaries and the Florida Everglades) that receive water from the lake. The second attribute is the lake's **fish and aquatic fauna.** Lake Okeechobee supports a commercial and recreational fishery that has an estimated economic value in excess of $480 million US dollars (Furse and Fox 1994). The fishery also supports a diverse community of birds and other animals. The third attribute of the lake is a diverse **native vegetation mosaic**. It provides nesting and foraging habitat for fish and other animals, areas of beauty for recreation, and the ability to mitigate poor water quality. This vegetation mosaic has been seriously degraded due to expansion of exotic plants in the littoral region and nearly a complete loss of submerged plant beds in the near-

shore region due to high water levels and turbidity. The fourth attribute is the lake's diverse community of birds and animals that includes **snail kites, wading birds, and water fowl**. The littoral zone of Lake Okeechobee provides one of the largest habitats in south Florida for the federally-endangered snail kite (Bennetts and Kitchens 1997), and it supports large resident and migratory populations of wading birds (Smith et al. 1995). A variety of migratory water fowl reside in the lake during winter, and the alligator population is one of the largest in the state of Florida.

ECOSYSTEM EFFECTS

The pathways linking cultural stressors to ecological attributes are complex (Figure 2), and have a solid foundation in research and modeling conducted by scientists at the SFWMD, Florida Fish and Wildlife Conservation Commission (FFWCC), and Florida public universities. As we learn more about how the ecosystem functions, it is possible that additional pathways could be added to the model, or adjustments made to existing pathways. The model is a flexible planning tool that, at any given time, reflects the current state of scientific knowledge about Lake Okeechobee. Ecosystem effects are described here in the context of sets of working hypotheses regarding how each identified attribute in the model is thought to be affected by the major ecosystem stressors.

LAKE WATER QUALITY

Water quality in Lake Okeechobee has been dramatically affected by nutrients associated with human activities in its watershed. Total phosphorus concentrations measured in the lake today (>100 ppb) are more than double those measured in the early 1970s, when the SFWMD first began to collect water quality data on a regular basis (James et al. 1995a). The high concentrations reflect a long history of excessive phosphorus inputs to the system (James et al. 1995b) and today, an internal load of phosphorus from the lake sediments approximately equals that of the external load in magnitude (Olila and Reddy 1993). Turbidity of the lake water also is high, especially in the central pelagic region, due to resuspension of sediment material from the lake bottom (Maceina and Soballe 1991, Hanlon et al. 1998). During times when lake stage is high (>15 ft) there appears to be substantial transport of turbid, phosphorus-laden water from mid-lake to the south and west shoreline areas (Maceina 1993, Havens 1997), where another water quality problem occurs -- the development of dense blooms of noxious cyanobacteria (blue-green algae). When these algae occur in high densities they can cause taste, odor, and trihalomethane problems for the five municipalities that draw water from the lake for drinking. When the blooms peak and then collapse, aquatic animal life is threatened because of reduced dissolved oxygen concentrations and decay products from the algae (Jones 1987, Paerl 1988).

In addition to phosphorus and its related water quality problems, Lake Okeechobee is considered impaired by the US Environmental Protection Agency based on its standards for dissolved oxygen, un-ionized ammonia, chlorides, coliform bacteria, and iron. From an ecosystem perspective, however, the major concerns are related to the excessive phosphorus levels and their direct and indirect effects. The following hypotheses describe the major factors considered to affect phosphorus dynamics in the lake.

Hypotheses and Predictions:

Hypothesis 1 - High rates of external phosphorus loading from tributaries and internal phosphorus loading from contaminated lake sediments are responsible for the high concentrations of phosphorus that occur in the water column of Lake Okeechobee.

The lake has experienced high rates of phosphorus loading from its watershed for many decades (SFWMD 1997). At present the loading is in excess of 600 metric tons/y, far greater than the amount considered appropriate by the USEPA (2000) or Florida Department of Environmental Protection (2000) to protect the ecosystem. When phosphorus enters the lake, a large fraction is stored in the lake sediments (James et al. 1995b). Due to the long history of high inputs, those sediments now contain over 30,000 metric tons of phosphorus in their upper 10 cm alone (Olila and Reddy 1993). This phosphorus can be mobilized into the overlying water column by various processes, including diffusion (Moore et al. 1998), wind re-suspension (Hanlon 1999), and bioturbation (Van Rees et al. 1996). This internal loading makes the lake ecosystem very resilient to changes in its phosphorus concentration when external inputs vary, a situation that is common in shallow eutrophic lakes (Sas 1989, Moss et al. 1996). From a management standpoint, this means that lake responses to load reductions based on the implementation of elements in CERP and the Lake Okeechobee Protection Plan are likely to occur with a long time lag. Eventually, however, phosphorus-rich surface sediments are expected to be covered by new sediment material with reduced phosphorus content. When this occurs, rates of internal loading should begin to decline.

Prediction - Watershed-scale treatment facilities (including large reservoirs and stormwater treatment areas) constructed under CERP and the Lake Okeechobee Protection Plan, along with enhanced phosphorus source control, will result in reduced rates of phosphorus loading to the lake. Given a sufficient period of time (perhaps decades or more), internal loading rates also will decline. The net result should be a decline in lake water phosphorus concentrations, but the timing of this response is uncertain.

Hypothesis 2 - H*igh lake stage results in conditions that exacerbate the problem of phosphorus pollution in the lake's water column.*

While it is clear that there is a link between stage and total phosphorus (Canfield and Hoyer 1988, Havens 1997), the underlying mechanisms may be complex, ranging from large-scale changes in the physics of water circulation to alterations in the interaction between biological communities. One of the first effects to be suggested (Maceina 1993) was that at high stage there is greater horizontal transport of phosphorus from the mid-lake region, where concentrations are highest due to the re-suspension of underlying mud sediment, into more phosphorus-deficient near-shore areas. The evidence for this hypothesis was largely observational, but it has been supported with results from the SFWMD Lake Okeechobee Hydrodynamic Model. The underlying mechanism is related to underwater currents and the morphology of the lake basin. When wind moves across the lake surface it creates large circulation gyres (Jin et al. 2000) whose spatial extent is affected by water depth. When lake stage is low (<13 ft), an elevated ridge of limestone along the south and west perimeter of the lake hinders mixing of water between the mid-lake and shoreline regions. This is thought

to reduce phosphorus and sediment transport to the shoreline region and be responsible, in part, for the low phosphorus concentrations and high transparency that occur there when stage is low (Maceina 1993, Havens 1997).

Another factor that may become important at low lake stage is uptake of phosphorus by submerged macrophytes. During years when stage is low, the lake can support a large spatial extent of submerged macrophytes (Hopson and Zimba 1993). For example, in 1989, after stage declined to below 11 ft, remote sensing indicated that submerged plants covered 12,400 ha of the lake bottom (Richardson and Harris 1995). In summer 2000, after a managed lake recession operation and a decline in stage to below 12 ft, the total extent of submerged plants determined from an intensive field survey was 17,700 ha.

Submerged macrophytes have the capability to reduce water column phosphorus concentrations by a number of processes. These include: (1) stabilization of lake sediments by their roots; (2) a reduction of water flow velocity and shearing stress on sediments due to wave attenuation (Vermaat et al. 2000); (3) trapping of sediment material; (4) direct uptake of phosphorus by roots in the sediments or from the water by epiphytic algae (Carrigan and Kalff 1982, Burkholder et al. 1990). In Florida lakes up to 96% of the combined water column and macrophyte phosphorus can occur in the tissues of macrophytes (Canfield et al. 1983).

Benthic micro-algae and *Chara*, a macro-alga, also can become abundant under low stage conditions in Lake Okeechobee (Steinman et al. 1997a,b), and these algae can directly compete for water column phosphorus with phytoplankton (Havens et al. 1996, Hwang et al. 1998). When lake stage is high, the growth of macrophytes and attached algae is suppressed due to light limitation caused by the deeper water and the high turbidity that accompanies greater materials transport from the mid-lake region. Hence lake stage can affect water column phosphorus concentrations by determining the relative mass of that nutrient that occurs in attached macrophytes and algae (high when lake stage is low) or phytoplankton (high when lake stage is high).

Prediction - When alternative water storage locations (ASR wells and regional storage reservoirs) are brought on line under CERP, it is predicted that there will be a reduced number of high lake stage events in Lake Okeechobee. This should directly benefit water quality in the lake, by providing conditions where there is both reduced horizontal transport of phosphorus into the shoreline area and increased growth of macrophytes and attached algae that can remove phosphorus from the water.

Hypothesis 3 - Biological and chemical changes that occurred in the lake due to cultural eutrophication have contributed to a "positive feedback" that helps maintain high phosphorus concentrations due to a lack of ecosystem assimilative capacity.

A phosphorus mass-balance for the lake indicates that every year, approximately 400 metric tons of that element is stored in lake sediments (James et al. 1995b). Hence the lake is described as a "net sink" for phosphorus. However, since the early 1970s, this internal storage of phosphorus has been declining (Havens and James 1997), suggesting that the lake's assimilative capacity is being used up. That might occur for example, if the binding

sites (calcium and iron minerals) on sediment particles became saturated with phosphorus. There is some evidence that this is occurring. Fisher et al. (2000) compared the concentrations of sediment pore-water phosphorus in samples collected from the lake in 1988 vs. 1998, and found that they had more than doubled. Pore-water phosphorus is unbound phosphorus that essentially is a surplus or non-assimilated fraction. At this point we assume that this increase in pore-water phosphorus reflects a reduction in binding sites, and hence a reduction in assimilative capacity. However, more research is needed to verify that the increase in pore-water phosphorus is not attributable to other factors, such as increased rates of phosphorus diagenesis.

If external phosphorus loading rates remain high, a further loss of sediment assimilative capacity might occur. On the other hand, this trend might be reversed after a period of substantially reduced loads.

Along with these chemical processes, there have been a number of biological changes in the lake that could reduce the system's capacity to assimilate phosphorus (Havens and Schelske 2000). In the lake's water column, diatoms have been replaced by cyanobacteria as the dominant phytoplankton (Cichra et al. 1995), and this could decrease the rate of phosphorus transport to sediments because cyanobacteria settle much slower than diatoms in the lake's water column (Reynolds 1984). Among the benthic macro-invertebrates, oligochaetes have replaced chironomids and other insect larvae as the dominant taxa (Warren et al. 1995), largely because they are able to tolerate the anoxic conditions that occur in the lake's enriched sediments (Warren et al. 1995). This macro-invertebrate trend may have resulted in a reduced net loss of phosphorus from the lake water because oligochaetes pump large quantities of soluble phosphorus from the sediments into the overlying water when they feed (Van Rees et al. 1996). Likewise, the lake's fish community contains a relatively large proportion of taxa that feed in the benthos, providing another pathway for upward phosphorus transport. There is a potential for reversal of these biological changes if phosphorus loads to the lake are substantially reduced.

Prediction - If projects implemented under CERP and the Lake Okeechobee Protection Act result in substantially reduced loads of phosphorus to the lake and lower water column phosphorus concentrations, there might be a reversal of physio-chemical and biological trends that have recently led to a low phosphorus assimilative capacity. If this occurs, lake assimilative capacity could increase, and might proceed more rapidly than presently anticipated.

Hypothesis 4 - Blooms of noxious cyanobacteria and their associated effects on water quality are a direct consequence of high phosphorus concentrations.

The relationship between cyanobacteria blooms and phosphorus enrichment has been well established in the literature (Horne 1979, Paerl 1988). In lakes with prolonged high rates of external loading, phosphorus often reaches concentrations where it is in surplus relative to algal demands. When this occurs, some other nutrient element (most often nitrogen) becomes "secondarily limiting" (Schelske 1984) to algal growth. Havens (1995) documented a trend in lake water quality indicative of a transition towards secondary nitrogen limitation

after the early 1980s, and Aldridge et al. (1995) and Phlips et al. (1997) documented that nitrogen now is the primary limiting factor for phytoplankton growth in the lake. In contrast, Brezonik et al. (1979) documented that there once was considerable phosphorus limitation. Nitrogen limitation favors dominance by bloom-forming cyanobacteria that can (1) remain buoyant in the water column, and (2) obtain nitrogen from the atmosphere by the process of nitrogen fixation (Horne 1977). Taxa that have this capacity include *Anabaena*, *Microcystis*, and *Aphanizomenon*; these taxa predominate in Lake Okeechobee when it experiences severe algal blooms.

Prediction - If projects carried out under CERP and the Lake Okeechobee Protection Plan result in reduced in-lake phosphorus concentrations, levels of surplus phosphorus may be reduced to the extent that phosphorus again becomes the nutrient most often limiting to phytoplankton growth. That condition would favor dominance of diatoms and other algae over cyanobacteria, resulting in a reduction in the frequency of algal blooms.

FISH AND AQUATIC FAUNA

Lake Okeechobee supports a nationally recognized sport fishery for largemouth bass (*Micropterus salmoides*) and black crappie (*Pomoxis nigromacultus*), as well as a commercial fishery for various catfish and bream (*Lepomis* spp.). According to Fox et al. (1993) these fisheries generate nearly $30 million per year for the local economies and they have an asset value that is in excess of $100 million (Bell 1987). Another estimate (Furse and Fox 1994) places the value of the fishery at more than $300 million, and considers only the recreational fish species.

In addition to the sport and commercial species, Lake Okeechobee supports a diverse community of fish, including (in total) 41 species (Bull et al. 1995, Havens et al. 1996b). These fish provide a food resource for wading birds, alligators, and other animals that use the lake as a foraging habitat. Fish use both the littoral and pelagic regions of the lake and some of the top predators (including largemouth bass and Florida gar, *Lepisosteus platyrhincus*) display a migration between the two habitats (Fry et al. 1999). Gut analysis and stable isotope data indicate that the fish depend on a wide range of food resources, including benthic macro-invertebrates and zooplankton (Havens et al. 1996b, Fry et al. 1999). These in turn are dependent on a continual input of energy in the form of plant, periphyton and phytoplankton primary productivity, and allochthonous inputs of carbon that can fuel bacterial growth. Fish also depend on the lake's aquatic plant communities to provide them with spawning habitat, to serve as a refuge from the environment and predators, and to support the complex food web described above (Fox et al. 1993).

As a result of human impacts on the lake, there have been dramatic changes in both the resource base that supports the fishery and the aquatic plant communities that provide fish habitat. These changes include eutrophication-related shifts in macro-invertebrate and plant community structure, and large-scale loss of certain plant community components due to stresses associated with high water. In fall 1999, scientists at the Florida Fish and Wildlife Conservation Commission (FFWCC) reported declines both in the population size and early age classes of important sport fish, a result that likely is related to some of the ecosystem

changes that recently have occurred. Other components of the lake's wildlife community (e.g., wading birds and migratory water fowl) also may have been affected by eutrophication and high-water related changes in the food web and habitat structure.

Hypotheses and Predictions:

The hypotheses presented here are closely linked with those provided under the sections of this document dealing with "native vegetation mosaic" and "snail kites, wading birds, and alligators." This reflects the tight linkage between these components of the lake's food web. The focus of this section is on fish and invertebrate animals. Hypotheses generally are related to particular regions of the lake (i.e., littoral, near-shore, and pelagic), although it is recognized that certain species migrate between these habitats.

Hypothesis 1 - The species composition, abundance, and biomass of benthic macro-invertebrate communities in the lake's pelagic region are primarily affected by the high rates of loading of nutrients and organic carbon to that region.

As a result of sustained high rates of nutrient loading and high rates of phytoplankton production, there has been a high rate of organic loading to the lake sediments, high rates of bacterial metabolism, and hypoxic or anoxic conditions in the near-surface sediments. These conditions collectively favor the dominance of "pollution tolerant" macro-invertebrates such as certain oligochaetes. Warren et al. (1995) documented that between the early 1970s and early 1990s, the relative abundance of oligochaetes increased in the pelagic sediments from 30 to 80% of the total community. This high relative abundance persisted during the last decade (Warren, personal communication), and species known to be pollution-tolerant (e.g., *Limnodrilus hoffmeisteri*) continued to be abundant. At the same time, species that previously occurred in the lake and still occur in nearby unpolluted lakes (various ephemeropterans and trichopterans), have become rare or absent in Lake Okeechobee. These trends are nearly identical to those observed in Lake Erie when it underwent rapid eutrophication between 1930 and 1960 (Carr and Hiltunen 1965).

The predominance of oligochaetes is a concern for two reasons. First, as mentioned above, they can contribute substantially to the internal loading of phosphorus. Second, they do not have an adult stage that emerges from the water (as occurs for ephemeropterans, trichopterans, and other aquatic insects), and therefore do not provide a food resource for animals that feed on such emergent forms. This includes migratory waterfowl and a variety of fish.

Prediction - If projects implemented under CERP and the Lake Okeechobee Protection Plan result in a substantial reduction in phosphorus loading to the lake, at some time in the future the surface lake sediments may be less enriched with nutrients and organic matter. If this occurs the sediments will be a more favorable habitat for a diverse benthic macro-invertebrate community, and the dominance of oligochaetes should decline. The timing and extent of this recovery are uncertain.

Hypothesis 2 - The biomass of zooplankton in the lake's open water region is controlled by

resource supply, while taxonomic composition is determined primarily by predation and temperature tolerance.

The zooplankton of Lake Okeechobee is comprised of 61 native and one exotic species (Havens et al. 1996b, Havens and East 1997), and includes rotifers, copepods, and sparse amounts of cladocerans. The total biomass correlates significantly with nutrient and chlorophyll concentrations (Crisman et al. 1995, Beaver and Havens 1996), suggesting resource limitation. This conclusion is supported by results of experimental nutrient-addition studies (Havens et al. 1996c). Havens and East (1996) also documented that the dominance of large cyanobacteria in the lake's phytoplankton community may contribute to resource limitation because the algae cannot be directly grazed by many of the lake's zooplankton. As a result, the major pathway for energy transfer to zooplankton involves multiple steps (phytoplankton → excreted organic carbon → bacteria → protozoa → zooplankton) and low ecological transfer efficiency (Havens et al. 2000). One reason this may occur is that the abundance of large cladoceran zooplankton, which can directly graze large algae at high rates, is very low in Florida lakes (Crisman and Beaver 1990).

Two factors may explain the absence of large cladocerans: (1) high rates of grazing by fish eliminates the largest most visible zooplankton taxa (large cladocerans); and (2) high water temperatures preclude the occurrence of cladocerans during all but the coolest months of the year. Both hypotheses are supported by experimental research on other lakes, as well as by work on Lake Okeechobee. Crisman and Beaver (1990) documented that in fish-free enclosures in the near-shore region of the lake, cladoceran biomass increased dramatically, and Beaver and Havens (1996) noted that the very high biomass of threadfin shad (*Dorosoma petenense*), a voracious zooplanktivore, should preclude occurrence of any large cladocerans. East et al. (1999) found that abundance of the native *Daphnia ambigua* is reduced dramatically during summer, when water temperatures are high, but *D. lumholtzi*, a tropical exotic, increases during that period. The exotic species also has large spines that may provide a greater defense against fish predation during summer months. Total zooplankton biomass generally is lower during mid-summer then in spring and fall in Lake Okeechobee and other Florida lakes.

Predictions - If projects implemented in CERP and the Lake Okeechobee Protection Plan result in reduced nutrient inputs to the lake and declines in phytoplankton and bacterial biomass, the total biomass of zooplankton might be expected to decline. However, this decline might be ameliorated by improvements in food quality (a shift from inedible cyanobacteria to edible diatoms). Effects of CERP on the taxonomic structure of zooplankton are uncertain because factors controlling this attribute may not be influenced by the project.

Hypothesis 3 - Macro-invertebrates in the near-shore region of the lake are strongly dependent on the habitat values provided by submersed and emergent macrophytes.

Under favorable conditions, near-shore macrophyte habitat, including *Hydrilla verticillata, Potamogeton illinoinsis* (peppergrass)*, Scirpus* sp. (bulrush) and *Vallisneria americana* (eelgrass) support a high biomass of macroinvertebrates (Warren and Vogel 1991). Many of

these mnacroinvertebrates, including the grass shrimp *Palaemonetes paludosus*, the amphipod *Hyalella azteca*, and larvae of the midge genera *Dicrotendipes, Glyptotendipes*, and Rheotanytarsus, are integral to the diets of largemouth bass, black crappie, redear sunfish (*Lepomis microlophus)*, and bluegill sunfish (*L. macrochirus*).

With the recent (1990s) declines in near-shore macrophytes, much of the habitat for invertebrates important in the diets of sport fish has been eliminated. In a June 2000 survey, Warren and Hohlt (FFWCC, unpublished data) recorded extremely low densities of invertebrates in habitats (bulrush and mud sediments) that formerly (1987-1991) supported high numbers. Scientists and members of the public who frequent the lake also noticed a near absence of winged adult midges emerging from the lake during summer 2000. As noted above, these kinds of changes have potential negative consequences for birds and fish that depend on immature and adult invertebrates as a food resource. The extent to which these communities recover as a result of low water levels (<12 ft) and increased macrophyte biomass in 2000 remains to be seen.

Prediction - If projects implemented in CERP result in a reduced frequency of prolonged and/or extreme high lake stage events, the near-shore bulrush community is likely to recover some of its previously greater spatial extent and density. When this occurs there should be a concomitant increase in the abundance of macroinvertebrates dependent upon submersed and emergent macrophyte habitats.

Hypothesis 4 - Macroinvertebrate community structure in the littoral zone is affected by variation in hydroperiod, distribution of plant communities, and dissolved oxygen concentrations.

Warren and Hohlt (1994) and Warren and Vogel (unpublished data) examined littoral macroinvertebrate community sturcture on *Eleocharis* sp. (spikerush), *Panicum repens* (torpedograss), *Pontaderia sp.,* bulrush, and *Typha* sp. (cattail). Because of their growth habits, the torpedograss, *Pontaderia* and cattail habitats were characterized by low dissolved oxygen concentrations and poor quality macroinvertebrate communities. Spikerush habitat had a more vertical growth form and lower production of thatch material, and was characterized by higher dissolved oxygen concentrations and a higher quality macroinvertebrate community.

Based on surveys conducted by the FFWCC, we also know that the littoral zone includes at least 174 macro-invertebrate taxa (Havens et al. 1996b), representing a wide range of functional and taxonomic groups. Analysis of fish gut contents and stable isotope studies reveal that macro-invertebrates represent important diet components for small forage fish and sport fish in the interior littoral zone (Havens et al., manuscript in prep.). Macro-invertebrates were found to account for >40% of the volumetric gut contents of redear sunfish, bluegill sunfish, largemouth bass, and bowfin (*Amia calva*) at a sampling site in Moonshine Bay, located in the west-central littoral zone.

One of the most visible members of littoral macro-invertebrate community, from a resource management perspective, is the Florida apple snail (*Pomacea paludosa*). This species is a principal food item for the federally endangered Everglades snail kite (*Rostramus sociabilis)* (Bennetts and Kitchens 1997), and it also is consumed by certain wading birds, migratory water fowl, turtles, and small alligators. As such, it is an important component of the littoral food web. Research dealing with apple snails in south Florida (Turner 1996, Darby et al. 1997) indicates that: (1) the most favorable habitat for these animals includes a mosaic of sparsely and densely vegetated habitats; (2) animals survive only for 12 to 18 months, and lay their eggs on emergent vegetation during a 4 to 12 week period between March and July; and (3) juvenile snails can survive drying for 2 to 3 months. Dry-downs are not necessarily harmful to the snail populations, as long as they do not coincide with the peak period of egg production or last for many months, so that a large percentage of the existing population is killed. Since snails are slow-moving animals, re-population of large areas following prolonged dry downs may require multiple years of favorable conditions.

Another factor that can significantly impact apple snails is reversal of lake stage during the egg laying period. Snails lay their eggs several cm above the water surface on the emergent stems of spike rush, bulrush, cattail and other plants (Darby et al. 1997). If lake stage rises during this period and eggs become flooded, they experience high mortality due to physiological effects on developing snail embryos and from loss of adhesion to stems (Turner 1994).

Research dealing with apple snail growth responses to varying food types indicates that the nutrient content of grazed material also could affect the populations. Sharfstein and Steinman (2000) maintained young apple snails in laboratory cultures, and provided the animals with either the epiphyton associated with spike rush stems, epiphyton of bladderwort, or metaphyton collected from near the sediment surface. These are three distinct and typical components of the periphyton community in the lake's central littoral zone (Havens et al. 1997). Snails feeding on bladderwort epiphyton grew significantly more than snails feeding on the other food types, perhaps because the bladderwort epiphyton had a higher nitrogen and chlorophyll content. Changes in plant community structure that shift the periphyton towards a dominance by less nutritious forms could potentially result in reduced apple snail growth. The extent to which human factors might be expected to bring about such a change is unclear.

Prediction - Three major predictions emerge from what is presently known about the littoral macroinvertebrate community. First, it is predicted that apple snails and other beneficial invertebrates will benefit from lake stage operations that minimize the frequency of prolonged spring draw-downs that dry out their habitat (i.e., prolonged lake stages below 12 ft). Second, it is predicted that snails and other invertebrates will benefit from operations that minimize the occurrence of stage reversals during the March-July period of maximal egg laying. Third, it is predicted that snails and other invertebrates will benefit from lake stage operations and other management actions (e.g., exotics control) that maintain a diverse mosaic of native littoral vegetation types, including spike rush, bladderwort, bulrush, sawgrass, and other emergent species.

Hypothesis 5 - The abundance and taxonomic composition of fish in the lake's pelagic zone is affected by nutrient inputs to the system, which determine the biomass of phytoplankton in the water column and macro-invertebrates in the benthos.

Bull et al. (1995) studied the distribution of fish in open-water habitats of the lake during the late 1980s and early 1990s, sampling fish at 25 sites with a large trawl net. They found that the deeper central and north regions of the lake supported distinct fish assemblages, which differed from those found in the near-shore and littoral habitats. The central assemblage was dominated by threadfin shad (*Dorosoma petenense*) and black crappie (*Pomoxis nigromaculatus*) in summer, and by black crappie and white catfish (*Ameirus catus*) in winter. The abundance of shad was significantly correlated with phytoplankton chlorophyll *a* concentrations. This reflects a feeding preference for phytoplankton and zooplankton (Baker and Schmitz 1971). White catfish abundance was strongly correlated with water depth, indicating the fact that these species tend to forage in the cooler deep water areas of the lake, where they prey on benthic macro-invertebrates, detritus, and smaller fish (Havens et al., manuscript in prep). Bull et al. (1995) documented that the north pelagic region is strongly dominated by threadfin shad and black crappie. It supports the highest densities of these species both in summer and winter, probably due to high food availability. Phlips et al. (1995) documented that the north region, in closest proximity to high nutrient inputs from agricultural tributaries, displays high phytoplankton biomass. The phytoplankton provides a direct source of food for shad, and also a source of organic matter loading to support a high biomass of benthic macro-invertebrates. Black crappie prey heavily on *Chironomus crassicaudatus*, a chironomid that occurs at extremely high densities (up to 21,000 per m^2) in the nutrient-rich mud sediments that occur in the northern region (Warren et al. 1995).

Prediction - Substantial reductions in nutrient loading to the lake, brought about by projects in CERP or the Lake Okeechobee Protection Plan, might lead to declines in the abundance of certain fish taxa (e.g., threadfin shad, black crappie). These fish presently occur at high densities due to an abundance of food resources (phytoplankton and certain chironomids) linked to high rates of nutrient inputs. On the other hand, other changes in the lake that benefit certain fish might counteract these declines. Crappie recruitment has been low in recent years (Michael Allen, University of Florida, personal communication) and this has been linked to high lake stage. Hence a rehabilitated lake, with lower stages and reduced nutrient loads, might actually support a healthier population of that sport fish than is the case for the existing lake system.

Hypothesis 6 - Fish in the near-shore region depend heavily on the occurrence of a healthy community of submersed and emergent plants.

Fisheries research conducted on other lakes has shown that vascular aquatic plants provide multiple benefits to fish communities. These include: (1) substrate and cover for spawning (Loftus and Kushlan 1987); (2) habitat for foraging (Janacek 1988); and (3) protective habitat for larval and young adult stages of fish (Barnett and Schneider 1974, Conrow et al. 1990). In Lake Okeechobee, Furse and Fox (1994) documented that bulrush, eelgrass, peppergrass, and *Hydrilla* provide important habitat for a variety of sport and forage fish (40 species total) in the near-shore area.

Furse and Fox (1994) noted that eelgrass, peppergrass, and spikerush provide important habitat in the lake for juvenile sport fish and small forage fish, and that bulrush, hydrilla, and pondweed account for most of the lake's recreational fishery value. Bulrush recreational value was four times higher than that estimated for any other component of the vegetation community in the near-shore area. Given these multiple functions, and the large-scale loss of both submerged aquatic vegetation, spikerush, and bulrush that has occurred in the last decade (details below), it is not surprising that in the most recent fisheries survey (October 1999), scientists noted significant declines in population densities and young age classes of economically important sport fish (FFWCC, unpublished data). It remains to be seen whether these populations will substantially recover in 2000, when a period of low lake stages has allowed for a limited recovery of the submerged plants and bulrush.

Prediction - If the modified hydrologic regime under CERP results in conditions that are more favorable for growth of submerged aquatic vegetation and bulrush in the near-shore zone of the lake, there will be substantial benefits to the lake's fish community.

Hypothesis 7 - Fish that spend all or part of their life cycle in the littoral zone of Lake Okeechobee are affected by factors that significantly alter the structure of the habitat, its resource base, and its water quantity and quality.

In general, a lake's vegetated littoral zone provides important habitat for fish, in particular for small forage fish taxa and the juvenile stages of larger species, which use the littoral zone as a refuge from predators and as a foraging area (Werner et al. 1983, Rozas and Odum 1988). In the case of Lake Okeechobee, surveys by Chick and McIvor (1994) documented a high biomass and diversity of fish in the littoral zone, with distinct fish assemblages occurring in different plant communities (eelgrass, peppergrass, and hydrilla). This is similar to the findings of Furse and Fox (1993) except that in this case, the focal point of the study was the interior and northern littoral regions, rather than the near-shore area. Fry et al. (1999) also documented, using stable isotope data, that a variety of fish may begin life in the lake's littoral zone and then migrate out into deeper water as they grow in size and "move up" in the food chain.

Chick and McIvor (1994) concluded that the littoral zone should be viewed as a complex landscape, comprised of distinct habitats that provide varying resource, refuge, and other features for the fisheries. This finding is important, but it seriously complicates our ability to understand the full suite of factors affecting fish while they are in the littoral zone. The landscape contains more than 30 distinct vegetation types, including emergent, submerged, and floating-leaf plants with dramatically different densities and growth forms. One thing that seems clear, however, is that certain rapidly expanding exotic and nuisance plants create conditions that generally are not favorable for fish. Species of particular concern are torpedograss and cattail. Greater detail regarding the expansion of these plants and conditions favoring their dominance is provided below under "native vegetation mosaic." In brief, both species have spread over tens of thousands of acres in the lake's littoral zone, displacing native plant communities that provide good habitat for fish and wildlife.

One of the displaced plants, spikerush, provides particularly good habitat for fish (Chick and McIvor 1994). It includes enough open water to allow large fish to effectively forage, but also provides cover associated with the emergent plant stems and associated whorls of bladderwort (*Utricularia* spp.) that are common in this habitat. The spikerush community also supports a high diversity of macro-invertebrates and attached periphyton that provide a food resource for the fish. In contrast, both torpedograss and cattail display a very dense growth form, with little open water for animals to move through and, as a result of the poor light conditions, little or no periphyton. Water quality inside dense stands of torpedograss also is not suitable for aquatic animals. Nighttime dissolved oxygen concentrations typically are near zero and mid-day values are as low as 0.5 mg/L (SFWMD, unpublished data).

The spread of torpedograss, as discussed below, may largely be a function of the occurrence of low lake stage, since expansion is favored when there is little or no standing water over the sediment surface. Expansion of cattail may be a function of phosphorus inputs from the pelagic zone and periods of long hydroperiod (Newman et al. 1996). The conditions that promote cattail expansion also may be responsible for the increased density of water lily (*Nymphaea* spp.) that has been observed in the interior littoral zone in the last several years. In areas where the density of this plant is high, there has been a deep accumulation of dead leaf material and coarse organic detritus, sometimes leaving only 5 to 10 cm of open water column. This habitat is not considered to be suitable for fish foraging or reproduction (FFWCC staff, personal communications). Recent years of long hydro-period also have allowed a deep accumulation of periphyton and detritus in spikerush areas, such that sandy substrate (good fish nesting habitat) is less available.

Predictions - If projects implemented in CERP result in a reduced occurrence of prolonged high or low stage, the conditions that have favored expansion of cattail, water lily, and torpedograss should be reduced in their occurrence. This situation, along with active measures (controlled fires and/or herbicide application) to kill torpedograss and cattail, should provide benefits to the lake's fish and wading bird communities.

Other aquatic fauna

There is insufficient information at this time to formulate hypotheses or predictions regarding other aquatic animals in the lake. The lake's littoral zone is used by society as a resource for hunting frogs and collecting snakes and turtles for commercial sales, but the distribution and abundance of these animals is unknown. The only study to consider herptofauna in the lake (USACE 1999) included sampling only at a few selected locations, but indicated that there are at least 15 common species. These included a variety of snakes, frogs, and turtles. The number of animals collected was reduced to near zero during a period when lake stage became very high, but it was impossible to determine if this was a real environmental impact or an artifact of low sampling efficiency (the traps were designed for sampling in shallower water).

NATIVE VEGETATION MOSAIC

The littoral zone of Lake Okeechobee, in its current form, is a relatively recent system. Much

of it was formed after construction of the Herbert Hoover Dike in the mid-1900s and control of the lake at a lower average surface elevation than under pre-settlement conditions. The lake's natural littoral zone probably was much larger and occurred to the west and south of its present location (Havens et al. 1996, Steinman et al. 2000a). Despite its young age, the existing littoral zone supported a diverse array of native plants when it first was mapped in the early 1970s (Pesnell and Brown 1973). The community included large areas of spikerush, sawgrass (*Cladium jamaicensis*), willow (*Salix caroliniana*) and beakrush (*Rhynchospora tracyi*). At the south end of the lake there were remnant stands of pond apple (*Annona glabra*) and along the western shore there was a nearly continuous band of dense bulrush immediately lake-ward of a zone dominated by spike rush and submerged plants. Although there is no quantitative record, various anecdotal reports from the early 1970s indicate that the submerged plant beds were both widespread and dense, including species such as eelgrass and peppergrass, which are favorable habitats for fish (Furse and Fox 1993).

Today the vegetation mosaic of the littoral zone is dramatically different (Richardson and Harris 1995). Upland areas that previously were dominated by beakrush and mixed grass assemblages now have been infested by the invasive exotic torpedograss. Certain areas have become dominated by the exotic tree melaleuca (*Melaleuca quinquenervia*), although much of that species has been killed by herbicide (SFWMD 1997). The spatial extent of willow has declined and there has been a large expansion of cattail. Pristine spikerush sloughs in the interior littoral zone now are surrounded by cattail (an invasive nuisance species) and torpedograss and contain a higher density of water lily (*Nymphaea* spp.) than in the 1970s. The long-shore bulrush stands now are sparse (just 50% of the former coverage) relative to their historic amounts, and the shoreline spike rush community no longer exists. Submerged vegetation was largely eliminated from the near-shore pelagic region in the late 1990s, although a marked recovery has occurred during a period of low water levels in spring-autumn 2000.

Hypotheses and Predictions:

Three main factors have interactively affected the native vegetation mosaic in Lake Okeechobee. These factors are *altered hydroperiod*, *excessive phosphorus loading*, and the *introduction and expansion of exotic plants*. The following general hypotheses describe how these factors are thought to affect the vegetation mosaic attribute, and are organized by geographic region (littoral zone, near-shore bulrush zone, and near-shore submerged vegetation zone).

Hypothesis 1 - In the littoral zone, the distribution of native and exotic plants primarily is determined by hydroperiod.

Short hydroperiod regions support native species including spikerush, beakrush, willow, and cordgrass (*Spartina bakeri*), and exotic species including torpedograss, melaleuca, and brazillian pepper (*Schinus terebinthifolius*). Long hydroperiod regions support spikerush, cattail, sawgrass, bladderwort, and water lily. Periods of extremely short or long hydroperiod (low and high lake stage events) that have occurred since the early 1970s are considered largely responsible for changes in the relative distribution of these plants.

Two periods of very low lake stage, in 1980-81 and 1989-90, may be responsible for much of the expansion that has occurred in exotic plant populations. Controlled experiments with melaleuca (Lockhart 1995) and torpedograss (Smith et al. 2000) have shown that these species cannot successfully invade native plant habitat that is inundated with water. Melaleuca seeds cannot effectively germinate under water, and fragments of torpedograss (this plants main mode of colonization) cannot establish roots when water depths exceed 50 cm. However, once these plants are established (e.g., during a period when water depth is low), they can tolerate relatively deep and prolonged flooding. Field observations indicate that much of the expansion of Melaleuca and torpedograss in the littoral zone occurred following droughts in 1981 and 1980, when lake stage fell below 11 ft, creating favorable habitat for colonization by seeds and fragments over nearly the entire littoral landscape.

When lake stage is low there also is an increased probability of fire occurring in the littoral zone, either due to natural causes (e.g., lightening strikes) or in controlled burn programs. Fires have documented benefits to the littoral vegetation mosaic. Fires burn away accumulated thatch in dense stands of emergent macrophytes, opening up the habitat to wildlife, and they also burn away much of the above-ground biomass of torpedograss monocultures, which allows for more effective control of this exotic with herbicide (Hanlon and Langeland 2000). Fires also allow buried seeds to germinate from the exposed sediments, providing the potential for species to re-colonize the habitat (Williges and Harris 1995).

Several years of high lake stage in the late 1990s are considered responsible for changes that have occurred in the dominance of native plant species in the interior littoral zone. From 1994 to 2000, lake stage exceeded 17 ft on four occasions and never fell substantially below 13 ft. These conditions may have favored development of dense stands of water lily in a west-central littoral region called "Moonshine Bay" where there previously was only spike rush and bladderwort. The dense lily communities may have degraded this habitat for fish and wildlife use due to a thick accumulation of dead leaf material and coarse organic detritus, which occupies up to 80% of the water column depth at some sites (SFWMD staff, personal observation).

Prediction - Because the lake stage regime expected under CERP more closely mimics that which occurred in the early 1970s, it is expected to favor the type of littoral vegetation mosaic that occurred at that time. However, the new stage regime is likely to include periods of low lake stage, which will have both positive effects (drying and oxidation of accumulated organic debris) and negative impacts (increased spread of exotics). An aggressive program to control the spread of torpedograss is under development, and along with the ongoing Melaleuca eradication program, may be a critical long-term measure to complement the modified hydroperiod that is established by CERP.

Hypothesis 2 - Excessive inputs of phosphorus from the lake's pelagic zone have promoted the spread of cattail in certain littoral areas and may have contributed to the expansion of water lily.

The pelagic zone of Lake Okeechobee has total phosphorus concentrations that average over 100 ppb (James et al. 1995), while concentrations in the interior littoral zone are typically between 10 and 15 ppb (Havens et al. 1997, Hwang et al. 1998). At high lake stage, currents transport phosphorus-rich water from mid-lake towards the pelagic-littoral interface (Maceina 1993, Havens 1997) and into the littoral zone proper. This phenomenon recently has been documented by the District's lake hydrodynamic model and by evaluation of water quality data during recent years when lake stage has been high. Studies of periphyton communities in the littoral zone indicate that there have been nutrient impacts similar to those observed in the Everglades (McCormick et al. 1996).

Aerial photographs and early maps (Pesnell and Brown 1973) of the littoral zone indicate that in the 1970s there was little or no cattail in the area of Moonshine Bay. In general, the area was characterized by a near-monocluture of spikerush. Today there is dense cattail along the edges of all boat trails leading from open water into Moonshine Bay from the north and west. There also is a dense "wall" of cattail along nearly the entire eastern edge of the littoral zone, where the plant community is in direct contact with pelagic water (Richardson and Harris 1995). Stimulation of cattail growth by phosphorus enrichment and high water levels in Lake Okeechobee is consistent with results from experimental research carried out in the Everglades (Newman et al. 1996).

Prediction - Under CERP, it is anticipated that the duration and return frequency of high water events will be reduced, and phosphorus inputs to the lake also should decline as a result of components of CERP and the Lake Okeechobee Protection Program. Taken together these actions are expected to result in less phosphorus transport into the littoral zone, and a reduced rate of cattail expansion.

Hypothesis 3 - Prolonged periods of deep water, combined with damage from wind-driven waves, have dramatically reduced the spatial extent and biomass of near-shore bulrush stands and submerged aquatic vegetation.

Recent estimates indicate that the spatial extent of bulrush has been reduced by 50% from its recorded maximum in the early 1970s (Florida DEP, unpublished data). Two factors may interactively have contributed to this decline. First, long periods of deep standing water may have resulted in conditions where only a small percentage of the plant's photosynthetic tissues were above water (Hanlon 2000). Under those circumstances, bulrush has been documented to draw on its underground rhizomes as an energy reserve, until eventually the plants have insufficient energy for net growth and survival (van der Valk 1994).

In a similar manner, high water had resulted in a dramatic decline in the spatial extent of submerged aquatic vegetation by 1999, following several years of high lake stage. High water levels have two related effects on underwater irradiance, and in turn, on the rate of growth and survival of submerged plants. First, when lake stage is high, light reaches the bottom only in a limited area close to the lake shore, where depths are shallow. This limits the lake-ward extent of submerged plant habitat. Second, under high stage conditions, there is increased transport of sediment-laden water from the mid-lake area (where these

sediments are resuspended by wind) to the near-shore area that supports submerged plants (Maceina 1993, Havens 1997). When combined with a deeper water column, the increased turbidity results in little or no light reaching the lake bottom. Research has shown that submerged plant biomass in Lake Okeechobee is negatively correlated with water depth (Hopson and Zimba 1993) and that the highest submerged plant biomass occurs when stage is very low (Phlips et al. 1993).

Once submerged plants are lost, a positive feedback maintains the turbid condition. Without plants to stabilize sediments, there is increased sediment resuspension and no competition with phytoplankton for nutrients. Resuspended sediments and algal blooms result in higher turbidity, which prevents plant recovery. This cycle is very difficult to break once it is established (Scheffer 1989). Only dramatic actions, such as a considerable lowering of stage, allow plants to re-colonize the site. Once this occurs, however, the plants can establish a different feedback loop that maintains clear water (the plants support sediments and they also remove nutrients from the water so that algal blooms do not occur).

During summer 2000, there was a switch from turbid conditions to clear water conditions in much of the lake's near-shore area. This coincided with a submerged plant recovery following a SFWMD "managed recession" operation that removed ~1 ft of water from the lake, after which an additional 2 ft of water left the system by evapotranspiration and water supply deliveries. The lake reached a stage of below 12 ft and remained below 13 ft for >5 months (to date).

Prediction - The goals of CERP include both a lowering of average water levels in the lake and a reduced frequency of extreme high water levels (when damaging wave effects occur). Under those conditions, the distribution and abundance of bulrush and submerged plants are expected to increase.

Hypothesis 4 - High water levels have eroded the eastern lakeward edge of the littoral zone and resulted in the accumulation of a dense organic "berm" of dead plant material and lake sediment at the pelagic-littoral interface.

According to biologists who have worked on the lake since the 1960s, these organic berms are a common feature of the impounded system. The recent berm, however, is considered to be the most large-scale and permanent one ever to have occurred.

In some areas the berm is over 1 m tall, greater than 10 m wide, and it has established a community of woody vegetation including small willow trees. Scientists at the Florida Fish and Wildlife Conservation Commission have expressed concern that this organic berm is ecologically harmful because: (1) it may prevent normal water exchange between the littoral zone and marsh, in particular, it may block the egress of water from the marsh after periods of heavy rainfall over that area; (2) it may block normal migration routes for fish; and (3) it may act as a "break-wall" that does not gradually attenuate waves in the manner that an edge of vegetation would, and this causes erosion of sediments and any submerged plants that might develop at its lake-ward edge.

District staff have documented that the lake-ward edge of the littoral zone and the berm are highly dynamic, forming and eroding in much the same manner that a sandy beach is eroded and re-deposited elsewhere by strong surf. In the case of the lake, however, the erosion is of the littoral plant community itself. Hanlon (2000) documented by comparison of historic GIS vegetation maps that the lake-ward edge of the northwest littoral zone was eroded by up to 300 m between 1996 and 1999. During a period of particularly high lake levels (near 18 ft) in fall-winter 1998, staff documented recession of the littoral edge of up to 10 m in just 90 days. Output from the District's lake hydrodynamic model indicates that under high stage conditions, and in the absence of dense bulrush stands to attenuate wave energy, there are strong long-shore currents that could scour sediments and submerged plants, and erode the lakeshore along much of the western edge.

Prediction - Under the lower lake stage schedule of CERP, it is predicted that littoral shoreline erosion and berm formation should be substantially reduced. It may be necessary, however, to carry out a project to remove the organic material that has accumulated during high water periods pre-CERP implementation.

SNAIL KITES, WADING BIRDS, AND WATERFOWL

Snail Kites

The littoral zone of Lake Okeechobee is designated as one of the critical habitats (Federal Register 42 [155]:40685-40688) for the Everglades Snail Kite, a federally-endangered species. Snail Kites use the littoral zone as a habitat for nesting and foraging; other habitats for this bird include Everglades National Park and the Everglades Water Conservation Areas, the Big Cypress basin and lakes & wetlands located to the north and east of Lake Okeechobee. Kites are known to migrate extensively across the south Florida landscape (Bennetts and Kitchens 1997), and as such, cannot be effectively managed in a site-specific context.

The availability of multiple wetland habitats is considered to be critical for kites and is the foundation of the "meta-habitat hypothesis" proposed by Bennetts and Kitchens (1997). In this hypothesis, the risk to the regional population is minimized by the ability of kites to move to different habitats within the regional network as the quality of localized habitats fluctuates. For this to be effective, it is important that conditions in the habitats not be degraded to the extent that they are no longer usable during a time when Snail Kites require their use. For example, when a regional drought occurs, the littoral zone of Lake Okeechobee may represent the only large wetland system with suitable foraging and nesting conditions. Hence the lake should not be degraded to the extent that it loses its apple snail populations or suitable foraging (e.g., spike rush slough areas) and nesting (e.g., willow) habitat.

Hypotheses and Predictions:

Hypothesis 1 - Snail kite foraging habitat in the littoral zone is degraded when dense cattail or torpedograss replaces relatively open spikerush habitat.

Bennetts and Kitchens (1997) noted that the quality of habitat for kites is adversely influenced both by certain changes in water quality and the expansion of exotic plants. In each case, the key factor is replacement of relatively open foraging habitat with habitat dominated by dense vegetation. They note that in the Everglades, nutrient enrichment favors dominance of cattail, and that this could impact kites, which require relatively open water areas for foraging because they must detect their prey visually (Sykes 1987, Bennetts et al. 1988). Likewise, dense stands of torpedograss cannot support animal prey due to low dissolved oxygen, and do not permit effective foraging by visual predators since the vegetation typically hides the water column. The same probably holds true where spikerush develops dense growth of floating-leaf plants such as water lily.

Hypothesis 2 - Snail kite foraging habitat in the littoral zone is degraded when the abundance of apple snails is substantially reduced.

Apple snails are the major food item of the Snail Kite. Therefore, if environmental conditions (e.g., a prolonged dry down coincident with the season of egg laying or a lake stage reversal after eggs are laid) result in a major "crash" of apple snails, the habitat will be unfavorable for kites until the food resource recovers.

Hypothesis 3 - Snail kite nesting habitat in the littoral zone is degraded when the spatial extent of sawgrass and willow is reduced.

According to Bennetts and Kitchens (1987), Snail Kites nest primarily in willow and other woody vegetation types. Hence the spatial extent of these plant types will directly affect whether or not the littoral zone represents viable habitat for kite nesting. Two factors contributing to loss of this habitat in Lake Okeechobee include prolonged periods of deep water and the expansion of torpedograss.

Hypothesis 4 - The Lake Okeechobee littoral zone is essential habitat for the Florida population of Snail kites during periods of extensive drought.

This hypothesis follows directly from the meta-habitat hypothesis of Bennetts and Kitchens (1987) and their findings regarding use of the lake by kites during years when other regional habitats are dry due to drought conditions.

Wading Birds

Lake Okeechobee has long been recognized as an important nesting location for wading birds. Anecdotal records from National Audubon Society game wardens during the 1940s documented large concentrations of nesting birds at the Lake (David 1994). More quantitative surveys during the period 1957-1978, showed that there were typically about 4700 nests per year, with peaks in nesting effort in 1972 and 1974. During those years, there were approximately 10,000 wading bird nests on the Lake, mostly of White Ibis at the

King's Bar colony, near the mouth of the Kissimmee River. It was considered to be one of the largest and most important wading bird colonies in central Florida. After an increase in the Lake regulation schedule in 1978, wading bird nesting effort declined and stabilized at about 2000 nests (David 1994), at least up until 1992, when it was last surveyed (Smith and Collopy 1995).

Hypotheses and Predictions:

The primary hypotheses to explain the general decline in nesting effort after 1978 as well as individual years of low nesting effort, is that increased Lake water levels water decreased the quality or quantity of habitat. The following hypotheses describe in more detail how water levels affect wading bird nesting on the Lake.

Hypothesis 1 – Seasonal lake stage recessions benefit wading bird populations.

In the Everglades, fish populations are 2-4 times higher in marshes that are inundated than in areas that dry out regularly (Loftus and Eklund 1994). However, as water levels fall during the dry season, small depressions in the marsh surface act as places where fish become concentrated. Fish concentrations increase by a factor of from 20 to 150 in the Everglades and Big Cypress National Preserve (Carter et al. 1973, Loftus and Eklund 1994, Howard et al. 1995). These patches of concentrated prey are typically shallow with no vegetation. Thus, individual fish become more vulnerable to capture and wading bird feeding success is increased (Kushlan 1976). Although these high-density food patches may be scattered in the landscape, wading birds have adaptations such as white plumage and social foraging that allow them to minimize their search time (Kushlan 1981, Erwin 1983). Thus, at the landscape scale, wading birds are able to exploit small patches of highly available prey and large foraging aggregations indicate good feeding conditions. Species such as Wood Storks, White Ibises, and Snowy Egrets appear to be more dependent, than are other wading bird species, on good feeding conditions to have years of high reproductive output (Gawlik in review). Hydrologic patterns that produce the maximum number of these patches with high prey availability (i.e., high lake stages at the end of the wet season and low lake stages at the end of the dry season) tend to produce good wading bird nesting effort (Smith and Collopy 1995).

Prediction – Because the lake stage regime expected under CERP more closely mimics that which occurred in the early 1970s, the frequency at which the marsh dries should increase and favor increased reproduction for Snowy Egrets and White Ibises.

Hypothesis 2 – Large stands of willow are beneficial to wading bird nesting.

In Everglades and Lake Okeechobee, most wading bird colonies occur in willow trees (Zaffke 1984, Frederick and Spalding 1994). Willow is thought to be the preferred nesting substrate because it can tolerate longer hydroperiods than most tree species and therefore is usually in deeper water than other species. Wading birds seem to prefer to nest in deep water

because it increases the likelihood that their nests will remain surrounded by water throughout the nesting season. Such conditions reduce the probability of their nests being predated by raccoons (Frederick and Spalding 1994). Despite the tolerance for long hydroperiods, even willow can not withstand prolonged periods of deep water. It Lake Okeechobee, high water has had negative impacts on willow stands in certain lower elevation regions of the littoral zone. Therefore it is possible that the preferred nesting sites for wading birds could be a factor limiting population sizes.

Prediction - The goals of CERP include both a lowering of average water levels in the lake and a reduced frequency of extreme high water levels. If this water management regime stops the loss of willow or increases the amount of willow, then nesting habitat quality for wading birds will be remain stable or increase.

Waterfowl

Lake Okeechobee hosts more than 100,000 migratory waterfowl in many years (ongoing mid-winter surveys of FFWCC), although the numbers vary greatly between years (Chamberlain 1960, Bellrose 1976). Migratory behavior allows these birds to exploit seasonally rich and variable habitats in the regional landscape (Weller 1969).

Most numerous in the mid-winter surveys are lesser scaup (*Aythya affinis*), which inhabit the pelagic zone of the Lake and whose numbers range from 50,000 to 300,000. Scaup dive for their food in water up to several meters deep (Bellrose 1976) and their diet on Lake Okeechobee is unknown. The second most abundant species has been the ring-necked duck (*Aythya collaris*), Florida's most harvested duck. Close to half of all Ring-necked Ducks wintering in the Atlantic Flyway formerly used Lake Okeechobee (Bellrose 1976), but the spread of *Hydrilla*, a highly preferred food, apparently has spread ringnecks around Florida (Johnson and Montalbano 1984, Jeske 1985, Esler 1990). Ring-necked duck numbers on Lake Okeechobee fell from an average of 5,807 from 1991-1995, to an average of 489 from 1996-2000. This 92% decline was apparently due to the loss of submerged plants on the lake during this period of high water, combined with the availability of alternate habitat locations.

Fisheating Bay is surveyed independently of the rest of the lake for waterfowl, and Ring-necked Duck numbers in that location declined from a 5-year average of 5,190 in 1991-1995 to 2,798 in 1996-2000 (data were missing in 1999), a 46% change. During the same period, American coots (*Fulica americana*) declined by 77% on the larger part of the lake, from a 5-year average of 15,303 between 1991-1995, to an average of 3,508 from 1996-2000. In Fisheating Bay, coots increased from 13,805 in 1991-1995 to 19,546 in 1996-2000, although lake-wide, there still is an overall downward trend (21%). Like ring-necked ducks, coots feed on submerged vegetation (Bellrose1976, Montalbano et al. 1979, Esler 1990) and their declining numbers are likely correlated with declining acres of those plants in the lake. The higher numbers of birds in Fisheating Bay may be due to the few surviving areas of H*ydrilla*

and other submerged plants (e.g., *Vallisineria*) that remained.

Dabbling ducks prefer marshy areas and are more difficult to accurately survey than the diving ducks discussed above. An average of 338 dabbling ducks was detected on the lake between 1991-2000 (mid-winter inventory, FFWCC). Considering that there are a potential 90,000 acres of habitat for these birds, this number is extremely low and reflects impaired habitat conditions. For comparison, Johnson and Montalbano (1984) detected an average of 11,886 dabbling ducks just in Fisheating Bay during a study in 1981-82. High water levels impede dabbling ducks from using the lake because they rarely dive to feed and prefer water less than 1 ft deep (White and James 1978, Johnson and Montalbano 1984, Gray 1993). Chronic high water levels, or more specifically, lack of a spring dry down, prevent the growth of moist soil vegetation that is important in producing seeds that many ducks prefer (Goodwin 1979, Fredrickson and Taylor 1982).

Hypotheses and Predictions

Hypothesis 1 - Numbers of ring-necked Ducks and Coots decline when submerged vegetation is lost due to high water levels.

Waterfowl numbers in any location in a given year are related to size of the fall flight, weather and habitat conditions north of Florida, and habitat conditions in the Florida peninsula. Lake Okeechobee is large enough that waterfowl will find it and if suitable habitat is available, they will use it in some numbers, related to quality of the habitat. Quality habitat in this case is submerged vegetation.

Hypothesis 2 - Numbers of dabbling ducks (genus Anas and Aix) are strongly correlated with areas of water less than 6 inches deep, and presence of a spring recession.

Dabbling ducks are expected to respond positively to quality habitat (Goodwin 1979). A spring recession produces somewhat predictable vegetation responses (Richardson et al. 1995) and shallow water for foraging.

UNCERTAINTIES / RESEARCH QUESTIONS

WATER QUALITY

Internal vs. external loads - Despite a considerable amount of research dealing with sediment-water phosphorus dynamics and internal loading in Lake Okeechobee, there is uncertainty regarding the timing of lake response to external load reductions. Particularly important factors that could influence the response include: (1) the rate of phosphorus deposition by particle sedimentation; (2) the depth of the "active sediment layer" that interacts with the overlying water column; (3) the rate of burial of sediment material into deep storage where it no longer plays a role in the lake's phosphorus cycle; and (4) removal by

mineral formation. In the recent Lake Okeechobee TMDL (total maximum daily load) process, there were differing viewpoints among experts regarding these factors, indicating an area of research need.

Lake stage vs. phosphorus - Although there is good evidence that lake stage affects water column total phosphorus concentrations in both the pelagic and littoral regions of Lake Okeechobee, some of the key mechanisms still have not been quantified to the extent that they can be incorporated into predictive models. Effects of stage on water currents and horizontal materials transport now can be effectively modeled using the lake hydrodynamic model, as can transport of nutrients into the littoral zone. Effects of plants and attached algae on water column phosphorus concentrations, however, presently cannot be predicted, despite the fact that they may be of considerable importance under moderate and low stage conditions. Efforts are underway to quantify how submerged plant communities respond to changes in underwater irradiance. This information, along with results of studies to quantify effects of plants on nutrients and turbidity, is needed for development of a landscape-type model of near-shore water quality and plant distribution. Similar information needs to be collected and incorporated into the models for periphyton and benthic algae, since these components of the community have the potential to attain a high biomass.

Phosphorus assimilative capacity - Although results from other shallow lakes indicate that biological recovery from cultural eutrophication in Lake Okeechobee might result in a greater lake assimilative capacity, the magnitude of these effects is uncertain. In order to periodically re-evaluate (and perhaps modify) the lake phosphorus loading target, there is a need to quantify some of the key relationships and incorporate them into predictive models. This will require an evaluation of phosphorus sources and sinks associated with algal settling, cyanobacteria vertical migration, oligochaete feeding and bioturbation, and aquatic insect emergence. Long-term assessment of the magnitude of these processes needs to accompany model development and validation. There also is a need to determine whether recent increases in sediment dissolved phosphorus reflects a loss of assimilative capacity or increased diagenesis.

Phosphorus and algal blooms - The relationship between excess phosphorus concentrations and algal bloom development is well established in the general limnological literature and in the literature dealing with Lake Okeechobee. That blooms will decline if in-lake phosphorus concentrations are substantially reduced is quite certain. One area of uncertainty that does exist, however, is the extent to which algal blooms in themselves might make the lake resilient to recovery. The taxa of cyanobacteria that occur in Lake Okeechobee are known to occur in a "dormant" state at the sediment surface, and during formation of blooms they may be responsible for a large transport of phosphorus upward from the sediments to the water column (Barbiero and Welch 1992, Havens et al. 1998). Quantifying the magnitude of this process would increase the certainty of predictions of lake recovery from excessive phosphorus loading.

In regard to the effects of blooms, we also lack information regarding quantitative linkages between bloom occurrence / magnitude and important societal values, such as drinking water quality (taste, odor, trihalomethanes), recreational use of the water resource, and fishing.

Since the lake is highly visible as a public natural resource and is the headwaters for the Everglades, we believe that it is important to quantify these relationships so that performance measures can be developed for these potential benefits of the project.

FISH AND AQUATIC FAUNA

Macro-invertebrates and zooplankton

Based on responses of other eutrophic lakes, it can be predicted with a relatively high degree of certainty that if the pelagic sediments develop a less enriched character due to reduced phosphorus inputs, the abundance of pollution-tolerant oligochaetes will decline and other less tolerant species will return. The timing and magnitude of recovery is uncertain, but can be determined with long-term monitoring.

Likewise there is a relatively high certainty that restoration of near-shore bulrush and submerged vegetation communities will result in an increased abundance of the macro-invertebrate taxa that use that habitat.

The uncertainty regarding responses of littoral macro-invertebrates to CERP is greater, reflecting a general lack of information about how invertebrate communities are distributed across that landscape. There has been a considerable amount of research in south Florida dealing with apple snails, and therefore there is a greater certainty regarding the responses of those particular animals.

Factors affecting zooplankton biomass and composition are relatively well studied, and long-term monitoring should suffice to document that timing and magnitude of any major changes in that community. It will be particularly important to keep track of abundances of cladocerans (including the exotic *Daphnia lumholtzii*) since these animals are the most effective grazers of phytoplankton and the optimal food resources of zooplanktivorous fish.

Open-water and littoral fish communities

The diet habits of fish in the pelagic region have been well documented, and the factors related to their distribution and abundance were quantified in a comprehensive study. Therefore there is relatively little uncertainty regarding responses of these fish to CERP. The timing and magnitude can be determined from the long-term monitoring program.

There also is relatively little uncertainty that near-shore fish habitat will be enhanced if CERP results in a reduced frequency of damaging high water levels. Benefits to the fish community are relatively predictable, and can be evaluated with long-term monitoring.

There is greater uncertainty regarding littoral fish because only a few of the region's major plant community types have been sampled for these animals. To accurately predict how CERP will affect the lake's fishery, which depends heavily on the littoral zone, better information is needed regarding use of particular native and exotic plant assemblages.

Furthermore, only preliminary diet studies have been conducted in the littoral zone (only in Moonshine Bay), and a more in depth study of feeding habits is needed to predict how littoral fish will respond to changes that CERP might cause at lower trophic levels.

Other animals

One area of great uncertainty regarding the lake ecosystem is in regard to reptiles, amphibians, and other aquatic animals that utilize the littoral zone as foraging and/or nesting habitat. Only limited survey studies have been performed. These need to be supplemented with more detailed studies of the relationship between vegetation, hydroperiod and aquatic animal occurrence, as well as studies to determine the role of the animals in the littoral food web. Preliminary data indicate that some of these animals (e.g., certain frogs) may be food resources for economically important species such as the largemouth bass.

NATIVE VEGEGATION MOSAIC

Littoral zone and hydroperiod - The uncertainty associated with this general relationship is quite low, because the linkage has been established experimentally in Lake Okeechobee (Steinman et al. 1997, 2000b) and on other systems as well as by multivariate models and GIS in Lake Okeechobee. One key area of uncertainty that now is under investigation is identification of a hydroperiod range that is least favorable for expansion of torpedograss into native plant-dominated habitat. In addition, the link between water lily expansion and long hydroperiod is circumstantial, since this species is known to respond both to hydroperiod and increased phosphorus inputs (McCormick et al. 1999). Because dense water lily degrades spikerush habitat, this is an area of uncertainty that merits further consideration.

Littoral zone and phosphorus - The uncertainty associated with this relationship also is low, again because we can draw inferences from research conducted in the nearby Florida Everglades. However, while nutrient effects on primary producers (plants and periphyton) are well established, little is known about how nutrients affect higher trophic levels in the littoral food web. It may be particularly important to quantify experimentally how increased or decreased nutrient-induced changes in plants and periphyton affect the productivity of certain key animal species such as apple snails (prey for snail kites) or small forage fish (prey for sport fish taxa and wading birds).

Bulrush & submerged vegetation and high water - It is clear that prolonged or extreme high water has damaging effects on these components of the lake's plant community. However, the causal mechanisms are only generally understood. Given the critical role that these plants play in terms of water quality and fish/wildlife habitat, research is needed to identify the "lake stage window" (yearly range of water levels) that is required to support a healthy community. There also is a need to determine conditions necessary to allow recovery of the community when unfavorable conditions do occur (e.g., two successive years of high rainfall and high stage). District staff also intends to modify the existing lake water quality model so that it can predict, with a fine spatial scale, the extent of submerged vegetation that might occur under different lake stage management scenarios. That tool will be useful to the RECOVER process, because it will allow plan evaluations by the RET to include not only

hydrologic and water chemistry predictions, but also predictions regarding responses of one of the lake's key biological communities.

Shoreline erosion and berm formation - Erosion of the western shoreline has been linked with high lake stage and wind-driven waves, and long-term monitoring will continue in order to keep track of any further shoreline degradation. The ecological impacts of the organic berm have not been documented, but this may not be a particularly high research priority if plans call for its removal.

SNAIL KITES, WADING BIRDSS, AND WATER FOWL

Prey Availability and water level recession - The uncertainty associated with this general relationship is fairly low. One of the first studies of wading birds in south Florida (Kahl 1964) reported this general relationship and subsequent studies, both observational (Kushlan 1976) and experimental (Gawlik in review), have substantiated it. The main area of uncertainty is in how different species will respond and why the level of response is still quite variable among years.

Nesting substrate as a population constraint - The uncertainty associated with this relationship is high. It is not clear whether the lack of willow as a nesting substrate is limiting the population size of any species of wading birds on the Lake. More importantly, there is no information on the consequences of birds using less preferred nesting substrate. It is assumed that the use of less preferred nest sites will reduce nesting success, but if that assumption is invalid then there will be little effect on the overall population size.

HYDROLOGIC PERFORMANCE MEASURES

A key feature of the Lake Okeechobee conceptual model is the high degree of interconnectedness; any given stressor may impact ecological attributes directly, or impact those same attributes indirectly, by exacerbating the effects of other stressors. Two stressors that display particularly strong effects (direct and indirect) on the attributes are high and low water levels. Taken together, they have the potential to affect the rate of lake eutrophication, the spatial extent and overall health of submerged and emergent plant communities, fisheries, birds, other wildlife, and the quality of water taken from the lake from human uses.

Water inputs and lake levels also are the variables most directly impacted by proposed components of the CERP. Therefore a suite of hydrologic performance measures was developed based on our understanding of the ecosystem and used by the Restudy Alternative Evaluation Team (AET) to evaluate potential impacts of various planning alternatives on lake ecosystem health. The Regional Evaluation Team (RET) of CERP will use these same performance measures during implementation of the program. Five priority performance measures were calculated, weighted and summed using the River of Grass Evaluation Model (ROGEM) for Lake Okeechobee. The Lake Okeechobee ROGEM is comprised of metrics (Suitability Index Variables, or SIVs) that describe the fluctuation and timing of lake stages. The model assumes that restoration of a more natural (within the constraints of the dike system) hydroperiod would result in positive biotic responses of the

lake community.

SIVs in the ROGEM range from 0 (worst score) to 1.0 (best score). Relationships between hydrologic attributes and SIVs in this model are not linear. Instead, they reflect expert opinion that the degree of ecosystem stress is exacerbated by an increasing occurrence of undesirable events. This gives rise to a curvilinear relationship between hydrologic attributes and their SIVs. I.e., once the ecosystem has been stressed, further stresses bring about more dramatic responses than were evidenced following the single event. At a certain point (considered here to be 4 events or more per decade), the degree of stress is so severe that the system cannot recover its ecological and societal functions. The five SIVs used in the model are as follows.

A. An extreme low lake stage (<11 ft) performance measure (**SIV_{MINX}**) indicates the frequency of events that: (1) result in a loss of over 95% of the littoral zone as habitat for aquatic biota; and (2) promote expansion of exotic plants. The goal is to have a minimal number of these events. A score is calculated as follows:

- Stage never falls below 11 ft = 1.0
- Stage falls below 11 ft on 1 occasion per 10 yrs = 0.9
- Stage falls below 11 ft on 2 occasions per 10 yrs = 0.7
- Stage falls below 11 ft on 3 occasions per 10 yrs = 0.4
- Stage falls below 11 ft on 4 or more occasions per 10 yrs = 0

B. A moderate low lake stage (<12 ft) performance measure (**SIV_{MINM}**) indicates the frequency of prolonged (>12 continuous month) events that substantially reduce the littoral area available as wildlife habitat, and promote exotic plant expansion. The goal is to have a minimal number of these events. A score is calculated as follows:

- Stage never falls below the 12 ft / 12 month criterion = 1.0
- Stage falls below the 12 ft / 12 month criterion on 1 occasion per 10 yrs = 0.9
- Stage falls below the 12 ft / 12 month criterion on 2 occasions per 10 yrs = 0.7
- Stage falls below the 12 ft / 12 month criterion on 3 occasions per 10 yrs = 0.4
- Stage falls below the 12 ft / 12 month criterion on $\geq$ occasions per 10 yrs= 0

C. An extreme high lake stage (>17 ft) performance measure (**SIV_{MAXX}**) indicates the frequency of events that: result in wind and wave damage to the shoreline plant communities that provide critical habitat for recreational fish and other wildlife; and transport phosphorus-laden pelagic water into pristine interior regions of the littoral zone. The goal is to have a minimal number of these events. A score is calculated as follows:

- Stage never exceeds 17 ft = 1.0
- Stage exceeds 17 ft on 1 occasion per 10 yrs = 0.9
- Stage exceeds 17 ft on 2 occasions per 10 yrs = 0.7
- Stage exceeds 17 ft on 3 occasions per 10 yrs = 0.4
- Stage exceeds 17 ft on $\geq$ 4 occasions per 10 yrs = 0

D. A moderate high lake stage (>15 ft) performance measure (**SIV_{MAXM}**) indicates the frequency of prolonged (>12 continuous months) events. These events limit light penetration to the lake bottom, resulting in a loss of the benthic plants and algae that stabilize sediments and provide habitat for invertebrates and fish; and promote greater circulation of phosphorus-rich turbid waters from mid-lake to less eutrophic near-littoral regions, where phosphorus inputs stimulate algal blooms. The goal is to have a minimal number of these events. A score is calculated as follows:

- Stage never exceeds the 15 ft / 12 month criterion = 1.0
- Stage exceeds the 15 ft / 12 month criterion on 1 occasion per 10 yrs = 0.9
- Stage exceeds the 15 ft / 12 month criterion on 2 occasions per 10 yrs = 0.7
- Stage exceeds the 15 ft / 12 month criterion on 3 occasions per 10 yrs = 0.4
- Stage exceeds the 15 ft / 12 month criterion on $\geq$ 4 occasions per 10 yrs = 0

E. A spring recession performance measure (**SIV_{VAR}**) indicates the number of years during which January to May lake levels decline from near 15 ft to 12 ft, without any reversals greater than 0.5 ft. These conditions are favorable to nesting birds and other wildlife in the marsh. They also allow for re-invigoration of willow stands, and permit fires to burn away cattail thatch. The goal is to have a substantial number of events. A score is calculated as follows:

- Stage recession between January and March from >14 ft to <13 ft NGVD, with no reversal greater than 0.5 ft NGVD, occurring every yr = 1.0
- Stage recession occurring only in 9 out of 10 yrs = 0.9
- Stage recession occurring only in 8 out of 10 yrs = 0.7
- Stage recession occurring only in 7 out of 10 yrs = 0.4
- Stage recession occurring only in 6 or fewer out of 10 yrs = 0

SIV Priority Weights

The five SIVs address important aspects of how water level and its seasonal variation affects the ecological attributes of Lake Okeechobee. However, the SIVs are not considered of equal importance in regard to indicating an absolute level of stress (or benefit). A weighting scheme was developed, on the basis of best professional judgement, to reflect the relative importance of each SIV as an index of lake ecosystem health. For simplicity, a weighting scale of 1 to 5 (1 being least important, and 5 being most important) was used.

The SIVs associated with the >17 ft and >15 ft / 12 month criteria were given priority weights of 5. Extreme or prolonged high water levels have been documented to affect numerous ecosystem attributes, including littoral plant and periphyton communities, benthic plants and periphyton, fisheries habitat, and water quality (including turbidity, phosphorus, and algal blooming). These effects are well documented by scientific research (Sheng and Lee 1991, Havens 1997, Steinman et al. 1997).

The SIVs associated with the <11 ft and <12 ft / 12 month criteria were given priority weights of 4. Extreme or prolonged low lake stages also may cause harm to the ecosystem,

but the impacts are less documented, and are not considered as serious on a lake-wide basis. I.e., the effects primarily are restricted to the littoral zone proper, and negative impacts (e.g., loss of fisheries habitat) may in part be compensated for by enhanced growth of submerged plants in the southern near-shore pelagic region.

The SIV for spring lake level recession describes a seasonally-variable hydro-pattern that is considered by experts to benefit a variety of littoral zone values, including wading birds and certain native plant communities (Smith et al. 1995). It is the only SIV that relates to seasonal variation in lake levels. Therefore it is given a weight of 5.

A Community Suitability Index (CSI) integrates the scores of five hydrologic SIVs and their respective weighting factors, and has an overall range of 0 to 1.0:

$$CSI = (4*SIV_{MINX} + 4*SIV_{MINM} + 5*SIV_{MAXX} + 5*SIV_{MAXM} + 5*SIV_{VAR}) / 23$$

ECOLOGICAL PERFORMANCE MEASURES

To quantify the current status of Lake Okeechobee and its responses to implementation of CERP components, it will be necessary to develop and implement a comprehensive ecological monitoring program. This program should focus on a set of ecological performance measures, which are measures of ecosystem attributes that have quantifiable targets (restoration goals or expectations). A set of specific monitoring parameters will be associated with each performance measure that is included in the program. By adopting this approach, it should be possible to quantify the status of the ecosystem at various scales of resolution, at any point before, during, or after completion of the CERP. Assuming that the hydrologic performance measures used in the planning process reflect conditions that are beneficial to the ecosystem, the overall “scores” of ecological performance measures should increase as the project is completed. If ecological scores do not display expected trajectories during the project, this may serve as an indicator that some adaptive management needs to occur (i.e., changes in structural or operational aspects of the project).

The Lake Okeechobee Conceptual Model working group developed a set of performance measures, targets, and monitoring parameters associated with the four ecosystem attributes (lake water quality, fish & aquatic fauna, native vegetation mosaic, and snail kite, wading birds & waterfowl) in the conceptual model. The information is summarized in Table 1, and details regarding each performance measure are provided in the standard Performance Measure Documentation Sheets developed by the Adaptive Assessment Team (AAT) of CERP. The following text highlights important points that are not explicitly indicated in the tables. The information should be considered a starting point for development of the ecological monitoring program. Detailed planning will need to consider the spatial and temporal aspects of sampling that are required for each parameter, the degree to which recommended parameters already are being monitored by certain state and federal agencies, methods to evaluate uncertainty (both for measured values and targets), and standard procedures for data collection, evaluation, reporting, and archiving.

WATER QUALITY

A number of the water quality parameters relate to the degree of cultural eutrophication of the lake. Given the high degree of uncertainty about the lake's natural trophic state, the targets do not correspond with "restoration," but rather, the attainment of water quality conditions as good as observed in a period of record (1973-1999) when quantitative data were collected. During the early 1970s, when total phosphorus concentrations were near 40 ug/L and total nitrogen to phosphorus ratios were above 30:1, blooms of blue-green algae were rare, and transparency was higher, especially in the near-shore region. Other parameters relate to toxic materials (Class I and III parameters) that can affect both the lake ecosystem and drinking water quality.

It is important to note that all water quality targets listed in Table 1 represent lake-wide average conditions. Given that the lake is heterogeneous in regard to water quality, the final monitoring program should establish region-specific (littoral, near-shore, pelagic) performance measures and targets. For example, the lake-wide total phosphorus target is 40 ug/L, while appropriate regional targets are likely to be approximately 5 ug/L (interior littoral), 20 ug/L (near-shore), and 70 ug/L (central pelagic). Likewise, targets related to bloom-forming cyanobacteria might be zero for the interior littoral region, somewhat higher than the lake-wide average for the near-shore region, and close to zero for the central pelagic (light limited) region.

FISH AND AQUATIC FAUNA

In addition to performance measures related to fish *per se*, it is noteworthy that some of the measures related to aquatic fauna and native vegetation mosaic determine the quality of the littoral and near-shore habitat for fish foraging and spawning, and quality of the lake food web from the standpoint of supporting a productive fishery. Without this information it would be impossible to determine the cause of any unexpected fisheries declines during the CERP implementation, and this would seriously compromise adaptive management. As is the case for water quality, the fisheries performance measures should be expanded to specify targets for distinct lake regions.

NATIVE VEGETATION MOSAIC

Performance measures focus on the littoral and near-shore regions, where vascular plants occur in the lake. In the littoral region, the performance measures reflect a primary objective of reducing the spatial extent of exotic and nuisance plant species, and restoring lost native plant communities. In the near-shore region, the performance measures focus primarily on restoring submerged vegetation communities and bulrush stands, which were lost during recent years of high lake stage. Elimination of the near-shore berm also is included as a target.

SNAIL KITE, WADING BIRDS, AND WATER FOWL

Performance measures related to birds are problematic, because for some key

species (including the Everglades Snail Kite), population dynamics are better evaluated on a system-wide basis, rather than for particular system components such as Lake Okeechobee. Snail kites migrate over much of the Florida peninsula (Bennett and Kitchens 1997), nesting in different areas as a function of habitat availability under different drought / flooding regimes. During some years the lake may provide habitat for a large number of kites and other birds, while in other years, numbers may be substantially reduced. Hence the overall performance of these attributes may best be determined by a system-wide program.

LITERATURE CITED

Aldridge, F.J., E.J. Phlips and C.L. Schelske. 1995, The use of nutrient enrichment bioassays to test for spatial and temporal distribution of limiting factors affecting phytoplankton dynamics in Lake Okeechobee, Florida. Archiv fur Hydrobiologie, Advances in Limnology 45: 177-190.

Baker, C.D. and E.H. Schmitz. 1971. Food habits of adult gizzard and threadfin shad in two ozark reservoirs. Pp. 385-395 in: Hall, G.E. (Ed.), Reservoir Fisheries and Limnology. American Fishery Society, Washington, DC.

Barbiero, R.P. and E.B. Welch. 1992. Contribution of benthic blue-green algal recruitment of lake populations and phosphorus translocation. Freshwater Biology 27: 249-260.

Barnett, B.S. and R.W. Schneider. 1974. Fish populations in dense submersed plant communities. Hyacinth Control Journal 12: 12-14.

Beaver, J.R. and K.E. Havens. 1996. Seasonal and spatial variation in zooplankton community structure and their relation to possible controlling variables in Lake Okeechobee. Freshwater Biology 36: 45-56.

Bell, F.W. 1987. The economic impact and valuation of the recreational and commercial fishing industies of Lake Okeechobee, Florida. Report, Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Bellrose, F. C. 1976. Ducks, Geese and Swans of North America. Stackpole Books, Harrisburg, PA.

Bennetts, R.E., M.W. Callopy and S.R. Beissinger. 1988. Nesting ecology of snail kites in water conservation area 3A. Report, US Geological Survey, Biological Resources Division, Cooperative Fish and Wildlife Research Unit, Gainesville, FL.

Bennetts, R.E. and W.M. Kitchens. 1997. The demography and mavements of snail kites in Florida. Technical report 56, US Geological Survey, Biological Resources Division, Florida Cooperative Fish and Wildlife Research Unit, Gainesville, FL.

Brezonik, P.L., E.C. Blancher, V.B. Myers, C.L. Hilty, M.K. Leslie, C.R. Kratzer, G.D. Marbury, N.R. Snyder, T.L. Crisman and J.J. Messer. 1979. Factors affecting primary production in Lake Okeechobee, Florida. Report 07-79-01 to the Florida Sugar Cane League, Clewiston, Florida.

Brezonik, P.L., and D.R. Engstrom. 1999. Modern and historic accumulation rates of phosphorus in Lake Okeechobee, Florida. Journal of Paleolimnology 20: 31-46.

Bull, L.A., D.D. Fox, D.W. Brown, L.J. Davis, S.J. Miller and J.G. Wullschleger. 1995. Fish distribution in limnetic areas of Lake Okeechobee, Florida. Archiv fur Hydrobiologie, Advances in Limnology 45: 333-342.

Burkholder, J.M., R.G. Wetzel and K.L. Klomparens. 1990. Direct comparison of phosphate uptake by adnate and loosely attached microalgae within an intact biofilm matrix. Applied and Environmental Microbiology 56: 2882-2890.

Canfield, D.E. and M.V. Hoyer. 1988. The eutrophication of Lake Okeechobee. Lake and Reservoir Management 4: 91-99.

Canfield, D.E., Jr., K.A. Langeland, M.J. Maceina, W.T. Haller, J.V. Shireman and J.R. Jones. 1983. Trophic classification of lakes with aquatic macrophytes. Canadian Journal of Fisheries and Aquatic Sciences 40: 1713-1718.

Carr, J.F. and Hiltunen, J.K. 1965. Changes in the bottom fauna of western Lake Erie from 1930 to 1961. Limnology and Oceanography 10: 551-569.

Carrigan, R. and J. Kalff. 1982. Phosphorus release by submerged macrophytes: significance to epiphyton and phytoplankton. Limnology and Oceanography 27: 419-427.

Carter, M.R., L.A. Burns, T.R. Cavinder, K.R. Dugger, P.L. Fore, D.B. Hicks, H.L. Revells and T.W. Schmidt. 1973. Ecosystems analysis of the Big Cypress Swamp and estuaries. U.S. Environmental Protection Agency Ecological Report Number DI-SFEP-74-51.

Chamberlain, E. B., Jr. 1960. Florida water populations, habitats and management. Tech. Bull. No. 7, Federal Aid Project W-19-R. Florida Game and Fresh Water Fish Comm., Tallahassee.

Chick, J.H. and C.C. McIvor. 1994. Patterns in the abundance and composition of fishes among beds of different macrophytes: viewing the littoral zone as a landscape. Canadian Journal of Fisheries and Aquatic Sciences 51: 2873-2882.

Cichra, M.F., S. Badylak, N. Henderson, B.H. Rueter and E.J. Phlips. 1995. Phytoplankton community structure in the open water zone of a shallow subtropical lake (Lake Okeechobee, Florida, USA). Archiv fur Hydrobiologie, Advances in Limnology 45: 157-175.

Conrow, R.A., A.V. Zale and R.W. Gregory. 1990. Distribution and abundance of early life stages of fishes in a Florida lake dominated by aquatic macrophytes. Transactions of the American Fisheries Society 119: 521-528.

Cooke, G.D., and R.E. Carlson. 1989. Reservoir management for water quality and THM precursor control. Report, American Water Works Association Research Foundation, Denver, CO.

Crisman, T.L. and J.R. Beaver. 1990. Applicability of biomanipulation for managing eutrophication in the subtropics. Hydrobiologia 200: 177-185.

Crisman, T.L., E.J. Phlips and J.R. Beaver. 1995. Zooplankton seasonality and trophic state relationships in Lake Okeechobee, Florida. Archiv fur Hydrobiologie, Advances in Limnology 45: 213-232.

Darby, P.C., P.L. Valentine-Darby, R.E. Bennetts, J.D. Croop, H.F. Percival and W.M. Kitchens. 1997. Ecological studies of apple snails (*Pomacea paludosa*). Report of the Florida Cooperative Fish and Wildlife Research Unit, Gainesville, FL.

David, P. 1994. Wading bird nesting at Lake Okeechobee, Florida: an historic perspective. Colonial Waterbirds 17:69-77.

East, T.L., K.E. Havens, A.J. Rodusky and M.A. Brady. 1999. *Daphnia lumholtzi* and *Daphnia ambigua*: population comparisons of an exotic and a native cladoceran in Lake Okeechobee, Florida. Journal of Plankton Research 21: 1537-1551.

Esler, D. 1990. Waterfowl habitat use on a Texas reservoir with hydrilla. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 44: 390-400.

Erwin, R.M. 1983. Feeding habitats of nesting wading birds: spatial use and social influences. The Auk 100:960-970.

FDEP. Multiple years. Florida aquatic plant survey report. Bureau of Aquatic Plant Management, Florida Department of Environmental Protection. Tallahassee, Florida.

FDEP. 2000. Draft phosphorus total maximum daily load (TMDL) for Lake Okeechobee. Florida Department of Environmental Protection, Tallahassee, Florida, USA.

Fisher, M.M, K.R. Reddy and R.T. James. 2000. Long-term changes in the sediment chemistry of a large shallow subtropical lake. Lake and Reservoir Management, in review.

Flaig, E.G., and K.E. Havens. 1995. Historical trends in the Lake Okeechobee ecosystem I. Land use and nutrient loading. Archiv fur Hydrobiologie Monographische Beitrage 107: 1-24

Flaig, E.G., and K.R. Reddy. 1995. Fate of phoshorus in the Lake Okeechobee watershed, Florida, USA: overview and recommendations. Ecological Engineering 5: 127-142.

Fox, D.D., S. Gornak, T.D. McCall, D.W. Brown and C.J. Morris. 1993. Lake Okeechobee fisheries investigations completion report. Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Frederick, P.C. and M.G. Spalding. 1994. Factors affecting reproductive success of wading birds (Ciconiiformes) in the Everglades ecosystem. Pages 659-692 *in* S. M. Davis and J. C. Ogden, editors. Everglades: the ecosystem and its restoration. St. Lucie Press, Delray Beach, Florida, USA.

Fredrickson, L. H., and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. U.S. Fish and Wildlife Service Research Publication #148, Washington, D.C.

Fry, B., P.L. Mumford, F. Tam, D.D. Fox, G.L. Warren, K.E. Havens and A.D. Steinman. 1999. Trophic position and individual feeding histories of fish from Lake Okeechobee, Florida. Canadian Journal of Fisheries and Aquatic Sciences 56: 590-600.

Furse, J.B. and D.D. Fox. 1994. Economic fishery valuation of five vegetation communities in Lake Okeechobee, Florida. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 48:575-591.

Gawlik, D.E. In review. The effects of food availability on the feeding tactics of wading birds. Ecology.

Gleason, P.J. 1984. Environments of South Florida Present and Past II. Miami Geological Society, Coral Gables, FL.

Goodwin, T.M. 1979. Waterfowl management practices employed in Florida and their effectiveness on native and migratory waterfowl populations. Florida Scientist 3:123-129.

Gray, P. N. 1993. The ecology of a southern mallard: Florida's Mottled Duck. Ph.D. Dissertation, University of Florida, Gainesville, FL.

Gliwicz, Z.M. 1986. Suspended clay concentrations controlled by filter-feeding zooplankton in a tropical reservoir. Nature 323: 330-332.

Hanlon, C.G. 1999. Relationships between total phosphorus concentrations, sampling frequency, and wind velocity in a shallow polymictic lake. Lake and Reservoir Management 15: 39-46.

Hanlon, C.G. 2000. The distribution of bulrush (Scirpus californicus) and influence of environmental conditions on plant growth during a 26 year period in a shallow subtropical lake. Aquatic Botany, in review.

Hanlon, C.G. and K. Langeland. 2000. Comparison of experimental strategies for control of torpedograss. Journal of Aquatic Plant Management, in press.

Hanlon, C.G., R.L. Miller and B.F. McPherson. 1998. Relationships between wind velocity and underwater irradiance in a shallow lake (Lake Okeechobee, Florida, USA). Journal of the American Water Resources Association 34: 951-961.

Havens, K.E. 1994. Secondary nitrogen limitation in a subtropical lake impacted by non-point source agricultural pollution. Environmental Pollution 89: 241-246.

Havens, K.E. 1997. Water levels and total phosphorus in Lake Okeechobee. Lake and

Reservoir Management 13:16-25.

Havens et al. (in prep). Food webs supporting fish in the littoral and open water habitats of a large lake based on gut contents and stable isotope analysis.

Havens, K.E., N.G. Aumen, R.T. James and V.H. Smith. 1996a. Rapid ecological changes in a large subtropical lake undergoing cultural eutrophication. Ambio 25:150-155.

Havens, K.E., L.A. Bull, G.L. Warren, T.L. Crisman, E.J. Phlips and J.P. Smith. 1996b. Food web structure in a subtropical lake ecosystem. Oikos 75: 20-32.

Havens, K.E. and T.L. East. 1997. Carbon dynamics in the grazing food chain of a subtropical lake. Journal of Plankton Research 19: 1687-1711.

Havens, K.E., T.L. East and J.R. Beaver. 1996c. Experimental studies of zooplankton-phytoplankton-nutrient interactions in a large subtropical lake (Lake Okeechobee, Florida, USA). Freshwater Biology 36: 579-597.

Havens, K.E., T.L. East, A.J. Rodusky and B. Sharfstein. 1997. Littoral periphyton responses to nitrogen and phosphorus: and experimental study in a subtropical lake. Aquatic Botany 63: 267-290.

Havens, K.E., C. Hanlon, and R.T. James. 1994. Seasonal and spatial variation in algal bloom frequencies in Lake Okeechobee, Florida, USA. Lake and Reservoir Management 10: 139-148.

Havens, K.E. and R.T. James. 1997. A critical evaluation of phosphorus management goals for Lake Okeechobee. Lake and Reservoir Management 13: 292-301.

Havens, K.E., E.J. Phlips, M.F. Cichra and B.L. Li. 1998. Light availability as a possible regulator of cyanobacteria species composition in a shallow subtropical lake. Freshwater Biology 39: 547-556.

Havens, K.E. and C.L. Schelske. 2000. The importance of considering biological processes when setting total maximum daily loads (TMDL) for phosphorus in shallow lakes and reservoirs. Environmental Pollution, in review.

Havens, K.E., K.A. Work and T.L. East. 2000. Relative efficiencies of carbon transfer from bacteria and algae to zooplankton in a subtropical lake. Journal of Plankton Research 22: 1801-1809.

Hopson, M.S. and P.V. Zimba. 1993. Temporal variation in the biomass of submersed macrophytes in Lake Okeechobee, Florida. Journal of Aquatic Plant Management 31: 76-81.

Horne, A.J. 1977. Nitrogen fixation - a review of this phenomenon as a polluting process. Progress in Water Technology 8: 359-372.

Horne, A.J. 1979. Nitrogen fixation in Clear Lake, California. Diel studies on *Aphanizomenon* and *Anabaena* blooms. Limnology and Oceanography 24: 329-241.

Howard, K. S., William F. Loftus, and Joel C. Trexler. 1995. Seasonal dynamics of fishes in artificial culvert pools in the C-111 basin, Dade County, Florida. Miami, Florida, Florida International University and National Biological Service.

Hwang, S.J., K.E. Havens and A.D. Steinman. Phosphorus kinetics of planktonic and benthic assemblages in a shallow subtropical lake. Freshwater Biology 40: 729-745.

James, R.T., and V.J. Bierman, Jr. 1995. A preliminary modeling analysis of water quality in Lake Okeechobee, Florida: calibration results. Water Research 29: 2755-2766.

James, R.T., V.H. Smith and B.L. Jones. 1995a. Historical trends in the Lake Okeechobee ecosystem III. water quality. Archiv fur Hydrobiologie, Monographische Beitrag 107:49-69.

James, R.T., B.L. Jones and V.H. Smith. 1995b. Historical trends in the Lake Okeechobee ecosystem II. Nutrient budgets. Archiv fur Hydrobiologie, Monographische Beitrag 107: 25-47.

Janacek, J.A. 1988. Literature review on fish interactions with aquatic macrophytes with special reference to the upper Mississippi River. Report, Upper Mississippi River Conservation Commission, Rock Island, IL.

Jeske, C.W. 1985. Time and energy budgets of wintering Ring-necked Ducks *Aythya collaris* (L.) in north-central Florida. M.S. thesis, University of Florida, Gainesville, FL.

Jin, K.R., J.H. Hamrick and T. Tisdale. 2000. Application of three-dimensional hydrodynamic model for Lake Okeechobee. Journal of Hydraulic Engineering 126: 758-771.

Johnson, F.A. and F. Montalbano. 1984. Selection of plant communities by wintering waterfowl on Lake Okeechobee, Florida. Journal of Wildlife Management 48: 174-178.

Jones, B. 1987. Lake Okeechobee eutrophication research and management. Aquatics 9:21-26.

Kahl, M.P., Jr. 1964. Food ecology of the wood stork (*Mycteria americana*) in Florida. Ecological Monographs. 34:97-117.

Kushlan, J.A. 1976. Wading bird predation in a seasonally fluctuating pond. The Auk 93:464-476.

Kushlan, J.A. 1981. Resource use strategies of wading birds. Wilson Bulletin 93:145-163.

Lockhart, C.S. 1995. The effect of water level variation on the growth of Melalauca seedlings

from the Lake Okeechobee littoral zone. MS Thesis, Florida Atlantic University, Boca Raton, FL.

Loftus, W. F., and A. Eklund. 1994. Long-term dynamics of an Everglades small-fish assemblage. Pages 461-484 *in* S. M. Davis and J. C. Ogden, editors. Everglades: the ecosystem and its restoration. St. Lucie Press, Delray Beach, Florida, USA.

Loftus, W.F. and J.A. Kushlan. 1987. Freshwater fishes of southern Florida. Bulletin of the Florida State Museum, Biological Sciences 31: 147-344.

Maceina, M.J. 1993. Summer fluctuations in planktonic chlorophyll a concentrations in Lake Okeechobee, Florida: the influence of lake levels. Lake and Reservoir Management 8:1-11.

Maceina, M.J. and D.M. Soballe. 1991. Wind-related limnological variation in Lake Okeechobee, Florida. Lake and Reservoir Management 6:93-100.

McCormick, P.V., S. Newman, S.L. Miao, R. Reddy, D. Gawlick, C. Fitz, T. Fontaine and D. Marley. 1999. Ecological needs of the Everglades. In: Everglades Interim Report, January 1, 1999. South Florida Water Management District, West Palm Beach, FL.

McCormick, P.V., P.S. Rawlik, K. Lurding, E.P. Smith and F.H. Sklar. 1996. Periphyton-water quality relationships along a nutrient gradient in the northern Florida Everglades. Journal of the North American Benthological Society 15: 433-449.

Midwinter Inventory. Annual waterfowl survey. Florida Fish and Wildlife Conservation Commission, Waterfowl Section, Tallahassee, FL.

Montalbano, F., S. Hardin and W.M. Hetrick. 1979. Utilization of hydrilla by ducks and coots in central Florida. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 33: 36-42.

Moore, P.A., K.R. Reddy and M.M. Fisher. 1998. Phosphorus flux between sediment and overlying water in Lake Okeechobee, Florida: spatial and temporal variations. Journal of Environmental Quality 27: 1428-1439.

Moss, B., J. Madgwick and G. Phillips. 1996. A Guide to the Restoration of Nutrient-Enriched Shallow Lakes. Environment Agency, Broads Authority, UK.

Newman, S., J.B. Grace and J.W. Koebel. 1996. Effects of nutrients and hydroperiod on *Typha, Cladium* and *Eleocharis*: implications for Everglades restoration. Ecological Applications 6: 774-783.

Olila, O.G. and K.R. Reddy. 1993. Phosphorus sorption characteristics of sediments in shallow eutrophic lakes of Florida. Archiv fur Hydrobiologie 129:45-65.

Paerl, H.W. 1988. Nuisance phytoplankton blooms in coastal, estuarine, and inland waters.

Limnology and Oceanography 33: 823-847.

Pesnell, G.L. and R.T. Brown. 1976. Map of the vegetation of Lake Okeechobee, Florida. South Florida Water Management District, West Palm Beach, FL.

Phlips, E.J., F.J. Aldridge and P. Hansen. 1995. Patterns of water chemistry, physical and biological parameters in a shallow subtropical lake (Lake Okeechobee, Florida, USA). Archiv fur Hydrobiologie, Advances in Limnology 45: 117-135.

Phlips, E.J., M. Cichra, K.E. Havens, C. Hanlon, S. Badylak, B. Rueter, M. Randall and P. Hansen. 1997. Relationships between phytoplankton dynamics and the availability of light and nutrients in a shallow subtropical lake. Journal of Plankton Research 19: 319-342.

Phlips, E.J., and J. Ihnat. 1995. Planktonic nitrogen fixation in a shallow subtropical lake (Lake Okeechobee, Florida, USA). Archiv fur Hydrobiologie, Advances in Limnology 45: 191-201.

Phlips, E.J., P.V. Zimba, M.S. Hopson and T.L. Crisman. 1993. Dynamics of the plankton community in submerged plant dominated regions of Lake Okeechobee, Florida, USA. Proceedings, International Association of Theoretical and Applied Limnology 25: 423-426.

Reddy, K.R., Y.P. Sheng and B.L. Jones. 1995. Lake Okeechobee phosphorus dynamics study volume I. Summary. Report, South Florida Water Management District, West Palm Beach, FL.

Reynolds, C.S. 1984. The Ecology of Freshwater Phytoplankton. Cambridge University Press, UK.

Richardson, J.R. and T.T. Harris. 1995. Vegetation mapping and change detection in the Lake Okeechobee marsh ecosystem. Archiv fur Hydrobiologie, Advances in Limnology 45:17-39.

Richardson, J.R., T.T. Harris and K.A. Williges. 1995. Vegetation correlations with various environmental parameters in the Lake Okeechobee marsh ecosystem. Archiv fur Hydrobiologie, Advances in Limnology 45: 41-61.

Rozas, L.P. and W.E. Odum. 1988. Occupation of submerged aquatic vegetation by fishes: testing the roles of food and refuge. Oecologia 77: 101-106.

Sas, H. 1989. Lake restoration by reduction of nutrient loading: expectation, experiences, extrapolations. Academia Verlag Richarz, Germany.

Scheffer, M. 1989. Alternative stable states in eutrophic shallow freshwater systems: a minimal model. Hydrobiological Bulletin 23: 73-85.

Schelske, C.L. 1984. In situ and natural phytoplankton assemblage bioassays. In: Shubert,

L.E. (Ed.), Algae as Ecological Indicators, pp. 15-47. Academic Press, NY.

SFWMD. 1997. Surface water improvement and management (SWIM) plan – update for Lake Okeechobee. South Florida Water Management District, West Palm Beach, FL.

Sharfstein, B. and A.D. Steinman. 2000. Growth and survival of the Florida apple snail (*Pomacea paludosa*) fed three naturally occurring macrophyte assemblages. Journal of the North American Benthological Society, in review.

Sheng, Y.P. and H.K. Lee. 1991. Computation of the phosphorus flux between the vegetation area and the open water in Lake Okeechobee. Report, South Florida Water Management District, West Palm Beach, FL.

Smith, J.P. 1997. Nesting season food habits of four species of Herons and Egrets and Lake Okeechobee, Florida. Colonial Waterbirds 20: 198-220.

Smith, J. P. and M. W. Collopy. 1995. Colony turnover, nest success and productivity, and causes of nest failure among wading birds (Ciconiiformes) at Lake Okeechobee, Florida (1989-1992). Archiv fur Hydrobiologie, Advances in Limnology 45:287-316.

Smith, J.P., J.R. Richardson and M.W. Callopy. 1995. Foraging habitat selection among wading birds (Ciconiiformes) at Lake Okeechobee, Florida, in relation to hydrology and vegetative cover. Archiv fur Hydrobiologie, Advances in Limnology 45: 247-285.

Smith, D., M. Smart and C.G. Hanlon. 2000. Hydrologic influences on torpedograss establishment in Lake Okeechobee, Florida. Aquatic Botany, in review.

Steinman, A.D., K.E. Havens, H.J. Carrick and R.VanZee. 2000. The past, present, and future hydrology and ecology of Lake Okeechobee and its watershed. In: Porter, J. and K. Porter (Eds.), Linkages Between Ecosystems in the South Florida Hydroscape. CRC Press, Boca Raton, FL, in press.

Steinman, A.D., R.H. Meeker, A.J. Rodusky, W.P. Davis and S.J. Hwang. 1997a. Ecological properties of charophytes in a large subtropical lake. Journal of the North American Benthological Society 16: 781-793.

Steinman, A.D., R.H. Meeker, A.J. Rodusky, W.P. Davis and C.D. McIntire. 1997b. Spatial and temporal distribution of algal biomass in a large subtropical lake. Archiv fur Hydrobiologie 139: 29-50.

Steinman, A.D., A.J. Rodusky and B. Sharfstein. 2000. Chara dynamics in a subtropical lake: Lake Okeechobee, Florida as a case study. Aquatic Botany, in revision.

Sykes, P.W., Jr. 1987. The feeding habits of snail kite in Florida, USA. Colonial Waterbirds 10: 84-92.

Thayer, P.L. and W.T. Haller. 1990. Fungal pathogens, *Phoma* and *Fusarium*, associated with declining populations of torpedograss growing under high water stress. Proceedings of European Weed Research Society, 8th Symposium on Aquatic Weeds, pp. 209-214.

Turner, R.L. 1994. The effects of hydrology on the population dynamics of the Florida apple snail (*Pomacea paludosa*). Special publication SJ94-SP3, St. Johns River Water Management District, Pilatka, FL.

Turner, R.L. 1996. Use of stems of emergent plants for oviposition by the Florida apple snail, *Pomacea paludosa*, and implications for marsh management. Florida Scientist 59: 34-49.

USACE. 1999. Wildlife survey and habitat utilization study of the western littoral zone of Lake Okeechobee, Florida. United States Army Corps of Engineers, Jacksonville District, FL.

USEPA. 2000. Total maximum daily load (TMDL) for Lake Okeechobee. United States Environmental Protection Agency, Atlanta, Georgia, USA.

Van der Valk, A.G. 1994. Effects of prolonged flooding on the distribution and biomass of emergent species along a freshwater wetland coenocline. Vegetatio 110: 186-196.

Van Rees, K.C.J., K.R. Reddy and P.S.C. Rao. 1996. Influence of benthic organisms on solute transport in lake sediments. Hydrobiologia 317: 31-40.

Vermaat, J.E., L. Santamaria and P.J. Roos. 2000. Water flow across and sediment trapping in submerged macrophyte beds of contrasting growth form. Archiv fur Hydrobiologie 148: 549-562.

Warren, G.L. and D.A. Hohlt. 1994. Lake Okeechobee invertebrate community investigations. Study IV in the Lake Okeechobee-Kissimmee River-Everglades Resource Evaluation Report. Wallop-Breaux Project F-52 Completion Report to the US Department of Interior

Warren, G.L. and M.J. Vogel. 1991. Lake Okeechobee invertebrate studies. Study II in the Lake Okeechobee-Kissimmee River-Everglades Resource Evaluation Report. Wallop-Breaux Project F-52 Completion Report to the US Department of Interior.

Warren, G.L., M.J. Vogel and D.D. Fox. 1995. Trophic and distributional dynamics of Lake Okeechobee sublittoral benthic invertebrate communities. Archiv fur Hydrobiologie, Advances in Limnology 45: 317-332.

Werner, E.E., J.F. Gilliam, D.J. Hall and G.G. Mittelbach. 1983. An experimental test of the effects of predation risk on habitat use in fish. Ecology 64: 1540-1548.

White, D.H. and D. James. 1978. Differential use of fresh water environments by wintering waterfowl of coastal Texas. Wilson Bulletin 90: 99-111.

Williges, K.A. and T.T. Harris. 1995. Seed bank dynamics in the Lake Okeechobee marsh ecosystem. Archiv fur Hydrobiologie, Advances in Limnology 45: 79-94.

Zaffke, M. 1984. Wading bird utilization of Lake Okeechobee marshes 1977-1981. South Florida Water Management District Technical Publication 84-9.

CONTRIBUTORS

Nicholas Aumen (DOI),
Hunter Carrick (SFWMD),
Steve Davis (SFWMD),
Dale Gawlick (SFWMD),
Paul Gray (Florida Audubon),
Charles Hanlon (SFWMD),
R. Thomas James (SFWMD),
Kang-Ren Jin (SFWMD),
Brad Jones (SFWMD),
Frank Mazzotti (U. Miami),
Elizabeth Manners (USACE),
John Ogden (SFWMD),
Robert Pace (USFWS),
Mary Anne Poole (FFWCC),
Alan Steinman (SFWMD),
David Swift (SFWMD),
Todd Tisdale (SFWMD),
Gary Warren (FFWCC),
Herbert Zebuth (FDEP),
Mark Ziminski (USACE)

LIST OF FIGURES

Figure 1. Map of Lake Okeechobee and part of its surrounding watershed, showing conditions prior to construction of the C&SF Project (PAST), todays conditions (PRESENT), and conditions anticipated after completion of the CERP (FUTURE). The figures show the spatial extent of the lake's open water region, the magnitude of various inflows and outflows, and ranges of water levels under each condition.

Figure 2. The Lake Okeechobee Conceptual Model, as described in the text. Rectangles at the top of the model are **external drivers**, ovals are **ecological sressors**, diamonds are **ecosystem effects**, hexagons are ecological **attributes**, and parallelograms are **performance measures**, all as defined in the text. Arrows indicated links, with arrowheads pointing towards the item being affected.

ELSEVIER

Environmental Pollution 113 (2001) 1–9

ENVIRONMENTAL POLLUTION

www.elsevier.com/locate/envpol

Commentary

The importance of considering biological processes when setting total maximum daily loads (TMDL) for phosphorus in shallow lakes and reservoirs

K.E. Havens [a,*], C.L. Schelske [b]

[a] *Department of Ecosystem Restoration, South Florida Water Management District, 3301 Gun Club Road, PO Box 24680, West Palm Beach, FL 33416, USA*
[b] *University of Florida, Gainesville, FL 32653, USA*

Received 3 November 2000; accepted 10 November 2000

"Capsule": *Biological processes affect lake phosphorous assimilation.*

Abstract

Total maximum daily loads (TMDL) are required by the US Environmental Protection Agency for pollutants that have impaired the designated uses of surface waters in the nation. Setting an appropriate TMDL requires quantitative information on both the external pollutant inputs and the processes affecting pollutant dynamics within the ecosystem. Here we focus on phosphorus (P), a globally important pollutant of freshwater lakes. We consider how biological processes (including those related to algae, plants, invertebrates and fish) can influence the ability of lakes to assimilate P, and in turn the ability of managers to select appropriate TMDLs. The primary focus is on shallow eutrophic lakes, with Lake Okeechobee (Florida, USA) serving as a case study. The paper deals only with in-lake processes as they relate to setting the TMDL and not the subsequent issue of load allocation among pollution sources. The results indicate that the ability of a shallow lake to assimilate P is substantially reduced when surplus levels of P occur in the water column, the phytoplankton becomes dominated by cyanobacteria, the benthic invertebrate community becomes dominated by oligochaetes, and submerged plant biomass is low. If some of these biological changes can be reversed in a rehabilitation program then the lake may be able to support a higher TMDL. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Phosphorus; Loading; TDML; Shallow lakes; Biological processing

1. Introduction

The US Clean Water Act establishes a process to facilitate recovery of surface waters not meeting their established water quality standards. In the Act, state and/or federal agencies are charged with developing an appropriate total maximum daily load (TMDL) for each water body and for each identified pollutant. Under Section 303(d)(1)(C) of the Act, a TMDL is identified as "the load necessary to implement the applicable water quality standards." In other words, it identifies the amount of pollutant loading that a water body can receive and still provide its designated uses (e.g. drinking water, recreation, fish and wildlife habitat). In the USA and other nations, one of the most frequently identified pollutants of lakes and reservoirs is phosphorus (P), which can originate from urban, residential, industrial and non-point agricultural sources (Reynolds, 1978; Cullen and Forsberg, 1988; Havens and Steinman, 1995). Because P is often limiting to phytoplankton production in freshwater lakes (Schindler, 1977; Hecky and Kilham, 1988), high inputs of this nutrient have led to accelerated eutrophication and in many instances to dense blooms of noxious cyanobacteria (Paerl, 1988; Smith et al., 1999). Prolonged high inputs of P result in a variety of other adverse impacts to the natural ecosystem, as we shall discuss below.

Setting a TMDL for P generally requires identification of a lake water concentration standard above which the uses of the resource are considered to be impaired. Empirical relationships or models are then used to quantify the external loading rate necessary to achieve the standard. In this computation, it is necessary to consider the extent to which the ecosystem can process and assimilate P into long-term (sediment) storage. Quantifying this lake "assimilative capacity" is a challenge because it is determined by a complex function

* Corresponding author. Fax: +1-561-687-6442.
E-mail address: karl.havens@sfwmd.gov (K.E. Havens).

0269-7491/01/$ - see front matter © 2001 Elsevier Science Ltd. All rights reserved.
PII: S0269-7491(00)00235-9

of physical, chemical, and biological processes that vary over time and space. Assimilative capacity is particularly difficult to quantify in shallow lakes where there are many different types of sediment-water interactions. Nevertheless, we can approximate the relationship between P assimilation and the TMDL using a mass-balance approach. This is patterned after the input–output models of Vollenweider (1975) and has been proposed as one method for setting a TMDL for Lake Okeechobee (Walker, 2000).

For a lake or reservoir, the total mass input of P can be related to the mass output and net storage according to Eq. (1). Under steady state conditions, the TMDL can be determined by expressing output and storage terms as concentration times volume (Eq. (2)) and then substituting into the equation the in-lake P concentration goal (Eqs. (3) and (4)). We assume here that the outflow P concentration is equal to that of the lake water.

$$M_{\text{in}} + M_{\text{atmos}} = M_{\text{out}} + M_{\text{sed}} \quad (1)$$

$$M_{\text{n}} + M_{\text{atmos}} = P_{\text{lake}} \times Q_{\text{out}} + P_{\text{lake}} \times A \times K_{\text{net}} \quad (2)$$

$$M_{\text{in}} + M_{\text{atmos}} = P_{\text{target}} \times Q_{\text{out}} + P_{\text{target}} \times A \times K_{\text{net}} \quad (3)$$

$$\text{TMDL} = P_{\text{target}} \times Q_{\text{out}} + P_{\text{target}} \times A \times K_{\text{net}} \quad (4)$$

In these equations, M_{in} is the P mass input (metric tons year^{-1}) from tributaries, M_{atmos} is the input from the atmosphere, M_{out} is the output to tributaries, and M_{sed} is the net loss of P to sediment storage. The term P_{lake} is the lake water P concentration (mg m^{-3}), Q_{out} is the outflow volume (km^3 year^{-1}), A is lake area (km^2), and K_{net} is the net P sedimentation rate (m year^{-1}). All of the model terms can be directly measured except K_{net}, which is calculated by solving Eq. (2) using data from the lake's yearly budget. The M_{sed} term is rarely measured and is generally calculated by difference using Eq. (1).

Understanding how K_{net} has changed over time and how it is anticipated to change under reduced P loads is critical to setting the TMDL. However, the linkage between K_{net} and P loads may be complicated where biological processes produce feedback loops and non-linear responses. A wide body of research has shown that this situation is common in shallow eutrophic lakes (e.g. Scheffer, 1998; Moss et al., 1997; Meijer, 2000). Here we illustrate that biological processes can affect K_{net} and the TMDL using shallow Lake Okeechobee, Florida, USA, as an example. The biological factors are described in a hierarchical manner, from the base of the food web upward.

2. Description of the study site

Lake Okeechobee is a large (~1,800 km^2), shallow (mean depth ~3 m) eutrophic lake located in South Florida, USA, at the center of the greater Florida Everglades ecosystem. The lake provides flood protection, water supply, recreational opportunities, wildlife habitat, and it supports productive sport and commercial fisheries. The lake has experienced high rates of P loading since at least the early 1970s, when regular data were first collected (James et al., 1995a), and in the last 30 years it has undergone accelerated eutrophication (Havens et al., 1996). The lake is designated by the USEPA as impaired by high concentrations of total P and a few other chemical constituents. Both the USEPA and the Florida Department of Environmental Protection (FDEP) have proposed TMDLs for P in Lake Okeechobee that are aimed at meeting an in-lake concentration goal of 40 mg m^{-3} that was established previously by Florida Statutes (sections 373.451 and 373.4595).

3. Observed trends in phosphorus assimilation

Based on the lake's P budget, there has been a dramatic decline in K_{net}, from above 3.0 m year^{-1} in the mid-1970s to below 1.0 m year^{-1} in recent years (Fig. 1a). This trend suggests that the lake has lost some of its capacity to assimilate P, perhaps due to saturation of P binding sites on lake sediment particles and/or other processes. The results of a recent study indicate that surface mud sediments contain a higher concentration (0.75 g m^{-3}) of dissolved reactive P than a decade ago (0.39 g m^{-3}), reflecting the effects of increased P loading and supporting the conclusion that assimilative capacity has declined (Fisher et al., 2000). The decline in K_{net} (Fig. 1a) appears to be slowing in recent years, perhaps indicating that the lake has reached equilibrium under the present state of high external loads. It is unclear whether K_{net} would tend to be higher, lower, or similar to the present value if the lake were to equilibrate under some new lower rate of P loading. We suspect that K_{net} might be higher, in part because of reversal of biological processes described below (Table 1). However, it is important to note that we presently do not have the information necessary to make a quantitative prediction of these biological effects.

4. Biological processes that affect lake phosphorus assimilation

4.1. Phosphorus deficiency vs. surplus

A major loss process for P from the water column of lakes is the settling of plankton (Stabel, 1985). When P is deficient, as is the natural state of many freshwater lakes, very little soluble P remains in the water column and most occurs within the phytoplankton cells, or

Table 1
Biological factors that may influence a lake's net phosphorus (P) assimilative capacity, which we index in this paper as K_{net}, the net P settling rate

Biological factor	Effect on K_{net}	Response to load reduction
Phosphorus surplus	Reduced when surplus is great	Surplus should be reduced if loads are reduced = increased K_{net}
Phytoplankton taxonomic structure	Highest when diatoms are dominant; lowest when buoyant cyanobacteria are dominant	Relative biomass of cyanobacteria expected to decrease if loads are reduced and P becomes limiting = increased K_{net}
Submerged plant biomass	Highest when there is widespread high biomass of plants	Unclear whether this factor is affected by nutrient inputs per se or primarily by water depths = uncertain effect on K_{net}
Macro-invertebrate taxonomic structure and mass	Highest when vertically migrating insects dominate with adult emergence from the lake; lowest with oligochaete dominance	Relative biomass of oligochaetes expected to decrease if loads are substantially reduced = increased K_{net}
Fish taxonomic structure and biomass	Highest when detritivores are not abundant; lowest when the biomass of these fish (especially gizzard shad) is very high	Reduced total fish biomass and decreased relative biomass of detritivores = increased K_{net}

when there is heavy grazing pressure, in the tissues of zooplankton (Gulati et al., 1992). Under these conditions, the P is contained in particles, which can readily transport it into sediment storage when they settle due to gravity. In contrast, lakes with many years of high P loading can develop a P surplus, where the supply of soluble P exceeds demands of phytoplankton. Under these circumstances some other factor, such as nitrogen (N) may become "secondarily limiting" (Schelske, 1984) and a large portion of the total P occurs in the dissolved form. The net loss of P from the water column is reduced, lowering a lake's K_{net}.

Another process that can affect the net loss of P from a shallow lake's water column is storage of polyphosphates in the algal cells. In Lake Apopka, a Florida lake that is highly enriched with P (Schelske et al., 2000), soluble P generated at the sediment-water interface is stored as polyphosphate by meroplanktonic algae that frequently are resuspended and settle in the water column (Carrick et al., 1993). Paleolimnological data indicate that the amount of settled P as polyphosphate has increased with increased nutrient loading during the last century in this lake (Kenny et al., in review).

In Lake Okeechobee, we do not have comparable data to evaluate the importance of polyphosphate storage, but there is evidence of an increased P surplus in the water column since the early 1970s. In particular, a switch from P-limited to N-limited conditions occurred in the early 1980s (Havens, 1995), coincident with an increase in the availability of soluble P relative to soluble N (Smith et al., 1995). In the early 1990s, chemical measurements and nutrient enrichment bioassays (Aldridge, 1994) quantified the amount of surplus P for plankton, defined as the sum of hot-water extractable P (Fitzgerald and Nelson, 1966) and SRP. It ranged from 20 to 100 mg m^{-3} and represented from 39 to 55% of total P in the water. Although the data for hot-water extractable P are limited to the early 1990s, James et al. (1995b) documented that there was a significant increase in lake-wide SRP concentrations from the early 1970s to the 1990s, and a re-analysis of the current data supports this conclusion (Fig. 1b). The increase coincides with the decline in K_{net}.

Under current conditions, the primary limiting nutrient for pelagic phytoplankton in Lake Okeechobee is N, with P acting only as a co-limiting factor in certain sheltered bays at the south end of the lake (Aldridge et al., 1995). If P loading to this lake is substantially reduced, one might expect these conditions to change, as lowered inputs of P lead to a decreased frequency of N limitation and an increase of P-limited conditions. As the P-limited phytoplankton sequester soluble P, there should be a corresponding reduction in the percent and quantity of P that occurs in that fraction in the water column, and an increased fraction of the total water column P that is susceptible to loss by sedimentation. That response might be accelerated if there is improvement of underwater irradiance along with lowered phytoplankton biomass, because rates of P uptake by freshwater phytoplankton are directly influenced by light availability (Nalewajko and Lee, 1983). Under present conditions, the phytoplankton in Lake Okeechobee are often light-limited due to a combination of abiotic turbidity and a relatively high lake stage. Future management of the lake may include (depending on feasibility) both a lower average lake stage and removal of mud sediment materials that contribute to the high turbidity (USACE, 1999). Those actions could be complementary to P load reduction, in terms of improving

the water quality of the lake, if they result in greater net P assimilation.

4.2. Phytoplankton community structure

The taxonomic composition of phytoplankton may also influence the extent to which P is lost from the water column by sedimentation, and hence the ability of a lake to assimilate external P loads. In considering the factors that affect the vertical distribution of phytoplankton in lakes, Reynolds (1984) identifies three general categories of algal cells: (1) non-motile, negatively buoyant; (2) positively buoyant; and (3) neutrally buoyant and motile. Among the negatively buoyant algae, planktonic diatoms are the prime example. Their protoplasts are surrounded by a siliceous frustule, which makes them very dense relative to the fresh water medium. As a result, they sink rapidly and only can maintain a net growth in turbulent water (Lund et al., 1963; Reynolds, 1973; Reynolds and Wiseman, 1982). When the lake water is thermally stratified, diatoms settle to the lake bottom, resulting in a downward flux of P. In contrast, many of the planktonic cyanobacteria are positively buoyant, meaning that they will float, rather than sink, in a stratified water column (Reynolds, 1984). By the formation of intra-cellular gas vacoules (Reynolds and Walsby, 1975), many cyanobacteria species can rise to the water surface forming scums or blooms. Cyanobacteria that occur at the sediment-water interface also may remain dormant until favorable conditions of irradiance, temperature, and/or nutrient availability occur, and then migrate upwards in the water column (Horne, 1979; Barbiero and Kann, 1994). Hence, the relative dominance of negatively buoyant vs. positively buoyant algae in a lake may influence that extent of P transport from the water to sediments (Barbiero and Welch, 1992), and therefore, determine in part, the lake's K_{net}. Dominance by diatoms would tend

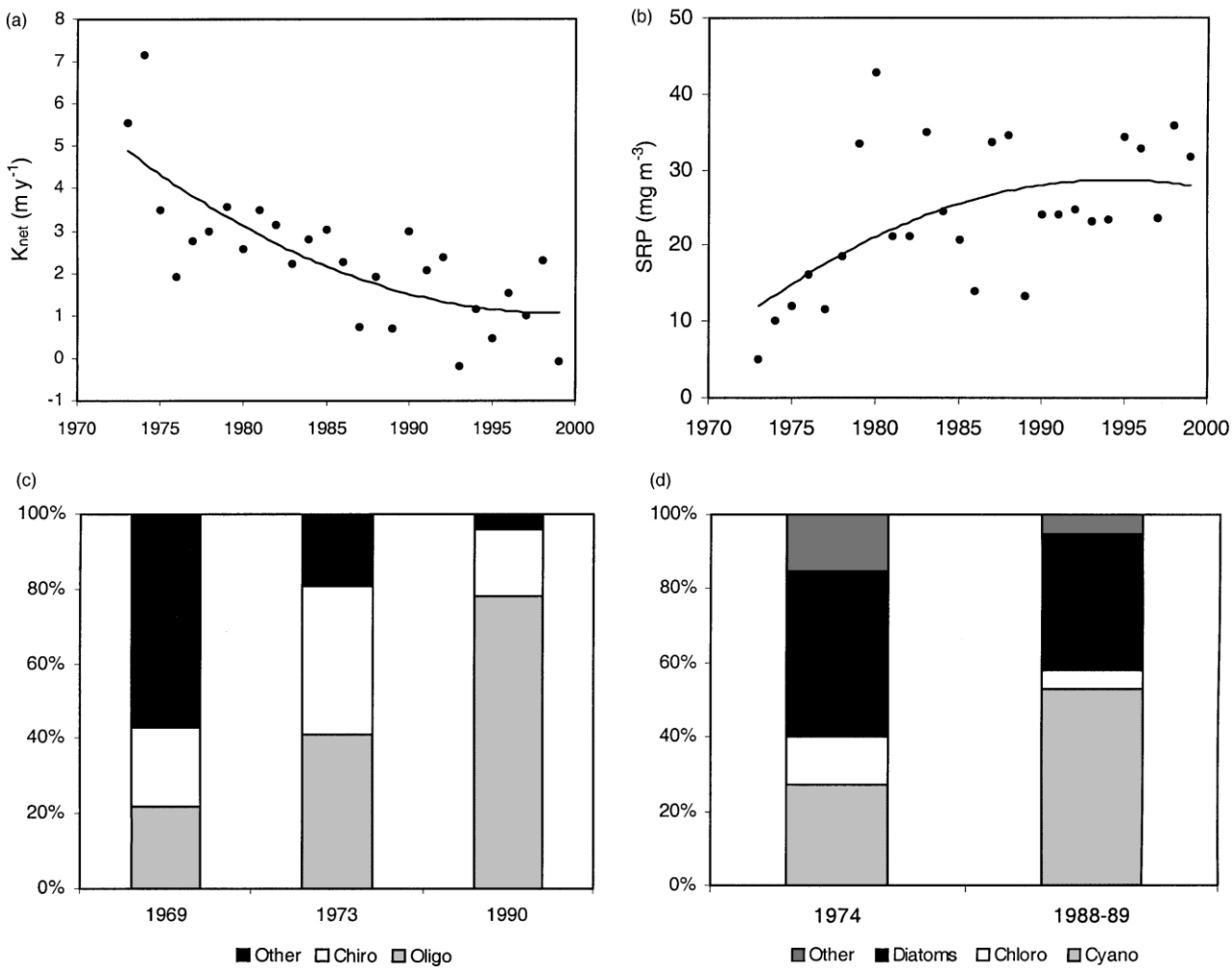

Fig. 1. Chemical and biological changes in Lake Okeechobee in the last 30 years. (a) Exponential decline in K_{net}, the net phosphorus settling rate calculated from mass-balance. (b) Increase in yearly-averaged soluble reactive phosphorus (SRP) concentrations measured at eight pelagic monitoring stations. (c) Changes in the relative abundance of different benthic invertebrate taxa, including chironomids (Chiro) and oligochaetes (Oligo). (d) Changes in the relative biovolume of different phytoplankton taxa, including diatoms, chlorophytes (Chloro) and cyanobacteria (Cyano).

to favor a high K_{net}, while dominance by cyanobacteria would contribute to a K_{net} that is relatively low.

In the case of Lake Okeechobee, there has been a dramatic change in phytoplankton taxonomic structure coincident with the observed decrease in K_{net} from the 1970s to the 1990s (Fig. 1c). In a survey conducted in 1974 (Marshall, 1977), diatoms comprised 45% of the total phytoplankton biomass in the lake's pelagic (open-water) region, while less than 30% was due to cyanobacteria. The remainder of the biomass was made up of cryptophytes and small chlorophytes, taxa that Reynolds (1984) classifies as neutrally buoyant. In contrast, the phytoplankton community that has dominated in the lake since the late 1980s contains over 60% cyanobacteria and just 20% diatoms (Cichra et al., 1995; Havens et al., 1998). The dominance by cyanobacteria probably is related to the secondary N limitation that now occurs in the lake (Smith et al., 1995; Phlips et al., 1997) and not a lack of silica in these silica-replete waters. The dominant taxa (e.g. *Anabaena circinalis*) are favored over other algae when N is limiting because they can sequester N_2 from the atmosphere when dissolved inorganic N is scarce (Horne, 1977). If the rate of P loading is substantially reduced and in-lake P concentrations decline, the frequency of N-limiting conditions may be reduced in Lake Okeechobee. If that occurs, there may be a reversal of the trend in phytoplankton taxonomic structure, with a return to diatom dominance, and perhaps an increase in K_{net}. With a greater K_{net}, the in-lake P concentration goal might be met with a higher TMDL.

4.3. Submerged plant distribution and biomass

Highly eutrophic shallow lakes can exist in two distinct states — clear and turbid (Scheffer, 1989; Scheffer et al., 1993). A low biomass of phytoplankton in the water column and widespread dense growth of submerged macrophytes characterize clear water lakes. The macrophytes provide a number of functions related to water quality and P dynamics. These include a stabilization of sediments by roots, a reduction of water flow velocity and shear stress on the sediment surface due to wave attenuation (Vermaat et al., 2000), trapping of sediments among the macrophytes, direct uptake of P by roots in the sediments and direct uptake of P from the water by epiphytic algae (Carrigan and Kalff, 1982; Burkholder et al., 1990; Hansson, 1990). The net result is that in lakes with strong macrophyte dominance, there is a positive feedback system that prevents phytoplankton from becoming abundant and maintains a strong in-lake sink for P. In Florida lakes dominated by macrophytes, as much as 96% of the combined water column and macrophyte phosphorus can occur in the tissues of the macrophytes (Canfield et al., 1983). These conditions should contribute to a high K_{net}. In contrast, turbid phytoplankton-dominated lakes generally contain sparse or no submerged macrophytes (Scheffer et al., 1994; Moss et al., 1997), and their sediments are more prone to wind and wave driven sediment resuspension. This alternative condition also generates a positive feedback, because increased phytoplankton → greater turbidity → insufficient light for submerged macrophytes → more nutrients available to phytoplankton → more phytoplankton. These lakes are characterized by P-replete conditions and cyanobacterial dominance (Smith, 1986; Hosper, 1997) and for the reasons listed above, can be expected to have lower values of K_{net} than their clear water counterparts.

In Lake Okeechobee, the central pelagic zone generally has a high degree of turbidity due to resuspension of inorganic bottom sediments, and as a result of the poor light conditions, does not support either rooted macrophytes or a high biomass of phytoplankton (Phlips et al., 1995; Zimba et al., 1995). The shoreline areas of the lake, by contrast, have displayed distinct transitions in the last 20 years between clear water with dense macrophytes and turbid water with dense phytoplankton, similar to what has been observed in some shallow European lakes that have experienced water level fluctuations (Blindow, 1992; Meijer, 2000). During the latter half of the 1990s, many successive years of high water levels led to a large-scale loss of submerged plant communities, and there was turbid water, high concentrations of P, and phytoplankton blooms (Havens, 1997; SFWMD, 2000). In contrast, the shoreline area of the lake dramatically switched to a clear water macrophyte-dominated state in summer 2000, coincident with a managed lake recession carried out by the South Florida Water Management District. Shoreline areas that had no macrophytes and over 150 mg m^{-3} total P in April had macrophyte plant beds and less than 20 mg m^{-3} total P in July–September. Although the transition between turbid and clear states appears to be controlled primarily by water depth (Steinman et al., 1997), reduced P loads might help to facilitate macrophyte growth by increasing light availability (less attenuation by phytoplankton) for any given depth regime.

Regardless of the causal mechanism, a high biomass of macrophytes in Lake Okeechobee could contribute to greater P assimilation and allow the lake water to maintain a lower average P concentration at any given rate of external loading.

4.4. Invertebrate and fish community structure

The taxonomic composition of benthic invertebrates also can influence the P dynamics of lakes, by processes including feeding/excretion and vertical migration. If migratory invertebrate predators occur at high densities, they may graze a large biomass of plankton in the water

column at night (Saunders and Lewis, 1988), and then transport this material and its associated P into the sediments during daytime hours. The total quantity of downward P transport will depend on the extent to which consumed P is excreted while the animals are still in the water column and whether fecal material produced in the water column is sedimented. *Chaoborus*, *Chironomus*, and other benthic invertebrates that exit the lake as winged adults at the end of their larval development may also serve to export P from the ecosystem into the watershed. The yearly emergence of chironomids from a shallow lake in Japan accounted for a net loss of 11 metric tons of P, which was more than 10% of the total P loss including outflow from tributaries (Iwakuma, 1992; Havens et al., 2000). In contrast, certain benthic invertebrates, such as oligochaete worms, do not undergo vertical migration or emergence from the lake and do not provide for these loss processes. Instead, they may facilitate a large upward flux of dissolved P into the water column as a result of their bioturbation and feeding activities (Van Rees et al., 1996). Oligochaetes consume particulate organic material in the sediments and excrete waste material containing the soluble nutrients into the overlying water. If a lake were to experience a strong transition towards oligochaete dominance, as often occurs during cultural eutrophication (Brinkhurst, 1974), one might expect this to contribute to a lower K_{net}.

In addition to the processes described above, certain macro-invertebrate assemblages can remove particulate P from the water column at high rates by filtration activities and this can dramatically affect a shallow lake's P cycle. One of the best examples is the zebra mussel (*Dreissena polymorpha*), which has caused dramatic increases in transparency, reduced phytoplankton biomass, and reduced water column total P concentrations in shallow regions of the Laurentian Great Lakes (Nalepa and Fahnenstiel, 1995; Makarewicz et al., 2000). The primary mechanism responsible for reduced total P is biological storage in mussel biomass, which has a very slow turnover rate compared to that of plankton populations.

Certain fish taxa also are known to strongly affect P cycling, especially in eutrophic shallow lakes (Moss et al., 1997). One of best-studied examples is the gizzard shad (*Dorosoma cepedianum*), a fish that ingests organic detritus in lake sediments and then excretes soluble N and P into the water column. In a shallow lake in Ohio, USA, Schaus et al. (1997) documented that the loading of dissolved P to the water column by shad "exceeded inputs from the relatively large and highly agricultural watershed." The calculated load was greater than diffusive release of P from the anoxic lake sediments. A number of studies have shown that other benthic feeding fish may contribute large quantities of P to the lake's water column (Lamarra, 1975; Brabrand et al., 1990; Mather et al., 1995). In lakes with a high percentage of benthivorous fish, one might expect a lower K_{net} than in lakes with fewer of these fish.

In Lake Okeechobee, current conditions of the macro-invertebrates and fish are consistent with high internal P loading and a low value of K_{net}. Warren et al. (1995) reported that oligochaete abundance was near 30% in 1969–1973, but accounted for 80% of total macro-invertebrate abundance by the 1990s (Fig. 1d). Van Rees et al. (1996) quantified the amount of dissolved P loading that could be attributed to these animals, and concluded that it might be two to 15 times greater than that caused by diffusive fluxes from the sediments. In Lake Okeechobee the density of the dominant oligochaete species, *Limnodrilus hoffmeisteri*, is typical of highly eutrophic lakes. The increased relative abundance of oligochaetes coincided with (and perhaps contributed to) the decline in observed K_{net}. It is unclear whether the trend in macro-invertebrate community structure will reverse if the lake experiences substantially lower rates of P loading.

There are no long-term data on fish community structure in Lake Okeechobee to allow for a comparison of changes in species dominance with the trend in K_{net}. A comprehensive study performed in the early 1990s, however, does indicate that the lake supports a high biomass of detritivorous fish, including gizzard shad and various types of catfish (Bull et al., 1995). It again is difficult to predict how the fish community might change under conditions of reduced external P loading in this subtropical system, but studies on temperate lakes suggest that both the total biomass of fish and the relative biomass of detritivores might decline (Persson et al., 1988).

5. Conclusion

Geochemical processes at the sediment–water interface (in particular diffusion of soluble P governed by redox potential and iron) may largely determine the equilibrium K_{net} in eutrophic lakes, as well as responses to external P loading. These processes are generally considered in lake water quality models, including one of the models used to establish a proposed TMDL for Lake Okeechobee (Pollman, 2000). However, biological processes such as those described above may also play a role, and should be given consideration when quantitative estimates of their impact on P dynamics become available. A complex water quality model for the lake (James et al., 1997) that is presently undergoing recalibration includes P uptake and settling losses of three distinct algal groups (diatoms, cyanobacteria, and chlorophytes). In the near future, this model could be modified to include: (1) the effects of submerged plant macrophyte; (2) a better consideration of the ecosystem's

spatial variability (Schelske, 1989; Phlips et al., 1993); and (3) other biological processes described herein. Recognizing that our understanding of the ecosystem is under development, state and federal agencies have recommended that the lake's TMDL be "revisited" at approximately 5-year intervals. The next iteration of a P loading target for Lake Okeechobee might, therefore, include explicit consideration of the biological processes described here. If reduced P loading ever does result in a reversal of biological changes that occurred with cultural eutrophication (this might take decades), the ultimate loading target might be greater than is presently proposed. Therefore, the iterative TMDL process is critical for management of this lake ecosystem, and it represents a sound approach for dealing with other nutrient-impacted shallow lakes.

Acknowledgements

The authors are grateful to R. Thomas James for providing historical nutrient loading data on Lake Okeechobee and to F.J. Aldridge, R.T. James, E. Phlips, G. Redfield, A. Steinman and G. Warren for constructive comments on an earlier version of this paper.

References

Aldridge, F.J., 1994. Application of nutrient enrichment bioassays to evaluate spatial and temporal limiting nutrient patterns and to estimate surplus phosphorus concentrations in Lake Okeechobee, Florida. Doctoral dissertation, University of Florida, Gainesville, FL.

Aldridge, F.J., Phlips, E.J., Schelske, C.L., 1995. The use of nutrient enrichment bioassays to test for spatial and temporal distribution of limiting factors affecting phytoplankton dynamics in Lake Okeechobee, Florida. Arch. Hydrobiol., Advances in Limnol. 45, 177–190.

Barbiero, R.P., Welch, E.B., 1992. Contribution of benthic blue-green algal recruitment of lake populations and phosphorus translocation. Freshwater Biol. 27, 249–260.

Barbiero, R.P., Kann, J., 1994. The importance of benthic recruitment to the population development of *Aphanizomenon flos-aquae* and internal loading in a shallow lake. J. Plankton Res. 16, 1581–1588.

Blindow, I., 1992. Long and short term dynamics of submerged macrophytes in two shallow lakes. Freshwater Biol. 28, 15–27.

Brabrand, A., Faafeng, B.A., Nilssen, J.P.M., 1990. Relative importance of phosphorus supply to phytoplankton production: fish excretion versus external loading. Can. J. Fish. Aquat. Sci. 47, 364–372.

Brinkhurst, R.C., 1974. The Benthos of Lakes. Macmillan Press, London, UK.

Bull, L.A., Fox, D.D., Brown, D.W., Davis, L.J., Miller, S.J., Wullschleger, J.G., 1995. Fish distribution in limnetic areas of Lake Okeechobee, Florida. Arch. Hydrobiol., Advances in Limnol. 45, 333–342.

Burkholder, J.M., Wetzel, R.G., Klomparens, K.L., 1990. Direct comparison of phosphate uptake by adnate and loosely attached microalgae within an intact biofilm matrix. Appl. Environ. Microbiol. 56, 2882–2890.

Canfield Jr., D.E., Langeland, K.A., Maceina, M.J., Haller, W.T., Shireman, J.V., Jones, J.R., 1983. Trophic classification of lakes with aquatic macrophytes. Can. J. Fish. Aquat. Sci. 40, 1713–1718.

Carrick, H.J., Aldridge, F.J., Schelske, C.L., 1993. Wind influences phytoplankton biomass and composition in a shallow productive lake. Limnol. Oceanogr. 38, 1179–1192.

Carrigan, R., Kalff, J., 1982. Phosphorus release by submerged macrophytes: significance to epiphyton and phytoplankton. Limnol. Oceanogr. 27, 419–427.

Cichra, M.F., Badylak, S., Henderson, N., Rueter, B. H., Phlips, E.J., 1995. Phytoplankton community structure in the open water zone of a shallow subtropical lake (Lake Okeechobee, Florida, USA). Arch. Hydrobiol., Advances in Limnology 45, 157–175.

Cullen, P., Forsberg, C., 1988. Experiences with reducing point sources of phosphorus to lakes. Hydrobiologia 170, 321–336.

Fisher, M.M, Reddy, K.R., James, R.T., 2000. Long-term changes in the sediment chemistry of a large shallow subtropical lake. Lake Reserv. Manage. (submitted for publication).

Fitzgerald, G.P., Nelson, T.C., 1966. Extractive and enzymatic analysis for limiting or surplus phosphorus in algae. J. Phycol. 2, 32–37.

Gulati, R.D., Ooms-Wilms, A.L., Van Tongeren, O.F.R., Postema, G., Siewertsen, K., 1992. The dynamics and role of limnetic zooplankton in the Loorsdrecht lakes (The Netherlands). Hydrobiologia 233, 69–86.

Hansson, L.A., 1990. Quantifying the impact of periphytic algae on nutrient availability for phytoplankton. Freshwater Biol. 24, 265–273.

Havens, K.E., 1995. Secondary nitrogen limitation in a subtropical lake impacted by non-point source agricultural pollution. Environ. Pollut. 89, 241–246.

Havens, K.E., 1997. Water levels and total phosphorus in Lake Okeechobee. Lake Reserv. Manage. 13, 16–25.

Havens, K.E., Steinman, A.D., 1995. Aquatic systems. In: Rechcigl, J.E. (Ed.), Soil Amendments: Impacts on Biotic Systems. CRC Press, Boca Raton, Florida, USA, pp. 121–151.

Havens, K.E., Aumen, N.G., James, R.T., Smith, V.H., 1996. Rapid ecological changes in a large subtropical lake undergoing cultural eutrophication. Ambio 25, 150–155.

Havens, K.E., Phlips, E.J., Cichra, M.F., Li, B.L., 1998. Light availability as a possible regulator of cyanobacteria species composition in a shallow subtropical lake. Freshwater Biol. 39, 547–556.

Havens, K.E., Fukushima, T., Xie, P., Iwakuma, T., James, R.T., Takamura, N., Hanazato, T., Yamamoto, T., 2000. Nutrient dynamics and the eutrophication of shallow lakes Kasumigaura (Japan), Donghu (P.R. China), and Okeechobee (USA). Environ. Pollut. 111, 263–272.

Hecky, R.E., Kilham, P., 1988. Nutrient limitation of phytoplankton in freshwater and marine environments: a review of recent evidence on the effects of enrichment. Limnol. Oceanogr. 33, 796–822.

Horne, A.J., 1977. Nitrogen fixation — a review of this phenomenon as a polluting process. Prog. Wat. Tech. 8, 359–372.

Horne, A.J., 1979. Nitrogen fixation in Clear Lake, California. Diel studies on *Aphanizomenon* and *Anabaena blooms*. Limnol. Oceanogr. 24, 241–329.

Hosper, H., 1997. Clearing lakes: an ecosystem approach to the restoration and management of shallow lakes in The Netherlands. Ministry of Transport, Public Works and Water Management, Lelystad, The Netherlands.

Iwakuma, T., 1992. Emergence of chironomidae from the shallow eutrophic Lake Kasumigaura, Japan. Hydrobiologia 245, 27–40.

James, R.T., Jones, B.L., Smith, V.H., 1995a. Historical trends in the Lake Okeechobee ecosystem II. Nutrient budgets. Arch. Hydrobiol. Suppl. 107, 25–47.

James, R.T., Smith, V.H., Jones, B.L., 1995b. Historical trends in the Lake Okeechobee ecosystem III. Water quality. Arch. Hydrobiol. Suppl. 107, 49–69.

James, R.T., Martin, J., Wool, T., Wang, P.F., 1997. A sediment resuspension and water quality model of Lake Okeechobee. J. Am. Water Res. Assoc. 33, 661–680.

Kenny, W.F., Schelske, C.L., Chapman, A., 2000. Polyphosphate sedimentation in a hypereutrophic lake: implications for modeling, management and paleolimnology (in review).

Lamarra Jr., V.A., 1975. Digestive activities of carp as a major contributor to the nutrient loading of lakes. Verh. Int. Ver. Limnol. 19, 2461–2468.

Lund, J.W.G., Mackereth, F.J.H., Mortimer, C.H., 1963. Changes in depth and time of certain chemical and physical conditions and of the standing crop of *Asterionella Formosa* Hass. in the north basin of Windermere in 1947. Phil. Trans. Royal Soc. London B 246, 255–290.

Makarewicz, J.C., Bertram, P., Lewis, T.W., 2000. Chemistry of the offshore surface waters of Lake Erie: pre- and post-*Dreissena* introduction (1983–1993). J. Great Lakes Res. 26, 82–93.

Marshall, M.L., 1977. Phytoplankton and primary productivity studies in Lake Okeechobee during 1974. South Florida Water Management District Technical Publication 77-2, West Palm Beach, Florida, USA.

Mather, M.A., Vanni, M.J., Wissing, T.E., Davis, S.A., Schaus, M.H., 1995. Regeneration of nitrogen and phosphorus by bluegill and gizzard shad: effect of feeding history. Can. J. Fish. Aquat. Sci. 52, 2327–2338.

Meijer, M.L., 2000. Biomanipulation in The Netherlands — 15 Years of Experience. Ministry of Transport, Public Works and Water Management, Lelystad, The Netherlands.

Moss, B., Madgwick, J., Phillips, G., 1997. A guide to the restoration of nutrient-enriched shallow lakes. Environment Agency, Broads Authority, UK.

Nalepa, T.F., Fahnenstiel, G.L., 1995. *Dreissena polymorpha* in the Saginaw Bay, Lake Huron ecosystem: overview and perspective. J. Great Lakes Res. 21, 411–416.

Nalewajko, C., Lee, K., 1983. Light stimulation of phosphate uptake in marine phytoplankton. Mar. Biol. 74, 9–15.

Paerl, H.W., 1988. Nuisance phytoplankton blooms in coastal, estuarine, and inland waters. Limnol. Oceanogr. 33, 823–847.

Persson, L., Andersson, G., Hamrin, S.F., Johansson, L., 1988. Predator regulation and primary production along the productivity gradient of temperate lake ecosystems. In: Carpenter, S.R. (Ed.), Complex Interactions in Lake Communities. Springer-Verlag, New York, pp. 45–65.

Phlips, E.J., Aldridge, F.J., Hansen, P., Zimba, P.V., Ihnat, J., Conroy, M., Ritter, P.R., 1993. Spatial and temporal variability of trophic state parameters in a shallow subtropical lake. Arch. Hydrobiol. 128, 437–458.

Phlips, E.J., Aldridge, F.J., Hansen, P., 1995. Patterns of water chemistry, physical and biological parameters in a shallow subtropical lake (Lake Okeechobee, Florida, USA). Arch. Hydrobiol., Advances in Limnol. 45, 117–135.

Phlips, E.J., Cichra, M., Havens, K.E., Hanlon, C., Badylak, S., Rueter, B., Randall, M., Hansen, P., 1997. Relationships between phytoplankton dynamics and the availability of light and nutrients in a shallow subtropical lake. J. Plankton Res. 19, 319–342.

Pollman, C., 2000. Phosphorus transport model for Lake Okeechobee — major model revisions. Technical document prepared for the Lake Okeechobee TMDL Technical Advisory Commmittee. Florida Department of Environmental Protection, Tallahassee, Florida, USA.

Reynolds, C.S., 1973. The seasonal periodicity of planktonic diatoms in a shallow eutrophic lake. Freshwater Biol. 3, 89–110.

Reynolds, C.S., 1978. Phosphorus and the eutrophication of lakes — a personal view. Ciba Foundation Symposium 57, 201–228.

Reynolds, C.S., 1984. The Ecology of Freshwater Phytoplankton. Cambridge University Press, UK.

Reynolds, C.S., Walsby, A.E., 1975. Water blooms. Biol. Rev. Cambridge Phil. Soc. 50, 437–481.

Reynolds, C.S., Wiseman, S.W., 1982. Sinking losses of phytoplankton in closed limnetic systems. J. Plankton Res. 4, 489–522.

Saunders, J.R., Lewis Jr., W.M., 1988. Dynamics and control mechanisms in a tropical zooplankton community (Lake Valencia, Venezuela). Ecol. Monogr. 58, 337–353.

Schaus, M.H., Vanni, M.J., Wissing, T.E., Bremigan, M.T., Garvey, J.E., Stein, R.A., 1997. Nitrogen and phosphorus excretion by detrivorous gizzard shad in a reservoir ecosystem. Limnol. Oceanogr. 42, 1386–1397.

Scheffer, M., 1989. Alternative stable states in eutrophic shallow freshwater systems: a minimal model. Hydrobiol. Bull. 23, 73–85.

Scheffer, M., 1998. Ecology of Shallow Lakes. Chapman and Hall, London, UK.

Scheffer, M., Hosper, S.H., Meijer, M.L., Moss, B., Jeppesen, E., 1993. Alternative equilibria in shallow lakes. Trends in Ecol. and Evol. 8, 275–279.

Scheffer, M., Van den Berg, M., Breukelaar, A., Breukers, C., Coops, H., Doef, R., Meijer, M.L., 1994. Vegetated areas with clear water in turbid shallow lakes. Aquat. Bot. 49, 193–196.

Schelske, C.L., 1984. In situ and natural phytoplankton assemblage bioassays. In: Shubert, L.E. (Ed.), Algae as Ecological Indicators. Academic Press, NY, pp. 15–47.

Schelske, C.L., 1989. Assessment of nutrient effects and nutrient limitation in Lake Okeechobee. Water Res. Bull. 25, 1119–1130.

Schelske, C.L., Aldridge, F.J., Kenny, W.F., Cable, J.E., 2000. Wind or nutrients: historic development of hypereutrophy in Lake Apopka, Florida: limnology and lake management. Arch. Hydrobiol., Advances in Limnol. 55, 543–563.

Schindler, D.W., 1977. Evolution of phosphorus limitation in lakes. Science 195, 260–262.

SFWMD, 2000. Surface water improvement and management (SWIM) plan for Lake Okeechobee, update. South Florida Water Management District, Florida, USA

Smith, V.H., 1986. Light and nutrient effects on the relative biomass of blue-green algae in lake phytoplankton. Can. J. Fish. Aquat. Sci. 43, 148–153.

Smith, V.H., Tilman, G.D., Nekola, J.C., 1999. Eutrophication: impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems. Environ. Pollut. 100, 179–196.

Smith, V.H., Bierman, V.J., Jones, B.L., Havens, K.E., 1995. Historical trends in the Lake Okeechobee ecosystem IV. Nitrogen: phosphorus ratios, cyanobacterial nitrogen fixation, and nitrogen fixation potential. Arch. Hydrobiol Suppl. 107, 71–88.

Stabel, H.H., 1985. Mechanisms controlling the sedimentation of various elements in prealpine lakes. In: Stumm, W. (Ed.), Chemical Processes in Lakes. John Wiley & Sons, New York, USA, pp. 143–167.

Steinman, A.D., Meeker, R.H., Rodusky, A.J., Davis, W.P., Hwang, S.J., 1997. Ecological properties of charophytes in a large subtropical lake. J. N. Am. Benthol. Soc. 16, 781–793.

USACE, 1999. Central and southern Florida project comprehensive review study. Final integrated feasibility report and programmatic environmental impact statement. US Army Corps of Engineers, Jacksonville, Florida, USA.

Van Rees, K.C.J., Reddy, K.R., Rao, P.S.C., 1996. Influence of benthic organisms on solute transport in lake sediments. Hydrobiologia 317, 31–40.

Vermaat, J.E., Santamaria, L., Roos, P.J., 2000. Water flow across and sediment trapping in submerged macrophyte beds of contrasting growth form. Arch. Hydrobiol. 148, 549–562.

Vollenweider, R.A., 1975. Input–output models with special reference to the phosphorus loading concept in limnology. Schweiz. Zeit. Hydrol. 37, 53–84.

Walker Jr., W.W., 2000. Revised TMDL calculations — refinements to steady-state model. Technical document prepared for Lake Okeechobee TMDL Technical Advisory Committee. Florida Department of Environmental Protection, Tallahassee, FL.

Warren, G.L., Vogel, M.J., Fox, D.D., 1995. Trophic and distributional dynamics of Lake Okeechobee sublittoral benthic invertebrate communities. Arch. Hydrobiol., Advances in Limnol. 45, 317–332.

Zimba, P.V., Hopson, M.S., Smith, J.P., Colle, D.E., Shireman, J.V., 1995. Chemical composition and distribution of submersed aquatic vegetation in Lake Okeechobee, Florida (1989–1991). Arch. Hydrobiol., Advances in Limnol. 45, 241–246.

APPENDIX B

APPENDIX B
SEDIMENT ANALYTICAL DATA
Comparison of Sediment Quality to FDEP Cleanup Target Levels (CTLs) for
Residential Direct Exposure
Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

Sample ID	Aluminum	Arsenic	Beryllium (b)	Cadmium	Calcium	Chromium VI	Copper	Iron	Lead (c)	Mercury	Nickel	Selenium	Silver	Zinc
Soil CTL	**72,000**	**0.8**	**120**	**75****	**NA**	**210**	**110****	**23,000**	**400**	**3.4**	**110****	**390**	**390**	**23000**
K8A 0-15 CM	8,420	**6.5**	<4.3	<3.4	96,600	23.1	<22	18,400	<86	<0.59	<34	<86	<8.6	22.7
K8A 15CM-BASE	9,990	**2.9**	<2.6	<2.0	83,400	22.8	<13	19,600	<51	<0.39	<20	<51	<5.1	14.4
K8B 0-15 CM	5,580	<3.9	<3.9	<3.2		15.6	<20	12,300	<79	<0.54	<32	<79	<7.9	17.7
K8B 15CM-BASE	9,710	**2.6**	<2.5	<2.0		22.4	<12	19,000	<49	<0.40	<20	<49	<4.9	13.7
K8C 0-15 CM	7,850	**5.6**	<3.1	<2.5		21.5	<16	17,200	<63	<0.56	<25	<63	<6.3	19.8
K8C 15CM-BASE	7,420	**2.8**	<1.8	<1.4		18.5	<8.9	16,600	<36	<0.36	<14	<36	<3.6	12.9
K10A 0-15 CM	10,200	<3.6	<3.6	<2.9	64,800	26.3	<18	19,400	<73	<0.58	<29	<73	<7.3	29.4
K10A 15CM-BASE	8,800	**5.1**	<1.8	<1.5	90,000	22.7	12.9	18,600	<37	0.39	<15	<37	<3.7	19.4
K10B 0-15 CM	8,470	**5.3**	<4.5	<3.6		24.2	<22	18,000	<90	0.67	<36	<90	<9.0	31.8
K10B 15CM-BASE	6,100	**3.1**	<1.7	<1.4		16.1	<8.6	14,000	<34	<0.30	<14	<34	<3.4	12.4
K10C 0-15 CM	9,840	**5.8**	<3.9	<3.1		26.7	<20	22,500	<78	0.81	<31	<78	<7.8	32.4
K10C 15CM-BASE	6,150	**3.3**	<1.5	<1.2		13.9	<7.5	11,500	<30	<0.22	<12	<30	<3.0	11.1
L11A 0-15CM	10,800	**4.2**	<2.6	<2.1	69,400	28.3	17.9	20,700	<51	<0.55	<21	<51	<5.1	30.7
L11A 0-15CM-BASE	7,140	**3.5**	<2.3	<1.8	70,700	18.3	<12	15,100	<46	<0.32	<18	<46	<4.6	20.5
L11B 0-15CM	9,870	**6.3**	<3.0	<2.4		28.4	18.9	20,700	<60	0.72	<24	<60	<6.0	33.2
L11B 0-15CM-BASE	10,100	**6.4**	<2.7	<2.1		25.6	14.3	20,300	<53	0.54	<21	<53	<5.3	27.8
L11C 0-15CM	11,100	**4.3**	<3.7	<3.0		29.6	<19	21,300	<75	<0.69	<30	<75	<7.5	33
L11C 0-15CM-BASE	9,180	**5.1**	<2.6	<2.1		23.7	13.5	18,600	<51	0.52	<21	<51	<5.1	25.8
M7A 0-15CM	8,170	**5.9**	<2.4	<1.9	109,000	21.9	12.3	18,600	<47	<0.39	<19	<47	<4.7	20.2
M7A 0-15CM-BASE	5,600	**2.9**	<1.7	<1.4	85,600	17.8	<8.5	12,400	<34	<0.30	<14	<34	<3.4	12.1
M7B 0-15CM	7,930	**4.6**	<2.1	<1.7		20.4	<11	17,100	<43	<0.37	<17	<43	<4.3	17.4
M7B 0-15CM-BASE	8,940	**3.1**	<2.0	<1.6		19.2	<10	16,200	<40	<0.30	<16	<40	<4.0	12.3
M7C 0-15CM	8,540	**4.4**	<1.7	<1.3		21.4	11.6	18,200	<34	<0.34	14.9	<34	<3.4	18
M7C 0-15CM-BASE	7,390	**2.4**	<1.7	<1.3		15.7	<8.4	14,300	<34	<0.28	<13	<34	<3.4	12.4
M9A 0-15CM	8,520	**6**	<2.1	<1.7	86,800	22.4	12.4	18,200	<42	<0.39	<17	<42	<4.2	18.7
M9A 0-15CM-BASE	6,330	**2.1**	<1.6	<1.3	131,000	16.7	<8.2	13,400	<33	<0.32	<13	<33	<3.3	10.2
M9B 0-15CM	6,570	**3.3**	<1.8	<1.5		15.9	9.3	13,600	<37	<0.37	<15	<37	<3.7	13.6
M9B 0-15CM-BASE	4,980	**2.7**	<1.4	<1.1		13.8	<7.0	10,600	<28	0.28	<11	<28	<2.8	8.6
M9C 0-15CM	7,070	**3.5**	<1.9	<1.5		17	<9.3	14,100	<37	<0.37	<15	<37	<3.7	13.5
M9C 0-15CM-BASE	6,410	**2.2**	<1.4	<1.1		15.1	<6.8	12,200	<27	<0.26	<11	<27	<2.7	8.4
N5A 0-15CM	9,360	**4.9**	<3.7	<2.9	130,000	24.3	<18	20,900	<73	<0.58	<29	<73	<7.3	22.9
N5A 0-15CM-BASE	4,000	**1.8**	<1.1	<0.87	63,200	12.5	6	9,770	<22	<0.18	<8.7	<22	<2.2	7.8
N5B 0-15CM	9,410	**6.6**	<2.9	<2.3		28.2	17.2	**24,200**	<58	<0.51	<23	<58	<5.8	33.5
N5B 0-15CM-BASE	7,960	**3.3**	<2.1	<1.7		21.5	10.1	16,700	<42	<0.29	<17	<42	<4.2	13.7
N5C 0-15CM	6,700	**9**	<3.0	<2.4		20.7	<15	16,900	<60	0.5	<24	<60	<6.0	23.8
N5C 0-15CM-BASE	6,430	**2.8**	<1.4	<1.1		17.8	8.3	14,300	<27	0.38	11	<27	<2.7	11.2

APPENDIX B
SEDIMENT ANALYTICAL DATA
Comparison of Sediment Quality to FDEP Cleanup Target Levels (CTLs) for
Residential Direct Exposure
Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

Sample ID	Aluminum	Arsenic	Beryllium (b)	Cadmium	Calcium	Chromium VI	Copper	Iron	Lead (c)	Mercury	Nickel	Selenium	Silver	Zinc
Soil CTL	**72,000**	**0.8**	**120**	**75****	**NA**	**210**	**110****	**23,000**	**400**	**3.4**	**110****	**390**	**390**	**23000**
O9A 0-15CM	9,350	**4.9**	<2.0	<1.6	91,600	23.8	13.5	19,700	<40	<0.39	<16	<40	<4.0	21
O9A 0-15CM-BASE	8,250	**2.7**	<1.8	<1.4	161,000	17.4	<8.8	14,600	<35	<0.30	<14	<35	<3.5	10.2
O9B 0-15CM	8,090	**7.8**	<2.8	<2.2		22	<14	20,500	<55	<0.41	<22	<55	<5.5	23.9
O9B 0-15CM-BASE	7,420	**2.2**	<1.6	<1.3		15.8	<7.9	13,200	<32	<0.26	<13	<32	<3.2	10
O9C 0-15CM	8,550	**5.6**	<2.4	<1.9		22.9	13.7	19,000	<48	<0.39	<19	<48	<4.8	24
O9C 0-15CM-BASE	8,680	**2.6**	<2.3	<1.8		20	<12	16,000	<46	<0.38	<18	<46	<4.6	11.4
O10A 0-15CM	8,460	**8.1**	<2.3	<1.8	83,900	24.2	15.2	19,900	<45	<0.51	<18	<45	<4.5	24.2
O10A 0-15CM-BASE	5,250	<2.3	<2.3	<1.8	77,900	11.9	<11	10,900	<46	<0.39	<18	<46	<4.6	<9.1
O10B 0-15CM	8,340	**5**	<3.2	<2.6		22.8	<16	17,900	<64	<0.45	<26	<64	<6.4	22.5
O10B 0-15CM-BASE	6,770	**2.3**	<1.6	<1.3	167,000	14	<8.1	12,400	<32	<0.29	<13	<32	<3.2	9.6
O10C 0-15CM	10,300	**8**	<2.7	<2.2		28.9	18.3	23,100	<54	<0.58	<22	<54	<5.4	31
O10C 0-15CM-BASE	7,840	<2.6	<2.6	<2.1		16.7	<13	14,900	<52	<0.33	<21	<52	<5.2	11.3
P9A 0-15CM	11,100	**7**	<2.9	<2.3	97,800	28.3	15.5	23,000	<57	<0.48	<23	<57	<5.7	26.6
P9A 0-15CM-BASE	8,390	**2.7**	<1.5	<1.2	130,000	18.3	<7.5	15,500	<30	<0.30	<12	<30	<3.0	10.8
P9B 0-15CM	8,800	**7.5**	<2.5	<2.0		25.4	15.8	21,600	<51	<0.52	<20	<51	<5.1	28.5
P9B 0-15CM-BASE	6,310	**2.8**	<1.3	<1.0		13.5	6.8	12,100	<25	<0.27	<10	<25	<2.5	8.7
P9C 0-15CM	11,300	**6.4**	<3.5	<2.8		29.9	18.5	**24,000**	<69	<0.52	<28	<69	<6.9	30.5
P9C 0-15CM-BASE	6,890	**3.7**	<1.5	<1.2		17.1	<7.6	13,700	<30	<0.35	<12	<30	<3.0	11.7
PDS1 0-15CM	7,620	**4.9**	<2.5	<2.0		17.5	<13	16,500	<50	<0.41	<20	<50	<5.0	19.4
PDS1 15CM-BASE	7,750	**2.7**	<1.7	<1.4		15.9	<8.4	13,200	<34	<0.27	<14	<34	<3.4	10.9
PDS2 0-15CM	8,520	**7.2**	<2.5	<2.0		23.2	14.7	19,100	<51	<0.38	<20	<51	<5.1	23.5
PDS2 15CM-BASE	6,890	**2.3**	<1.8	<1.4		15.5	<9.0	13,000	<36	<0.27	<14	<36	<3.6	9.2

Notes:
All values are in milligrams per kilogram (mg/kg).
Residential Direct Exposure in accordance with provisions of Chapter 62-777, Table II, "Soil Cleanup Target Levels," 8/99
Bold exceeds cleanup levels
(b) - Phytotoxicity must be considered.
(c) - Residential direct exposure value from USEPA Revised Interim Soil Guidance for CERCLA and RCRA Corrective Action Facilities. OSWER Directive 9355.4-12 (1994). The industrial direct exposure value was derived using methodologies outlined in USEPA 'Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil,' December 1996.
** - Direct Exposure value based on acute toxicity considerations.
NA - Not available at time of rule adoption.

DRAFT

APPENDIX B
SEDIMENT ANALYTICAL DATA
Comparison of Sediment Quality to EPA Concensus Based Probable Effects Concentrations (PECs) for Freshwater
Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

Sample ID	Aluminum	Arsenic	Beryllium	Cadmium	Calcium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Sediment Cleanup Target Level	**NA**	**33**	**NA**	**4.98**	**NA**	**111**	**149**	**NA**	**128**	**1.06**	**48.6**	**NA**	**NA**	**459**
K8A 0-15 CM	8,420	6.5	<4.3	<3.4	96,600	23.1	<22	18,400	<86	<0.59	<34	<86	<8.6	22.7
K8A 15CM-BASE	9,990	2.9	<2.6	<2.0	83,400	22.8	<13	19,600	<51	<0.39	<20	<51	<5.1	14.4
K8B 0-15 CM	5,580	<3.9	<3.9	<3.2		15.6	<20	12,300	<79	<0.54	<32	<79	<7.9	17.7
K8B 15CM-BASE	9,710	2.6	<2.5	<2.0		22.4	<12	19,000	<49	<0.40	<20	<49	<4.9	13.7
K8C 0-15 CM	7,850	5.6	<3.1	<2.5		21.5	<16	17,200	<63	<0.56	<25	<63	<6.3	19.8
K8C 15CM-BASE	7,420	2.8	<1.8	<1.4		18.5	<8.9	16,600	<36	<0.36	<14	<36	<3.6	12.9
K10A 0-15 CM	10,200	<3.6	<3.6	<2.9	64,800	26.3	<18	19,400	<73	<0.58	<29	<73	<7.3	29.4
K10A 15CM-BASE	8,800	5.1	<1.8	<1.5	90,000	22.7	12.9	18,600	<37	0.39	<15	<37	<3.7	19.4
K10B 0-15 CM	8,470	5.3	<4.5	<3.6		24.2	<22	18,000	<90	0.67	<36	<90	<9.0	31.8
K10B 15CM-BASE	6,100	3.1	<1.7	<1.4		16.1	<8.6	14,000	<34	<0.30	<14	<34	<3.4	12.4
K10C 0-15 CM	9,840	5.8	<3.9	<3.1		26.7	<20	22,500	<78	0.81	<31	<78	<7.8	32.4
K10C 15CM-BASE	6,150	3.3	<1.5	<1.2		13.9	<7.5	11,500	<30	<0.22	<12	<30	<3.0	11.1
L11A 0-15CM	10,800	4.2	<2.6	<2.1	69,400	28.3	17.9	20,700	<51	<0.55	<21	<51	<5.1	30.7
L11A 0-15CM-BASE	7,140	3.5	<2.3	<1.8	70,700	18.3	<12	15,100	<46	<0.32	<18	<46	<4.6	20.5
L11B 0-15CM	9,870	6.3	<3.0	<2.4		28.4	18.9	20,700	<60	0.72	<24	<60	<6.0	33.2
L11B 0-15CM-BASE	10,100	6.4	<2.7	<2.1		25.6	14.3	20,300	<53	0.54	<21	<53	<5.3	27.8
L11C 0-15CM	11,100	4.3	<3.7	<3.0		29.6	<19	21,300	<75	<0.69	<30	<75	<7.5	33
L11C 0-15CM-BASE	9,180	5.1	<2.6	<2.1		23.7	13.5	18,600	<51	0.52	<21	<51	<5.1	25.8
M7A 0-15CM	8,170	5.9	<2.4	<1.9	109,000	21.9	12.3	18,600	<47	<0.39	<19	<47	<4.7	20.2
M7A 0-15CM-BASE	5,600	2.9	<1.7	<1.4	85,600	17.8	<8.5	12,400	<34	<0.30	<14	<34	<3.4	12.1
M7B 0-15CM	7,930	4.6	<2.1	<1.7		20.4	<11	17,100	<43	<0.37	<17	<43	<4.3	17.4
M7B 0-15CM-BASE	8,940	3.1	<2.0	<1.6		19.2	<10	16,200	<40	<0.30	<16	<40	<4.0	12.3
M7C 0-15CM	8,540	4.4	<1.7	<1.3		21.4	11.6	18,200	<34	<0.34	14.9	<34	<3.4	18
M7C 0-15CM-BASE	7,390	2.4	<1.7	<1.3		15.7	<8.4	14,300	<34	<0.28	<13	<34	<3.4	12.4
M9A 0-15CM	8,520	6	<2.1	<1.7	86,800	22.4	12.4	18,200	<42	<0.39	<17	<42	<4.2	18.7
M9A 0-15CM-BASE	6,330	2.1	<1.6	<1.3	131,000	16.7	<8.2	13,400	<33	<0.32	<13	<33	<3.3	10.2
M9B 0-15CM	6,570	3.3	<1.8	<1.5		15.9	9.3	13,600	<37	<0.37	<15	<37	<3.7	13.6
M9B 0-15CM-BASE	4,980	2.7	<1.4	<1.1		13.8	<7.0	10,600	<28	0.28	<11	<28	<2.8	8.6
M9C 0-15CM	7,070	3.5	<1.9	<1.5		17	<9.3	14,100	<37	<0.37	<15	<37	<3.7	13.5
M9C 0-15CM-BASE	6,410	2.2	<1.4	<1.1		15.1	<6.8	12,200	<27	<0.26	<11	<27	<2.7	8.4
N5A 0-15CM	9,360	4.9	<3.7	<2.9	130,000	24.3	<18	20,900	<73	<0.58	<29	<73	<7.3	22.9
N5A 0-15CM-BASE	4,000	1.8	<1.1	<0.87	63,200	12.5	6	9,770	<22	<0.18	<8.7	<22	<2.2	7.8
N5B 0-15CM	9,410	6.6	<2.9	<2.3		28.2	17.2	24,200	<58	<0.51	<23	<58	<5.8	33.5
N5B 0-15CM-BASE	7,960	3.3	<2.1	<1.7		21.5	10.1	16,700	<42	<0.29	<17	<42	<4.2	13.7

DRAFT

APPENDIX B
SEDIMENT ANALYTICAL DATA
Comparison of Sediment Quality to EPA Concensus Based Probable Effects Concentrations (PECs) for Freshwater
Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

Sample ID	Aluminum	Arsenic	Beryllium	Cadmium	Calcium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Selenium	Silver	Zinc
PEC Concentration	**NA**	**33**	**NA**	**4.98**	**NA**	**111**	**149**	**NA**	**128**	**1.06**	**48.6**	**NA**	**NA**	**459**
N5C 0-15CM	6,700	9	<3.0	<2.4		20.7	<15	16,900	<60	0.5	<24	<60	<6.0	23.8
N5C 0-15CM-BASE	6,430	2.8	<1.4	<1.1		17.8	8.3	14,300	<27	0.38	11	<27	<2.7	11.2
O9A 0-15CM	9,350	4.9	<2.0	<1.6	91,600	23.8	13.5	19,700	<40	<0.39	<16	<40	<4.0	21
O9A 0-15CM-BASE	8,250	2.7	<1.8	<1.4	161,000	17.4	<8.8	14,600	<35	<0.30	<14	<35	<3.5	10.2
O9B 0-15CM	8,090	7.8	<2.8	<2.2		22	<14	20,500	<55	<0.41	<22	<55	<5.5	23.9
O9B 0-15CM-BASE	7,420	2.2	<1.6	<1.3		15.8	<7.9	13,200	<32	<0.26	<13	<32	<3.2	10
O9C 0-15CM	8,550	5.6	<2.4	<1.9		22.9	13.7	19,000	<48	<0.39	<19	<48	<4.8	24
O9C 0-15CM-BASE	8,680	2.6	<2.3	<1.8		20	<12	16,000	<46	<0.38	<18	<46	<4.6	11.4
O10A 0-15CM	8,460	8.1	<2.3	<1.8	83,900	24.2	15.2	19,900	<45	<0.51	<18	<45	<4.5	24.2
O10A 0-15CM-BASE	5,250	<2.3	<2.3	<1.8	77,900	11.9	<11	10,900	<46	<0.39	<18	<46	<4.6	<9.1
O10B 0-15CM	8,340	5	<3.2	<2.6		22.8	<16	17,900	<64	<0.45	<26	<64	<6.4	22.5
O10B 0-15CM-BASE	6,770	2.3	<1.6	<1.3	167,000	14	<8.1	12,400	<32	<0.29	<13	<32	<3.2	9.6
O10C 0-15CM	10,300	8	<2.7	<2.2		28.9	18.3	23,100	<54	<0.58	<22	<54	<5.4	31
O10C 0-15CM-BASE	7,840	<2.6	<2.6	<2.1		16.7	<13	14,900	<52	<0.33	<21	<52	<5.2	11.3
P9A 0-15CM	11,100	7	<2.9	<2.3	97,800	28.3	15.5	23,000	<57	<0.48	<23	<57	<5.7	26.6
P9A 0-15CM-BASE	8,390	2.7	<1.5	<1.2	130,000	18.3	<7.5	15,500	<30	<0.30	<12	<30	<3.0	10.8
P9B 0-15CM	8,800	7.5	<2.5	<2.0		25.4	15.8	21,600	<51	<0.52	<20	<51	<5.1	28.5
P9B 0-15CM-BASE	6,310	2.8	<1.3	<1.0		13.5	6.8	12,100	<25	<0.27	<10	<25	<2.5	8.7
P9C 0-15CM	11,300	6.4	<3.5	<2.8		29.9	18.5	24,000	<69	<0.52	<28	<69	<6.9	30.5
P9C 0-15CM-BASE	6,890	3.7	<1.5	<1.2		17.1	<7.6	13,700	<30	<0.35	<12	<30	<3.0	11.7
PDS1 0-15CM	7,620	4.9	<2.5	<2.0		17.5	<13	16,500	<50	<0.41	<20	<50	<5.0	19.4
PDS1 15CM-BASE	7,750	2.7	<1.7	<1.4		15.9	<8.4	13,200	<34	<0.27	<14	<34	<3.4	10.9
PDS2 0-15CM	8,520	7.2	<2.5	<2.0		23.2	14.7	19,100	<51	<0.38	<20	<51	<5.1	23.5
PDS2 15CM-BASE	6,890	2.3	<1.8	<1.4		15.5	<9.0	13,000	<36	<0.27	<14	<36	<3.6	9.2

Notes:
All values are in milligrams per kilogram (mg/kg).
EPA Document # 905/R-00/007, June 2000
Prediction of sediment toxicity using consensus-based freshwater sediment quality guidelines
United States Geological Survey
Christopher G. Ingersoll, Donald D. MacDonald
Fisheries and Wildlife Sciences
National Oceanic and Atmospheric Administration, et.al.
Bold exceeds cleanup levels
*** - Leachability values may be derived using the SPLP Test to calculate site-specific SCTLs or may be determined using TCLP in the event oily wastes are present.

DRAFT

APPENDIX B
SEDIMENT ANALYTICAL DATA
Comparison of Sediment Quality to FDEP Cleanup Target Levels (CTLs) for
Leachability Based on Fresh Water
Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

Sample ID	Aluminum	Arsenic (a)	Beryllium (a), (b)	Cadmium (a)	Calcium	Chromium VI (a)	Copper	Iron	Lead	Mercury	Nickel (a)	Selenium (a)	Silver (a)	Zinc (a)
Soil CTL	***	***	***	***	**NA**	***	***	***	***	**0.01**	***	***	***	***
K8A 0-15 CM	8,420	6.5	<4.3	<3.4	96,600	23.1	<22	18,400	<86	<0.59	<34	<86	<8.6	22.7
K8A 15CM-BASE	9,990	2.9	<2.6	<2.0	83,400	22.8	<13	19,600	<51	<0.39	<20	<51	<5.1	14.4
K8B 0-15 CM	5,580	<3.9	<3.9	<3.2		15.6	<20	12,300	<79	<0.54	<32	<79	<7.9	17.7
K8B 15CM-BASE	9,710	2.6	<2.5	<2.0		22.4	<12	19,000	<49	<0.40	<20	<49	<4.9	13.7
K8C 0-15 CM	7,850	5.6	<3.1	<2.5		21.5	<16	17,200	<63	<0.56	<25	<63	<6.3	19.8
K8C 15CM-BASE	7,420	2.8	<1.8	<1.4		18.5	<8.9	16,600	<36	<0.36	<14	<36	<3.6	12.9
K10A 0-15 CM	10,200	<3.6	<3.6	<2.9	64,800	26.3	<18	19,400	<73	<0.58	<29	<73	<7.3	29.4
K10A 15CM-BASE	8,800	5.1	<1.8	<1.5	90,000	22.7	12.9	18,600	<37	**0.39**	<15	<37	<3.7	19.4
K10B 0-15 CM	8,470	5.3	<4.5	<3.6		24.2	<22	18,000	<90	**0.67**	<36	<90	<9.0	31.8
K10B 15CM-BASE	6,100	3.1	<1.7	<1.4		16.1	<8.6	14,000	<34	<0.30	<14	<34	<3.4	12.4
K10C 0-15 CM	9,840	5.8	<3.9	<3.1		26.7	<20	22,500	<78	**0.81**	<31	<78	<7.8	32.4
K10C 15CM-BASE	6,150	3.3	<1.5	<1.2		13.9	<7.5	11,500	<30	<0.22	<12	<30	<3.0	11.1
L11A 0-15CM	10,800	4.2	<2.6	<2.1	69,400	28.3	17.9	20,700	<51	<0.55	<21	<51	<5.1	30.7
L11A 0-15CM-BASE	7,140	3.5	<2.3	<1.8	70,700	18.3	<12	15,100	<46	<0.32	<18	<46	<4.6	20.5
L11B 0-15CM	9,870	6.3	<3.0	<2.4		28.4	18.9	20,700	<60	**0.72**	<24	<60	<6.0	33.2
L11B 0-15CM-BASE	10,100	6.4	<2.7	<2.1		25.6	14.3	20,300	<53	**0.54**	<21	<53	<5.3	27.8
L11C 0-15CM	11,100	4.3	<3.7	<3.0		29.6	<19	21,300	<75	<0.69	<30	<75	<7.5	33
L11C 0-15CM-BASE	9,180	5.1	<2.6	<2.1		23.7	13.5	18,600	<51	**0.52**	<21	<51	<5.1	25.8
M7A 0-15CM	8,170	5.9	<2.4	<1.9	109,000	21.9	12.3	18,600	<47	<0.39	<19	<47	<4.7	20.2
M7A 0-15CM-BASE	5,600	2.9	<1.7	<1.4	85,600	17.8	<8.5	12,400	<34	<0.30	<14	<34	<3.4	12.1
M7B 0-15CM	7,930	4.6	<2.1	<1.7		20.4	<11	17,100	<43	<0.37	<17	<43	<4.3	17.4
M7B 0-15CM-BASE	8,940	3.1	<2.0	<1.6		19.2	<10	16,200	<40	<0.30	<16	<40	<4.0	12.3
M7C 0-15CM	8,540	4.4	<1.7	<1.3		21.4	11.6	18,200	<34	<0.34	14.9	<34	<3.4	18
M7C 0-15CM-BASE	7,390	2.4	<1.7	<1.3		15.7	<8.4	14,300	<34	<0.28	<13	<34	<3.4	12.4
M9A 0-15CM	8,520	6	<2.1	<1.7	86,800	22.4	12.4	18,200	<42	<0.39	<17	<42	<4.2	18.7
M9A 0-15CM-BASE	6,330	2.1	<1.6	<1.3	131,000	16.7	<8.2	13,400	<33	<0.32	<13	<33	<3.3	10.2
M9B 0-15CM	6,570	3.3	<1.8	<1.5		15.9	9.3	13,600	<37	<0.37	<15	<37	<3.7	13.6
M9B 0-15CM-BASE	4,980	2.7	<1.4	<1.1		13.8	<7.0	10,600	<28	**0.28**	<11	<28	<2.8	8.6
M9C 0-15CM	7,070	3.5	<1.9	<1.5		17	<9.3	14,100	<37	<0.37	<15	<37	<3.7	13.5
M9C 0-15CM-BASE	6,410	2.2	<1.4	<1.1		15.1	<6.8	12,200	<27	<0.26	<11	<27	<2.7	8.4
N5A 0-15CM	9,360	4.9	<3.7	<2.9	130,000	24.3	<18	20,900	<73	<0.58	<29	<73	<7.3	22.9
N5A 0-15CM-BASE	4000	1.8	<1.1	<0.87	63,200	12.5	6	9,770	<22	<0.18	<8.7	<22	<2.2	7.8
N5B 0-15CM	9410	6.6	<2.9	<2.3		28.2	17.2	24,200	<58	<0.51	<23	<58	<5.8	33.5
N5B 0-15CM-BASE	7960	3.3	<2.1	<1.7		21.5	10.1	16,700	<42	<0.29	<17	<42	<4.2	13.7

DRAFT

APPENDIX B
SEDIMENT ANALYTICAL DATA
Comparison of Sediment Quality to FDEP Cleanup Target Levels (CTLs) for
Leachability Based on Fresh Water
Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

Sample ID	Aluminum	Arsenic (a)	Beryllium (a), (b)	Cadmium (a)	Calcium	Chromium VI (a)	Copper	Iron	Lead	Mercury	Nickel (a)	Selenium (a)	Silver (a)	Zinc (a)
Soil CTL	***	***	***	***	**NA**	***	***	***	***	**0.01**	***	***	***	***
N5C 0-15CM	6700	9	<3.0	<2.4		20.7	<15	16,900	<60	**0.5**	<24	<60	<6.0	23.8
N5C 0-15CM-BASE	6430	2.8	<1.4	<1.1		17.8	8.3	14,300	<27	**0.38**	11	<27	<2.7	11.2
O9A 0-15CM	9350	4.9	<2.0	<1.6	91,600	23.8	13.5	19,700	<40	<0.39	<16	<40	<4.0	21
O9A 0-15CM-BASE	8250	2.7	<1.8	<1.4	161,000	17.4	<8.8	14,600	<35	<0.30	<14	<35	<3.5	10.2
O9B 0-15CM	8090	7.8	<2.8	<2.2		22	<14	20,500	<55	<0.41	<22	<55	<5.5	23.9
O9B 0-15CM-BASE	7420	2.2	<1.6	<1.3		15.8	<7.9	13,200	<32	<0.26	<13	<32	<3.2	10
O9C 0-15CM	8550	5.6	<2.4	<1.9		22.9	13.7	19,000	<48	<0.39	<19	<48	<4.8	24
O9C 0-15CM-BASE	8680	2.6	<2.3	<1.8		20	<12	16,000	<46	<0.38	<18	<46	<4.6	11.4
O10A 0-15CM	8460	8.1	<2.3	<1.8	83,900	24.2	15.2	19,900	<45	<0.51	<18	<45	<4.5	24.2
O10A 0-15CM-BASE	5250	<2.3	<2.3	<1.8	77,900	11.9	<11	10,900	<46	<0.39	<18	<46	<4.6	<9.1
O10B 0-15CM	8340	5	<3.2	<2.6		22.8	<16	17,900	<64	<0.45	<26	<64	<6.4	22.5
O10B 0-15CM-BASE	6770	2.3	<1.6	<1.3	167,000	14	<8.1	12,400	<32	<0.29	<13	<32	<3.2	9.6
O10C 0-15CM	10300	8	<2.7	<2.2		28.9	18.3	23,100	<54	<0.58	<22	<54	<5.4	31
O10C 0-15CM-BASE	7840	<2.6	<2.6	<2.1		16.7	<13	14,900	<52	<0.33	<21	<52	<5.2	11.3
P9A 0-15CM	11100	7	<2.9	<2.3	97,800	28.3	15.5	23,000	<57	<0.48	<23	<57	<5.7	26.6
P9A 0-15CM-BASE	8390	2.7	<1.5	<1.2	130,000	18.3	<7.5	15,500	<30	<0.30	<12	<30	<3.0	10.8
P9B 0-15CM	8800	7.5	<2.5	<2.0		25.4	15.8	21,600	<51	<0.52	<20	<51	<5.1	28.5
P9B 0-15CM-BASE	6310	2.8	<1.3	<1.0		13.5	6.8	12,100	<25	<0.27	<10	<25	<2.5	8.7
P9C 0-15CM	11300	6.4	<3.5	<2.8		29.9	18.5	24,000	<69	<0.52	<28	<69	<6.9	30.5
P9C 0-15CM-BASE	6890	3.7	<1.5	<1.2		17.1	<7.6	13,700	<30	<0.35	<12	<30	<3.0	11.7
PDS1 0-15CM	7620	4.9	<2.5	<2.0		17.5	<13	16,500	<50	<0.41	<20	<50	<5.0	19.4
PDS1 15CM-BASE	7750	2.7	<1.7	<1.4		15.9	<8.4	13,200	<34	<0.27	<14	<34	<3.4	10.9
PDS2 0-15CM	8520	7.2	<2.5	<2.0		23.2	14.7	19,100	<51	<0.38	<20	<51	<5.1	23.5
PDS2 15CM-BASE	6890	2.3	<1.8	<1.4		15.5	<9.0	13,000	<36	<0.27	<14	<36	<3.6	9.2

Notes:
All values are in milligrams per kilogram (mg/kg).
Leachability Based on Fresh Water in accordance with provisions of Chapter 62-777, Table II, "Soil Cleanup Target Levels," 8/99
Bold exceeds cleanup levels
(a) - Leachability values derived from USEPA Soil Screening Guidance (1966). These values were derived assuming soil pH 6.8. These leachability values are dependant on both the metal concentration and soil characteristics. Thus, if site-specific soil characteristics are different than the defaults, these leachability values may not apply. If this is the case, site-specific leachability values should be derived using methods such as TCLP or SPLP.
(b) - Phytotoxicity must be considered.
*** - Leachability values may be derived using the SPLP test to calculate site-specific SCTLs or may be determined using TCLP in the event oily wastes are present.
NA - Not available at time of rule adoption.

DRAFT

APPENDIX B
SEDIMENT ANALYTICAL DATA
Comparison of Sediment Quality to FDEP Cleanup Target Levels (CTLs) for
Leachability Based on Groundwater
Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

Sample ID	Aluminum	Arsenic (a)	Beryllium (a), (b)	Cadmium (a)	Calcium	Chromium VI (a)	Copper	Iron	Lead	Mercury	Nickel (a)	Selenium (a)	Silver (a)	Zinc (a)
Soil CTL	***	**29**	**63**	**8**	**NA**	**38**	***	***	***	**2.1**	**130**	**5**	**17**	**6,000**
K8A 0-15 CM	8,420	6.5	<4.3	<3.4	96,600	23.1	<22	18,400	<86	<0.59	<34	<86	<8.6	22.7
K8A 15CM-BASE	9,990	2.9	<2.6	<2.0	83,400	22.8	<13	19,600	<51	<0.39	<20	<51	<5.1	14.4
K8B 0-15 CM	5,580	<3.9	<3.9	<3.2		15.6	<20	12,300	<79	<0.54	<32	<79	<7.9	17.7
K8B 15CM-BASE	9,710	2.6	<2.5	<2.0		22.4	<12	19,000	<49	<0.40	<20	<49	<4.9	13.7
K8C 0-15 CM	7,850	5.6	<3.1	<2.5		21.5	<16	17,200	<63	<0.56	<25	<63	<6.3	19.8
K8C 15CM-BASE	7,420	2.8	<1.8	<1.4		18.5	<8.9	16,600	<36	<0.36	<14	<36	<3.6	12.9
K10A 0-15 CM	10,200	<3.6	<3.6	<2.9	64,800	26.3	<18	19,400	<73	<0.58	<29	<73	<7.3	29.4
K10A 15CM-BASE	8,800	5.1	<1.8	<1.5	90,000	22.7	12.9	18,600	<37	0.39	<15	<37	<3.7	19.4
K10B 0-15 CM	8,470	5.3	<4.5	<3.6		24.2	<22	18,000	<90	0.67	<36	<90	<9.0	31.8
K10B 15CM-BASE	6,100	3.1	<1.7	<1.4		16.1	<8.6	14,000	<34	<0.30	<14	<34	<3.4	12.4
K10C 0-15 CM	9,840	5.8	<3.9	<3.1		26.7	<20	22,500	<78	0.81	<31	<78	<7.8	32.4
K10C 15CM-BASE	6,150	3.3	<1.5	<1.2		13.9	<7.5	11,500	<30	<0.22	<12	<30	<3.0	11.1
L11A 0-15CM	10,800	4.2	<2.6	<2.1	69,400	28.3	17.9	20,700	<51	<0.55	<21	<51	<5.1	30.7
L11A 0-15CM-BASE	7,140	3.5	<2.3	<1.8	70,700	18.3	<12	15,100	<46	<0.32	<18	<46	<4.6	20.5
L11B 0-15CM	9,870	6.3	<3.0	<2.4		28.4	18.9	20,700	<60	0.72	<24	<60	<6.0	33.2
L11B 0-15CM-BASE	10,100	6.4	<2.7	<2.1		25.6	14.3	20,300	<53	0.54	<21	<53	<5.3	27.8
L11C 0-15CM	11,100	4.3	<3.7	<3.0		29.6	<19	21,300	<75	<0.69	<30	<75	<7.5	33
L11C 0-15CM-BASE	9,180	5.1	<2.6	<2.1		23.7	13.5	18,600	<51	0.52	<21	<51	<5.1	25.8
M7A 0-15CM	8,170	5.9	<2.4	<1.9	109,000	21.9	12.3	18,600	<47	<0.39	<19	<47	<4.7	20.2
M7A 0-15CM-BASE	5,600	2.9	<1.7	<1.4	85,600	17.8	<8.5	12,400	<34	<0.30	<14	<34	<3.4	12.1
M7B 0-15CM	7,930	4.6	<2.1	<1.7		20.4	<11	17,100	<43	<0.37	<17	<43	<4.3	17.4
M7B 0-15CM-BASE	8,940	3.1	<2.0	<1.6		19.2	<10	16,200	<40	<0.30	<16	<40	<4.0	12.3
M7C 0-15CM	8,540	4.4	<1.7	<1.3		21.4	11.6	18,200	<34	<0.34	14.9	<34	<3.4	18
M7C 0-15CM-BASE	7,390	2.4	<1.7	<1.3		15.7	<8.4	14,300	<34	<0.28	<13	<34	<3.4	12.4
M9A 0-15CM	8,520	6	<2.1	<1.7	86,800	22.4	12.4	18,200	<42	<0.39	<17	<42	<4.2	18.7
M9A 0-15CM-BASE	6,330	2.1	<1.6	<1.3	131,000	16.7	<8.2	13,400	<33	<0.32	<13	<33	<3.3	10.2
M9B 0-15CM	6,570	3.3	<1.8	<1.5		15.9	9.3	13,600	<37	<0.37	<15	<37	<3.7	13.6
M9B 0-15CM-BASE	4,980	2.7	<1.4	<1.1		13.8	<7.0	10,600	<28	0.28	<11	<28	<2.8	8.6
M9C 0-15CM	7,070	3.5	<1.9	<1.5		17	<9.3	14,100	<37	<0.37	<15	<37	<3.7	13.5
M9C 0-15CM-BASE	6,410	2.2	<1.4	<1.1		15.1	<6.8	12,200	<27	<0.26	<11	<27	<2.7	8.4
N5A 0-15CM	9,360	4.9	<3.7	<2.9	130,000	24.3	<18	20,900	<73	<0.58	<29	<73	<7.3	22.9
N5A 0-15CM-BASE	4,000	1.8	<1.1	<0.87	63,200	12.5	6	9,770	<22	<0.18	<8.7	<22	<2.2	7.8
N5B 0-15CM	9,410	6.6	<2.9	<2.3		28.2	17.2	24,200	<58	<0.51	<23	<58	<5.8	33.5
N5B 0-15CM-BASE	7,960	3.3	<2.1	<1.7		21.5	10.1	16,700	<42	<0.29	<17	<42	<4.2	13.7

DRAFT

APPENDIX B
SEDIMENT ANALYTICAL DATA
Comparison of Sediment Quality to FDEP Cleanup Target Levels (CTLs) for
Leachability Based on Groundwater
Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

Sample ID	Aluminum	Arsenic (a)	Beryllium (a), (b)	Cadmium (a)	Calcium	Chromium VI (a)	Copper	Iron	Lead	Mercury	Nickel (a)	Selenium (a)	Silver (a)	Zinc (a)
Soil CTL	***	**29**	**63**	**8**	**NA**	**38**	***	***	***	**2.1**	**130**	**5**	**17**	**6,000**
N5C 0-15CM	6,700	9	<3.0	<2.4		20.7	<15	16,900	<60	0.5	<24	<60	<6.0	23.8
N5C 0-15CM-BASE	6,430	2.8	<1.4	<1.1		17.8	8.3	14,300	<27	0.38	11	<27	<2.7	11.2
O9A 0-15CM	9,350	4.9	<2.0	<1.6	91,600	23.8	13.5	19,700	<40	<0.39	<16	<40	<4.0	21
O9A 0-15CM-BASE	8,250	2.7	<1.8	<1.4	161,000	17.4	<8.8	14,600	<35	<0.30	<14	<35	<3.5	10.2
O9B 0-15CM	8,090	7.8	<2.8	<2.2		22	<14	20,500	<55	<0.41	<22	<55	<5.5	23.9
O9B 0-15CM-BASE	7,420	2.2	<1.6	<1.3		15.8	<7.9	13,200	<32	<0.26	<13	<32	<3.2	10
O9C 0-15CM	8,550	5.6	<2.4	<1.9		22.9	13.7	19,000	<48	<0.39	<19	<48	<4.8	24
O9C 0-15CM-BASE	8,680	2.6	<2.3	<1.8		20	<12	16,000	<46	<0.38	<18	<46	<4.6	11.4
O10A 0-15CM	8,460	8.1	<2.3	<1.8	83,900	24.2	15.2	19,900	<45	<0.51	<18	<45	<4.5	24.2
O10A 0-15CM-BASE	5,250	<2.3	<2.3	<1.8	77,900	11.9	<11	10,900	<46	<0.39	<18	<46	<4.6	<9.1
O10B 0-15CM	8,340	5	<3.2	<2.6		22.8	<16	17,900	<64	<0.45	<26	<64	<6.4	22.5
O10B 0-15CM-BASE	6,770	2.3	<1.6	<1.3	167,000	14	<8.1	12,400	<32	<0.29	<13	<32	<3.2	9.6
O10C 0-15CM	10,300	8	<2.7	<2.2		28.9	18.3	23,100	<54	<0.58	<22	<54	<5.4	31
O10C 0-15CM-BASE	7,840	<2.6	<2.6	<2.1		16.7	<13	14,900	<52	<0.33	<21	<52	<5.2	11.3
P9A 0-15CM	11,100	7	<2.9	<2.3	97,800	28.3	15.5	23,000	<57	<0.48	<23	<57	<5.7	26.6
P9A 0-15CM-BASE	8,390	2.7	<1.5	<1.2	130,000	18.3	<7.5	15,500	<30	<0.30	<12	<30	<3.0	10.8
P9B 0-15CM	8,800	7.5	<2.5	<2.0		25.4	15.8	21,600	<51	<0.52	<20	<51	<5.1	28.5
P9B 0-15CM-BASE	6,310	2.8	<1.3	<1.0		13.5	6.8	12,100	<25	<0.27	<10	<25	<2.5	8.7
P9C 0-15CM	11,300	6.4	<3.5	<2.8		29.9	18.5	24,000	<69	<0.52	<28	<69	<6.9	30.5
P9C 0-15CM-BASE	6,890	3.7	<1.5	<1.2		17.1	<7.6	13,700	<30	<0.35	<12	<30	<3.0	11.7
PDS1 0-15CM	7,620	4.9	<2.5	<2.0		17.5	<13	16,500	<50	<0.41	<20	<50	<5.0	19.4
PDS1 15CM-BASE	7,750	2.7	<1.7	<1.4		15.9	<8.4	13,200	<34	<0.27	<14	<34	<3.4	10.9
PDS2 0-15CM	8,520	7.2	<2.5	<2.0		23.2	14.7	19,100	<51	<0.38	<20	<51	<5.1	23.5
PDS2 15CM-BASE	6,890	2.3	<1.8	<1.4		15.5	<9.0	13,000	<36	<0.27	<14	<36	<3.6	9.2

Notes:
All values are in milligrams per kilogram (mg/kg).
Leachability Based on Groundwater in accordance with provisions of Chapter 62-777, Table II, "Soil Cleanup Target Levels," 8/99
Bold exceeds cleanup levels
(a) - Leachability values derived from USEPA Soil Screening Guidance (1966). These values were derived assuming soil pH 6.8. These leachability values are dependant on both the metal concentration and soil characteristics. Thus, if site-specific soil characteristics are different than the defaults, these leachability values may not apply. If this is the case, site-specific leachability values should be derived using methods such as TCLP or SPLP.
(b) - Phytotoxicity must be considered.
Assessing Risks Associated with Adult Exposures to Lead in Soil,' December 1996.
*** - Leachability values may be derived using the SPLP test to calculate site-specific SCTLs or may be determined using TCLP in the event oily wastes are present.
NA - Not available at time of rule adoption.

DRAFT

TABLE 8
SEDIMENT ANALYTICAL DATA
Comparison of Sediment Quality to FDEP Cleanup Target Levels (CTLs) for
Commercial Direct Exposure
Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

Sample ID	Aluminum	Arsenic	Beryllium (b)	Cadmium	Calcium	Chromium VI	Copper	Iron	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Soil CTL	*	**3.7**	**800**	**1,300**	**NA**	**420**	**76,000**	**480,000**	**920**	**26**	**28,000**	**10,000**	**9,100**	**560,000**
K8A 0-15 CM	8,420	**6.5**	<4.3	<3.4	96,600	23.1	<22	18,400	<86	<0.59	<34	<86	<8.6	22.7
K8A 15CM-BASE	9,990	2.9	<2.6	<2.0	83,400	22.8	<13	19,600	<51	<0.39	<20	<51	<5.1	14.4
K8B 0-15 CM	5,580	<3.9	<3.9	<3.2		15.6	<20	12,300	<79	<0.54	<32	<79	<7.9	17.7
K8B 15CM-BASE	9,710	2.6	<2.5	<2.0		22.4	<12	19,000	<49	<0.40	<20	<49	<4.9	13.7
K8C 0-15 CM	7,850	**5.6**	<3.1	<2.5		21.5	<16	17,200	<63	<0.56	<25	<63	<6.3	19.8
K8C 15CM-BASE	7,420	2.8	<1.8	<1.4		18.5	<8.9	16,600	<36	<0.36	<14	<36	<3.6	12.9
K10A 0-15 CM	10,200	<3.6	<3.6	<2.9	64,800	26.3	<18	19,400	<73	<0.58	<29	<73	<7.3	29.4
K10A 15CM-BASE	8,800	**5.1**	<1.8	<1.5	90,000	22.7	12.9	18,600	<37	0.39	<15	<37	<3.7	19.4
K10B 0-15 CM	8,470	**5.3**	<4.5	<3.6		24.2	<22	18,000	<90	0.67	<36	<90	<9.0	31.8
K10B 15CM-BASE	6,100	3.1	<1.7	<1.4		16.1	<8.6	14,000	<34	<0.30	<14	<34	<3.4	12.4
K10C 0-15 CM	9,840	**5.8**	<3.9	<3.1		26.7	<20	22,500	<78	0.81	<31	<78	<7.8	32.4
K10C 15CM-BASE	6,150	3.3	<1.5	<1.2		13.9	<7.5	11,500	<30	<0.22	<12	<30	<3.0	11.1
L11A 0-15CM	10,800	**4.2**	<2.6	<2.1	69,400	28.3	17.9	20,700	<51	<0.55	<21	<51	<5.1	30.7
L11A 0-15CM-BASE	7,140	3.5	<2.3	<1.8	70,700	18.3	<12	15,100	<46	<0.32	<18	<46	<4.6	20.5
L11B 0-15CM	9,870	**6.3**	<3.0	<2.4		28.4	18.9	20,700	<60	0.72	<24	<60	<6.0	33.2
L11B 0-15CM-BASE	10,100	**6.4**	<2.7	<2.1		25.6	14.3	20,300	<53	0.54	<21	<53	<5.3	27.8
L11C 0-15CM	11,100	**4.3**	<3.7	<3.0		29.6	<19	21,300	<75	<0.69	<30	<75	<7.5	33
L11C 0-15CM-BASE	9,180	**5.1**	<2.6	<2.1		23.7	13.5	18,600	<51	0.52	<21	<51	<5.1	25.8
M7A 0-15CM	8,170	**5.9**	<2.4	<1.9	109,000	21.9	12.3	18,600	<47	<0.39	<19	<47	<4.7	20.2
M7A 0-15CM-BASE	5,600	2.9	<1.7	<1.4	85,600	17.8	<8.5	12,400	<34	<0.30	<14	<34	<3.4	12.1
M7B 0-15CM	7,930	**4.6**	<2.1	<1.7		20.4	<11	17,100	<43	<0.37	<17	<43	<4.3	17.4
M7B 0-15CM-BASE	8,940	3.1	<2.0	<1.6		19.2	<10	16,200	<40	<0.30	<16	<40	<4.0	12.3
M7C 0-15CM	8,540	**4.4**	<1.7	<1.3		21.4	11.6	18,200	<34	<0.34	14.9	<34	<3.4	18
M7C 0-15CM-BASE	7,390	2.4	<1.7	<1.3		15.7	<8.4	14,300	<34	<0.28	<13	<34	<3.4	12.4
M9A 0-15CM	8,520	**6**	<2.1	<1.7	86,800	22.4	12.4	18,200	<42	<0.39	<17	<42	<4.2	18.7
M9A 0-15CM-BASE	6,330	2.1	<1.6	<1.3	131,000	16.7	<8.2	13,400	<33	<0.32	<13	<33	<3.3	10.2
M9B 0-15CM	6,570	3.3	<1.8	<1.5		15.9	9.3	13,600	<37	<0.37	<15	<37	<3.7	13.6
M9B 0-15CM-BASE	4,980	2.7	<1.4	<1.1		13.8	<7.0	10,600	<28	0.28	<11	<28	<2.8	8.6
M9C 0-15CM	7,070	3.5	<1.9	<1.5		17	<9.3	14,100	<37	<0.37	<15	<37	<3.7	13.5
M9C 0-15CM-BASE	6,410	2.2	<1.4	<1.1		15.1	<6.8	12,200	<27	<0.26	<11	<27	<2.7	8.4
N5A 0-15CM	9,360	**4.9**	<3.7	<2.9	**130,000**	24.3	<18	20,900	<73	<0.58	<29	<73	<7.3	22.9
N5A 0-15CM-BASE	4000	1.8	<1.1	<0.87	63,200	12.5	6	9,770	<22	<0.18	<8.7	<22	<2.2	7.8
N5B 0-15CM	9410	**6.6**	<2.9	<2.3		28.2	17.2	24,200	<58	<0.51	<23	<58	<5.8	33.5
N5B 0-15CM-BASE	7960	3.3	<2.1	<1.7		21.5	10.1	16,700	<42	<0.29	<17	<42	<4.2	13.7

DRAFT

TABLE 8
SEDIMENT ANALYTICAL DATA
Comparison of Sediment Quality to FDEP Cleanup Target Levels (CTLs) for
Commercial Direct Exposure
Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

Sample ID	Aluminum	Arsenic	Beryllium (b)	Cadmium	Calcium	Chromium VI	Copper	Iron	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Soil CTL	*	**3.7**	**800**	**1,300**	**NA**	**420**	**76,000**	**480,000**	**920**	**26**	**28,000**	**10,000**	**9,100**	**560,000**
N5C 0-15CM	6700	**9**	<3.0	<2.4		20.7	<15	16,900	<60	0.5	<24	<60	<6.0	23.8
N5C 0-15CM-BASE	6430	2.8	<1.4	<1.1		17.8	8.3	14,300	<27	0.38	11	<27	<2.7	11.2
O9A 0-15CM	9350	**4.9**	<2.0	<1.6	91,600	23.8	13.5	19,700	<40	<0.39	<16	<40	<4.0	21
O9A 0-15CM-BASE	8250	2.7	<1.8	<1.4	161,000	17.4	<8.8	14,600	<35	<0.30	<14	<35	<3.5	10.2
O9B 0-15CM	8090	**7.8**	<2.8	<2.2		22	<14	20,500	<55	<0.41	<22	<55	<5.5	23.9
O9B 0-15CM-BASE	7420	2.2	<1.6	<1.3		15.8	<7.9	13,200	<32	<0.26	<13	<32	<3.2	10
O9C 0-15CM	8550	**5.6**	<2.4	<1.9		22.9	13.7	19,000	<48	<0.39	<19	<48	<4.8	24
O9C 0-15CM-BASE	8680	2.6	<2.3	<1.8		20	<12	16,000	<46	<0.38	<18	<46	<4.6	11.4
O10A 0-15CM	8460	**8.1**	<2.3	<1.8	83,900	24.2	15.2	19,900	<45	<0.51	<18	<45	<4.5	24.2
O10A 0-15CM-BASE	5250	<2.3	<2.3	<1.8	77,900	11.9	<11	10,900	<46	<0.39	<18	<46	<4.6	<9.1
O10B 0-15CM	8340	**5**	<3.2	<2.6		22.8	<16	17,900	<64	<0.45	<26	<64	<6.4	22.5
O10B 0-15CM-BASE	6770	2.3	<1.6	<1.3	167,000	14	<8.1	12,400	<32	<0.29	<13	<32	<3.2	9.6
O10C 0-15CM	10300	**8**	<2.7	<2.2		28.9	18.3	23,100	<54	<0.58	<22	<54	<5.4	31
O10C 0-15CM-BASE	7840	<2.6	<2.6	<2.1		16.7	<13	14,900	<52	<0.33	<21	<52	<5.2	11.3
P9A 0-15CM	11100	**7**	<2.9	<2.3	97,800	28.3	15.5	23,000	<57	<0.48	<23	<57	<5.7	26.6
P9A 0-15CM-BASE	8390	2.7	<1.5	<1.2	130,000	18.3	<7.5	15,500	<30	<0.30	<12	<30	<3.0	10.8
P9B 0-15CM	8800	**7.5**	<2.5	<2.0		25.4	15.8	21,600	<51	<0.52	<20	<51	<5.1	28.5
P9B 0-15CM-BASE	6310	2.8	<1.3	<1.0		13.5	6.8	12,100	<25	<0.27	<10	<25	<2.5	8.7
P9C 0-15CM	11300	**6.4**	<3.5	<2.8		29.9	18.5	24,000	<69	<0.52	<28	<69	<6.9	30.5
P9C 0-15CM-BASE	6890	3.7	<1.5	<1.2		17.1	<7.6	13,700	<30	<0.35	<12	<30	<3.0	11.7
PDS1 0-15CM	7620	**4.9**	<2.5	<2.0		17.5	<13	16,500	<50	<0.41	<20	<50	<5.0	19.4
PDS1 15CM-BASE	7750	2.7	<1.7	<1.4		15.9	<8.4	13,200	<34	<0.27	<14	<34	<3.4	10.9
PDS2 0-15CM	8520	**7.2**	<2.5	<2.0		23.2	14.7	19,100	<51	<0.38	<20	<51	<5.1	23.5
PDS2 15CM-BASE	6890	2.3	<1.8	<1.4		15.5	<9.0	13,000	<36	<0.27	<14	<36	<3.6	9.2

Notes:
All values are in milligrams per kilogram (mg/kg).
Commercial Direct Exposure in accordance with provisions of Chapter 62-777, Table II, "Soil Cleanup Target Levels," 8/99
Bold exceeds cleanup levels
(b) - Phytotoxicity must be considered.
* - Contaminant not a health concern for this default exposure scenario.
** - Direct Exposure value based on acute toxicity considerations.
NA - Not available at time of rule adoption.

APPENDIX B
ELUTRIATE TESTING DATA

Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

STATION ID	Total P	Total Dissolved P	Ortho-P	P in Sediment	% Solids	TSS	TURB	Aluminum	Arsenic	Beryllium
Units ---->	mg/L	mg/L	mg/L	mg/kg	%	mg/L	ntu	ug/L	ug/L	ug/L
K8 SEDIMENT	NR	NR	NR	870	16.5	NR	NR	NR	NR	NR
K8-BACKGROUND WATER	0.092	0.047	0.057	NR	NR	11	11.0	183	3.2	< 0.2
K8-MODIFIED ELUTRIATE	0.050	0.025	0.027	NR	NR	24	16	313	< 2.5	0.2
M9 SEDIMENT	NR	NR	NR	620	24.1	NR	NR	NR	NR	NR
M9-BACKGROUND WATER	0.108	0.054	0.069	NR	NR	14	13.0	238	< 2.5	< 0.2
M9-MODIFIED ELUTRIATE	0.076	0.037	0.054	NR	NR	20	39	504	< 2.5	< 0.2
O10 SEDIMENT	NR	NR	NR	830	20.6	NR	NR	NR	NR	NR
O10-BACKGROUND WATER	0.091	0.047	0.059	NR	NR	9	11.0	212	< 2.5	< 0.2
O10-MODIFIED ELUTRIATE	0.089	0.026	0.056	NR	NR	36	45	484	< 2.5	< 0.2

NR = Not Requested
mg/L - milligrams per liter
mg/kg - milligrams per kilogram
ntu - nephelometric units
ug/L - micrograms per liter

TABLE 9
ELUTRIATE TESTING DATAL DATA

Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

STATION ID	Cadmium	Chromium	Copper	Iron	Lead (c)	Mercury	Nickel	Selenium	Silver	Zinc
Units ---->	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
K8 SEDIMENT	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
K8-BACKGROUND WATER	< 0.4	< 0.5	0.9	336	< 2.4	<1.0	< 2.0	< 2.0	<0.20	< 2.0
K8-MODIFIED ELUTRIATE	< 0.4	< 0.5	< 0.4	528	< 2.4	<1.0	< 2.0	< 2.0	<0.20	< 2.0
M9 SEDIMENT	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
M9-BACKGROUND WATER	< 0.4	< 0.5	1.0	424	< 2.4	<1.0	< 2.0	< 2.0	<0.20	< 2.0
M9-MODIFIED ELUTRIATE	< 0.4	< 0.5	0.5	927	< 2.4	<1.0	< 2.0	2.3	<0.20	< 2.0
O10 SEDIMENT	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
O10-BACKGROUND WATER	< 0.4	0.5	0.9	400	< 2.4	<1.0	< 2.0	< 2.0	<0.20	< 2.0
O10-MODIFIED ELUTRIATE	< 0.4	< 0.5	0.7	838	< 2.4	<1.0	< 2.0	< 2.0	<0.20	< 2.0

NR = Not Requested
mg/L - milligrams per liter
mg/kg - milligrams per kilogram
ntu - nephelometric units
ug/L - micrograms per liter

APPENDIX B
LAKE OKEECHOBEE
SURFACE WATER SAMPLING
CONFINED DISPOSAL FACILITY (CDF) FOR PILOT DREDGED SEDIMENTS
SEPTEMBER/OCTOBER 2002
RESULTS OF ANALYSES
SFWMD

	Antimony µg/l		Arsenic µg/l		Barium µg/l		Beryllium µg/l		Cadmium[3] µg/l	
Surface Water CTLs[1]	**4300**		**50**		**NA**		**0.13 (annual avg.)**		**0.985183601**	
EPA Test Method	EPA 6010B		EPA 6010B		EPA 6010B		EPA 6010B		EPA 6010B	
Sample ID	Result (RL)	Result (IDL)	Result (RL)	Result (IDL)	Result (RL)	Result (IDL)	Result (RL)	Result (IDL)	Result (RL)	Result (IDL)
CDF East	<5.0	<1.5	<10	<2.8	18.4B	<0.49	<5.0	<0.26	<5.0	<0.26
CDF West	<5.0	<1.5	<10	<2.8	14.2B	<0.49	<5.0	<0.26	<5.0	<0.26

	Chromium µg/l		Cobalt µg/l		Copper[3] µg/l		Lead[3] µg/l		Nickel[3] µg/l	
Surface Water CTLs[1]	**11[(CrVI)]**	**0.486209**	**NA**		**10.30**		**2.59**		**13.40**	
EPA Test Method	EPA 6010B		EPA 6010B		EPA 6010B		EPA 6010B		EPA 6010B	
Sample ID	Result (RL)	Result (IDL)	Result (RL)	Result (IDL)	Result (RL)	Result (IDL)	Result (RL)	Result (IDL)	Result (RL)	Result (IDL)
CDF East	<10	<0.43	<50	<0.50	<25	<0.44	<5.0	<1.2	<40	<1.1
CDF West	<10	<0.43	<50	<0.50	<25	<0.44	<5.0	<1.2	<40	<1.1

Notes:
[1] FDEP Surface Water Cleanup Target Levels for Fresh Water Surface Water Criteria (µg/l), May 26, 1999 - 62-302 - As provided in Chapter 62-302, Florida Administrative Code (FAC). If the PQL using the most sensitive and currently available technology is higher than the specified criterion, the PQL shall be used.
[2] MPN or MF counts ahll not exceed a monthly average of 200, nor exceed 400 in 10% of the samples, nor exceed 800 on any ony day. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30 day period.
[3] Hardness-dependent per Chapter 62-302, FAC
[4] Backgound dependant, but if natural background is greater than 8.5, no higher than natural background.
[5] Analysis run on both filtered and unfiltered samples, with the same results.

µg/l - micrograms per liter
mg/l - milligrams per liter
CTLs - Cleanup Target Levels
NA - Not Applicable
RL - Reporting Limit

col/100ml - colonies per 100 milliliters
B - Result less than RL, but greater than or equal to IDL
IDL - Instrument Detection Limit
PQL - Practical Quantitation Limit
SU - Standard Units

APPENDIX B
LAKE OKEECHOBEE
SURFACE WATER SAMPLING
CONFINED DISPOSAL FACILITY (CDF) FOR PILOT DREDGED SEDIMENTS
SEPTEMBER/OCTOBER 2002
RESULTS OF ANALYSES
SFWMD

	Selenium µg/l		Silver µg/l		Thallium µg/l		Vanadium µg/l		Zinc µg/l	
Surface Water CTLs[1]	**5.0**		**0.1**		**6.3**		**NA**		**20.16**	
EPA Test Method	EPA 6010B		EPA 6010B		EPA 6010B		EPA 6010B		EPA 6010B	
Sample ID	Result (RL)	IDL	Result (RL)	Result (IDL)	Result (RL)	Result (IDL)	Result (RL)	Result (IDL)	Result (RL)	Result (IDL)
CDF East	<10	<2.0	<10	<0.55	<10	<1.5	<50	<0.47	3.9B	<0.59
CDF West	<10	<2.0	<10	<0.55	<10	<1.5	<50	<0.47	1.9B	<0.59

	Nitrogen, Ammonia mg/l	Nitrogen, Nitrate[5] mg/l	Nitrogen, Nitrite[5] mg/l	Nitrogen, Total Kjeldahl mg/l	Phosphorus, Total[5] mg/l	Total Organic Carbon mg/l	Coliform, Fecal (a) col/100ml	Alkalinity, Total mg/l	Hardness, Total mg/l	pH SU
Surface Water CTLs[1]	**NA**	**NA**	**NA**	**NA**	**0.1**	**NA**	**200[2] (monthly avg)**	**NA**	**NA**	**6.5-8.5[4]**
EPA Test Method	EPA 350.2	EPA 300/ SWA846 9056	EPA 300/ SWA846 9056	EPA 351.3	EPA 365.3	EPA 415.2	SM18 9222D	EPA 310.1	SW846 6010B/2340B	EPA 150.1
Sample ID	Result (RL)	Result (RL)	Result (RL)	Result (RL)	Result (RL)	Result (RL)	Result (RL)	Result (RL)	Result (RL)	Result (RL)
CDF East	0.62	<0.10	<0.10	1.2	<0.10	9.2	<1	80	85.1	**8.9**
CDF West	1.2	<0.10	<0.10	2.9	<0.10	19.3	28	55	85.4	**10.0**

Notes:
[1] FDEP Surface Water Cleanup Target Levels for Fresh Water Surface Water Criteria (µg/l), May 26, 1999 - 62-302 - As provided in Chapter 62-302, Florida Administrative Code (FAC). If the PQL using the most sensitive and currently available technology is higher than the specified criterion, the PQL shall be used.
[2] MPN or MF counts ahll not exceed a monthly average of 200, nor exceed 400 in 10% of the samples, nor exceed 800 on any ony day. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30 day period.
[3] Hardness-dependent per Chapter 62-302, FAC
[4] Backgound dependant, but if natural background is greater than 8.5, no higher than natural background.
[5] Analysis run on both filtered and unfiltered samples, with the same results.

µg/l - micrograms per liter
mg/l - milligrams per liter
CTLs - Cleanup Target Levels
NA - Not Applicable
RL - Reporting Limit

col/100ml - colonies per 100 milliliters
B - Result less than RL, but greater than or equal to IDL
IDL - Instrument Detection Limit
PQL - Practical Quantitation Limit
SU - Standard Units

APPENDIX B
SEDIMENT ANALYTICAL DATA
CONFINED DISPOSAL FACILITY (CDF) FOR PILOT DREDGED SEDIMENTS
LAKE OKEECHOBEE
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WEST PALM BEACH, FLORIDA
SEPTEMBER/OCTOBER 2002

Leachability Based on Groundwater[1]

Sample ID	Aluminum	Arsenic	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Phosphorus	Selenium	Silver	Zinc
Soil CTL	***	**29**	**63**	**8**	**38**	***	***	***	**2.1**	**130**	**NA**	**5**	**17**	**6,000**
CDF EAST	7,970	6.2	<0.14(I)	<0.14(I)	21.1	13.1B	17,800	18.4B	0.28B	15.8B	1000	4.2B	<0.30(I)	20.3
CDF WEST	7,590	4.1	<0.14(I)	<0.14(I)	19.8	12.1B	16,800	16.5B	0.21B	13.4B	1050	3.4B	<0.30(I)	19.7

Leachability Based on Fresh Water[1]

Sample ID	Aluminum	Arsenic	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Phosphorus	Selenium	Silver	Zinc
Soil CTL	***	***	***	***	***	***	***	***	**0.01**	***	**NA**	***	***	***
CDF EAST	7,970	6.2	<0.14(I)	<0.14(I)	21.1	13.1B	17,800	18.4B	0.28B	15.8B	1000	4.2B	<0.30(I)	20.3
CDF WEST	7,590	4.1	<0.14(I)	<0.14(I)	19.8	12.1B	16,800	16.5B	0.21B	13.4B	1050	3.4B	<0.30(I)	19.7

Commercial Direct Exposure

Sample ID	Aluminum	Arsenic	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Phosphorus	Selenium	Silver	Zinc
Soil CTL	*	**3.7**	**800**	**1,300**	**420**	**76,000**	**480,000**	**920**	**26**	**28,000**	**NA**	**10,000**	**9,100**	**560,000**
CDF EAST	7,970	**6.2**	<0.14(I)	<0.14(I)	21.1	13.1B	17,800	18.4B	0.28B	15.8B	1000	4.2B	<0.30(I)	20.3
CDF WEST	7,590	**4.1**	<0.14(I)	<0.14(I)	19.8	12.1B	16,800	16.5B	0.21B	13.4B	1050	3.4B	<0.30(I)	19.7

Residential Direct Exposure[1]

Sample ID	Aluminum	Arsenic	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Phosphorus	Selenium	Silver	Zinc
Soil CTL	**72,000**	**0.8**	**120**	**75****	**210**	**110****	**23,000**	**400**	**3.4**	**110****	**NA**	**390**	**390**	**23000**
CDF EAST	7,970	**6.2**	<0.14(I)	<0.14(I)	21.1	13.1B	17,800	18.4B	0.28B	15.8B	1000	4.2B	<0.30(I)	20.3
CDF WEST	7,590	**4.1**	<0.14(I)	<0.14(I)	19.8	12.1B	16,800	16.5B	0.21B	13.4B	1050	3.4B	<0.30(I)	19.7

Comparison of Sediment Quality to EPA Concensus-Based Probable Effects Concentrations (PECs) for Freshwater[2]

Sample ID	Aluminum	Arsenic	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Phosphorus	Selenium	Silver	Zinc
PEC Concentration	**NA**	**33**	**NA**	**4.98**	**111**	**149**	**NA**	**128**	**1.06**	**48.6**	**NA**	**NA**	**NA**	**459**
CDF EAST	7,970	6.2	<0.14(I)	<0.14(I)	21.1	13.1B	17,800	18.4B	0.28B	15.8B	1000	4.2B	<0.30(I)	20.3
CDF WEST	7,590	4.1	<0.14(I)	<0.14(I)	19.8	12.1B	16,800	16.5B	0.21B	13.4B	1050	3.4B	<0.30(I)	19.7

Notes:
All values are in milligrams per kilogram (mg/kg).
[1]Residential Direct Exposure, Commercial, and Leachability llimits from Chapter 62-777, Table II, "Soil Cleanup Target Levels," 8/99
[2] Probable Effects Concentrations, EPA Document # 905/R-00/007, June 2000, "Prediction of sediment toxicity using consensus-based freshwater sediment quality guidelines"
Bold exceeds cleanup levels
* - Contaminant is not a health concern for this default exposure scenario.
*** - Leachability values may be derived using the SPLP Test to calculate site-specific SCTLs or may be determined using TCLP in the event oily wastes are present.
(I) - Result was below the Instrument Detection Limit (IDL)
B - Value was below the Reporting Limit (RL), but above the IDL

TABLE 12

Geotechnical Results for Lake Okeechobee Sediment Samples
South Florida Water Management District
West Palm Beach, Florida

September/October 2002

Table 1: Lab Results for Okeechobee Samples																		
	Organic	Moisture	Specific	Sieve Analysis (% Passing)										Hydrometer %			Atterberg Limits	
Sample	(%)	Content (%	Gravity	#10	#16	#20	#30	#40	#50	#60	#80	#100	#200	Sand	Silt	Clay	LL	PL
K-8	30.6	382.8	2.03	100	97	93	89	86	83	81	78	77	76	23.6	42.6	34	82	NP
K-10	34.2	333.6	2.09	100	99	98	97	94	90	88	84	82	72	27.6	42.5	30	82	NP
L-11	41.4	601.7	2.04	100	91	85	81	79	77	76	75	74	72	27.6	37.8	35	75	NP
M-7	35.3	311.0	2.25	100	98	95	93	90	96	94	80	77	63	37.4	40.5	22	65	NP
M-9	38.9	354.7	2.32	100	97	96	94	94	93	93	92	91	82	18.4	56.8	25	81	NP
N-5	14.7	172.1	2.25	100	93	88	85	81	77	75	72	70	63	37.1	39.1	24	69	NP
O-9	31.2	334.7	2.25	100	97	95	93	91	88	86	83	81	71	29	39.3	32	71	NP
O-10	40.0	340.0	2.16	100	91	85	81	77	75	73	71	69	92	37.8	37.1	26	75	NP
P-9	30.0	421.2	2.13	100	95	90	95	81	78	76	73	71	63	36.9	37	26	73	NP
PDS-1	37.7	262.0	2.16	100	95	90	86	83	80	78	74	72	61	38.8	28.6	33	71	NP
PDS-2	39.2	354.6	2.15	100	98	95	93	91	89	88	86	83	81	18.9	34.1	47	79	NP

APPENDIX B

PHOSPHORUS ANALYTICAL DATA

Post Dredging Pilot Test Samples

Lake Okeechobee
South Florida Water Management District
West Palm Beach, Florida
September/October 2002

Sample ID	Phosphorus mg/kg
PDS1 0-15CM	1510
PDS1 15CM-BASE	699
PDS2 0-15CM	784
PDS2 15CM-BASE	579

Notes:
mg/kg - milligrams per kilogram
PDS - Post Dredging Sample

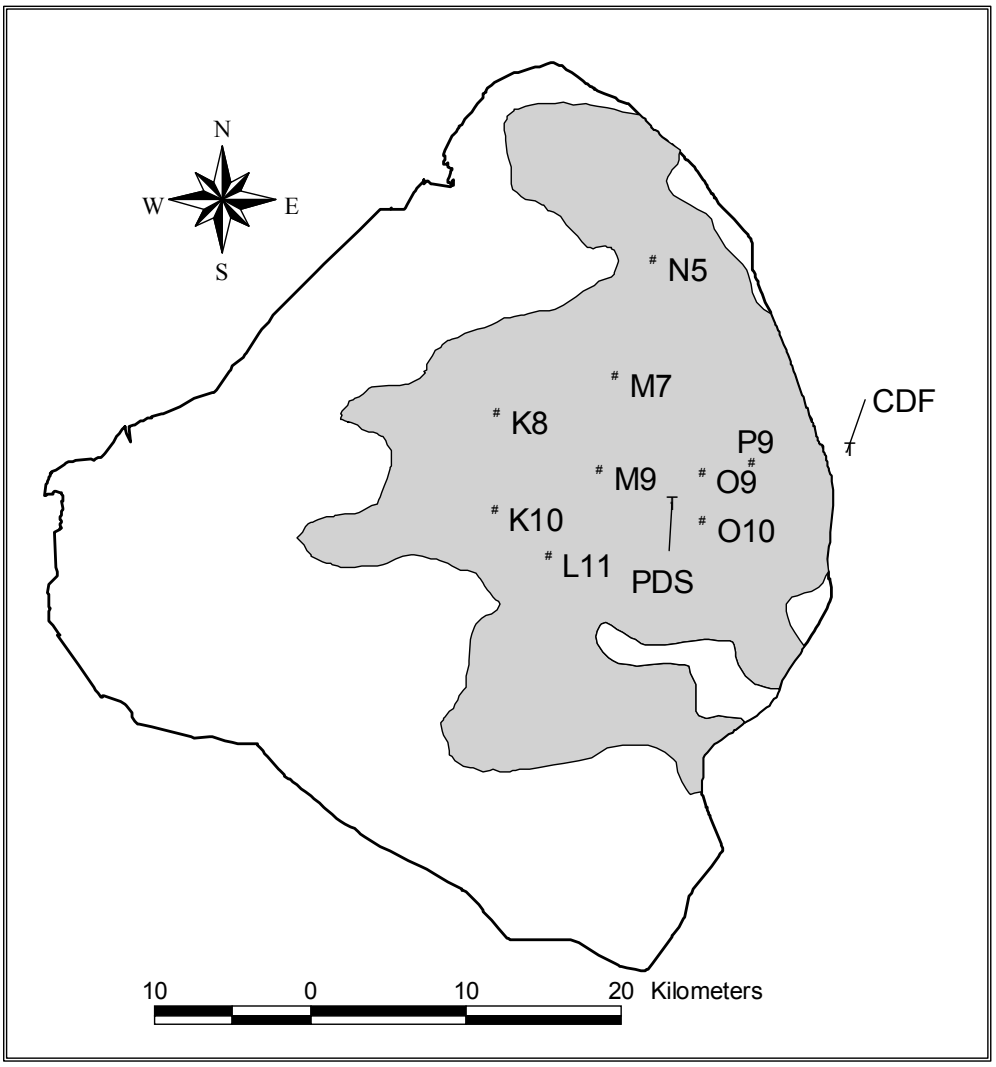

Figure 1. Sediment sampling locations for metals characterization. Shaded area represents approximate extent of mud sediments (Fisher and Reddy, 2001).

APPENDIX C

APPENDIX C

OUTREACH INFORMATION SUMMARY

Public/Interagency Outreach and Coordination

The Evaluation of Alternatives in relation to public acceptance is an ongoing process of qualitatively measuring actions and reactions of the public and governmental agencies at each phase of the feasibility study. As the South Florida Water Management District (District) desires broad-based public and interagency participation in the Lake Okeechobee Sediment Management Feasibility Study, every effort has been made to foster a fluid mechanism for communicating with the public and numerous interagency personnel. To accomplish this objective, a Public and Interagency Outreach Plan was developed early on in the study that clearly articulates a framework for involving the public and interagency personnel at each phase of the project. The Plan describes various actions required for successful implementation of a comprehensive program engaging the public citizenry, stakeholders, and interagency personnel in the feasibility study at each phase of the process. Implementation of the Public Outreach Plan has permitted the project team to continually interface with the public and interagency personnel through a wide variety of mechanisms including:

- conducting public workshops;
- developing a stakeholder database;
- encouraging print and broadcast mass media pieces;
- utilizing electronic media, including the District website;
- developing printed materials;
- maintaining a reference library; and
- providing technical experts for a speaker's bureau, as needed.

Database Development, Maintenance and Use

A database of project-specific interested parties, stakeholders, and interagency personnel has been developed and maintained to reflect the growing interest in the feasibility study. The database was developed as a tool to record public, stakeholder, and interagency participation activities and input throughout the study's 3-year process. Information stored in the database has been queried to gage public acceptance for each Alternative under evaluation:

1) No In-Lake Action
2) Chemical Treatment
3) Dredging with a variety of Sediment Management Alternatives

APPENDIX C
OUTREACH INFORMATION SUMMARY

Extraordinary effort has been made to research a wide variety of possible interested parties, gain their contact information for incorporation into the database and mailing lists, and further utilize the database as a tool for contacting groups and individuals; thus enlisting participation from all sectors of citizenry, government, and ideological perspective.

Identified stakeholders include:

- public citizens and community leaders from municipalities and unincorporated areas that surround the lake to the north, south, east, and west;
- local, regional, state, and federal governments (including Florida Fish and Wildlife Conservation Commission, U.S. Fish and Wildlife Service, Florida Department of Environmental Protection, U.S. Environmental Protection Agency, Town Managers, County Commissions, U.S. Army Corps of Engineers, special taxing districts, water utilities directors, etc.);
- environmental organizations;
- agricultural concerns;
- Native American Indians;
- business; and
- educational institutions.

The stakeholder database includes groups and individuals with an interest in or responsibility for Lake Okeechobee issues and/or expertise in areas such as water resources, conservation, community life, limnology, permitting, land use, policy planning, education, and sediment management, to name a few. Each group or individual has been entered into the database along with contact information, zip code, title, affiliation, primary interest of individual or association, date of initial contact with the District on this study, method of communication, and related resource materials and courses of action taken. Further use of the database includes entering of all input received from and all contact made with groups or individuals associated with this feasibility study. Records of attendance for each meeting and any specific input offered (either in person at the public workshops, in writing, in personal conversations, or in the print or broadcast media) is stored in the database and has been queried and reviewed for incorporation

into the evaluation process. This database holds record to 881 parties interested in Lake Okeechobee water resources issues including the public citizenry, stakeholders, and interagency personnel. The database information is provided at the end of this Appendix.

Public Workshops

Prior to completion of each of the four tasks in the feasibility study, a public workshop was scheduled to solicit participation and input from the public, stakeholders, and interagency personnel. To date, three public workshops have been conducted in three diverse geographic locations around the lake. Locations at different points around the lake were chosen for public meetings because each community has a population with distinct socioeconomic makeup and a unique point of view on issues relating to Lake Okeechobee. All public/interagency workshops were held in public facilities at commonly known locations.

Several methods of communication were used to notify the public and interagency personnel of upcoming project activities such as the public/interagency meetings. Each notification identified the time, place, and purpose of the meeting and actively invited members of the public and interagency personnel to attend. Methods of notification include:

- Contacting District Outreach Specialists to arrange a meeting time and place which served the population in the vicinity, while inquiring if any additional interested parties should be added to the database;
- Development of a *Fact Sheet* announcing the meeting and describing the project status/progress. Fact Sheets were mailed to all stakeholders, interested parties, and interagency personnel as well as distributed to the District headquarters, District Service Centers, libraries, and governmental centers;
- Mailing an invitational letter to identified interagency personnel with an interest in and/or responsibility for the Lake Okeechobee issues. The invitational letter announced the meeting and encouraged the participation of the individual as well as others who work in the department and agency. Project team contact information is provided within the letter to foster communication and identify an individual who may be contacted with any questions.

APPENDIX C

OUTREACH INFORMATION SUMMARY

- A reminder postcard was sent to all stakeholders, interested parties, and interagency personnel reminding them of the upcoming meeting and encouraging their participation;
- Notification was posted in the Legal Notices section of all local papers including the Palm Beach Post, Okeechobee News, Pahokee Sun, Clewiston Sun, and the Okeechobee Democrat;
- Personal phone calls were made to members of the public, members of the media and interagency personnel to further invite participation in the workshop;
- Notification of the meetings was also posted on the District's website at www.sfwmd.gov; and
- Project documents were also posted on the District's project website – http://www.sfwmd.gov/org/wrp/wrp_okee/projects/sedimentmanagement.html providing another means of accessing materials relating to the feasibility study.

The first meeting was conducted on January 10, 2001 at District Headquarters in West Palm Beach, followed by a second meeting at the District's Okeechobee Service Center located in the City of Okeechobee to the north of the lake. These meetings engaged primarily agency staff at the West Palm Beach location and members of the public at the Okeechobee meeting. The purpose of first public/interagency meeting was to introduce the feasibility study to the public and seek input on Task 1- Development of Goals, Performance Measures, and Potential Impacts. In addition to public notices in the newspapers and on the District website, invitations to participate in the workshop were sent to 670 individuals, including interagency personnel and members of the public. Forty-five people attended the workshop, providing input on project documents as well as specific thoughts on Lake Okeechobee and various remediation processes. Minutes for the January 10, 2001 meeting are provided at the end of this Appendix.

A second public/interagency meeting was conducted on July 19, 2001 at the Palm Beach Community College, Glades Campus near the City of Belle Glade, located on the east side of the lake. The purpose of the workshop was to present Task 2-Development of Alternatives to the public and interagency personnel, and solicit further input on the study. In addition to public notices in the newspapers and on the District website, invitations were sent to 703 interested parties and stakeholders; including 480 to members of the public and 223 to interagency

personnel. Fifty-four individuals participated in the workshop providing a productive exchange of diverse ideas and feedback regarding the acceptance of generalized sediment management alternatives. Minutes for the January 19, 2001 meeting are provided at the end of this Appendix.

On April 4, 2002, a third public/interagency workshop was conducted at the Doyle Connor Agricultural Center in the City of Moore Haven, located on the western shore of Lake Okeechobee. The purpose of this workshop was to present an overview of the feasibility study to date and present information pertaining to the end of Task 3-Work Plan for Evaluation of Alternatives. In addition to public notices in the newspapers and on the District website, 847 meeting announcements and invitations were sent to individuals and organizations encouraging participation, including 513 to members of the public and 334 to agency personnel. Thirty-one parties attended the workshop. Discussions included the District's Pilot Dredging Project and the pros and cons of alternatives including No In-Lake Action, Dredging, Chemical Treatment, treatment ponds and others. Minutes for the April 4, 2002 meeting are provided at the end of this Appendix.

All public workshops were conducted in a manner which enabled the project team to present an overview of the feasibility study and recent study findings (including providing the attendees with project documents, visual references, and graphic posters) while allowing ample time for public, stakeholder, and interagency personnel questions. Each meeting provided a forum for attendees to raise ideas and concerns regarding sediment management processes and to address internal (and at times, external) loading of phosphorus in Lake Okeechobee. Information gathered at the public/interagency meetings was recorded in the database for future reference and analysis.

It should be noted that each invitation to attend and participate in the public/interagency meetings included information on how to contact the project manger and access project materials either on the District website or by requesting a hard copy from the District.

A fourth public/interagency meeting is scheduled for January 14, 2003 at the District's Okeechobee Service Center. The purpose of this meeting is to present the findings of Task 4-

Evaluation of Alternatives and solicit input from the public, stakeholders, and interagency personnel. Minutes for the project District's Technical Review Team (TRT) meetings are located in the project files.

Additional Meetings

Additional meetings have been held to gain supplementary information and insight. The project team has been meeting regularly with the TRT comprised of scientific specialists to discuss modeling, progress, and updates. The project team also conducted a meeting to discuss the issue of beneficial reuse of materials that would be generated if dredging were to be implemented. A meeting summary for the beneficial reuse meeting is provided at the end of this Appendix. Numerous meetings and conference calls were also held with Florida Fish and Freshwater Conservation Commission, Lake Okeechobee Business Owners, FDAC, Florida Department of Environmental Protection, and IFAS to obtain input for development of goals, alternatives, and performance measures for the Feasibility Study.

Media

Since the inception of the feasibility study, the project team has subscribed to and reviewed the local print media for articles on Lake Okeechobee and on the Lake Okeechobee Sediment Management Feasibility Study. Approximately 100 articles collected throughout the project period, of October 2000 through March 2003 have been reviewed by the team so that priorities and community sentiment are well understood.

Three main issues were consistently presented in local newspapers during the study period. They include the following:

- water quality – in the lake and in the watershed;
- fishing activities – commercial/recreational; relationship of habitat restoration to fishing; and
- lake stage (water levels) – relationship of lake levels to the health of the lake; socioeconomic impacts of lake stage.

APPENDIX C
OUTREACH INFORMATION SUMMARY

Journalists for various newspapers were present at most of the Outreach Meetings around the lake. Articles written pertaining to the Lake Okeechobee Feasibility Study meetings were relatively accurate and on point. Articles reviewed during the project period are stored in the project files.

The data and feedback collected throughout the outreach process serves as the basis for discussion regarding the Feasibility Study performance measure "Maximize Community Acceptance" (5B). Each alternative, No In-lake Action, Chemical Treatment, and Dredging, is evaluated against this performance measure in Sections 3, 4, and 5. An overview of the community thoughts and concerns are provided below.

Community Perceptions

Community acceptance may be measured qualitatively as a dimension of quality-of-life by taking into account the community's desire for increased water clarity and water quality. An increase in the water clarity would, in effect, make the lake more desirable to the community in relation to the recreational amenities including boating, fishing, and swimming. A ripple effect of increased water clarity (decrease in Total Suspended Solids and algal blooms) could have an impact on the tourism market surrounding the lake, thus increasing the desirability perceived by visitors and an increase in community pride by the residents. An improvement in water quality to the lake is perceived as critical for the lake to overcome the image/perception held by some that Lake Okeechobee is Florida's cesspool. At least five communities – Pahokee, Belle Glade, Moore Haven, Clewiston and Okeechobee use Lake Okeechobee their primary source for drinking water. The citizenry and their governments are emphatic about the need to improve water quality in the lake. The environmental community also has concerns relating to the quality of water in the lake. The Comprehensive Everglades Restoration Plan's (CERP's) basic focus is increasing the amount of water available to restore the Everglades and provide enough water for the projected population increase in south Florida. Lake Okeechobee is a main source of water earmarked for many of these restoration efforts. Increasing the water quality of Lake Okeechobee is not only mandated by the Lake Okeechobee Action Plan, it is also critical for the implementation of many aspects of CERP.

APPENDIX C

OUTREACH INFORMATION SUMMARY

Questions raised by the community:

Time – How long will the alternative project take to show initial and ultimate results? Is this just another study that will yield no results and keep us in the same situation for yet another 20 years? What about the permitting process - is it possible and how long will it take to permit any given Alternative?

Perception – Has the public, stakeholder and interagency received sufficient education on the pros and cons of the Alternative to knowledgably perceive the process and outcome? Is there a perception that the alternative will cause health or environmental impacts? Is the Alternative perceived to be logical, of low risk and doable?

Cost – How much will the Alternative cost – long term/short term? Is there any guarantee that the chosen Alternative will solve the problem, or perceived problem? Does the alternative include the cost in dollars over a 20-year period as well as the cost to the socio-economic gain or loss?

Health effects - How will the Alternative affect the health of our families and the next generation? How will the Alternative affect the water supply and the natural system?

References

Meeting Minutes - Public/Interagency Meeting #1 January 10, 2002

Meeting Minutes - Public/Interagency Meeting #2 July 19, 2001

Meeting Minutes - Public/Interagency Meeting #3 April 4, 2002

Newspapers

Palm Beach Post – Palm Beach County, FL

Glades County Democrat – Moore Haven, FL

The Sun – Pahokee and Belle Glade, FL

Clewiston News - Clewiston

Okeechobee News- Okeechobee, FL

Public and Interagency Public Outreach Plan. (BBL 2000)

NO. 766452

NOTICE OF PUBLIC MEETING
LAKE OKEECHOBEE
SEDIMENT MANAGEMENT
FEASIBILITY STUDY

Wednesday, January 10, 2001
6:30 p.m. to 8:00 p.m.
SFWMD's Okeechobee
Service Center
205 N. Parrott Ave, Suite 201
Okeechobee, FL

The South Florida Water Management District announces a public meeting to solicit input on the Lake Okeechobee Sediment Management Feasibility Study. The purpose of the three-year study, now underway, is to identify and evaluate alternatives for reducing internal phosphorus loading in the lake. The high concentrations of phosphorus currently in the lake's sediments decrease water quality and may lead to other problems in Lake Okeechobee and downstream water bodies.

Come to the meeting to learn about the project and provide comment. For more information visit the South Florida Water Management District's web site at
www.sfwmd.gov
/org/wrp/wrp okee/projects-
/sedimentmanagement.html
or call Karen Smith, the District Project Manager, at (561) 682-2731.

PUB: The Palm Beach Post
January 3, 2001

NOTICE OF PUBLIC MEETING

LAKE OKEECHOBEE SEDIMENT MANAGEMENT FEASIBILITY STUDY

Thursday, July 19, 2001
6:30 p.m. to 8:00 p.m.
Glades Campus, Palm Beach
Community College
Lecture Hall, Room 122
1977 Campus Drive, Belle Glade, FL

The South Florida Water Management District announces the second in a series of four public meetings to solicit input on the Lake Okeechobee Sediment Management Feasibility Study. The purpose of the three-year study is to identify and evaluate alternatives for reducing internal phosphorous loading in the lake. On July 19th, an array of technologies that could be used to address the internal phosphorus loading issue in Lake Okeechobee will be presented, followed by a discussion of specific alternatives being considered for detailed evaluation later in the feasibility study process.

The public and interested interagency personnel are invited to the meeting to learn about the progress of the project and provide input. For more information or to review the draft ***Development of Alternatives*** documents, visit the District's project website at www.sfwmd.gov/org/wrp_okee/projects/seditmentmanagement.html or call Karen Smith, the Project Manager at (561) 682-2731.

204593 - ON/BL/BG 7/12; CN 7/11

Public Notice 5005

NOTICE OF PUBLIC MEETING

LAKE OKEECHOBEE SEDIMENT MANAGEMENT FEASIBILITY STUDY

Thursday, April 4, 2002
6:30 p.m. to 8:00 p.m.
Doyle Connor Agricultural Center
900 U.s. Highway 27
Moore Haven, FL

The South Florida Water Management District announces the third in a series of four public meetings to solicit input on the Lake Okeechobee Sediment Management Feasibility Study. The purpose of the three-year study is to identify and evaluate alternatives for reducing internal phosphorous loading in the lake.

The public and interested interagency personnel are invited to the Doyle Connor Agricultural Center in Moore Haven on April 4 for a project update, an opportunity to talk with project team members, and a change to provide feedback on future plans. For more information on the feasibility sturdy, contact Jorge Patino, the District Project Manager at (561)682-2731 or jpatino@sfwmd.gov or visit the project website at www.sfwmd.gov/org/wrp/wrp_okee/projets/sedimentmanagement.html.

268281-CN3/20,ON,BG,GL3/21

The Sun, Thursday, March 21, 2002

Draft

Lake Okeechobee Sediment Management Feasibility Study

Interagency and Public Meeting Minutes

January 10, 2001

Interagency Meeting
1:30 p.m.- 3:00 p.m.
South Florida Water Management District
Storch Room
3301 Gun Club Road
West Palm Beach, FL 33406

Public Meeting
6:30 p.m.- 8:00 p.m.
South Florida Water Management District
Okeechobee Service Center
205 North Parrot Avenue
Okeechobee, FL 34972

In attendance at the Interagency Meeting:

Lothian Ager, Florida Fish and Wildlife Conservation Commission
Bob Barry, Palm Beach Community College
James Barry, Palm Beach County Environmental Resources Management
Linda Bolton, Village of Wellington
Rick Brust, Florida Fish and Wildlife Conservation Commission
Laurene Capone, University of Florida
Nancy Case O' Bourke, Case Engineering
Angie Charles, US Army Corps of Engineers
Samica Daroub, University of Florida
James Erskine, Miccosukee Tribe
Don Fox, Florida Fish and Wildlife Conservation Commission
Karl Havens, South Florida Water Management District
Kevin Henderson, St. Lucie River Initiative
Ernest J. Hewitt, University of Florida, EREC
Lewis Hornung, South Florida Water Management District
Kang- Ren Jen, South Florida Water Management District
Anwar Khan, EA Science Engineering and Technology
John Mitnik, Florida Department of Environmental Protection/SED
John Morgan, South Florida Water Management District
Al Paglia, Village of Wellington
Sherry Scott, South Florida Water Management District
Sam Sharpe, Natural Resources Conservation Service

Margaret Shooshani, MSA, Inc.
Ken Todd, Palm Beach County
Bill Veach, City of Okeechobee
Joe Walsh, Florida Fish and Wildlife Conservation Commission
Ross J. Wilcox, Martin County
Carl Woelhke, South Florida Water Management District
Bishop Wright Jr., Everglades Coordinating Council
Herb Zebuth, Florida Department of Environmental Protection/SED

In attendance at the Public Meeting:

Missie Barletto, South Florida Water Management District
Jim Collins, EA Engineering, Science and Technology
James Erskine, Miccosukee Tribe
Tanya Foster, Kimly-Horn & Associates, Inc.
Carroll Head, Friends of Lake Okeechobee
Sorrel Hoover, Orion
Kevin Ingram, Chemical Lime
Frank Muricci, Fast Break
Rick Price, Lockhart Ag Technologies
T.C. Valentine, Okeechobee News
Bill Veach, City of Okeechobee
Odi Villapando, South Florida Water Management District
John Welch, Okeechobee, FL
Wellison, DRW Land Co.
Dongwei Zhu, Macvicar Fredrico & Lamb, Inc.

Introduction/Purpose of the Meetings

Karen Smith, Project Manager, South Florida Water Management District (District) welcomed the attendees and opened the meeting with self-introductions.

The District's representative made the following key points:
The Lake Okeechobee Sediment Management Feasibility Study (Study) is required by Florida Legislature House Bill 991, Amending F.S. 373.4595. The Study was approved by the District's Governing Board and recommended by the Lake Okeechobee Issues Team Action Plan. The findings of the Study will provide support for sediment management decisions by the District's Governing Board.

The purpose of this meeting is to introduce the Study, present the first task of the Study - *Project Goals, Performance Measures and Potential Impacts* for review and to invite all persons with an interest in the future of Lake Okeechobee (Lake) to get involved in this Study and share their thoughts, ideas and comments. Active participation from both governmental agencies and members of the public during this and future meetings as well as throughout the entire Study process will be a key component of the Study's success.

The purpose of the Lake Okeechobee Sediment Management Feasibility Study is to determine the best methods of sediment management within the Lake that will achieve maximum reductions in internal phosphorus loads.

The goal of this project is to find satisfactory and cost-effective ways to address the issue of phosphorus in Lake Okeechobee's sediments with the ultimate effect of improving water quality, reducing algae blooms, and protecting the fishery and wildlife resources and socioeconomic interests that are vital to the region.

The Study is needed because an estimated 51,600 metric tons of phosphorus are in Lake Okeechobee's mud sediments. Along with new phosphorus arriving from the surrounding watershed, this internal load of phosphorus is seriously undermining the Lake's water quality and capacity to support healthy ecosystems.

The District, under a contract with the consulting engineering firm of Blasland, Bouck and Lee, Inc. (BBL), will conduct this three-year Study. The District and consultants enter this project with no preconceived notions about what sediment management strategy is best for Lake Okeechobee and the viability of our region. This study, with interagency and public input, will consider a wide array of possible options in light of each option's potential benefits and costs to the people and wildlife of South Florida.

The phosphorus problem and its potential economic and ecological implications are daunting. The Study seeks to find what can be done, how it would be done, how much it would cost, and what impacts (positive and/or negative) it should have.

Discussion of the Problem

Dr. Karl Havens, Chief Environmental Scientist with the District, presented an overview of the phosphorus problem in Lake Okeechobee. Key issues discussed include the legacy of high phosphorus load effects on internal cycling, the increasing trend in total phosphorus in the lake, and seasonal (wind and wave generated) variations in phosphorus levels in the sediment throughout the lake. Data collected indicates an increase in phosphorus levels over time. The processes affecting sediment/water phosphorus exchange were illustrated.

Dr. Havens noted that identified alternatives may or may not benefit the ecology of the Lake, but that reducing the turbidity of the water and other such improvements would be examined in the Study.

Dr. Havens questioned the future condition of the Lake if nothing is done to manage the trend of increasing phosphorus levels. He suggested that measures both internal and external to the lake should be carefully considered.

Discussion of Draft Goals, Performance Measures and Potential Impacts

Kathy "Luke" Lukasiewicz, P.G., representing BBL, made the following key points:
The major tasks of the Study are:

1. Develop goals, performance measures and potential impacts that will be used to evaluate alternatives for managing phosphorus levels in the Lake's sediment;
2. Explore all feasible alternatives;
3. Evaluate those alternatives;
4. Facilitate ranking and prioritization of the alternatives; and
5. Present findings to the District's Governing Board, and others.

Active participation by all interested parties - including the public, groups and organizations, Indian Nations, media, and government agencies are integral to this evaluation process. The Study process is to be interactive with the public, other organizations and agencies. BBL asks the public for help and input on developing the goals and performance measures of this project.

There are no preconceived judgments about the outcome of this Study. BBL wants to conduct the Study in a balanced, objective way and see where that leads. Some of the sediment management technologies have the potential to be very costly, time consuming and disruptive to wildlife, so all the pros and cons of each option will be weighed by the District before moving forward with a proposed strategy.

One option that will be evaluated is called "natural recovery." Natural recovery may be described as allowing the Lake's own natural healing powers to improve the system over time. As external inputs of phosphorus decrease in response to the ongoing actions of the District and the Florida Department of Environmental Protection (DEP) in the watershed along with the continued cooperation of landowners, we may see that the Lake begins to improve without further intervention. This option will be carefully weighed against other options such as chemical treatment, capping, dredging, combinations of alternatives and other approaches identified during the Study.

No decisions will be made about which alternative will be recommended until the Study is completed. The goal of the Study is to understand the problem, then to determine the most practical ways to solve it.

Table 3 *Summary of Draft Goals, Performance Measures and Potential Impacts* was introduced and discussed.

The Study's five goals are:

1: Treat, remove, or manage sediments to reduce internal phosphorus loading;
2: Minimize time to achieve substantial water quality improvement;
3: Minimize project costs, both in the short term and long term;
4: Minimize potential impacts of sediment management; and
5: Satisfy all applicable regulatory permitting and legal requirements.

The Study will include identification of alternatives (technologies or approaches) for mitigating the phosphorus problem in the lake. The alternatives will be evaluated using performance measures, each with specific targets used to evaluate the relative performance or each alternative in achieving project goals.

Attendees were invited to review and discuss the draft goals, performance measures, and potential impacts.

There will be ongoing opportunities to comment on the Study throughout the process. The *Draft Goals, Performance Measures and Potential Impacts* document is available on the Internet at the District's website:
(www.sfwmd.gov/org/wrp/wrp_okee/projects/sedimentmanagement.html).

The document may also be obtained in hard copy upon request. Comments regarding the draft document should be submitted to the District Project Manager, Karen Smith.

This is the largest scale project of this type ever proposed. Findings from other new studies will be incorporated into this Study. These other new and concurrent studies include a Pilot-Dredging Project being conducted by the District in Lake Okeechobee and a Laboratory Sediment Core Evaluation being conducted by the University of Florida.

At the end of the presentations, the floor was opened for attendees to ask questions, offer comments, and voice concerns. These questions, comments, and concerns are summarized below. Where appropriate, a summary of the response offered follows the question.

Question and Answer Session at the Interagency Meeting

Representatives for the **Florida Department of Environmental Protection** raised the following issues/questions:

- What technologies will be tested during the Study?
  Ms. Luke responded: Due to time and cost constraints, dredging is the only technology to be tested within the scope of this Study. The Pilot Dredging Study, under a separate contract with the District, will provide data for the Sediment Management Feasibility Study.
- Will sediments and effluent be tested for pesticides or other toxic components such as metals?
  Ms. Luke responded: The sediment will be tested for specific constituents during the Pilot Dredging Project, but further testing of the sediment is not currently in the scope of this study.
  Ms. Smith commented: There are on-going studies within the lake that have been collecting data on sediment composition. Certain areas, known as "hot spots," contain higher concentrations of some elements.
  A DEP representative noted: DDT has been found in five to ten of the samples DEP examined in their lab.

Ms. Smith suggested that DEP provide any data concerning sediment constitution to the District for incorporation into this Study.

Representatives for the **St. Lucie River Initiative** raised the following issues/questions:

- Will the Study include findings of where the sediments are coming from, and their composition?
  Dr. Havens responded: A past study performed by Pat Gleason using Carbon 13 to date sediment in the lake has some useful information, yet the study may be flawed due to some false readings. He noted that the dredged material would be tested for some constituents.
  An attendee offered: Another study that may be considered is an ongoing study by Tom Kristman of the origins of sediment in the lake.
  Ms. Luke added: To the extent possible, the Study will incorporate all studies and data that are made available to us.
- Will the Study consider other uses for the sediment if it were dredged?
  Ms. Luke responded: Other uses and disposal of the sediment will be considered in this Study.
- The goals of the Study are biased toward phosphorus being the sole causality damaging the Lake. Habitats and substrata should be included in the Study. The St. Lucie River Study is looking at high turbidity and anoxic affects from sediments. These issues are just as important as nutrients. The St. Lucie Study considers these issues as fundamental matters of habitat systems.

Representatives of the **Florida Fish and Wildlife Conservation Commission** raised the following issues/questions:

- What technology is available to potentially cap only portions of the Lake?
  Ms. Luke responded: Partial capping will be evaluated as part of the study.
- What about the pollution in the sediments, and what impacts would be realized in the surface water when the material is dredged?
  Dr. Havens responded: Current and new data will be considered during the Study.
  Ms. Smith added: There are data from ongoing water quality monitoring programs within the Lake that will be considered.
- Historically, there was never vegetation in the areas that are now high in phosphorus. There is concern regarding the impact of dredging on a system. The Environmental Protection Agency (EPA) has a "surgical" method.
- Scott Welch was doing a dredge-cut study along with a dredging project in Lake Panasoffkee. His data may be useful to this Study.
  Ms. Luke responded: Findings from the separately funded dredge-cut study could be important for this Study and will be explored, if made available.

Representatives of the **Village of Wellington** raised the following issue/question:

- The Village of Wellington has an action team to improve water quality. Does this Study have any connection to the 2006 Clean Water Mandate?
  Dr. Havens responded: This Study is a different issue, but in fact, the Everglades Forever Act does not yet have final levels determined.

Representatives of **Martin County** raised the following issues/questions:

- Why will the Study take so long? Can it be compressed to a shorter time frame?
  Ms. Luke responded: Three years are necessary for a comprehensive study of all of the issues of this complex phosphorus problem. Further, the closely linked Lake Okeechobee Pilot Dredging Project will require 1 1/2 to 2 years to complete once the final Work Plan is determined. This information will be incorporated into the alternative evaluation phase of this Study.

A representative of the **University of Florida** raised the following issues/questions:

- Other studies conducted by the District should be incorporated into this Study. Specifically, Susan Grey is currently conducting an alum study.
  Ms. Luke responded: Thank you. Yes, this information is important. Those studies' findings will be incorporated, if made available.

The following issues/questions were also offered by attendees:

- Would dredging a maintenance area be part of the Study?
  Dr. Havens responded: Yes.
- Will the evaluation assume external loads have been reduced into the Lake?
  Dr. Havens responded: Yes. Different external loads will be tested at various levels using computer models.
- How thick are the Lake sediments?
  Ms. Luke responded by referring to a map in the hand-out packet, and noted the varying thickness of sediments in the Lake, adding that water depth varies as well.
- Is alum present in the sediments?
  Ms. Luke responded: This is not known at this time, but ongoing studies will be incorporated.
- It was suggested that the "fluffy" sediments could be pumped-out and tested.
- Are biotic evaluations part of the Study?
  Ms. Luke responded: Biotic evaluations are not within the Scope of Work of this Study.
- Will the short-term benefits of dredging be explored in the Study?
  Ms. Luke responded: Yes, short-term effects will be evaluated.
- Will the Study explore the short-term improvement of invertebrates?
  Ms. Luke responded: The study of invertebrates is not within the Scope of Work of this Study, but if anyone knows of available data, you are encouraged to bring it forward for exploration.
- What is the public process by which recommendations will be chosen by the District?
  Ms. Luke responded: Public and interagency participation will be ongoing throughout the study process.

With no further questions or comments, the Interagency Meeting was adjourned.

Question and Answer Session at the Public Meeting
Attendees at the Public Meeting offered the following issues/questions:

- How does the study address:
  - Future external loading of phosphorus into the lake;
  - Other studies such as Lower East Coast Water Supply Study, Dairy Buy-Out Program and other complex problems within the area;
  - Lake Okeechobee water regulations; and
  - Interagency coordination?

    Ms. Luke responded: Each of these topics will be explored during the Study.
- How do we measure the effect that the phosphorus problem has on the economy such as sports fishing, boating, etc.? Is this impact known? Is it measurable?
  Ms. Luke responded: The Study includes a socioeconomic study of the Lake region.
- Will the Study's goal be to avoid adverse effects to the current conditions of the lake (which are poor) or will it look towards previous, healthier conditions?
  Ms. Luke responded: Computer modeling of the current and projected conditions of the Lake will include multiple scenarios.
- What is the mud thickness within the lake? Is there a correlation between mud thickness and lake water depth? A diagram showing this information would be helpful.
  Ms. Luke and Dr. Havens responded: Both sediment thickness and water depth may be depicted using contour lines on maps. The map used during the presentation only illustrates sediment thickness, but additional maps may be produced during the study.
- Low water levels have had an adverse effect on tourism, especially when associated with fishing tournaments.
- Turbidity is directly associated with the quality of fishing experience in the lake. Lower lake stages have had a positive effect on water clarity.
- Concern was expressed regarding the Kissimmee River outfall.
- Wind and wave action are main causes of reduced water clarity.
- Algae blooms may be misinterpreted as sediment and particulate suspension.
- How much sediment should be removed from the lake to restore its health?
  Ms. Luke responded: This issue will be evaluated during the Study.
- It was suggested that coffer dams be built within the lake.
- Nitrogen has a direct relationship with phosphorus. The current ratio in the lake is conducive to algae blooms. Efforts should be made to address this issue.
- Will the study examine increasing fisheries habitat? Increased vegetation? Creating barrier islands/breakwaters?

Ms. Luke responded: Alternatives designed to reduce internal phosphorus loads and increase water quality will be evaluated. Currently, project goals, performance measures and potential impacts are being drafted.

- Lower Lake water levels have a direct correlation to biomass accumulation and reintroduction of phosphorus.

With no further comments or questions, the Public Meeting was adjourned.

Lake Okeechobee Sediment Management Feasibility Study

PUBLIC / INTERAGENCY MEETING #2

MEETING MINUTES

July 19, 2001

6:30 PM – 9:00 PM
Palm Beach Community College
Glades Campus
1977 College Drive
Belle Glade, FL 33430

Public / Interagency Meeting Attendees:

Lester Baird, Hendry County
Bob Barry, Palm Beach Community College
Esther Barry, City of South Bay
Brian Blackwelder, ELULC, Inc.
Linda Bolton, Village of Wellington
Mali Chamness, City of Clewiston
Angie Charles, U.S. Army Corps of Engineers
Jim Collins, EA Engineering, Inc.
Tommy Cone, City of Belle Glade
David C. Cook, South Florida Conservancy
Dennis Duke, U.S. Army Corps of Engineers
James Eiskin, Miccosukee Tribe
Todd Ellison, City of Belle Glade
Jamie C. Feddersen, Florida Fish & Wildlife Conservation Commission
Mitch Flinchum, IFAS, University of Florida
Harry Gibbons, Tetra Tech, Inc.
John C. Hess, U.S. Army Corps of Engineers
Ernest J. Hewett III, University of Florida, EREC
Clyde Hopple, U.S. Army Corps of Engineers
Mark Howell, U.S. Sugar Corporation
Eric Hughes, U.S. Environmental Protection Agency
Michael E. Jackson, City of South Bay
K.S. Butch Jones, Glades County Commission
Anwar Khan, EA Engineering, Inc.
Pepe Lopez, U.S. Sugar Corporation
Byron Maharrey, Florida Sportsman Conservation Association
Kim O'Dell, South Florida Water Management District
Mary Orsenigo, Citizen Interest
Jorge Patino, South Florida Water Management District
Max Quackenbos, St. Lucie River Initiative
Ken Schenck, City of Pahokee

Steve Schubert, U.S. Fish & Wildlife Service
Thomas Schueneman, Palm Beach County Agricultural Extension Service
Vicki Silver, Palm Beach County Planning Division
Roy Singletary, City of Pahokee
Houston L. Tate, City of Belle Glade
Curt Thompson, U.S. Army Corps of Engineers
Ken Todd, Palm Beach County Water Resources Department
Twila Valentine, Okeechobee News
Joe Walsh, Florida Fish & Wildlife Conservation Commission
Gary Warren, Florida Fish & Wildlife Conservation Commission
Eva Webb, Florida Farm Bureau
John C. Welsh, Citizen Interest
Benita Whalen, South Florida Water Management District
Charles Wilson, U.S. Sugar Corporation
Theresa Woody, U.S. Army Corps of Engineers
Bishop Wright, Jr., Everglades Coordinating Council
Herb Zebuth, Florida Department of Environmental Protection

Also in attendance via telephone conference call:

Megan Eves, Blasland, Bouck & Lee, Inc.
Alan Fowler, Blasland, Bouck & Lee, Inc.
Russell Houck, Blasland, Bouck & Lee, Inc.
Ram K. Mohan, P.E., Blasland, Bouck & Lee, Inc.
Curt Pollman, Tetra Tech, Inc.

Introduction/Purpose of Meeting

Kathy Lukasiewicz of Blasland, Bouck & Lee, Inc. (BBL) welcomed attendees and opened the meeting with introductions of the South Florida Water District Management (SFWMD) staff members in attendance and BBL consultant team members.

Ms. Lukasiewicz informed attendees that the purpose of this meeting was to discuss the development of alternatives (Task 2) for the Lake Okeechobee Sediment Management Feasibility Study, and to solicit input from the public, interagency personnel, and other interested parties. (see attached agenda)

All persons with an interest in the future of Lake Okeechobee were encouraged to involve themselves in this Feasibility Study and share their thoughts, ideas, and comments. Ms. Lukasiewicz emphasied that active participation from all members of the public attending this and future meetings is a key component of the Feasibility Study process.

The following is a summary of Ms. Lukasiewicz's presentation (a complete set of slides is attached to these minutes):

Ms. Lukasiewicz presented an overview of the project and specific information relating to Task 2 – Development of Alternatives. She explained that the project objective is to determine the best

sediment management methods for reducing internal phosphorus loading in Lake Okeechobee. Thus, the purpose of this meeting was to discuss a wide variety of technologies and process options that may be feasible for reducing phosphorus in Lake Okeechobee, and to solicit public/interagency input on these technologies and the associated sediment management alternatives.

Ms. Lukasiewicz provided a brief summary of why the Feasibility Study is needed. For example, there are an estimated 51,600 metric tons of phosphorus in the mud sediments in Lake Okeechobee, the internal phosphorus loading from these sediments approximately equals the phosphorus loading from external sources. Without measures taken to reduce internal phosphorus loads, the lake may not respond as quickly to external reductions as a result of ongoing programs such as Works of the District and the best management practices to be implemented under the Lake Okeechobee Restoration Program. The Feasibility Study was recommended by the Lake Okeechobee Issue Team Action Plan and was subsequently required by Florida Statute 373.4595(3)(f). The Feasibility Study's findings are further needed to support management decisions by the SFWMD's Governing Board.

There are five major tasks of the Feasibility Study:

Task 1 – Development of Goals and Performance Measures
Task 2 – Development of Alternatives
Task 3 – Work Plan for Evaluation of Alternatives
Task 4 – Evaluation of Alternatives
Task 5 – Stakeholder Prioritization of Alternatives

Two other studies currently underway that will play an important role in the Feasibility Study are the Pilot Dredging Project (EA Engineering, Inc. for SFWMD) and the Laboratory Sediment Core Evaluation (University of Florida). These studies will provide data specific to Lake Okeechobee that will be incorporated into the Evaluation of Alternatives (Task 4).

The project team completed Task 1 (development of Goals and Performance Measures) in June 2001. As a result, five overall goals for the project were established:

- Maximize water quality improvements
- Maximize engineering feasibility and implementability
- Maximize cost effectiveness
- Maximize environmental benefits
- Maximize socioeconomic benefits

Each potentially feasible sediment management alternative identified in Task 2 will be measured against these goals and the associated 26 specific performance measures during Task 4.

Task 2 (Development of Alternatives) is now underway and involves the development of an array of sediment management alternatives to be evaluated in detail in Task 4. There are three main steps in Task 2.

Step 1. Identify a wide array of potentially applicable sediment management technologies and process options, including a no in-lake action option. (see attached slides for a complete listing)

Step 2. Evaluate all identified technologies and process options and "screen out" those that are not feasible for reducing internal phosphorus loads in Lake Okeechobee.

Step 3. Combine retained technologies and process options into several complete sediment management alternatives.

Ms. Lukasiewicz introduced Harry Gibbons, Ph.D., a limnologist (from Tetra Tech, Inc.) working on the BBL consulting team. Dr. Gibbons presented an overview of in-lake chemical treatment options that are under consideration in the Feasibility Study. A number of options have been researched and screened for applicability to Lake Okeechobee's physical and chemical characteristics and the project goals.

Dr. Gibbons went on to discuss several other sediment management technologies under consideration, including:

In-Lake Chemical Treatment Options
Dredging (Sediment Removal) Options
Other Options (e.g., biomanipulation, capping)

After an initial screening of more than 35 possible sediment management techniques (i.e., a number of techniques were "screened out" for being ineffective, unreliable, or extremely difficult to implement), the retained technologies are used as "building blocks" to create a set of sediment management alternatives. Theretained technologies are:

No in-lake action
In-place chemical treatment/inactivation
Water column management
Dredging
Transport of materials
Sediment dewatering
Treatment of water from dredged material
Dredged sediment disposal
Dredged sediment reuse

These potentially feasible technologies and process options were then combined into a draft list of alternatives applicable to Lake Okeechobee. The six draft alternatives currently under discussion are:

Alternative 1 - No In-Lake Action with Monitoring of External Loads
Alternative 2 - Water Column Management Using Breakwaters
Alternative 3 - In-Situ Chemical Treatment
Alternative 4 - Hydraulic Dredging with Disposal in Confined Disposal Facilities (CDF)
Alternative 5 - Hydraulic Dredging with Disposal in In-Lake Sumps/Confined

Aquatic Disposal Cells
Alternative 6 - Hydraulic Dredging with Beneficial Reuse of Materials

A brief discussion of each of these alternatives, as well as a detailed assessment of all the technologies considered, may be found in the draft Development of Alternatives document, which can be viewed and downloaded from the project website: http://www.sfwmd.gov/org/wrp/wrp_okee/projects/sedimentmanagement.html

After completing the project and Task 2 overview, Ms. Lukasiewicz opened the meeting for participant discussion and a question and answer period. A summary of the open discussion involving presenters and meeting attendees follows.

Discussion / Question and Answer Session

A representative from the **Florida Sportsman Conservation Association** raised the following issue/question:

1. Please explain in more detail alternative #4, Hydraulic Dredging with Disposal in CDF.

   Ms. Lukasiewicz responded by describing the hydraulic dredging process, indicating there are many established/conventional and innovative dredging techniques that are being considered for Lake Okeechobee. For example, the Pilot Dredging Study will be testing an innovative technique to remove the top layer of lake sediments in a small area of Lake Okeechobee and disposing those flocculent materials into a CDF near Port Mayaca.

   Mr. Anwar Khan and Mr. Jim Collins of EA Engineering, Inc., the consultants to the SFWMD on the Pilot Dredging Study added additional information on the dredge type that has been designed for the pilot study. They also noted the CDF will be built on SFWMD-owned property adjacent to the C-44 canal near Port Mayaca.

A representative from the **St. Lucie River Initiative** raised the following issues/questions:

1. Following the completion of the Feasibility Study, is the Florida Legislature ready to provide funding for the recommended alternative?

   Ms. Benita Whalen of the SFWMD responded that a critical decision will have to be made once the study is completed and the most feasible alternatives are presented. The alternatives will have to be analyzed from an economic, engineering, and ecological standpoint. The chosen alternative may require a significant amount of money, and a decision will have to be made whether or not to fund its implementation.

2. Will permits be required by Florida Department of Environmental Protection and the U.S. Army Corps of Engineers?

   Ms. Lukasiewicz responded that there will be various permits required from several agencies prior to implementation of any chosen alternative, including Department of

Environmental Protection, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, and review by U.S. Fish and Wildlife Service and Florida Fish and Wildlife Conservation Commission. Ms. Lukasiewicz noted that ongoing participation by interagency personnel, including attendance at Public/Interagency Meetings is an important aspect of the Feasibility Study that helps to communicate project issues and coordinate activities among all involved.

A representative from the **Department of Environmental Protection** raised the following issues/questions:

1. Will the Feasibility Study evaluate the possible environmental impacts of each alternative?

   Ms. Lukasiewicz responded that each alternative will be evaluated against the Goals and Performance Measures defined in Task 1 of the Feasibility Study. One of the main goals defined is to maximize environmental benefits; therefore an alternative with comparatively low adverse environmental impact would be rated more favorably than one with greater negative impacts.

2. Will the Feasibility Study examine the chemical relationships between phosphorus and nitrogen and the biodegradation process in the Lake?

   Ms. Lukasiewicz responded affirmatively. A number of these interactions will be evaluated with the aid of computer-based modeling techniques and consultation with subject-area experts.

3. Is the Feasibility Study expected to determine a point at which the external loads are reduced to a level low enough to allow the greatest benefit of a recommended alternative for internal phosphorus reduction? Also, will the Feasibility Study incorporate the uncertainty of rates of reduction from external tributary sources (inflow vs. outflow rates)?

   Ms. Lukasiewicz and Dr. Curt Pollman (a scientist with Tetra Tech, Inc. and a member of the BBL consulting team) responded by discussing the planned modeling efforts. The Feasibility Study will incorporate a number of modeling scenarios, including the No In-Lake Action alternative. This baseline will be used to compare alternatives and simulate varying lake conditions.

   Further, Ms. Lukasiewicz and Dr. Pollman discussed structuring modeling efforts to learn the point of equilibrium of external and internal phosphorus loads and the point at which mitigation of internal loading would gain maximum benefit for the Lake. This may include a long-term option of coupling external loading reductions with active sediment management while considering long-term changes in the lake.

General discussion describing the Pilot Dredging Study commenced.

Ms. Lukasiewicz, Mr. Khan, and Mr. Collins explained that the pilot dredging study will involve construction of a confined disposal facility, or CDF, on the north shore of the C-44 canal, east of Port Mayaca on SFWMD-owned property. The proposed CDF will be 250' wide and contain 2 cells (each 200' long by 100' wide by 12' deep each), all lined with a PVC-like material to avoid seepage back into the lake. The cells will be approximately 15' high. Hydraulically removed sediments will be transported via a hopper barge and processed in the CDF cells. Sediment processing will remove phosphorus to 40 ppm and will include a dewatering process, atmospheric evaporation and physical separation.

Ms. Lukasiewicz reminded the meeting attendees of the difference in magnitude of the small (6000 cubic yards) Pilot Dredging Study compared to the volume of phosphorus-containing sediments targeted in this study (261 million cubic yards or 193 million cubic meters.

An attendee requested further information concerning the hydraulic dredging process.

Ms. Lukasiewicz explained that dredging is often a long-term procedure that sometimes becomes a maintenance dredging program continuing for many years.

The top 10 cm of sediments are known to be most active in distribution of phosphorus in the water column. When the top 10 cm are removed in a given area, flocculent sediments from surrounding areas are gravitationally drawn into the 'sump'. Maintenance dredging of a sump area may continue for up to 50 years in a lake of this size before the sump can be permanently closed. The University of Florida Study (the Reddy Study) will analyze sediment core samples and is expected to reveal more specific details about the content and dynamics of the sediments in Lake Okeechobee.

A representative from the **Miccosukee Tribe** raised the following issues/questions:

1. What is the expected water quality after pilot study processing/treatment?

   Ms. Lukasiewicz, Mr. Khan, and Mr. Collins responded that the final phosphorus concentration will be 40 ppm. Also, the process is designed to remove all solids, including all particulate phosphorus, from the fluid sediments. Chemical precipitation, may be used to bind the phosphorus and allow it to be removed from the water.

2. Will the study indicate the quantity and concentrations of alum that will be used/needed to reduce internal phosphorus loads in the lake?

   Ms. Lukasiewicz responded affirmatively. Dr. Gibbons added that the Feasibility Study will use data and information from numerous case studies that have used alum for the purpose of reducing phosphorus in lakes. The Feasibility Study will take into account the need to adjust the dose of alum in order for this treatment to be effective on the large, complex scale Lake Okeechobee.

3. Will the Feasibility Study consider the uncertainty of hurricanes and other storms?

   Ms. Lukasiewicz responded that the Feasibility Study will evaluate each alternative according to its long term ability to perform during and after severe weather. Those alternatives that would not retain their effectiveness through the type of storm events frequently occurring in South Florida would be rated less favorably.

   Dr. Ram Mohan of BBL described ongoing projects in the Chesapeake Bay and the correlation to this Feasibility Study. He stated that a cost/benefit analysis is often undertaken to determine the feasibility of engineering projects of this magnitude. Also, physical barriers such as rip-rap constructed of various materials, including metal and cement, may be used to stabilize any containment facility.

A representative from **The City of Belle Glade** raised the following issues/questions:

1. Have there been any studies or research done to determine any possible effects on Lake Okeechobee from the phosphate mine in Bartow, Florida (approximately 60 miles north)?

   Ms. Lukasiewicz noted that this issue has come up in the past and is an issue that may be considered in the Feasibility Study. Further discussion pursued with Ms. Lukasiewicz explaining that typically, groundwater movement does not correlate with surface water movement and that the groundwater flow of this particular watershed typically flows west towards Tampa, although some relationship may exist.

2. Who will fund the implementation of the Feasibility Study recommendations, the State of Florida or the SFWMD?

   Ms. Lukasiewicz responded that a funding source has not been determined. (See response to the representative from the St. Lucie River Initiative on page 5.)

A representative from **The City of Pahokee** raised the following issue/question:

1. If dredging to remove the first 10 centimeters of sediment will reveal native sand as indicated in the discussions, wouldn't the remaining flocculent materials again soon cover the sand after removal?

   Ms. Lukasiewicz responded affirmatively, noting the potential need for a very long term commitment to a maintenance dredging program to address this issue.

Representatives from **The City of South Bay** raised the following issues/questions:

1. Will any of the project alternatives, including dredging, have an adverse impact on municipalities that depend upon the lake as a source of municipal water supply?

   Ms. Lukasiewicz responded by referring to the project Goals and Performance Measures. Each alternative will be evaluated against specific performance measures defined in Task 1 of the Feasibility Study. One of those performance measures is that there must be no

negative impact to municipal water supply. Any alternative that is expected to have an adverse impact on the water supply would be rated unfavorably.

2. Could the Feasibility Study determine that more than one alternative is feasible?

   Ms. Lukasiewicz responded affirmatively. The final outcome of the Feasibility Study may be any of a number of results, including one sediment management alternative, a combination of alternatives, or no in-lake action.

A representative from the **Florida Fish and Wildlife Conservation Commission** raised the following issues/questions:

1. Has the use of alum been studied in relation to the impact on biotic communities in the Lake?

   Ms. Lukasiewicz and Dr. Gibbons responded that the use of alum in eutrophic lake systems is common. 90% of the case studies show that alum is safe and effective in treatment of eutrophic lakes due to chemical bonding of phosphorus and aluminum. Chemical treatment has a long, established track record. Discussion continued on the magnitude of other studies in relation to the actual size of the water bodies and that of Lake Okeechobee. Ms. Lukasiewicz added that the Feasibility Study will evaluate each alternative taking into account potential impacts on biotic communities.

A representative from the **Okeechobee News** raised the following issues/questions:

1. Is there any concern that the U.S. Army Corps of Engineers may delay implementation of the resultant recommendation from the Feasibility Study due to permitting issues?

   Ms. Lukasiewicz responded that interagency participation is an integral part of this Feasibility Study. The project team is reaching out to all agencies, including the U.S. Army Corps of Engineers to solicit active participation. Ms. Lukasiewicz noted that several representatives from the U.S. Army Corps of Engineers were in attendance at the meeting.

   Also, the project team has been working cooperatively with other agencies including the Florida Fish and Wildlife Conservation Commission and the Florida Department of Environmental Protection to encourage ongoing interaction throughout the study period, with the goal of streamlining the future permit application and approval process and reducing the chance of delays.

A representative from the **U.S. Fish and Wildlife Service** raised the following issues/questions:

1. The previous use of alum has had a negative impact on some benthic communities. Studies show alum may have adverse effects on density and diversity.

Ms. Lukasiewicz requested continued efforts to coordinate available case studies; also noting that if an alternative is found to have adverse impacts to biotic communities, it would not be rated favorably and may encounter problems during the permitting process.

2. Any project proposed would necessitate a review for compatibility with the Endangered Species Act.

   This point was acknowledged, and there was general agreement.

3. Has a draft permit application for the pilot dredging study been submitted to the Department of Environmental Protection?

   Mr. Khan responded that the SFWMD is expected to submit an application in 3 – 4 weeks.

4. The U.S. Fish and Wildlife Service usually requires 90 days to review permits.

A representative from the **U.S. Environmental Protection Agency** raised the following issues/questions:

1. Class I (drinking water supply) bodies are required to monitor for a number of specific water quality criteria. The Feasibility Study should be certain to consider this.

   Additionally, the Feasibility Study process should include analysis of the results from alum/sulfate interaction. Case studies have indicated problems with mercury methylation in other areas.

   Ms. Lukasiewicz responded that part of the process includes weighing alternatives against all local, state and federal regulations. The Florida Administrative Code sets specific criteria for drinking water (62-302 F.A.C.) and soils (62-777 F.A.C.), which will be included in the evaluation process.

   Dr. Pollman indicated that Lake Okeechobee does have a mercury methylation problem, but that it does not seem to negatively affect the fish populations. Mercury flowing south from the Water Catchment Area is an issue that is currently under separate study.

2. Because the Pilot Dredging Study will require review under the 404 Program, an attendee suggested scheduling a pre-application meeting including the Environmental Protection Agency, U.S. Army Corps of Engineers, Florida Department of Environmental Protection, U.S. Fish and Wildlife Service, Florida Wildlife Conservation Commission, and the South Florida Water Management District. This proactive permitting procedure may be beneficial to all parties.

   Ms. Lukasiewicz agreed and encouraged the affected parties to set up pre-application meeting. Mr. Khan indicated that two pre-application meetings had been held with the FDEP. Mr. Jorge Patino of the SFWMD suggested that representatives from agencies

interested in the permitting process get together after the meeting to coordinate a multi-agency meeting for the Pilot Dredging Project.

A representative from the **South Florida Conservancy** raised the following issue/question:

1. In order to reduce internal phosphorus loading, external sources such as the Kissimmee River and Disney World should be mitigated. The attendee suggested the construction of cleansing stations such as created wetlands.

   Ms. Lukasiewicz responded that although the Feasibility Study is directed to internal phosphorus loading in Lake Okeechobee, external loading from various sources is an issue that is important to this Feasibility Study and the SFWMD.

Other questions/issues raised by meeting attendees include:

1. What is the time line for permitting and implementation of the Pilot Dredging Study?

   Mr. Khan responded that the permit will be submitted in 3 to 4 weeks and dredging is anticipated to take place during the months of October through December, 2001.

2. Why wait until external loading is reduced to a minimum before implementation?

   Ms. Lukasiewicz responded that a timeframe for implementing measures to address internal loading of phosphorus has not been established and suggested that SFWMD may not wait for external reductions. She further indicated that a variety of alternatives are under consideration, and all would have varying implementation time frames, including the possibility of very long-term (50 years estimate) maintenance dredging within a phosphorus/sediment sump area. This three-year study will determine the feasibility of all alternatives.

3. An attendee commented that the removal of any phosphorus-laden sediment would be beneficial to Lake Okeechobee's recovery.

4. Will the SFWMD have to wait 2 -3 years after the Feasibility Study is complete for an Environmental Impact Statement (EIS) to be produced by the U.S. Army Corps of Engineers?

   Ms. Lukasiewicz responded that although a time line is difficult to determine at this time, it is certain that an EIS would be required

5. A suggestion was made that phosphorus being produced by agricultural areas surrounding Lake Okeechobee should be studied in detail. The Kissimmee River was also raised as a potential source of external phosphorus loading.

6. If a phosphorus sump is constructed, what is the expected size and depth?

Ms. Lukasiewicz responded that details of a sump size, depth, and location would be determined later in the study.

7. An attendee raised a concern about any possible saltwater intrusion problems resulting from dredging or other technologies.

8. An attendee asked how much sediment is expected to be transported during dredging operations.

   Ms. Lukasiewicz responded that details on dredging have not been formulated to date.

9. An attendee inquired as to the procedure for providing additional input at this phase and how the public and agencies can follow the progress of the Feasibility Study.

   Ms. Lukasiewicz responded that there are a number of vehicles for continued participation:

   - *Contact the SFWMD project manager Jorge Patino at (561) 682-2731 or via e-mail at jpatino@sfwmd.gov*

   - *Visit the project website at: http://www.sfwmd.gov/org/wrp/wrp_okee/projects/sedimentmanagement.html*

   - *Attend future Public/Interagency Meetings (at least two more are planned); watch for future mailings and project update notices*

   - *Review project documents on the project website and respond to the SFWMD, or call Ms. Lukasiewicz directly at (561) 750-7334 x115.*

Ms. Lukasiewicz thanked all attendees for taking the time to participate in the meeting. With no further questions or comments, the Task 2 Public/Interagency Meeting was adjourned at 9:00 PM.

After the meeting was adjourned, a representative of the **Environmental & Land Use Law Center, Inc**. handed SFWMD staff the following typewritten list of comments:

Questions Concerning Lake Okeechobee Alternatives Feasibility Study – Public Meeting of July 19, 2001, Belle Glade, Florida for the Environmental and Land Use Law Center, Inc. by Brion Blackwelder, of Counsel.

Can use of phased-in test of approaches and inclusion of rapid response address unforeseen adverse consequences?

The channelization of the Kissimmee River (for example) rapidly became recognized as a mistake, but a long time was required to engineer, approve and fund the de-channelization to correct the mistake. The alternatives for sediment management should have phased-in approaches, and as part of their authorization the "un-doing" of any restoration actions found to exceed criteria of harmful consequences should be included.

What other features of the provenance and characterization of the sediments would assist full evaluation of the alternatives?

The "BBL/SFWMD" draft of June 15, 2001 does not fully state the provenance (origin) of the sediments. The key nutrient (P) is described. However, what is the specific source or sources of the ash (p. 2-2) which composes 50% of the sediment to be removed? Is the 25% carbonate content of the sediment of mineral precipitation from solution origin or through biomineralization (Fig. 14)? Is the organic matter a product of algal blooms, is it aggregated enough to require "cutter" dredges to suction dredge, or is it derived from management of aquatic weeds in the lake or shorelines? Does the sediment contain other chemical or biological traits that would influence choice alternatives, such as especially mercury, or aquatic weed treatment or agricultural chemicals (DDT for instance) that may require special consideration? (There are no detailed profiles of such pollutant parameters included in the discussion.)

What secondary effects are implicit in the alternatives?

For instance, removal of lake sediment in Florida can result in a change to the light absorption/reflection/root formation of aquatic plants (an experience at Disney World in its development that they addressed) which in turn strongly influences water temperatures and algal blooms. Blooms do not depend solely on nutrient levels. The effect of the resulting sediment on the lake waters and biota is not a simple "restoration" situation.

In the discussion of dredging, selection of the dredge type is a crucial factor, which in turn determines the disposal area (dewatering) site size. What dredge types and disposal sites and sizes are the alternatives?

Discussion of special purpose dredges suitable for soft sediment removal in shallow lakes is contained in Restoration and Management of Lakes and Reservoirs, 2nd Edition, Cooke et al, Lewis Publishers, 1993. The process option of hydraulic dredging discusses many of these at 2-47 and other sections of the EEL/SFWMD draft. However, because apparently pilot studies are needed, the calculations and locations of disposal sites are not described. Some organic dredged

sediments are even suitable for sale to support the sediment removal costs. At this point, there are still substantial uncertainties as the draft recognizes at 2-55.

Additional questions asked following the conclusion of the meeting:

An attendee handed in the following written question: "Is there a/or few page document that gives a profile analysis of various spots on the bottom of the lake - with a range of acceptable levels? Like your blood chemical analysis report. If so, please send to me."

> *Recent sediment quality data is currently under peer review and will be released in the near future in the SWIM plan update and in a separate report. Tom James of the SFWMD may be contacted for additional information (561-682-6356).*

South Florida Water Management District

Lake Okeechobee Sediment Management Feasibility Study

PUBLIC / INTERAGENCY MEETING # 3

MEETING MINUTES

April 4, 2002

6:30 – 8:00 PM
Doyle Connor Agricultural Center
Moore Haven, FL

In Attendance

Robert Akre, Terra Kinetics Engineering Company
Bill Baker, MacVicar, Federico & Lamb, Inc.
Ann & Ross Bennett, Citizens and Lake Okeechobee Business Owners and Supporters (LOBOS)
Brion Blackwelder, Nova Southeastern University, Shepard Broad Law Center, ELULC, Inc.
Jerry Brooks, Florida Department of Environmental Protection
Allen Dupont, Case O'Bourke Engineering, Inc.
Mitch Flinchum, University of Florida, IFAS
C.S. Fry, Citizen
Paul Gray, Ph.D., Audubon of Florida
Sam Griffin, Fisherman's Heaven
Robert G. Harris, City of Moore Haven
Ernest James Hewett, III, Ph.D., University of Florida
Clyde Hopple, U.S. Army Corps of Engineers, Jacksonville
Tom James, Ph.D., South Florida Water Management District
Craig Jones, Terra Kinetics Engineering Company
Anwar Khan, EA Engineering, Science and Technology, Inc.
Cynthia Laramore, A.C.T.I.O.N.
Pepe Lopez, U.S. Sugar Corporation
Kathy Lukasiewicz, Blasland, Bouck & Lee, Inc.
Dan McCall, Florida Fish and Wildlife Conservation Commission
Katharine Murray, Environmental Quality, Inc.
Travis Murray, Lockhart Agricultural Technologies
Jim Owens, U.S. Army Corps of Engineers, Clewiston
Jorge Patino, P.E., South Florida Water Management District
Ryan Peck, U.S. Army Corps of Engineers, Clewiston
Ken Schenck, City of Pahokee
Kimberly Shugar, Florida Department of Environmental Protection
K. Thomas, City of South Bay
Ken Todd, P.E., Palm Beach County
Alvin Ward, Commissioner, Glades County, FL
Curt Pollman, Ph.D., Tetra Tech, Inc. (via teleconference)

Introduction/Purpose of the Meeting

On behalf of the South Florida Water Management District (District), Kathy Lukasiewicz, P.G., of Blasland, Bouck & Lee, Inc. (BBL) welcomed the meeting attendees, thanking all in attendance for their interest and participation in the Lake Okeechobee Sediment Management Feasibility Study (Feasibility Study). Ms. Lukasiewicz began the meeting with introductions District staff members, including Mr. Jorge Patino (Project Manager) and Dr. Tom James.

Ms. Lukasiewicz informed the attendees that this is the third public meeting designed to gather input from the public and agencies on the Feasibility Study. Ms. Lukasiewicz explained that during this meeting, the project team will discuss the status of the Feasibility Study and the draft Work Plan for the Evaluation of Alternatives (Work Plan). The Work Plan summarizes the tools and methods that will be used to evaluate the expected performance of the proposed sediment management alternatives relative to the study's goals and performance measures.

Ms. Lukasiewicz explained that public and interagency participation is an integral component of the Feasibility Study and all interested parties are encouraged to participate and provide input. Methods of participation throughout the Feasibility Study include discussions during public meetings, discussion with project team members or the Project Manager, Jorge Patino, and written comments sent to Mr. Patino. The District has also undertaken a variety of outreach efforts to inform and involve interested parties. Mr. Patino can be reached via telephone at 561-682-2731 at the District or e-mail (jpatino@sfwmd.gov). The attendees were also encouraged to fill out and submit Comment Cards located on the sign-in tables if attendees preferred writing their comments instead of speaking at the meeting.

Feasibility Study Overview

Based on the meeting agenda (attached), Ms. Lukasiewicz began a brief presentation to summarize the project and its status. The Feasibility Study is a three-year desktop study conducted by the District through a contract with BBL. The project was initiated in the fall of 2000 to address internal phosphorus loading in Lake Okeechobee.

The objective of the Feasibility Study is to evaluate a variety of sediment management alternatives to address internal phosphorus loading in Lake Okeechobee, improve water quality in the lake, decrease turbidity and decrease the occurrence of blue-green algae blooms.

Ms. Lukasiewicz generally discussed the difference between internal and external phosphorus loading in the lake. Internal loading occurs when phosphorus entrained in the sediments are introduced into the water column predominately through wind and wave induced resuspension of sediment particles containing high concentrations of phosphorus. External loading pertains to phosphorus that comes into the lake from external sources, including tributaries from throughout the Lake Okeechobee watershed that flow into the lake.

Ms. Lukasiewicz addressed the question "Why is this study needed?" by noting that there are an estimated 51,000 metric tons of phosphorus in the mud sediments within Lake Okeechobee, so much so that the internal phosphorus loads are now equal to the external phosphorus loads entering the lake from the watershed. Due to the extreme internal phosphorus loading

conditions, the lake may not respond as quickly to external reductions in phosphorus loading without measures taken to manage the internal inputs.

The Feasibility Study is required by the Lake Okeechobee Protection Act (Florida Statute 373.495(3)(f)). The information gained throughout this Feasibility Study will provide support for management decisions, which will be made in the future by the District's Governing Board (with further public and interagency input).

Water-column phosphorus levels in the lake's pelagic zone have more than doubled since the 1970s to currently exceed 100 parts per billion (ppb). The present external phosphorus loads are in excess of 600 metric tons per year. This excessive external loading has essentially used up the phosphorus storage capacity of the lake (Harvey & Havens, 1999).

This Feasibility Study focuses on the sediments in the pelagic zone of Lake Okeechobee, including an estimated 193 million cubic meters of phosphorus-rich fluid sediments that range in depth from a few centimeters at the edge to more than 75 centimeters in the center. The phosphorus concentrations in the pelagic zone range from 200 to 2,000 milligrams per kilogram (mg/kg); with the average phosphorus concentration in the upper 10 cm of sediment equaling approximately 1200 mg/kg. The average concentration in the upper 30 cm of sediment layer reaches as high as 990 mg/kg.

There are five major tasks in the Feasibility Study:

- Task 1 - Development of Goals & Performance Measures
  - Public/Interagency Outreach Meeting held in January 2001
  - Goals and Performance Measures Report finalized in June 2001
- Task 2 - Development of Alternatives
  - Public/Interagency Outreach Meeting held in July 2001
  - Development of Alternatives Report finalized in October 2001
- Task 3 - Work Plan for Evaluation of Alternatives
  - Public/Interagency Outreach Meeting held on April 4, 2002
- Task 4 - Evaluation of Alternatives
  - Public/Interagency Outreach Meeting planned for early 2003
- Task 5 - Stakeholder Prioritization of Alternatives
  - Public/Interagency Outreach Meeting to be determined

The sediment management goals developed during Task 1 of the Feasibility Study are:

- Maximize water quality improvements;
- Maximize engineering feasibility and implementability;
- Maximize cost effectiveness;
- Maximize environmental benefits; and
- Maximize socioeconomic benefits.

These goals and associated 26 performance measures developed in Task 1 are the result of a collaborative effort of the District; BBL (including Tetra-Tech, Inc. and other project team members); scientists and engineers from several federal, state, and local agencies; various interested organizations and the public.

Task 2 focused on development of sediment management alternatives, and was completed in October 2001. The project team (with input from the public, interested parties and governmental agencies) developed a set of sediment management alternatives using a three step process:

Step 1: Identify potentially applicable technologies and process options
(36 technologies were identified)
Step 2: Determine potential feasibility of technologies selected in Step 1
(14 options were retained after screening)
Step 3: Combine retained technologies into alternatives
(7 alternatives were developed for further evaluation)

The seven sediment management alternatives developed for further evaluation are:

Alternative 1 – No in-lake action
Alternative 2 – In-lake chemical treatment (single application)
Alternative 3 – Long term periodic in-lake chemical treatment
Alternative 4 – Dredging
Alternative 5 – In-lake chemical treatment followed by dredging
Alternative 6 – Dredging followed by in-lake chemical treatment
Alternative 7 – Long-term periodic dredging from in-lake sumps with or without follow-up in-lake chemical treatment

Ms. Lukasiewicz explained that the task currently underway is Task 3, development of the Work Plan for Evaluation of Alternatives. The draft Work Plan is available from the District and may be obtained through Jorge Patino, the District website, or by filling out a document request form available on the meeting sign-in tables. The Work Plan addresses the question of how the alternatives will be evaluated and essentially lays out the process for Task 4 - Evaluation of Alternatives.

The Work Plan describes how the alternatives will be evaluated, and specifically describes the targets, tools, critical data/input, methods, scoring process, interrelationships with other performance measures, and uncertainty considerations that will be used during evaluation of alternatives against the pre-established goals and performance measures.

Examples of tools that will be used in the evaluation process are water quality models (LOWQM), sediment resuspension models (LOHTM), chemical equilibrium models (MINEQL+), a correlation matrix to analyze socio-economic impacts and qualitative ecological assessments.

A broad spectrum of methods will be used to evaluate the alternatives including, for example, water quality modeling, case study evaluation and comparison, engineering analyses/estimates, socioeconomic assessments, qualitative assessments, collaboration with regulatory and wildlife agencies, and public input. The project team will be working closely with other governmental agencies including, but not limited to, the U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife Service (USFWS), the Florida Department of Environmental Protection (DEP), U.S. Coast Guard, Florida Fish and Wildlife Conservation Commission (FWCC), lakeside counties and municipalities, and other stakeholders.

Status of Related Lake Okeechobee Studies
Mr. Patino explained that there are two other District-managed studies currently underway that will provide data and information which to be integrated into the Feasibility Study. One such study is the Pilot Dredging Project, which is being led by EA Engineering, Science and Technology, Inc. (Mr. Patino introduced Mr. Anwar Khan, the Project Manager EA Engineering). The second District-sponsored project is a laboratory study by the University of Florida titled: Potential Impacts of Sediment Dredging on Internal Phosphorus Load in lake Okeechobee (Dr. Tom James is the District's Project Manager).

Pilot Dredging Project
The main purpose of the pilot dredging project is to assess the viability of removing the phosphorus-laden, extremely fluid mud layer without removing a great deal of water in the process (sediments contain approximately 12% solids). The project has been successfully coordinated with multiple agencies including DEP, USACE, FWCC, USFWS and Martin County. It was necessary to obtain a construction permit from Martin County in order to construct a Confined Disposal Facility (CDF) within the county.

The dredge area is a 425-foot by 425-foot area within Lake Okeechobee; approximately 5 miles southeast of Port Mayaca. The CDF, a constructed holding facility where the dredged material will be transported (by barge), dried and tested is located approximately ¼ mile east of Port Mayaca, on the north side of the St. Lucie Canal. The CDF is lined to ensure containment of all dredged materials and consists of cells which will be utilized for each stage of processing. Various treatment methods will be used to test dewatering techniques and reducing the phosphorus level in the water to 40 ppb. The water will be treated and returned to the CDF. The sediments will be dried by evaporation and stored in the CDF. The District is currently working with DEP to determine where the dried sediments will eventually be deposited.

There will be 10 days of dredging within the pilot study area in Lake Okeechobee, where sediments are approximately 30 cm deep.

The dredge, designed by EA Engineering specifically for this project, is a hydraulic dredge that will move above the fluid mud layer at varying speeds during the project. Intake sizes will also be adjusted and monitored to gain as much technical information as possible. During the study, samples will be collected and analyzed for multiple parameters, including turbidity and other water quality measures.

Questions and Discussion Regarding the Pilot Dredging Project:

Ms. Laramore asked:
How far out from the actual dredging site will the contractors be monitoring water quality?

> *Mr. Patino responded:*
> Monitoring will be ongoing and extensive. The monitoring program is two-fold, and will include both equipment performance and regulatory/environmental parameters.

Mr. Kahn added:
The pilot dredging is a demonstration project that is designed to gather data and information regarding the dredging process involving this substrate. Monitoring will be continuous, incorporating pre-dredge, during dredging, and post-dredging operations. The extensive monitoring program will also include data collection on changes in substrate during dredging. The project will try to answer as many questions as possible.

We will specifically monitor turbidity and water quality; conduct bathymetric surveys; collect data on intake opening sizes, dredging speed, and the thickness of the layers removed from the bottom. The project will attempt to gather information on the pressing question of what happens to the surrounding mud when a portion of the fluid mud is removed. This and other information will be valuable for future projects.

Mr. Bennett asked:
Will the underwater visibility go to zero, therefore not allow the contractor an ability to monitor the dredging process by video?

Mr. Patino responded:
The District and EA Engineering are currently exploring techniques to ensure visible access during dredging. Suggestions from the public and agencies are welcome.

Mr. Bennett expressed:
There is value in seeing what is happening around the intake opening of the dredge.

Mr. Khan responded:
EA Engineering will video monitor the auger. Also, the fluid mud is so light in weight that any movement in the water disrupts the sediments and creates decreased visibility. One challenge of the project is to create as little disruption to the water column as possible. Even the dragline deploying the dredge creates turbidity in the water column.

Mr. Patino added:
The dredging area will be limited each day by the volume capacity of the barge.

Mr. Schenck asked:
When will the results of the pilot project be available? Mr. Schenck explained that he is the City Manager of the City of Pahokee, and they are currently working with the District on a project to dredge portions of the Pahokee Marina. Information gathered during the pilot project will be beneficial in understanding the behavior of the sediment and may assist in determining options as they proceed with the marina dredging project.

Mr. Khan responded:
The draft report is expected to be available in 30 to 60 days after dredging.

Mr. Patino added:

The District is interested in working with the City of Pahokee on this issue and in sharing information gained during the pilot project. An exchange of contact information after the meeting was suggested.

Mr. Patino noted that the CDF was constructed 2 to 3 weeks ago. The liner will be installed on April 5, 2002. The CDF is located on the north side of the St. Lucie Canal nearly ¼ mile east of the lake.

Ms. Laramore asked:
Will the pilot project incorporate any chemical treatment during the dredging process?

Mr. Patino responded:
The project will not include any chemical application; it is strictly a dredging project.

University of Florida Laboratory Study
Mr. Patino began discussions on the University of Florida study on the "Potential Impacts of Sediment Dredging on Internal Phosphorus Load in Lake Okeechobee," which is often referred to as the "Reddy Study" because Dr. Ramesh Reddy is the study's Principal Investigator. The study hopes to answer two very important questions (among others):

1) What is the present capacity of mud sediments in the lake to assimilate phosphorus, and how would this capacity change if the sediments were dredged to various depths (including complete removal of mud down to underlying substrate)?

2) What is the present rate of internal loading of phosphorus from the sediments to the water column (by diffusion and resuspension) and how would this rate change if sediments were dredged to various depths (including complete removal of mud down to underlying substrate)?

The laboratory study will address these questions by examining sediment core samples collected from Lake Okeechobee and analyzing the different layers of sediments under different controlled conditions. The study will address how much phosphorus will diffuse out of the sediments and what impacts will occur as different and increased layers are removed at 0, 50, 75 and 100 percent (thereby simulating removal via dredging). The study will also assess the flux of phosphorus from sediments into the water column, under experimental laboratory conditions.

A draft report on the study is expected to be available within a few weeks.

Mr. Patino asked if there were any further questions. No additional questions were raised.

<u>Additional Comments, Questions, and Discussion</u>
Ms. Lukasiewicz continued the presentation noting that the Lake Okeechobee Sediment Management Feasibility Study will incorporate the results of both the University of Florida study and the pilot dredging study into the engineering evaluation of the sediment management alternatives. She reiterated that the final Feasibility Study report will combine the engineering cost estimates, scientific evaluation, water quality modeling information, and other data in raw form for presentation to the District. The District will then further involve the public and other

agencies to weight the relative importance of each performance measure, and finally perform prioritization and decision analyses to develop a reasonable course of action.

Below is a summary of the additional discussion that followed:

Mr. Bennett asked:
How long has this problem been in existence?

> *Ms. Lukasiewicz responded:*
> As a clarification, Ms. Lukasiewicz asked if the problem being referenced is the accumulation of phosphorus in the sediments of the lake. After affirmation, in response Ms. Lukasiewicz noted that studies show that there has been significant deterioration of the lake's health due to internal phosphorus loading at least since the 1970s.
>
> *Dr. James added:*
> A study from the late 1980s estimated that the majority of impact on the lake dates back as far as 1910, followed by a steady increase in phosphorus loading. Since then, based on the yearly nutrient budgets for phosphorus (going in and coming out) over time and the fact that the phosphorus levels in the water column have doubled, the District has been able to determine that the assimilation capacity for the lake has been decreasing. This has given scientists the sense that in the last 30 to 40 years, phosphorus levels and lake conditions have really come to an historically significant level.

Mr. Bennett commented:
The local commercial fishermen have reported over the past numerous years, that while using fishing nets in certain parts of the lake, they have seen an increase in the amount of sediment in the water column. The perception of the local fishermen is that loading of the phosphorus in the lake, particularly in the shallow areas, is due to the shallow depth combined with wind-wave action. The sediment problem is not new.

Further, many local residents think the bottom sediment phosphorus loading problem is caused by exotic vegetation spraying. Why is that issue not being addressed?

> *Dr. James responded:*
> The District has analyzed the constituents in sediment samples and has not found evidence of plant materials that lead the District to believe that spraying of aquatic plants and the decaying process are the source of phosphorus in the sediments. The mud sediments are flocculent in nature and do not show this type of plant material. Some phosphorus may be contained in the algae (phytoplankton) within the sediments. The influx of solids from tributary canals, not from vegetation in the marsh zones, which have been sprayed for exotic species control purposes, appear to be the source of phosphorus.

Commissioner Ward asked:
Is the concentration in the north eastern portion of the lake, as shown in a display map at the meeting, due to a high concentration of phosphorus in a collection basin?

Ms. Lukasiewicz responded:
The map indicates sediment thickness, showing that as you move to the center of the pelagic zone located in the northeast portion of the lake, there is an increase in the accumulation of sediments. Another map at the meeting was referenced, showing phosphorus concentrations in the lake. Ms. Lukasiewicz noted that most of the higher concentrations are occurring in the deeper, pelagic zone. The lake has natural circulation patterns, resulting in higher deposition of sediments in the pelagic zones. Sustained wind directions within seasonal timeframes will continue to create this deposition process in the pelagic zones.

Ms. Laramore asked:
Is there any relationship between the concentration of phosphorus-rich sediments and the water depth in the lake?

Ms. Lukasiewicz responded:
Sediments appear to be accumulating in the deepest portion of the lake.

Dr. Gray asked:
What are the characteristic fluid properties of the mud in relation to the thickness through the layers?

Mr. Khan responded:
The system is very dynamic. With slight gradation, the flocculent throughout the layers becomes thicker as you move lower, with an increase in density towards the bottom. The upper layers are the most fluid, making in-situ dredging particularly problematic. The system changes from day to day, due to wind currents and boat traffic. It often takes 24 hours for the flocculent to settle again after disruption before analyses can recommence.

The goal of the pilot dredging project is to trap the top layer in-situ for collection and analyses. Because the system is so dynamic and easily disturbed, the team will dredge predominately in the morning to allow a settling time of flocculent mud layers.

Dr. Gray asked:
If the lower layers have the greatest density, why are the top layers so problematic in relation to phosphorus?

Ms. Lukasiewicz responded:
Scientists believe that the majority of the phosphorus is occurring within the top 30 cm of the mud layer. The phosphorus concentration tends to reduce as you reach the lower, more consolidated materials in the sediment layer. The laboratory sediment core study will provide additional information as to the characteristic properties of the mud in the different layers (e.g., 10cm, 30cm, 45cm, 55cm), all the way down to the native sand. The study will also evaluate what happens if only the native sand is left, considering the continuing flux in the system. With each new layer, analyses will determine the characteristics of the resulting substrate and the resulting conditions in the water column.

Commissioner Ward asked:
Will the pilot dredging project pump everything (water and slurry) into a barge?

Ms. Lukasiewicz responded:
All of the dredged material will be pumped onto a barge and transported to a CDF where it will be stored. A CDF is a confined, contained area that has been designed and constructed to safely contain all of the dredged material. The dredged material will first be allowed to settle in the CDF. The materials will then be tested and returned to the CDF. Decanted water from the CDF will be analyzed for phosphorus.

Mr. Khan added:
The CDF is to be located on the north side of the St. Lucie Canal ¼ mile east of the mouth of the canal, on District owned land.

Commissioner Ward asked:
Will there be different types of chemical treatment used during the pilot dredging project to determine how the sediment reacts?

Mr. Khan continued:
No chemical treatment will take place at the site. After an extensive laboratory process, the scientists have come to the conclusion that the water should first be settled out. The decanted water will then be treated in the laboratory with two different methodologies. One process involves a polymer, another involves a new technology that binds phosphorus.

Dredging will take place for approximately two weeks, 2-3 hours per day. The purpose of the project is demonstration in nature, showing how the dredging process works in this environment. Only 6,000 cubic yards will be dredged during the pilot project. If dredging is finally the alternative of choice, duration and rate of dredging will be determined at that time.

Commissioner Ward commented:
This dredging alternative seems like it could last for years, and years, and years.

Ms. Lukasiewicz added:
Using, in part, the information gained during the pilot project, the Feasibility Study will attempt to predict the magnitude of dredging that will be required to achieve the desired results of reduced internal phosphorus loading in the lake. Potentially, considering the size of the water body, and the magnitude of the project, if dredging is determined to be a viable option, dredging could last nearly 15 to 20 years, non-stop. This is why the methodical approach and Feasibility Study are so important.

Dredging of a lake of this magnitude would be a huge infrastructure intensive project the likes of which has never been attempted yet anywhere else in the world (assuming the entire pelagic zone is targeted). Commissioner Ward is correct. Using dredging, this problem will not be solved within a five-year period.

Mr. Khan added:
Often, with large-scale projects such as this, multiple dredges are used, depending on the scale of the project.

Mr. Harris asked:
Considering chemical treatment again, what happens to the phosphorus after the chemical treatment, and to the mud itself? Will we end up with the same turbidity that we have now, even after the chemical treatment?

Ms. Lukasiewicz responded:
The success that has occurred with chemical treatment has occurred when aluminum sulfate has been mixed with another buffering material such as sodium aluminate. Theoretically, the chemical mixture would be loaded onto a barge and released into the water column as slurry. As it moves through the water column, the slurry essentially inactivates and binds the phosphorus in the water column. As it reaches the bottom sediments, it continues to inactivate phosphorus. It is very important not to lower the pH of the water during this process. Aluminum sulfate alone has the potential to lower the pH of the system, so monitoring and management of the pH is a critical aspect of chemical treatment.

Lake Okeechobee has a fairly neutral pH of approximately 7. If the pH is closely managed during application, studies show that chemical treatment can remain effective for as many as 20 years, in some cases. Thus, chemical treatment can be a very effective method of inactivating the phosphorus within the system.

Theoretically, if you inactivate the phosphorus, there will be a decrease in the amount of blue-green algae and a decrease in turbidity. Also, theoretically, if the phosphorus is taken out of the system, the overall water quality improves. In cases where chemical treatment has been utilized successfully, the goals of the project have been to reduce blue-green algae, decrease turbidity, and increase overall water quality by decreasing the phosphorus levels. But, the sediments (mud) remain.

Ms. Laramore asked:
How will the Feasibility Study take the information gained during the pilot dredging project (6,000 cubic yards) to scale, making it applicable to the whole lake (200 million cubic meters)?

Ms. Lukasiewicz responded:
The magnitude of problem within Lake Okeechobee presents one of the challenges of the Feasibility Study. Taking the small scale of the pilot project to the large scale of actual dredging will necessitate a combination of data collection and case-study applications. There are data from a number of other very large-scale case study sites that will be incorporated into the Feasibility Study along with the data from the pilot project. Further, one of the goals for the pilot project is to evaluate how to scale this demonstration project up to the magnitude of the lake. At each phase of the

demonstration project, the contractors will consider how the pilot project can be scaled up. The final report will include an analysis of scalability.

Mr. Khan added:
One of the reasons for using this specially designed, innovative dredge technology is so that the pilot project can demonstrate its capability to dredge the flocculent material in-situ. Most conventional dredges require extensive intake of water during the dredging process. The pilot project will identify each stage and component of the project that is scalable.

Mr. Bennett asked:
What will be done with the dredged material?

Ms. Lukasiewicz responded:
The Feasibility Study will include a number of options for disposal of dredged material. Some of the options include:

- Confined disposal within the lake; using the dredged material to build islands within the lake
- Constructing a confined disposal facility outside the lake
- Dewatering the material and using the dried material as a blended soil, top soil, or agricultural mix.

For every alternative that includes sediment removal, there are a series of process options that will be considered as possible, or practical to address reuse or disposal of the dredged sediments. An example of reuse would involve taking the solids remaining after the dewatering process and mixing them with other materials for sale as beneficial materials such as compost/top soil. The study will consider the market for an organic, phosphorus-rich soil amendment.

Mr. Bennett asked:
Have you considered using the dredged material as a fuel for a natural gas power plant?

Members of the community previously approached the government with the idea of removing materials from the lake and spreading the sludge/sediments on agricultural fields. The suggestion was not acted upon due to the probability that the newly spread material would run back into the lake following rainfall.

Ms. Lukasiewicz responded:
Sufficient confinement and monitoring of the dredged material within a designated area is extremely important to ensure avoiding run-off into the lake and tributaries.

Mr. Fry asked:
Lake Apopka may be a good place to actually test some of the chemical application because Lake Apopka is considered by some as already "dead." Lake Trafford may also benefit from the Feasibility Study. Will there be sharing of applicable information?

Ms. Lukasiewicz responded:
Yes, the information will be shared. The USACE is currently studying Lake Trafford, and there are many similarities between Lake Trafford and Lake Okeechobee.

Scientists studying Lake Apopka have seen some increase in water quality due to decreased external loads entering the lake. There are also efforts to use biomanipulation in Lake Apopka to change the habitat. A group of fishermen have been contracted to remove the fish known as the "Gizzard Shad" from the lake in an effort to improve water quality.

Dr. James added:
Another effort to improve the water quality involves removing water from the lake, running the water through a marsh pit containing native vegetation, and finally returning the water to the lake. This vegetative treatment, although slow acting, has improved the water quality.

Ms. Lukasiewicz added:
The District is also using alum in designated stormwater treatment areas to treat water prior to its entering the lake.

Mr. Thomas asked:
Will there be a detrimental effect to the environment caused by the use of alum? Water treatment plants have an MCL for aluminum that must be monitored regularly. The addition of alum to the municipal water storage area for the City of South Bay (Lake Okeechobee) may impact the water treatment facility's operations.

Ms. Lukasiewicz responded:
The application of aluminum sulfate, if properly managed, will not create a problem. If the pH in the lake system is not properly managed, the aluminum sulfate can cause toxicity for fish. Understanding the pH in the system is extremely important when considering chemical treatment.

One of the performance measures that will be used while evaluating each of the alternatives is that the alternative cannot impact the water quality to the point that it negatively affects users. Performance Measure 5D states "No impacts on water supply and operations." Each alternative will be evaluated against this and all other performance measures. If the alternative does not score well relative to the performance measure, the overall scoring of that alternative will be lowered.

Ms. Laramore asked:
What is the probability that the lake will require dredging more than once? How will chemically treating the water and dredging the sediments affect the water storage capacity of the lake/reservoir and the use of the lake's water for Aquifer Storage and Recovery (ASR)?

Ms. Lukasiewicz responded:

Studies preliminarily show that it may be necessary to dredge more than once. Studies also indicate that after dredging, due to wind currents and other factors, the sediments may again accumulate in the pelagic zone. There is a strong likelihood that the pelagic zone would have to be redredged in 10 years.

Dr. James added:
The plans under consideration by the District now indicate that the water for the ASR wells will not come from Lake Okeechobee. The water for the ASR wells will come from the Stormwater Treatment Areas after the rainy season. On the other hand, during dry periods, the water from the ASR wells could be pumped into the lake, providing an additional source of water for the lake. This process may actually change the chemistry of the water in the lake. This may be good and this may be bad. One of the projects under ASR research will be to determine, by modeling, given the quality of water from the ASR wells, what the impacts will be to the receiving water bodies.

Ms. Laramore added:
One concern is that given the uncertainty of all of the projects around Lake Okeechobee, there is little integration of planning, information, and data. At what point will these activities become integrated?

Ms. Lukasiewicz responded:
In relation to this Feasibility Study, the performance measures for each alternative will be evaluated for minimum impact on the other projects.

Mr. Hopple added:
Many of the Comprehensive Everglades Restoration Plan (CERP) projects and pilots will begin within the next two to three years. Many of the questions that are being asked and answered through the Feasibility Study and the pilot dredging project will provide information that will be integrated into other projects. We hope to see correlation between the various projects.

Mr. Schenck asked:
How is the restoration of the Kissimmee River coming along?

Dr. Gray responded:
Phase I of the Kissimmee River Restoration has been successfully completed. Land acquisition is necessary and underway for the remaining portions of the project. The project is on schedule.

Mr. Bennett asked:
There have been two articles in the Florida Sportsman Magazine that point to wells as having a detrimental effect on the reef systems in the ocean. How is this related to the Feasibility Study?

Ms. Lukasiewicz responded:

There are at least two types of wells under study and discussion. One, the ASR wells, store water in the aquifer for future use. Another type of well, called deep injection well, pumps water into a much lower geologic layer.

Mr. Brooks added:
One researcher has reported his findings indicating the wells have a negative impact on the reef systems. Other researchers are also looking at that data. Ultimately, the data need further study to prove or disprove the theory suggested.

Commissioner Ward asked:
Why not, during the pilot project, just remove all of the phosphorus-laden layers in the lake? Instead of just taking the top layers, bring the soils down to the clean, native sand.

Ms. Lukasiewicz responded:
The purpose of the two concurrent studies is not to actually remove sediment to lower the phosphorus levels in the lake, but to collect scientific and technical information that will be incorporated into the Feasibility Study and future projects.

The current in-field pilot dredging project will demonstrate dredging and treatment technologies to determine if, and how, the fluid mud can be collected. The scope of work involves collecting the flocculent material up to 30cm deep in the sediment layer and is on a much smaller scale than the entire lake.

The University of Florida laboratory study will analyze cores collected from throughout the lake. The analyses will include an assessment of the quality of sediment and the quality of water at each successive layer of sediment removed until all flocculent layers are removed and the sandy bottom is reached. However, the analyses will take place in the laboratory, not the field.

The feasibility study process, by incorporating all the available data, technology, and information, will determine if it is actually most beneficial to remove all layers of flocculent sediments and leave only the sandy bottom.

Ms. Hewett asked:
How long has it been since the lake has been in a pristine condition?

Dr. James responded:
Studies looking at sediment cores using isotope dating technology that can trace sediments back to the 1800s found an increase in the amount of sediment coming into the lake after about 1910.

Mr. Khan added:
There is no interest in removing uncontaminated sediment.

Commissioner Ward asked:

Has the project team looked into an earlier idea that divided the lake into four equal, separate segments? The idea is to physically divide the lake into four cells, cleaning each one of the four cells independently. Theoretically, the plan would remove the water and contaminated sediments from one cell at a time, and proceed on to the next cell. The increased water quality that results from cleaning one section of the lake would help to stabilize the other three quarters of the lake. The scenario would correspond with the wet and dry seasons for optimum results. Although this idea seemed a bit far fetched, it now looks more realistic and may be a feasible alternative to addressing the problem.

> *Ms. Lukasiewicz responded:*
> In-situ dredging is one of the alternatives that will be evaluated in the Feasibility Study. One of the process options linked with dredging includes dealing with the sediment from the lake in cells. This option includes creating isolated (contained) areas in the lake. Dredging would commence and the dredged materials would be pumped into the cell, creating islands. After the dredged material is settled and dewatered, the remaining water would be pumped back into the lake. To date, studies evaluating the process of dewatering the lake by means of sheet piling the entire lake and pumping water out indicate the process as cost prohibitive.

Commissioner Ward added:
Yes, the cost of sheet piling and dewatering in 10-mile segments would be high, but it appears that the cost of any alternative is also going to be extremely high.

> *Ms. Lukasiewicz responded:*
> Agreed.

Dr. Gray asked:
My understanding is that alum becomes toxic when the system is acidic. Is that correct?

> *Ms. Lukasiewicz responded:*
> The alum becomes "bioavailable" when the system is acidic. Under acidic conditions, if the alum is ingested, it may become toxic to the fish. The potential for toxicity in fish, as a result of an imbalance in the pH level in the lake, is of critical importance when using alum as a chemical treatment.

Dr. Gray commented:
The water collected near agricultural fields during limnology studies indicates an acidic pH of 3, 4, and 5 in the littoral zone partially due to rainfall.

We at Audubon are hoping dredging is going to work. Phosphorus in the mud is the cause of the problem in the water column. Dredging would remove the mud. Chemical treating the mud may affect benthic organisms within the substrate ecosystem. Audubon is supportive of the pilot project and the Feasibility Study. This issue must be approached scientifically.

Further, part of the Everglades Restoration Plan includes sending water from Lake Okeechobee that currently goes into the Caloosahatchee and St. Lucie Rivers south, to the Everglades.

Unfortunately, demucking the lake is not part of CERP. If we send water from the lake as it is now, the Everglades would suffer. We must clean the lake water up prior to sending it to the south. We must clean the lake water up to make it available for the Everglades restoration efforts.

Commissioner Ward added:
Why not build settling areas in the area between Lake Okeechobee and the Everglades to treat raw water in the marsh areas, send the surface water to the Everglades, and treat the sediments in the marsh areas during the dry season?

> *Dr. Gray responded:*
> The District and USCAE are currently building filter marshes to cleanse the water. The phosphorus levels input into the filter marshes is approximately 70 ppb and the resultant treated water is nearly 10 ppb. Lake Okeechobee has a phosphorus level much higher (100-130 ppb), creating difficulty in completely treating the water.
>
> *Ms. Lukasiewicz added:*
> The areas Dr. Gray is referring to are called Stormwater Treatment Areas (STAs) that are constructed wetlands designed and constructed to treat the water using vegetation.

Commissioner Ward commented:
When I was a boy, the water was clear as gin. Back then, the lake had the capability to circulate and flush naturally. Commercial fishermen would use their bottom nets and stir up the sediments in the lake. Historically, the sediment-laden lake water could flow to the south and out the Caloosahatchee and St. Lucie Rivers, thus allowing some of the sediment to leave the lake. The problem began when the water was physically dammed so that it would not flush naturally.

One alternative to solving the problem would be to stir up the sediments in the lake and allow that water to flow into treatment areas.

> *Ms. Lukasiewicz responded:*
> Yes, the watershed's natural dynamics changed when the lake was physically restricted.
>
> *Dr. James added:*
> Some parts of the lake are becoming very clean.

Mr. Bennett commented:
The historical method of removing vegetation, grass and hyacinths (water lettuce) was a natural phenomenon. The plants cleared the water. During a hurricane, the wind would push all of the plants to the shore and clear the lake of the weeds. They would grow back over time and begin the cleansing process again.

No one here can argue that the 0% tolerance to hyacinths rule is important. Our concern is the practice of spraying the vegetation and dropping it to the bottom in the shallow portions of the lake. We are now working to encourage more projects like the north shore project where the water levels were low in the littoral zone, and the layers of phosphorus rich sediments were

removed. Some of the best fishing in the lake right now is on the north shore. This is in part due to the recent sediment scraping and removal project. Vista Boca has great fishing these days.

Mr. Harris commented:
We are fortunate to have the combination of intellect and science combined in the Feasibility Study's project team. Ideally, the study would combine science with the experience of the local population knowledgeable about the everyday and historical aspects of Lake Okeechobee. The solution to this problem is going to come together when we combine technology with common passions of the people who know the pulse of the lake. The most important thing is to find a solution for the sake of the lake.

> *Ms. Lukasiewicz responded:*
> There is no substitute for the passion and knowledge of the local population. We encourage continued participation by the public and agency staff. The solution to the problem is going to come from a group of people with a passion for working together toward a solution.
>
> It is vitally important that the public and agency staff participate in this process. An additional opportunity for public participation is through a brainstorming session on beneficial sediment reuse, which Mr. Patino is organizing. The purpose of the brainstorming session is to gain ideas for beneficial reuse of the dredged sediments.

Mr. Bennett added:
Beneficial reuse of the sediments will be a key factor in finding a solution to the problem. Enterprise should be sought to cover the cost of the cleanup measures involved in this project.

With no further comments or questions, Ms. Lukasiewicz thanked the public and agency representatives for attending the meeting and participating in such an engaging manner.

The meeting was adjourned at 8:45 p.m.

OA Systems Corporation
2201 Civic Circle, Suite 511 • Amarillo, Texas 79109 • (806) 354-8218 • FAX (806) 359-3718

TO: Jorge R. Patino, P.E., South Florida Water Management District

FROM: Patricia A. Spaine, P.E., OA Systems Corporation
(970) 663-1752

Re: Beneficial Uses Brainstorming Meeting Summary

Date: September 18, 2002

Lake Okeechobee Dredging Alternative
Beneficial Use Brainstorming Session
September 10, 2002
Lake Okeechobee Service Center

The attendees and phone participants list is attached. The purpose of the meeting was to gain local input to the development and evaluation of alternatives considered for beneficial use of dredged material (DM) from Lake Okeechobee.

Basic information regarding the proposed dredging alternative to reduce in-lake concentrations of phosphorous had been distributed to all participants in advance of the meeting. These handouts are also attached.

Kathy Luke (BBL) and Trish Spaine of OAS Systems lead the discussions. After a brief overview of the Feasibility Study and dredging component the discussions immediately turned to various land applications and other alternatives. A summary of discussion points are below, grouped by general category. These are general opinions expressed by the agencies and individuals present and should be considered during the alternatives evaluations.

Inlake Land Creation

OAS General Scenario: The preferred site locations and arrangements for land creation included 1.) a few large islands in the center of the lake taking advantage of the lake depth to dispose of large volumes of DM and to trap additional circulating DM and 2.) a chain of multiple nearshore

islands in the northeastern area of the lake. Some of the benefits that would come include: upland habitats that may support bird nesting and other wildlife habitat, edge effects would provide increase littoral zone for fish and other wildlife habitat, etc.

Is the issue of obtaining necessary materials to create required structure being considered?

Conceptualizing creating islands from DM (Kim Love, Martin Co.)
The feasibility of creating and stabilizing a land feature from DM muck was questioned. Also, concerns regarding high winds and storm events impacting or degrading the stability of "in lake" or "nearshore" islands were raised. It was explained that these would be highly engineered structures designed and sited with those criteria in mind. It was explained that these islands would be constructed with methods such as: diking and riprap-type armoring, multi-cells, shallow lifts to enhance drying; the islands and island habitats would evolve over time through the dredging application and sediment consolidation process.

Water Quality Concerns (Phillip Metcalf, FDOAC, Kim Shugar, FDEP, Scott Kuipers, NRCS)
There were concerns expressed regarding whether creating islands would in fact reduce P in the surface waters of the Lake. The SFWMD explained that 99% of the phosphorous was in the sediments and 1% was in the waters of the lake. Consolidating the DM into islands would likely reduce the flux from the sediment to the waters. The group felt that if dredging and island building were to occur, no increases in P to surface water would be allowed (i.e. from dredging, island creation, and\or stormwater runoff from the islands). There was a strong belief that FDEP would not allow or permit any discharge in excess of the 40 ppb TMDL set for the Lake (i.e. from any activity either "in lake" or "lakeside").

How do past sediment studies relate to this assumption?

Question Long Term Habitat Value (Kim Shugar, FDEP, Linda Crane, FDOAC)
There are examples of created islands in lakes in South Central Florida where fisheries improve and then decrease, so that the long term habitat values are now being questioned. Another concern raised was bird island habitats increasing phosphorous through increase in bird guano. OAS and BBL explained that conceivably these islands if they were to be constructed, would be highly engineered, relatively massive construction projects. Long term maintenance would have to be factored into the overall cost. Enhanced habitat if desired could also conceivably be sustained with proper management.

What would this mean relative to historic bird populations being an order of magnitude or greater then current populations?

Will references to these cases, through published studies, be documented, and referenced in the report?

<u>Upland Uses</u>

<u>OAS General Scenario:</u> There are a variety of DM uses in upland areas that have been proposed, such as, agricultural, recreational, mine land, etc. As well as the many uses, there are various DM streams that can be utilized: pumped dredged material, decanted liquid and subsequent thickened sediment slurry, and dewatered dredged material and the many stages in between these options.

Water Quality Considerations within the Lake O Drainage Basin (John Folks, FDOAC, Kim Love, Martin Co., Mitch Flinchum, FDOACS, Scott Kuipers, NRCS, Kim Shugar, FDEP)
Phosphorous is highly regulated within the Lake O drainage basin. Each parcel of land over 5 acres must have WQ permit for any activity that may add P to the land. There is no P need agriculturally within the basin, therefore the P content of the DM adds no value. Individual landowners would take on the liability for controlling P from applications on their lands. The

need for organic material to supplement sod operations and poor soils in Hardy, Desoto and WPB counties would not likely overcome the disadvantages of the WQ and permitting requirements. Rates of application that would be allowed would follow the agricultural guidelines (agronomic application rate of about ½ inch per acre per year). This is much less than the 1-foot or more depths for single applications that have been successful in many DM applications. The above considerations would make community acceptance of pumped dredged material, slurried material or even dried material within the Lake O basin, unlikely and the amount of material successfully used minimal in the broader scheme of things.

Palm Beach county, or City of West Palm Beach

Decant Water Uses (Kim Shugar, FDEP, Kim Love Martin Co., Phillip Metcalf FDAOCS, Scott Kuipers NRCS, Linda Crane FDAOCS)

With the lower P content in the water fraction, several participants saw the value of the decant water for irrigation and other uses. Water particularly for citrus and sod operations appeared to generate the most interest (application rates of 1 inch /week including precipitation). These crops utilize spray irrigation, which provides control over application rates and field drainage. The spray systems use microjets and the decant water would likely need to be filtered. Sugar cane operations did not appear to provide as good a fit; irrigation is currently accomplished via ditch flooding and there are already issues associated with control and management of P release from sugar cane lands. Another use of decanted water would be to supplement water to the Everglades Reclamation Project's Storage Treatment Areas (STA) in dry seasons. These massive treatment cells are wetland areas used to polish the water prior to releasing waters back into the lake and into the Everglades natural areas. The Nubbin Slough is a STA within reasonable proximity to Lake O and in need of water. Transport of water would require easements and perhaps permits from a variety of agencies: DOT, RR, cable companies, etc.

Are the potential impacts to the life of STAs going to estimated?

Mine Land Reclamation (Greg White, SFWMD)

The phosphorous mine lands near Barstow (80 – 100 miles from Lake O) have a lot of lands that are required to be reclaimed by the mining companies or by the state in the case of abandoned lands. Much land has not been reclaimed due to a lack of organic material. The DM could provide a source of organics. The advantages are: the areas are hydraulically isolated (the mining was conducted in a manner to intentionally preserve the integrity of the aquifers), there are large tracts of land, it removes the DM from the Lake O drainage basin, P is not a problem since it is being returned to a P mined area, and there is an existing pipeline (Gulf Stream Natural Gas Pipeline) easement that follows the general path that a project from Lake O would follow. The pumping distance is pretty extreme, however a variety of state and corporate funds may be available to fund the DM transport.

The following DM uses were not discussed in great detail. It was felt by the participants that these alternatives were either a poor fit for the DM characteristics or that too little DM would be consumed in the use to make it a true consideration.

Reclamation of Military Lands

The proximity of large tract military lands to the lake are few. The Avon Park AF Range is nearly as far away as the mined lands and the mined lands are a more attractive use to the participants.

Corps of Engineers Use of DM in their Dike Vegetation Maintenance.
The Corps at WES has some test plots for use of DM to add organics to maintain vegetative cover on some areas of the dikes around Lake O. Dick Lee is the WES researcher. The participants were unaware of the study. Many felt the control of P back into the lake and within the general basin would be an issue.

Compositing Operations
The composting operations in existence are few and have operated only sporadically. The composting operations mostly need a carbon source, not organics such as P. The DM characteristics do not fit those needs.

Parks, Golf Courses, other Recreation Areas
The parks and recreation areas compost their own grass clippings and debris and would not have use for the material unless it was in a highly processed dry state. The same is true of nurseries. The DM would have to be heavily amended with other material that may or may not be available in great quantities locally. Again, local regulatory agencies would look at water quality issues associated with the P content of any DM use within the Lake O drainage basin.

Building Materials
Compression bricks or a gravel material would require considerable import of materials from outside the region. There are no co-located industries that could provide supplemental materials that are generally used for production of building materials. The DM characteristics just don't offer much for building material manufacturing.

Wetland Mitigation within the DOT Framework
There was little known about the needs or requirements of the DOT wetlands banking and mitigation system. However, agencies raised the possibility of permits, and water quality with respect to groundwater and surface water.

Agency full names at the meeting:

FDOAC - Florida Department of Agriculture and Consumer Services
NRCS - Natural Resource Conservation Service
FAS - Institute of Food & Agricultural Sciences
EQI - Environmental Quality, Inc. (on the phone MBE)
SFWMD - South Florida Water Management District
FDEP: Florida Department of Environmental Protection

LAKE OKEECHOBEE SEDIMENT MANAGEMENT FEASIBILITY STUDY
OKEECHOBEE SERVICE CENTER, OKEECHOBEE, FLORIDA

BENEFICIAL USE "BRAINSTORM" MEETING

9/10/02

SIGN-IN SHEET

NAME	ORG.	ADDRESS	PHONE #	E-MAIL
Phillip Metcalf	FDOACs Ag Water Policy	305 E. N. Park Street, Suite C Okeechobee, FL 34972	863-462-5885	Metcalp@doacs.state.fl.us
Kim Shugar	FDEP	800 N. Congress Ave. West Palm Beach, FL	561-861-6616	Kimberly.shugar@dep.state.fl.us
Scott Kuipers	NRCS	452 Hwy. 98 North Okeechobee, FL 34972	863-763-3619	Scott.Kuipers@fl.usda.gov
Linda Crane	FDOACS	305 E. N. Park Street, Suite C Okeechobee, FL 34972	863-462-5897	CraneL@doacs.state.fl.us
John Welch	Guide	2151 N.W. 399 Street Okeechobee, FL 34972	863-357-1581	jcwelch@strato.net
Kim Love	Martin County	19225 N.W. 80th Dr. Okeechobee, FL 34972	772-463-3263	klove@martin.fl.us
Jorge Patino	SFWMD	3301 Gun Club Road West Palm Beach, FL	561-682-2731	jpatino@sfwmd.gov
Greg White	SFWMD	3301 Gun Club Road West Palm Beach, FL	561-682-2085	gwhite@sfwmd.gov
Tom James	SFWMD	3301 Gun Club Road West Palm Beach, FL	561-682-6356	Tjames@sfwmd.gov
Greg Kennedy	SFWMD	205 N. Parrot Ave., Suite 201 Okeechobee, FL 34972	863-462-5260 ext. 3023	akennedy@sfwmd.gov
John Morgan	SFWMD	205 N. Parrot Ave., Suite 201 Okeechobee, FL 34972	863-462-5260 ext. 3014	jmorganj@sfwmd.gov
John Folks (by phone)	FDOACS		850-414-9928	
Katharine Murray (by phone)	EQI		561-575-6778	
Mitch Flinchum (by phone)	IFAS		561-993-1523	

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Mr.	Adams	Steve	City Engineer	City of Punta Gorda	326 W. Marion Ave.	Punta Gorda	FL	33950-4417	(941) 575-3302	steve_w_adam@yahoo.com
Mr.	Ager	Lothian		Florida Fish & Wildlife Conservation Commission	3939 Rose Petal Lane	Orlando	FL	32808	(409) 290-0639	agerl@gfc.fl.us
Mr.	Aguirre	Alejandro		Dia Las Americas	2900 NW 39th Street	Miami	FL	33142-5193	(305) 633-3341	
Ms.	Alberto	Debbie		News Sun	203 W. Main Street	Avon Park	FL	33825		
Representative	Alexander	J.D.	Representative	Florida House of Representatives	391 Avenue Ave S.W.	Winter Haven	FL	33880		
Mr.	Allen	Michael	Publisher	Florida Grower	1555 Howell Branch Rd, Suite C-204	Winter Park	FL	32789		
Mr.	Aller	Charles	Director	Florida Department of Agriculture & Consumer Affairs	The Capitol, Room LL-29	Tallahassee	FL	32399-0810	(850) 922-5155	allerc@doacs.state.fl.us
Mr.	Andree	Jeffrey		Osceola County Farm Bureau	1230 Windway Circle	Kissimmee	FL	34744		
Mr.	Angell	Shawn		Miami- Dade County Community Action Agency	2902 NW Second Ave	Miami	FL	33127		
Ms.	Anholt	Betty			3064 Poinciana Circle	Sanibel	FL	33957-5605		
Ms.	Annya	Cathy	Director	ASPIRA Palm Beach	P.O. Box 19908	West Palm Beach	FL	33416-4908		
Mr.	Aquilina	Robert		Spring Lake Improvement District	115 Spring Lake Blvd.	Sebring	FL	33870-6143		
Ms.	Argenziano	Nancy	Representative	Florida House of Representatives	1102 The Capitol, 402 S Monroe Street	Tallahassee	FL	32399-2300		
Mr.	Armstrong	Dennis	Commissioner	Martin County Board of Commissioners	2401 S.E. Monterey Road	Stuart	FL	34996		
Mr.	Arnold	Monroe			14627 N.W. 34th Terrace	Okeechobee	FL	34972-0945		
Mr.	Aziz	Taufiqul	Sr. Environmental Scientist	Florida Department of Environmental Protection	Twin Towers Office Building - 2600 Blairstone Rd.	Tallahassee	FL	32399-2400	(850) 921-9927	taufiquil.aziz@dep.state.fl.us
Mr.	Baird	Lester	County Administrator	Hendry County Administration	P.O. Box 1760	Labelle	FL	33935-1760	(863) 675-5220	lbaird@hendryfla.net
Mr. & Mrs.	Baird	William & Betty			10301 S. Indian River Drive	Ft. Pierce	FL	34982		
Ms.	Baker	Susan	Manager	Okee-Tantie Recreation Area	10430 Highway 78 West	Okeechobee	FL	34974		
Mr.	Ball	James			702 North Ride	Tallahassee	FL	32303-5131		
Mr.	Barletto	Joe			19650 NW 80th Drive	Okeechobee	FL	34972-9621		
Mr.	Barnett	Brian		Florida Fish & Wildlife Conservation Commission	620 South Merridian Street	Tallahassee	FL	32399-1600	(904) 488-6661	
Mr.	Barychko	Daniel			7033 NW 63rd Way	Parkland	FL	33067		
Ms.	Bass	Patricia			20609 N.W. 176 Ave	Okeechobee	FL	34972		
Mr.	Beluschak	Robert		Lee County Division of Planning	1500 Monroe Street	Fort Myers	FL	33901-5500		
Mr.	Benavides	Armando		Johnson, Prewitt & Associates, Inc.	P.O. Box 1029	Clewiston	FL	33440		
Mr.	Benedict	Rick			2600 S. Miami Road	Ft. Lauderdale	FL	33316		
Mr.	Benefield	Tom		Florida Turfgrass Association	P.O. Box 1783	Hobe Sound	FL	33475		
Mr.	Bengtson	Carl			2546 Palm Road	West Palm Beach	FL	33406		
Ms.	Bentolila	Natalie			2680 Lake Way	Cooper City	FL	33026-3601		
Mr.	Berger	Mitchell		Berger Davis & Singerman, P.A.	350 East Las Olas Boulevard	Fort Lauderdale	FL	33301	(954) 525-9900	
Mr.	Bibler	Barton			1913 Sherwood Drive	Tallahassee	FL	32303-4433		
Ms.	Billie	Bobbie	Spiritual Leader	Independent Traditional Seminole Nation	710 N. Oleander Ave	Daytona Beach	FL	32118		
Mr.	Bishop	Rim	Executive Director	Seacoast Utility Authority	4200 Hood Road	Palm Beach Gardens	FL	33410-2174	(561) 627-2920	
Mr.	Blackburn	Russ	County Administrator	Martin County Administration	2401 S.E. Monterey Road	Stuart	FL	34996		
Ms.	Blackwell	Ricki			1142 SW 24th Ave.	Okeechobee	FL	34974		
Mr.	Bloetscher	Frederick		Florida Government Utilities Authority	15 SW 5th Street	Dania	FL	33004		
Mr.	Bloom	John			3728 Quail Ridge Drive North	Boynton Beach	FL	33436		
Mr.	Bohanon	Luther	President	Highlands County Cattlemen's Association	P.O. Box 448	Venus	FL	33960		
Mr.	Bolusky	Ben		Florida Nurseymen & Growers Association	1533 Park Center Drive	Orlando	FL	32835		
Mr.	Borgmann	Jim	Assistant City Manager	City of Miami Springs	201 Westward Drive	Miami Springs	FL	33166-5259		
Mr.	Botts	Daniel		Florida Fruit and Vegetable Association	P.O. Box 140155	Orlando	FL	32814-0155		
Mr.	Bowers	Steven		Liaison/Governor Council Seminole Indian	6300 Stirling Road	Hollywood	FL	33024-2161		
Ms.	Bowman	Dari	President	Leadership Palm Beach County	19198 Pine Tree Drive	Tequesta	FL	33469		
Mr.	Boyd	William		USDA Natural Resource Conservation Service	12765 W. Forest Hill Blvd, Suite 1307	Wellington	FL	33414-4729		
Mr.	Boyer	Dave			1615 Bradley Ave	Lake Placid	FL	33852		
Mr.	Bragg	Rick		The New York Times	100 North Biscayne Blvd., Suite 3020	Miami	FL	33132	(305) 358-6066	
Mr.	Brandon	Walter			2321 Fairway Drive	West Palm Beach	FL	33409		
Mr.	Brantley	Michael	Utilities Director	City of Moore Haven	P.O. Box 399	Moore Haven	FL	33471		
Mr.	Brashier	L. B.		Sunniland Pipe Line Company	P.O. Box 350463	Fort Lauderdale	FL	33335-1087		
Mr.	Britt	Gene			82 Maple Streett, BHR	Okeechobee	FL	34974		
Mr.	Brobston	Charles			337 W. Aztec Ave	Clewiston	FL	33440		
Mr.	Brogan	Frank	Lieutenant Governor	The Capitol		Tallahassee	FL	32399-0400		
Ms.	Bromberg	Joan		League of Women Voters	1270 N.W. 22nd Ave	Delray Beach	FL	33445		
Representative	Bronson	Irlo	Representative	Florida House of Representatives	P.O. Drawer 422469	Kissimmee	FL	34742-2469		
Mr.	Brooks	Jerry	Deputy Director, Water Resource Managem	Department of Environmental Protection	2600 Blairstone Road, Mail Stop 3500	Tallahassee	FL	32399-2400	(850) 921-9462	jerry.brooks@dep.state.fl.us
Mr.	Dunn	Carl R.	Central Florida Restoration Branch, Lake Ok	U.S. Army Corps of Engineers, Jacksonville District	ATTN: CESAJ-DR-C/Carl Dunn P.O. Box 4970	Jacksonville	FL	32232-0019	904-232-3471	Carl.R.Dunn@saj02.usace.army.mil
Mr.	Brown	David	Subdistrict Chief	United States Geological Survey	224 W. Central Parkway #1006	Altamonte Springs	FL	32714		
Ms.	Brown	Susan			2600 N. Flagler Drive, # 906	West Palm Beach	FL	33407-5519		
Mr.	Brust	Rick	Waterfowl Biologist	Florida Fish & Wildlife Conservation Commission	3200 TM Goodwin Road	Fellsmere	FL	32948	(321) 726-2862	brustr@fwc.state.fl.us
Ms.	Buitrago	Donna		Passport Publications & Media	2161 Palm Beach Lakes Blvd., Suite. 310	West Palm Beach	FL	33409		
Mr.	Buker	Robert		U.S. Sugar Corporation	P.O. Drawer 1207	Clewiston	FL	33440-1207		
Mr.	Bukley	Ron		The Forum	11420 Fortune Circle, G-32	Wellington	FL	33414	(561) 791-7990	
Ms.	Buntin	Brenda	Editor	Belle Glade Sun	417 NW 16th Street	Belle Glade	FL	33430	(561) 996-4404	
Mr.	Burdeshaw	Ben		Diamond R Fertilizer Co., Inc	710 NE 5th Ave	Okeechobee	FL	34972		

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Mr.	Burns	Robert		Florida News Channel					(954) 532-6932	
Mr.	Burns	Richard		Star Ranch Enterprises, Inc.	1001 NE Third Street	Belle Glade	FL	33430		
Mr.	Burr	Marvin			64 Perch Street	Haines City	FL	33844		
Mr.	Busha	Michael	Executive Director	Treasure Coast Regional Planning Council	301 East Ocean Blvd, Suite 300	Stuart	FL	34990	(561) 221-4060	
Mr.	Calder	Fred		Florida Department of Environmental Protection	3900 Commonwealth Blvd.	Tallahassee	FL	32399-3000	(904) 488-3704	
Mr.	Campbell	Walter	Senator	Florida State Senate	10094 McNab Road	Tamarac	FL	33321		
Mr.	Campbell	K		University of Florida	P.O. Box 110570	Gainesville	FL	32611-0570		
Mr.	Capone	Matt			12698 White Coral Drive	West Palm Beach	FL	33414		
Ms.	Capone	Laurene	Scientific Research Project Manager	University of Florida, IFAS	P.O. Box 8003	Belle Glade	FL	33430-8003	(561) 993-1541	ltca@gnv.ifas.ufl.edu
Ms.	Carter	Vera M.			P.O. Box 126	Windermere	FL	34786	(407) 876-2859	
Mr.	Chamblee	James		Six Mile Bend Corporation	P.O. Box 1785	Belle Glade	FL	33430		
Councilwoman	Chamness	Mali	Councilwoman	City of Clewiston	115 W Ventura Ave.	Clewiston	FL	33440-3799	(863) 983-1484	mali@onearrow.net
Mr.	Chinquina	Don		Tropical Audubon Society, Inc.	5530 Sunset Drive	Miami	FL	33143		
Mr.	Claeys	David			2517 SW Versailles Terrace	Stuart	FL	34997		
Ms.	Clayton	Becky	Director of Education	Florida Aquarium	701 Channelside Drive	Tampa	FL	33602		
Ms.	Clement	Dana		County Line Drainage District	12008 NE Highway 70	Arcadia	FL	34266		
Ms.	Clemons	Susanne			4853 NW 30th Street	Okeechobee	FL	34972		
Mr.	Click	David			810 Saturn Street, Suite 15	Jupiter	FL	33477		
Mr.	Click	James		Click Ranch & Citrus Grove	2485 N Osceola Road	Avon Park	FL	33825-9304		
Mr.	Cobb	William			11097 Wagontrail	Bonita Springs	FL	34135		
Mr.	Coffman	Daniel			11409 Eagle Nest Drive	Boynton Beach	FL	33437		
Mr.	Cohen	Fred	City Editor	Palm Beach Daily News	265 Royal Poinciana Way	Palm Beach	FL	33480	(561) 820-3866	
Mr.	Coker	Robert		U.S. Sugar Corporation	P.O. Drawer 1207	Clewiston	FL	33440		
Ms.	Collier	Kim		Okeechobee County Utility Authority	107 SW 17th Street, Suite 1	Okeechobee	FL	34974		
Mr.	Collins	Michael	Governing Board Member	South Florida Water Management District	P.O. Box 803	Islamorada	FL	33036	(305) 852-5837	
Mr.	Compton	Jim			12166 53rd Street	Royal Palm Beach	FL	33411		
Representative	Constantine	D. Lee	Representative	Florida House of Representatives	232 House Office Bldg, 402 S Monroe Street	Tallahassee	FL	32399-1300		
Mr.	Contral	Ralph		Florida Department of Community Affairs	2555 Shumard Oak Blvd	Tallahassee	FL	32399-2100		
Mr.	Cook	Rick	Public Affairs Officer	Everglades National Park	P.O. Box 279	Homestead	FL	33030	(305) 242-7714	
Mr.	Cook	Richard			6060 West 10th Ave	Hialeah	FL	33012		
Mr.	Coultas	Pete		A. Duda & Sons, Inc.	P.O. Box 620257	Oviedo	FL	32762		
Ms.	Coven	Sheri	Senior Planner	Florida Regional Council Association	314 East Central Ave	Blountstown	FL	32424-2242		
Assistant Commi	Rhodes	Ms. Terry	Assistant Commissioner	Department of Agriculture & Consumer Services	PL 10 Capitol	Tallahassee	FL	32399-0810	(850) 488-3022	
Ms.	Cromwell	Bobbi Jo		Osceola County Engineering Department	17 S. Vernon Ave., Room 249	Kissimmee	FL	34741-3603		
Ms.	Crosby	Polly		League of Women Voters	10118 Mangrove Drive, #102	Boynton Beach	FL	33437		
Mr.	Crosby	Griffin		Crosby Well Drilling, Inc.	P.O. Box 1648	Lake Wales	FL	33853		
Mr.	Crowder	Robert	Sheriff	Martin County	800 S.E. Monterey Road	Stuart	FL	34994		
Mr.	Crowley	T. Spencer			2585 Prosperity Oaks Court	Palm Beach Gardens	FL	33410		
Mr.	Cruz-Lopez	Hector			801 NW 40th Street	Boca Raton	FL	33431		
Ms.	Culligan	Carol			HC 61 Box 83	Clewiston	FL	33440		
Ms.	Cummings	Dianne		Archbold Biological Station	P.O. Box 2057	Lake Placid	FL	33862		
Mr.	Cummings	James	President	James A Cummings, Inc.	3575 NW 53rd Street	Fort Lauderdale	FL	33309-6311		
Mr. & Mrs.	Dale	Betty & Kenneth			7747 Spivey Lane	Sebring	FL	33870-9767		
Mr.	Daltry	Wayne	Executive Director	Southwest Florida Regional Planning Council	P.O. Box 3455	Fort Myers	FL	33918		
Mr.	Davidson	Robert		Palm Beach County Library System	3650 Summit Blvd	West Palm Beach	FL	33406-4198		
Mr.	Davis	Edward		R & D Sod Farms, Inc	674 NW 113 Drive	Okeechobee	FL	34972		
Mr.	Davis	Patrick		Hazen & Sawyer	4000 Hollywood Blvd, 7th Floor, N Tower	Hollywood	FL	33021		
Ms.	Davis	Joanne		1000 Friends of Florida	224 Datura Street	West Palm Beach	FL	33401	(561) 582-8128	
Mr.	De Armas	Oswaldo		Shawano Drainage District	P.O. Box 2136	Belle Glade	FL	33430		
Ms.	Deady	Erin		National Audubon Society	444 Brickell Avenue, Suite 850	Miami	FL	33131	(305) 371-6399	
Mr.	Dearborn	Ed	Station Manager	WWFR-FM 91.7	P.O. Box 277	Okeechobee	FL	34973-0277		
Mr.	Degraaf	Rob			12803 Thonotosassa Road	Dover	FL	33527-3701		
Mr.	Denham	Paul			2331 S.E. Holland Street	Port St. Lucie	FL	34952-4830		
Mr.	Derlan	Gary	Director of Utilities	Palm Beach County	P.O. Box 16097	West Palm Beach	FL	33416-6097		
Mr.	Diamond	Charles			4278 Diamond Road	Lake Worth	FL	33461		
Mr.	Dorling	Paul	Principal Planner	City of Delray Beach	100 N.W. 1st Ave	Delray Beach	FL	33444-2612		
Mr.	Dowling	Aaron	Executive Director	East Central Florida Regional Planning Council	1011 Wynmore Road, Suite 105	Winter Park	FL	32789	(407) 623-1075	
Mr.	Doyle	Billy			5541 S.W. Markel Street	Palm City	FL	34990-5118		
Ms.	Drake	Emily		Drake Ranch	Route 2, Box 173	Clewiston	FL	33440		
Mr.	Draper	Eric		National Audubon Society	102 E. 4th Ave	Tallahassee	FL	32303		
Mr.	Driscoll	Tom		Florida Department of Transportation	7900 Forest Hill Blvd.	West Palm Beach	FL	33413	(561) 434-3903	
Lt. Col.	Dunford	Lt. Col. Dan	Regional Director	Florida Fish & Wildlife Conservation Commission	620 South Merridian Street	Tallahassee	FL	32399-1600	(904) 640-6100	
Mr.	Dunkleman	John		Florida Sugar Cane League	P.O. Drawer 1208	Clewiston	FL	33440		
Ms.	Dunson	Lisa	Executive Director	Highland County Citrus Growers	6419 US Highway 27 South	Sebring	FL	33870-5712		
Ms.	Durando	Rosa		Audubon Society of the Everglades	10308 Heritage Farms Road	Lake Worth	FL	33467-6720		

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Mr.	Easterly	Mark		The Observer	240 Royal Palm Beach Blvd.	Royal Palm Beach	FL	33411	(561) 791-9687	
Mr.	Ednoff	Mike		Harbor Branch Oceanographic Institute	2601 N. Indian River Drive, Suite 4	St. Lucie Village	FL	34946-1817		
Mr.	Eiland	Barney		Okeelanta Corporation	P.O. Box 86	Clewiston	FL	33493		
Mr.	Entus	Mel	Utilities Director	City of Plantation	400 NW 73rd Ave	Plantation	FL	33317		
Ms.	Erami	Abdula	Engineer	Florida Department of Environmental Protection	P.O. Box 15425	West Palm Beach	FL	33416		
Mr.	Eric	Dennis			1227 NW 111th Ave.	Coral Springs	FL	33071		
Ms.	Everett	Eddy			Rt 1, Box 1395 S. Connors Hwy	Okeechobee	FL	34974-9724		
Ms.	Eves	Megan F.	Sr. Project Scientist I	Blasland, Bouck & Lee, Inc.	6723 Towpath Road	Syracuse	NY	13214-0066	(315) 446-2570 X 42	mfe@bbl-inc.com
				SFWMD - Martin/ St. Lucie Service Center	210 Atlantic Avenue	Stuart	FL	34994	(800) 250-4100	
Mr.	Fairbanks	J		U. S. Sugar Corporation	P.O. Drawer 1207	Clewiston	FL	33440-1207		
Mr.	Faried	Sammy		Lee County Regional Water Supply Authority	2180 W. First Street, Suite 208	Ft. Myers	FL	33901		
Ms,	Fentress	Pam		4-D Citrus & Sod, Inc.	P.O. Box 488	Lake Placid	FL	33862		
Mr.	Ferrell	David	Supervisor -South Florida Restoration	U.S. Fish and Wildlife Service	P.O. Box 2676	Vero Beach	FL	32961-2676		
Ms.	Fike	Dana		Department of Environmental Protection	1801 SE Hillmoor Drive, Suite C-204	Port St. Lucie	FL	34952		
Mr.	Filo	Ed		The Stuart News	1939 S. Federal Highway	Stuart	FL	34995	(561) 221-4205	
Mr.	Finkler	A. E.			24 Suffolk A	Boca Raton	FL	33434-4968		
Mr.	Fleshler	David		The Sun-Sentinel	200 Las Olas Blvd.	Ft. Lauderdale	FL	33301	(954) 356-4535	
Mr.	Flint	Joe	Clerk of Courts	Glades County	P.O. Box 10	Moore Haven	FL	33471-0010		
Mr.	Foley	Mark	Representative	U.S. House of Representatives	4400 PGA Boulevard	Palm Beach Gardens	FL	33408		
Mr.	Folks	John		Office of Agricultural Water Policy	3125 Conner Blvd.	Tallahassee	FL	32399-1650		
Ms.	Fortin	Madeline			21801 SW 152nd Street	Miami	FL	33186		
Ms.	Foster	Charlene			P.O. Box 593527	Orlando	FL	32859-3527		
Mr.	Fox	Donald		Florida Fish & Wildlife Conservation Commission	3991 SE 27th Ct.	Okeechobee	FL	34974-7336	(863) 462-5190	dfox@ircc.net
Mr.	Fralick	Roy			16935 NE 34th Court	Citra	FL	32113		
Mr.	Friedman	Allan			8101 Rosemarie Circle	Boynton Beach	FL	33431		
Ms.	Fritz-Quincy	Debbie		Hobe Sound Nature Center, Inc.	P.O. Box 214	Hobe Sound	FL	33475		
Ms.	Froscher	Yvonne			623 Sailfish Road	Winter Springs	FL	32708-3115		
Mr.	Fulford	Gene			24951 NW 160th Drive	Okeechobee	FL	34972		
Mr.	Fuller	Manley		Florida Wildlife Federation	2545 Blairstone Pines Drive	Tallahassee	FL	32314-6870		
Commissioner	Gainey	Elmira	Commissioner	Martin County Board of Commissioners	2401 SE Monterey Road	Stuart	FL	34996		
Mr.	Gale	Kevin		South Florida Business Journal	4000 Hollywood Blvd., Suite 695-S	Hollywood	FL	33021	(954) 459-2120	
Mr.	Gallon	Dennis	President	Palm Beach Community College	4200 Congress Ave.	Lake Worth	FL	33461-4796		
Mr.	Galvin	David		Lee County Health Department	3920 Michigan Ave	Cape Coral	FL	33916		
Mr.	Ghioto	Rod			8008 S Orange Ave	Orlando	FL	32809		
Mr.	Gibson	William			139 Sparrow Drive, Suite 2B	Royal Palm Beach	FL	33411		
Mr.	Gilio	Joseph	President	Wetlands Management Inc.	P.O. Box 1122	Jensen Beach	FL	34958-1122		
Mr.	Gissendanner	Elton			2282 SE 27th Drive	Homestead	FL	33035-1337		
Mr.	Gleason	Joseph		Florida Citrus Mutual	P.O. Box 89	Lakeland	FL	33802-0089		
Mr.	Godley	Steve		Biological Research Associates	3910 N. US Hwy 301 North, Suite 180	Tampa	FL	33619-1282		
Ms.	Goodyear	Carol		NOAA/NMFS - Southeast Fisheries Science Center	75 Virginia Beach Drive	Miami	FL	33149		
Mr.	Gore	Robert			P.O. Box 10053	Naples	FL	34101		
Ms.	Gosa	Mary Ann		Florida Farm Bureau Federation	222 SW 77th Terrace	Okeechobee	FL	34974		
Mr.	Graham	Bob	Senator	United States Senate	524 Hart Senate Office Building	Washington	DC	20510-0903		
Ms.	Gray	Susan		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406		
Mr.	Graydon	Dwight		Clewiston Drainage District	350 W Arroyo Ave.	Clewiston	FL	33440-9704		
Mr.	Gregg	Bruce		Seacoast Utility Authority	4200 Hood Road	Palm Beach Gardens	FL	33410		
Ms.	Griffin	Jacquelyn	Public Affairs	U.S. Army Corps of Engineers	400 West Bay Road	Jacksonville	FL	32232-0019	(904) 232-2236	jacquelyn.j.griffin@usace.army.mil
Mr.	Gunsten	Jeff	News Director	WOKC AM-1570	P.O. Box 1247	Okeechobee	FL	34973		
Mr.	Gutierrez, Jr.	Nicolas	Governing Board Member	South Florida Water Management District	1101 Brickell Ave., Suite 1400	Miami	FL	33131		
Mr.	Hall	Robert		Florida Department of Environmental Protection	3900 Commonwealth Blvd.	Tallahassee	FL	32399		
Mr.	Hamann	Richard		University of Florida	P.O. Box 117629	Gainesville	FL	32611-7629		
Mr.	Hamel	Ron		Gulf Citrus Growers, Inc.	P.O. Box 1319	Labelle	FL	33935-1319		
Mr.	Hamilton	Pat		Lykes Brothers	7 Lykes Road	Lake Placid	FL	33852		
Mr.	Hamilton	Ed		A. Duda & Sons, Inc.	P.O. Box 257	Oviedo	FL	32765		
Mr.	Hammock	Alan		Frierson Farms	P.O. Box 1686	Clewiston	FL	33440-1686		
Mr.	Hankinson	John		Department of Environmental Protection	61 Forsythe Street, S.W.	Atlanta	GA	30303	(404) 562-8327	
Mr.	Harclerode	Kurt		Fort Myers Service Center	2301 McGregor Boulevard	Fort Myers	FL	33901	(941) 339-2929	
Ms.	Harrison	Debbie		World Wildlife Fund	8075 Overseas Highway	Marathon	FL	33050-3228		
Mr.	Hartman	Brad	Director, Office of Environmental Services	Florida Fish & Wildlife Conservation Commission	620 S. Meridan Street	Tallahassee	FL	32399-1600	(850) 488-6661	hartmab@gfc.fl.us
Ms.	Hartney	Mary		Florida Fertilizer & Agrichemical	P.O. Box 9326	Winter Haven	FL	33883-9326		
Ms.	Harvey	Norma			7612 Lake Marsha Drive	Orlando	FL	32819-7736		
Mr.	Harvey	Richard	Director, South Florida Office	U.S. Environmental Protection Agency	400 N. Congress Ave, Suite 120	West Palm Beach	FL	33401		
Mr.	Hauser	Ralph			P.O. Box 1478	Fort Myers	FL	33902-1478		
Mr.	Head	Malcolm			2703 Cullens Court	Ocoee	FL	34761-9112		
Mr.	Hebb	Jack		St. Lucie County Soil Conservation Service	8400 Picos Road, Suite 101	Ft. Pierce	FL	34954		

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Mr.	Hebert	Paul	Southern Director	National Weather Service	11691 SW 17th Street	Miami	FL	33165-2149	(305) 229-4500	
	Jupiter Courier				P.O. Box 1486	Jupiter	FL	33468	(561) 746-5111	
Mr.	Hess	Terry		Treasure Coast Regional Planning Council	301 E. Ocean Blvd., Suite 300	Stuart	FL	34994		
Mr.	Hickson	James			5311 SW 164 Terrace	Ft. Lauderdale	FL	33305		
Mr.	Higer	Aaron	Senior Scientist	U.S. Geological Survey	9100 NW 36th Street	Miami	FL	33178	(305) 594-0655	
Mr.	Hilliard	J. Marland		Sugar Land Drainage District	Route 2, Box 175	Clewiston	FL	33440		
Mr.	Hoff	John			3185 Riddle Road	West Palm Beach	FL	33405		
Mr.	Hoffman	Ken			530 Camelia Lane	Vero Beach	FL	32963		
Mr.	Hofstetter	Ronald		University Of Miami		Coral Gables	FL	33124-9118		
Ms.	Hollingsworth	Jan		Tampa Tribune	P.O. Box 191	Tampa	FL	33601	(813) 259-7600	
Mr.	Holloway	Ken			1480 Winkler Ave.	Ft. Myers	FL	33901		
Mr.	Hora	Peter			1861 SW 37th Way	Ft. Lauderdale	FL	33312		
Ms.	Hord	Lindsey		Florida Fish & Wildlife Conservation Commission	8122 U.S. Hwy 441 SE	Okeechobee	FL	34974	(863) 462-5195	hordl@gfc.fl.us
Ms.	Horne	Linda		Martin County Utilities Division	P.O. Box 9000	Stuart	FL	34995-9000		
Mr.	Howard	Willie		Palm Beach Post	2751 S. Dixie Hwy	West Palm Beach	FL	33405		
Mr.	Howell	Mark		U.S. Sugar Corporation	P.O. Box 1207	Clewiston	FL	33440-1207		ussch20@ussugar.com
Mr.	Hufschmid	John			376 NW Sherry Lane	Port St. Lucie	FL	34986-2192		
Mr.	Hughes	Eric		U.S. Environmental Protection Agency, Jacksonville District	P.O. Box 4970	Jacksonville	FL	32232-0019	(904) 232-2464	hughes.eric@epa.gov
Mr.	Hulon	Mike		Florida Fish & Wildlife Conservation Commission	701 Marllo Road	Kissimmiee	FL	34744	(407) 846-5041	hulonm@gfc.fl.us
Mr.	Hutcheson	Clayton	Agricultural Extension Agent	PBC Cooperative Extention Service	559 N Military Trail	West Palm Beach	FL	33415-1358		
Mr.	Huttenmeyer	Bob			81 Fairview E.	Tequesta	FL	33469		
Mr.	Irwin	Richard			23 Rhett Road	Leesburg	FL	34788-2519		
Mr.	Izuno	Forrest		University of Florida, IFAS	P.O. Box 8003	Belle Glade	FL	33430-8003		
Mr.	Jackson	James			14465 Larspur Lane	Wellington	FL	33414		
Mr.	Jackson-Ross	Su		WPBF-TV	3970 RCA Blvd., Suite 7007	Palm Beach Gardens	FL	33410-4231	(561) 624-6397	
Mr.	Jernigan	R.		Economic Development Council of Broward County	P.O. Box 2266	Fort Lauderdale	FL	33303-2266		
Mr.	Johnson	Hugh			P.O. Box 1423	Vero Beach	FL	32961		
Mr.	Johnson	Bill	Director	Osceola County Library System	211 E. Dakin Ave.	Kissimmee	FL	34741		
Mr.	Jones	Ronald		Florida International University	University Park, OE 148	Miami	FL	33199		
Mr.	Jordan	Bishop			306 Shearer	Cocoa	FL	32922		
Ms.	Jordan Smith	Jackie	Department of Aquatic Plant Management	Florida Department of Environmental Protection	3111-B-13 Fortune Way	Wellington	FL	33414	(561) 791-4720	
Mr.	Kamien	Theodore			8941 SE Sandcastle Circle	Hobe Sound	FL	33455		
Mr.	Kampert	Elliot	Director of Community Development	Charlotte County	18500 Murdock Circle	Port Charlotte	FL	33948-1094		
Mr.	Kane	Dick	Public Information Director	Florida Department of Transportation	605 Suwannee Street - Mail Station 54	Tallahassee	FL	32399	(904) 488-3111	
Mr.	Kassawara	Thomas	Engineer	City of Sunrise	10770 W. Oakland Park Blvd. 1st Floor	Sunrise	FL	33351-6816		
Mr.	Keck	Ken	Director of Legislature Regional Affairs	Florida Citrus Mutual	P.O. Box 89	Lakeland	FL	33802-0089		
Ms.	Keller	Elaine			50 Kindred Street, Suite 301	Stuart	FL	34994-3058		
Mr.	Keller	Toy		Florida Department of Community Affairs	2555 Shumard Oak Blvd.	Tallahassee	FL	32399-2100		
Mr.	Kelley	Herbert			7310 West Lake Drive	Lake Clarke Shores	FL	33406-6722		
Mr.	Kelly	Dennis		Rotary Club of North Palm Beach	501 US Highway 1	North Palm Beach	FL	33408		
Mr.	Keown	David			7206 Cabana Lane	Ft. Pierce	FL	34951		
Mr.	Keppel	Toby			676 Elkcam Circle West, Apt. 1213	Marco Island	FL	33937		
Mr.	Kerr	Robert			P.O. Box 632	Davenport	FL	33836		
Mr.	Khan	Anwar	Project Manager	EA Engineering, Science, and Technology, Inc.	Laurel Court, Suite 200, 15500 New Barn Road	Miami Lakes	FL	33014	(305) 819-2212	aak@eaest.com
Mr.	King	Robert	Environmental Reporter	Palm Beach Post	2751 South Dixie Highway	West Palm Beach	FL	33405	(561) 820-4417	
Ms.	Kippenberger	Susie	Director	Seminole Tribe Utilities Department	6300 Stirling Road, Suite 105	Hollywood	FL	33024-2153		
Mr.	Kirby	Tom	Executive Director	Dade County Farm Bureau	1850 Old Dixie Highway	Homestead	FL	33033		
Mr.	Kirk	James	Mayor	City of Okeechobee	55 SE 3rd Ave.	Okeechobee	FL	34974-2903		
Ms.	Kohler	Judi			P.O. Box 3297	Florida City	FL	33034		
Mr.	Kohn	David		Mcgraw-Hill World News	3117 Lakeshore Drive	Deerfield Beach	FL	33442		
Mr.	Kowalski	Hank		Audubon Society of Highland County	242 Serenade Drive	Lake Placid	FL	33852-8581		
Mr.	Kramer	William		Sugar Cane Growers Co-op of Florida	P.O. Box 666	Belle Glade	FL	33430-5556		
Mr,	Kuhl	Kenneth		Florida Department of Agriculture	3125 Conner Blvd, Room 151	Tallahassee	FL	32399-1650		
Mr,	Lambou	Victor			233 Bay Pine Drive	Crawfordville	FL	32327-9210		
Ms.	LaRocque	Shannon		Town of Jupiter	210 Military Trail	Jupiter	FL	33458		
Mr.	Larson	L		Larson Dairy Corporation	P.O. Box 1249	Okeechobee	FL	34973-1242		
Mr.	Lavetsky	Joe			8455 SE May Terrace	Hobe Sound	FL	33455		
Mr.	Lawlor	Kevin		The News-Press	2442 Martin Luther King, Jr Blvd	Ft. Myers	FL	33901	(941) 335-0389	
Mr.	Lee	Charles		Florida Audubon Society	1331 Palmetto Ave, Suite 110	Winter Park	FL	32789		
Mr.	Lee	Ronald	Sheriff	Hendry County	P.O. Box 579	Labelle	FL	33935-0579		
Mr.	Leffingwell	Lee	Town Administrator	Town of Glen Ridge	1660-C Southern Blvd.	West Palm Beach	FL	33406		
Mr.	Lehmann	John Charles	Executive Director	PBC Tourist Development Council	1555 Palm Beach Lakes Blvd., Suite 414	West Palm Beach	FL	33401		
Mr.	Leonard	Douglas	Executive Director	Central Florida Regional Planning Council	P.O. Box 2089	Bartow	FL	33830	(941) 534-7130	
Mr.	Leto	Frank			4503 Piccidally Street	Tampa	FL	33634		
Mr.	Levy	Daniel J.	Southeast Regional Branch Manager	EA Engineering, Science, and Technology, Inc.	Laurel Court, Suite 200, 15500 New Barn Road	Miami Lakes	FL	33014	(305) 819-2212	dlevy@eaest.com

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
	Library			Archbold Biological Station	123 Main Drive	Venus	FL	33960		
Ms.	Lindquist	Joan		Mini Day Trip Books	24287 Buchaneer Blvd.	Punta Gorda	FL	33955		
Mr.	Lindsey	Tom		Hobe Sound-St. Lucie Conservancy District	P.O. Box 1045	Hobe Sound	FL	33475-1045		
Mr.	Linley	George			15140 71st Terrace Drive North	Palm Beach Gardens	FL	33418		
Mr.	Livingston	Eric		Florida Department of Environmental Protection	2600 Blairstone Road	Tallahassee	FL	32399		
Ms.	Llewellyn	Janet		Florida Department of Environmental Protection	3900 Commonwealth Blvd, MS 46	Tallahassee	FL	32399-2400		
Mr.	Lobaina	Gaspar		Florida Department of Transportation	1000 NW 111th Ave	Miami	FL	33172-5802		
Mr.	Lockhart	Mike		Lockhart Ag Technologies	P.O. Box 388	Lake Harbour	FL	33459		
Ms.	Lodge	Patti		Seminole Tribe of Florida	6300 Sterling Road	Hollywood	FL	33024-2161		
Ms.	Lofton	Irene			10751 NW 144th Trail	Okeechobee	FL	34972		
Mr.	Luckey	Larry	Property Appraiser		P.O. Box 1106	Moore Haven	FL	33471		
Ms.	Lukasiewicz	Kathy	Vice President	Blasland, Bouck & Lee, Inc.	185 N.W. Spanish River Boulevard, Suite 110	Boca Raton	FL	33431-4230	(561) 750-3733	KL@BBL-Inc.com
Mr.	Lyons	Doug		The Sun-Sentinel	200 East Las Olas Blvd	Ft. Lauderdale	FL	33301	(954) 356-4638	
Mr.	Machek	Richard			17 NW 16th Street	Delray Beach	FL	33444		
Mr.	MacNamara	Thomas			3426 NW 49th Terrace	Gainesville	FL	32606-5989		
Mr.	Mades	Dean			7231 S. Leewynn Drive	Sarasota	FL	34240		
Mr.	Magnaghi	Rob	County Manager	Osceola County Administration	17 S. Vernon Ave, Room 117	Kissimmee	FL	34741-5488		
Mr.	Malefatto	Alfred J.		Greenberg Traurig, P.A.	777 S. Flagler Dr. Suite 300	West Palm Beach	FL	33401-6164	(561) 650-7980	malefattoa@gtlaw.com
Ms.	Malone	Denise			9614 Arbor Meadow Drive	Boynton Beach	FL	33437		
Ms.	Maness	Kim			1900 Darby Road	Sarasota	FL	34240		
Ms.	Mann	Sally		Florida Department of Environmental Protection	3900 Commonwealth Blvd., MS 47	Tallahassee	FL	32399-3000		
Mr.	Manning	John		The Town Crier	12794 West Forest Hill Blvd. Suite 21	Wellington	FL	33414	(561) 793-7606	
Mr.	Marcinkowski	Tom	Director, Environmental Engineering	Florida Institute of Technology	150 W. University Blvd.	Melbourne	FL	32901-6988		
Mr.	Marhefka	Joe		Broward County Mosquito Control	1200 S. University Drive	Pembroke Pines	FL	33025		
Mr.	Marshall	John			525 South Flagler Drive, Apt. 10C	West Palm Beach	FL	33401	(561) 833-4425	
Mr.	Marsocci	Frank			645 NW 106th Street	Okeechobee	FL	34972		
Mr.	Martin	Dean		University of South Florida	4202 E. Fowler Ave.	Tampa	FL	33620-5250		
Mr.	Masilotti	Tony	Commissioner	Palm Beach County Board of Commissioners	P.O. Box 1989	West Palm Beach	FL	33401-1989		
Mr.	Mason	Palmer		Florida Association of Counties	P.O. Box 549	Tallahassee	FL	32302		
Mr.	Masterson	Thomas	County Engineer	Okeechobee County	499 NW 5 Ave	Okeechobee	FL	34972		
Mr.	McAdams	James		U.S. Army Corps of Engineers	P.O. Box 4970	Jacksonville	FL	32232-0019		
Mr.	McAlleenan	Mal			21771 SW 202 Ave	Miami	FL	33170		
Mr.	McCants	James			3308 Taconic Drive	West Palm Beach	FL	33406		
Ms.	McCarthy	Linda		Florida Department of Agriculture and Consumer Services	3301 Gun Club Road	West Palm Beach	FL	33406	(561) 627-2845	
Mr.	McCleland	Richard			P.O. Box 142	Lorida	FL	33857		
Mr.	McCrutchan	James			P.O. Box 4066	Tequesta	FL	33469		
Mr.	McEachern	Joel			1545 Sunset Circle	Mt. Dora	FL	32757		
Mr.	McElroy	Tom			P.O. Box 140	Sugarloaf Shores	FL	33044		
Ms.	McFadden	Kris		Florida Department of Environmental Protection	Congress Avenue	West Palm Beach	FL	33416	(561) 681-6714	
Mr.	McLaughlin	John			5473 Mt. Vernon Way	Dunwoody	GA	30338		
Dr.	McPherson	Ben	Hydrologist	U.S. Geological Survey	4710 Eisenhower Blvd. Suite B-5	Tampa	FL	33634	(813) 243-5800	
Ms.	McVety	Pam		Department of Environmental Protection	3900 Commonwealth Blvd.- MS 45	Tallahassee	FL	32399		
Mr.	Mealey	Brian	Director of Environmental Sciences	Miami Museum of Science & Space	3280 S Miami Ave.	Miami	FL	33129		
Ms.	Meeker	Melissa		Florida Department of Environmental Protection	400 N. Congress Ave.	West Palm Beach	FL	33401		
Mr.	Menhennett	John		Okeelanta Corporation	P.O. Box 86	South Bay	FL	33493		
Mr.	Michaels	Pat		WCPX-TV Ch-6	4466 N. John Young Parkway	Orlando	FL	32804		
Mr.	Michaels	James			8535 Ganey Lane	Zolfo Springs	FL	33890		
Mr.	Middleton	Ed		U.S. Army Corps of Engineers	P.O. Box 4970	Jacksonville	FL	32232-0019		
Ms.	Miedema	Barbara		Sugar Cane Growers Co-op of Florida	P.O. Box 666	Belle Glade	FL	33430-5556		
Mr.	Milian	Arsenio			2657 SW 23rd Street	Miami	FL	33145		
Mr.	Milita	M. Dale			P.O. Box 35	Canal Point	FL	33438		
Mr.	Millar	Paul	Director	SFWMD - Martin/ St. Lucie Service Center	210 Atlantic Avenue	Stuart	FL	34994	(561) 223-2600	
Ms.	Miller	Mabel		Friends of Virginia Key	210 Seaview Drive, #308	Key Biscayne	FL	33145		
Mr.	Miller	Pat		Okeechobee County Extension Office	458 Highway 98 N	Okeechobee	FL	34972-2303		
Mr.	Mills	Bubba		ABC Ranch	P.O. Box 835	LaBelle	FL	33935		
Mr.	Minton	Michael		Dean, Mead & Minton	1903 South 25th Street, Suite 200	Ft. Pierce	FL	34947	(941) 263-4780	
Mr.	Mitzelfeld	Charles			17160 41st Road N.	Loxahatchee	FL	33470		
Mr.	Mohney	David		Sugar Cane Growers Co-op of Florida	P.O. Box 666	Belle Glade	FL	33430-5556		
Mr.	Moller	Jack		Florida Wildlife Federation	610 NW 93 Ave.	Pembroke Pines	FL	33024-6329		
Mr.	Montgomery	Neale			P.O. Drawer 1507	Fort Myers	FL	33902-1507		
Mr.	Moore	H.			3315 N. Indian River Drive	Ft. Pierce	FL	34946		
Mr.	Moore	Jim			P.O. Box 7365	Indian Lake Estates	FL	33855		
Mr.	Morello	Frank		Florida Fish & Wildlife Conservation Commission	8535 Northlake Blvd	West Palm Beach	FL	33412	(561) 625-5127	morelf@gfc.fl.us
Mr.	Morgan	William			7 - 6th Street BHR	Okeechobee	FL	34974		
Mr.	Morgan	John	Director	SFWMD- Okeechobee Service Center	205 North Parrot Avenue, Suite 201	Okeechobee	FL	34973	(800) 250-4200	jmorgan@sfwmd.gov

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Mr.	Morgan	Curtis		The Miami Herald	One Herald Plaza	Miami	FL	33132	(305) 376-3610	
Mr.	Moriber	Lloyd			21000 NE 28th Ave.	Aventura	FL	33180-1421		
Mr.	Morra	John		Florida Department of Environmental Protection	P.O. Box 15425	West Palm Beach	FL	33416		
Mr.	Moser	Jack			905 Garden Court	West Palm Beach	FL	33411-3425		
Mr.	Moyer	Ed	Director, Fisheries	Florida Fish & Wildlife Conservation Commission	600 N Thacker Ave., Suite 1A	Kissimmee	FL	34741-4807	(850) 488-0331	moyere@gfc.fl.us
Mr.	Sullivan	Terry	Government Relations	The Nature Conservancy	625 N Adams Street	Tallahassee	FL	32301-1113		
Mr.	Murley	Jim			220 SE 2nd Avenue, Suite 709	Ft. Lauderdale	FL	33301		
Mr.	Murphy	Larry	Councilman	City of Cape Coral	4649 Palm Tree Blvd, Apt. 1	Cape Coral	FL	33904		
Mr	Murray	Travis		Lockhart Agricultural Technology	P.O. Box 388	Lake Harbor	FL	33459	561-261-6479	
Ms.	Murray	Katharine	President	Environmental Quality, Inc.	382 Tequesta Drive	Tequesta	FL	33469	(561) 575-6778	
Mr.	Musaus	Mark		ARM Loxahatchee National Wildlife Refuge	Route 1, Box 278	Boynton Beach	FL	33437-9741	(561) 732-3684	
Ms.	Musgrove	Martha	Associate Editor	The Miami Herald	One Herald Plaza	Miami	FL	33132-1693		
Ms.	Myers	Michele	Chief Cabinet Aide	Florida Department of Agriculture & Consumer Service	The Capitol, Rm. LL-29	Tallahassee	FL	32399-0810		
Mr.	Myers	Paul			P.O. Box 1437	Eagle Lake	FL	33839		
Mr.	Neal	Pat		CNN	12000 Biscayne Blvd, Suite 701	Miami	FL	33181	(305) 892-5100	
Mr.	Nearhoff	Frank		Florida Department of Environmental Protection	2600 Blairstone Road, Room 105	Tallahassee	FL	32399-2400		
Mr.	Neil	Richard	Town Attorney	St. Lucie Village	P.O. Box 1270	Fort Pierce	FL	34954		
Mr.	Nevitt, Jr.	Joseph			6309 South Mangrove Cay Way	Lantana	FL	33462		
Mr.	Nikolits	Gary	Property Appraiser	Palm Beach County	301 N Olive Ave.	West Palm Beach		33401-4705		
Mr.	Nogueiras	Alex			7981 NW 54th Street	Lauderhill	FL	33351		
Mr.	Nottingham	Ben		U.S. Fish and Wildlife Service	3860 Tollgate Blvd, Suite 30	Naples	FL	34114		
Mr.	O'Quinn	H.C.		Old Plantation Water Control District	P.O. Box 15405	Plantation	FL	33318		
Ms.	Ocher	Lisa	Managing Editor	Boca Raton Magazine	6413 Congress Avenue	Boca Raton	FL	33447	(561) 997-8683	
Mr.	Ogden	Curtis			1483 San Marcos Blvd	Naples	FL	34104		
Mr.	Oldehoff	Gary	County Attorney	Martin County	2401 SE Monterey Road	Stuart	FL	34996-3320		
Mr.	Oliveri	Len			19410 NW 80th Drive	Okeechobee	FL	34972		
Mr.	Olson	Fritzi			20810 NE 132 Ave	Waldo	FL	32694		
Mr.	Oswald	Parker			215 Pollywog Point	LaBelle	FL	33935		
Mr.	Otto	Thomas			261 SW 6th Street	Miami	FL	33130		
Mr.	Owens	Wayne	Councilman - Finance Officer	City of Moore Haven	P.O. Box 399	Moore Haven	FL	33471		
Mr.	Pace	Bob		U.S. Fish & Wildlife Service	P.O. Box 2676	Vero Beach	FL	32961-6276	(407) 562-3909	
Mr.	Padera	Chuck			4704 Shore Drive	St. Augustine	FL	32086		
Mr.	Paglia	Albert	Vice Mayor	Village of Wellington	14000 Greenbriar Blvd.	Wellington	FL	33414	561-308-0501	Apaglia@gate.net
Mr.	Palmer	Alan			5200 Jeffery Ave.	West Palm Beach	FL	33407		
Mr.	Palmer	Ray			701 SE Karrigan Terrace	Port St. Lucie	FL	34983-3215		
Mr.	Panella	Michael			2216 SW Ranch Trail	Stuart	FL	34997-7955		
Mr.	Parsons	Philip		Florida Sugar Cane League	P.O. Box 271	Tallahassee	FL	32302-0271		
Mr.	Patterson	Keith			4521 W. Hiawatha	Tampa	FL	33614		
Mr.	Pearce	Keith			P.O. Box 369	Okeechobee	FL	34973		
Ms.	Perez	Amy			21410 NW 3 Street	Pembroke Pines	FL	33029		
Mr.	Perez	Evan		The Wall Street Journal		Tallahassee	FL		(850) 224-5826	
Mr.	Perkins	James			529 32nd Street	West Palm Beach	FL	33407		
Ms.	Petitjean	Yvette			P.O. Box 300	Estero	FL	33928-0300		
Mr.	Pierce	Kevin	Producer	The Florida Environment	P.O. Box 1774	Sanibel	FL	33957	(941) 472-3663	
Mr.	Pimentel	Peter	Executive Director	Northern Palm Beach County Improvement District	357 Hiatt Drive	Palm Beach Gardens	FL	33418		
Mr.	Pitt	William		Rust Environment & Infrastructure, Inc	10131 Kendale Blvd	Miami	FL	33176		
Mr.	Podgor	Joseph			244-A Westward Drive	Miami Springs	FL	33166		
Mr.	Poggi	John		REP & Associates, Inc.	3932 RCA Blvd, Suite 3204	Palm Beach Gardens	FL	33410	(561) 627-1810	JohnP@repenvironmental.com
Ms.	Pollard	Shareen		Glades County	P.O. Box 549	Moore Haven	FL	33471-0010		
Mr.	Pollard	Gene			2036 SE 35th Lane	Okeechobee	FL	34974-7004		
Mr.	Ponder	Richard		U.S. Sugar Corporation	P.O. Drawer 1207	Clewiston	FL	33440-1207		
Ms.	Potts	Elsa	Administrator	Florida Department of Environmental Protection	2600 Blairstone Road	Tallahassee	FL	32399-2400		
Mr.	Powell	Tim		Florida Department of Environmental Protection	P.O. Box 15425	West Palm Beach	FL	33416-5425		
Mr.	Price	Jim		DEP/BOMR	2051 East Dirac Drive	Tallahassee	FL	32310		
Ms.	Pugh	Joyce	Legislative Analyst	Florida House of Representatives	40 House Office Building	Tallahassee	FL	32399-1300		
Mr.	Pullen	Curtiss			P.O. Box 727	Clewiston	FL	33440		
Mr.	Pullen	Jon			134 Kilpatrick Road	Clewiston	FL	33440		
Mr.	Putnam	Adam	Representative	Florida House of Representatives	4416 Florida National Drive	Lakeland	FL	33813		
Mr.	Quackenbos	Max		St. Lucie River Initiative	1778 NW Palmetto Terrace	Stuart	FL	34994-9423	(561) 692-1451	
Mr.	Quiroga	Eduardo	Director-Publisher	El Noticiero	2613 W. Davie Blvd	Fort Lauderdale	FL	33312		
Mr.	Ramadan	H.			8051 Damascus Drive	Palm Beach Gardens	FL	33418-6003		
Mr.	Rasmussen	Jay			1262 Sugar Sands Blvd, Apt. 228	Riviera Beach	FL	33404		
Ms.	Recio	Fern		Northwest Florida Water Management District	Route 1, Box 3100	Havana	FL	32333		
Mr.	Reddy	Ramesh		U.S. Soil & Water Science	P.O. Box 110510	Gainesville	FL	32611-0510		
Mr.	Reddy	Steve		Tiger Ranch Cattle Company	P.O. Box 6766	Nalcrest	FL	33856		

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Mr.	Reed	Nathaniel			P.O. Box 1213	Hobe Sound	FL	33455		
Mr.	Resen	Warren			630 J Sea Pine Way	West Palm Beach	FL	33415-8947		
Ms.	Rhodes Manne	Lizabeth	Planning Division	U.S. Army Corps of Engineers	P.O. Box 4970 PD-ES	Jacksonville	FL	32232-0019		
Mr.	Rimes	Tommy	Road Maintenance Director	City of Okeechobee	804 NW 2nd Street	Okeechobee	FL	34972		
Ms.	Riviere	Amber	Chief Planner	Orange County	P.O. Box 1393	Orlando	FL	32802-1393		
Mr.	Roberts	William			217 S Adams Street	Tallahassee	FL	32301-1720		
Mr.	Robinson	James	Director	House Resource & Land Mangement Council	402 S Monroe Street	Tallahassee	FL	32312		
Mr.	Robson	Mark	Regional Director, South Region	Florida Fish & Wildlife Conservation Commission	551 North Military Trail	West Palm Beach	FL	33415	(561) 625-5130	robsonm@gfc.fl.us
Mr.	Roche	Joseph	Director, Public Works	Town of Haverhill	4585 Charlotte Street	Haverhill	FL	33417		
Mr. & Mrs.	Rosenfeld	Stewart & Roslyn			15074 Witney Road, Apt. 209	Delray Beach	FL	33484		
Ms.	Rosenthal	Danielle	Information Systems Manager	Southwest Florida Regional Planning Council	P.O. Box 3455	Fort Myers	FL	33918-3455		
Mr.	Rothe	Richard	Parks & Facilities	City of Wilton Manors	524 NE 21st Court	Wilton Manors	FL	33305-2111		
Mr.	Royce	Bill		Okeechobee County Planning Dept.	499 NW 5th Ave.	Okeechobee	FL	34972-4146		
Mr.	Rucks	Tommy			P.O. Box 95	Okeechobee	FL	34973-0095		
Ms.	Ruffner	Donna		Florida Department of Environmental Protection	3900 Commonwealth Blvd.	Tallahassee	FL	32399-3000		
Ms.	Russell	Linda		The Nature Conservancy	625 N. Adams Street	Tallahassee	FL	32301		
Ms.	Ruth	Barbara			P.O. Box 399	Vero Beach	FL	32961-0399		
Mr.	Ryan	Tim	Representative	Florida House of Representatives	P.O. Box 36	Dania	FL	33004-0036		
Ms.	Sanchez	Judy	Director of Communications	U.S. Sugar Corporation	P.O. Drawer 1207	Clewiston	FL	33440-1207		
Mr.	Santaniello	Neil		The Sun-Sentinel	3333 South Congress	Delray Beach	FL	33445	(561) 243-6625	nsantaniello@sun-sentinel.com
Mr.	Sapp	Steve		Dade County Farm Bureau	1850 Old Dixie Highway	Homestead	FL	33033		
Mr.	Sasser	Lowell			3124 McNeil Road	Ft. Pierce	FL	34981		
Mr.	Satz	Michael	State Attorney	Broward County	201 SE 6th Street, Suite 640	Fort Lauderdale	FL	33301-3303		
Ms.	Schad	Lea		LGS Inc.	3634 North Federal Highway	West Palm Beach	FL	33407	(561) 848-9984	
Ms.	Schaufele	Jennifer		Planning & Environmental Protection	218 SW First Ave.	Ft. Lauderdale	FL	33301		
Mr.	Schenck	Bruce		Harbour Ridge Yacht & Country Club	12600 Harbour Ridge Blvd.	Palm City	FL	34990		
Mr.	Schenck	Kenneth	City Manager	City of Pahokee	171 N. Lake Ave.	Pahokee	FL	33476-1861	(561) 924-5534	cpahokee@aol.com
Mr.	Schiff	Mark			2324 SW 31 Ave.	Pembroke Park	FL	33009-3048		
Mr.	Schueneman	Thomas		Palm Beach County Cooperative Extension Service	2976 SR 15	Belle Glade	FL	33430		
Mr.	Schultz	Randy		The Palm Beach Post	2751 South Dixie Highway	West Palm Beach	FL	33405	(561) 820-4447	
Mr.	Seal	Thomas		Florida Department of Environmental Protection	3900 Commonwealth Blvd. MS #46	Tallahassee	FL	32399-3000		
Mr.	Seibert	Steven		Florida Department of Community Affairs	2555 Shumard Oak Blvd.	Tallahassee	FL	32399-2100		
Mr.	Selfridge	Gordon	Chief Deputy County Attorney	Palm Beach County	301 N. Olive Ave., #601	West Palm Beach	FL	33401-4705		
Mr.	Serrano	Elivio	Vice President for Programs	Community Foundation/P.B. and Martin Co.	324 Datura Street, Suite 340	West Palm Beach	FL	33401		
Ms.	Sewell	AnEta	Media Relations	South Florida Water Management District	P.O. Box 24680	West Palm Beach	FL	33416-4680	(561) 682-6171	
Mr.	Sexton	Matthew		Conservation Fund	224 Datura Street, Suite 209	West Palm Beach	FL	33401		
Mr.	Shapiro	Noel		Star Ranch Enterprises, Inc.	P.O. Box 2001	Hollywood	FL	33022		
Mr.	Sharpe	Sam		USDA - Natural Resources Conservation Service	452 Hwy 98 N.	Okeechobee	FL	34972-2303	(561) 763-3615	sam.sharpe@fl.usda.gov
Mr.	Shelton	Theodore		Rutgers, The State University of New Jesey	80 Nichol Ave.	New Brunswick	NJ	08901		
Mr.	Shine	Jim		Sugar Cane Growers Co-op of Florida	P.O. Box 666	Belle Glade	FL	33430		
Ms.	Shirey	Juanette	Tax Collector	Okeechobee County	307 NW 5th Ave.	Okeechobee	FL	34972-4146		
Mr.	Shoun	Janel		Naples Daily News	P.O. Box 40	Bonita Springs	FL	33959	(941) 992-2110 ext223	
Mr.	Shuler	Kenneth		Cooperative Extension Service, PBC	559 N. Military Trail	West Palm Beach	FL	33415-1311		
Ms.	Sigala	Trish			2360 SE 7th PL	Homestead	FL	33033		
Mr.	Sims	Kenneth			28221 SW 162nd Ave.	Homestead	FL	33033		
Ms.	Singer	Miriam			175 NW First Ave., 28th FL	Miami	FL	33128-1999		
Mr.	Smith	Wayne		Hilliard Brothers of Florida, Ltd.	Route 2, Box 175	Clewiston	FL	33440		
Mr.	Smith	Nevin	Deputy Assistant Executive Director	Florida Department of Environmental Protection	3900 Commonwealth Blvd. MS 45	Tallahassee	FL	32399	(904) 488-2955	
Ms.	Smith	Dawn	Librarian	FAU-Government Documents	P.O. Box 3092	Boca Raton	FL	33431-0992		
Ms.	Smith	Gail			14015 NW 144th Trail	Okeechobee	FL	34972		
Mr.	Smith	Hanley		U.S. Army Corps of Engineers	P.O. Box 4970	Jacksonville	FL	32201-4970		
Mr.	Smith	W. Shelton	City Manager	City of Belle Glade	110 SW Avenue E	Belle Glade	FL	33430		
Ms.	Smith	Cheryl	City Editor	The Tribune	600 Edwards Road	Fort Pierce	FL	34954	(561) 451-2050	
Ms.	Smith	Marjorie			6491 Wild Olive Lane	Stuart	FL	34997		
Mr.	Snyder	Robert			95 Lighthouse Drive	Jupiter	FL	33469-3511		
Mr.	Soles	Tom			4542 SW VanDyke	Port St. Lucie	FL	34953		
Mr.	Spratt	Joseph	Representative	Florida House of Representatives	205 S. Commerce Ave., Suite B	Sebring	FL	33870		
Ms	Springthorpe	Barbara		Greenberg Traurig Hoffman Lippoff Rosen & Quentel,P.A.	777 S. Flagler Dr., Suite 300 E	West Palm Beach	FL	33401		
Ms.	Stallings	Fran	Chairman	Save The Manatee	P.O. Box 366457	Bonita Springs	FL	34136-6457		
Mr.	Stambaugh	Shawn		Agroviron, Inc.	1417 Wedgworth Road	Belle Glade	FL	33430		
Ms.	Stern	Gail			P.O. Box 1208	Loxahatchee	FL	33470		
Ms.	Stock	Grace			274 Kingfisher Ave.	Ft. Pierce	FL	34982		
Mr.	Stossel	Robert		Florida Sportsmen Conservation Association	7407 Southern Blvd.	West Palm Beach	FL	33908		
Mr.	Striska	Joe		Florida Association of Recreation Vehicle	1340 Vickers Ave.	Tallahassee	FL	32303		
Mr.	Strom	Douglas		Florida Department of Environmental Protection	1801 SE Hillmoor Drive, C-204	Port St. Lucie	FL	34952		

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Ms.	Strutzel	Janet			13661-B1 Abbey Drive	Fort Myers	FL	33919		
Ms.	Stubbins	Abraham		City of Margate	5790 Margate Blvd.	Margate	FL	33063-3525		
Ms.	Andrews	Katherine		The Nature Conservancy	625 North Adams Street	Tallahassee	FL	32301-1113	(850) 222-0199	
Ms.	Swartz	Sally		The Palm Beach Post	2101 South Kanner Highway	Stuart	FL	34994	(561) 820-3553	
Mr.	Tanner	Gene		Clewiston Field Station	SR 832/Route 1, Box 103	Clewiston	FL	33440	(863) 983-1431	
Mr.	Tapping	Mitchell			13910 Eagle Ridge Lakes Drive, Suite 202	Fort Myers	FL	33912-1771		
Mr.	Tarr	William		Florida Crystals Corporation	P.O. Box 1059	Palm Beach	FL	33480		
Mr.	Tears	Clarence	Director	Big Cypress Basin	6089 Janes Lane	Naples	FL	34109		
Mr.	Tepper	Craig		Seminole Tribe of Florida	6300 Stirling Road	Hollywood	FL	33024-2198		
Ms.	Thacker	Jo	County Attorney	Osceola County	17 S. Vernon Street, Room 117	Kissimmee	FL	34741-5488		
Mr.	Thames	Gabe			P.O. Box 5124	Miramar	FL	33083		
Ms.	Thomas	Elizabeth			2305 Cold Stream Drive	Winter Park	FL	32792		
Mr.	Thomas	Richard		Town of St. Lucie Village	3772 Outrigger Court	Fort Pierce	FL	34946		
Mr.	Thompson	Joe		J.E.T. Farms, Inc.	P.O. Box 1370	Loxahatchee	FL	33470		
Mr.	Tibbals	Charles		U.S. Geological Survey	224 West Central Parkway, Suite 1006	Altamonte Springs	FL	32714	(407) 648-6191	
Ms.	Tillinghost	Camille			1812 E Oakland Park Blvd., Apt. 33	Oakland Park	FL	33306		
Ms.	Tisdale	Kim		Economic Council of Palm Beach County	1555 Palm Beach Lakes Blvd, Suite 400	West Palm Beach	FL	33401		
Mr.	Torielli	Jack		Sunniland Pipe Line Co., Inc.	P.O. Box 221450	Hollywood	FL	33022-1450		
Mr.	Townsend	Dallas	Director	Hendry County Extension Service	P.O. Box 68	Labelle	FL	33975		
Mr.	Trueman	Adam			P.O. Box 330666	Miami	FL	33233		
Mr.	Tulka	Hester		Florida Federation of Garden Clubs	148 Gregory Place	West Palm Beach	FL	33405-5028		
Mr.	Ulevich	Bob		SFWMD - Okeechobee Field Station	1000 NE 40th Avenue	Okeechobee	FL	34972	(863) 462-5280	
Mr.	Ulmer	Mark			11900 Biscayne Blvd., Suite 612	Miami	FL	33181		
Mr.	Underbrink	Robert		Consolidated Citrus LP	P.O. Box 1210	Belle Glade	FL	33430-6210		
Mr.	Van Sleet	Ron		Sarasota County	1301 Cattlemen Road	Sarasota	FL	34232		
Ms.	Varela	Susan			P.O. Box 1149	Christmas	FL	32709		
Mr.	Vearil	James		U.S. Army Corps of Engineers	P.O. Box 4970	Jacksonville	FL	32232-0019		
Mr.	Vecchioli	John		U.S. Geological Survey	227 N. Bronough Street, Room # 3015	Tallahassee	FL	32301	(904) 942-9500	
Ms.	Vickers	Audrey			1825 Wright Lane	Lorida	FL	33857		
Mr.	Vickers	Richard			375 NW 123 Street	N. Miami	FL	33168		
Mr.	Viollis	George			9825 SW 85 Street	Miami	FL	33173		
Ms.	Vogel	Cathleen			2655 LeJeune Road, Suite 511	Coral Gables	FL	33134		
Mr.	Vossen	Ed			6121 SE Landing Way, Unit 1	Stuart	FL	34997-1804		
Mr.	Waddill	Van	Ctr. Director	University of Florida, IFAS	P.O. Box 8003	Belle Glade	FL	33430-8003		
Mr.	Wade	Malcolm	Sr. Vice President	U. S. Sugar Corporation	P.O. Drawer 1207	Clewiston	FL	33440-1207		
Mr.	Wade	Jeffry		University of Florida	P.O. Box 117629	Gainesville	FL	32611		
Mr.	Waldie	David		City of Cape Coral Public Works	P.O. Box 150027	Cape Coral	FL	33915-0027		
Mr.	Walesky	Richard	Director	Palm Beach County Environmental Resource Management	3323 Belvedere Road, Bldg. 502	West Palm Beach	FL	33406		
Mr.	Walker	Bill			1127 Lowell Road	Concord	MA	01742		
Mr.	Ward	James		City of Weston	210 N University Drive, Suite 301	Coral Springs	FL	33071		
Mr.	Ward	John	President	J-7 Ranch, Inc.	P.O. Box 1687	Ft. Myers	FL	33902		
Mr.	Ward	Gerald		Gerald M Ward Consulting Engineering	P.O. Box 10441	Riviera Beach	FL	33404		
Mr.	Warren	Gary		Florida Fish & Wildlife Conservation Commission	7922 NW 71st Sreet	Gainesville	FL	32653	(941) 462-5190 X279	gwarren@atlantic.net
Mr.	Watford	Cole			1852 NW 9th Street	Okeechobee	FL	34972		
Mr.	Watkins	Mike	Manager	Hundley Farms, Inc.	P.O. Box H	Loxahatchee	FL	33470-0309		
Mr.	Wattendorf	Robert		Florida Fish & Wildlife Conservation Commission	620 South Merridian Street - Farris Bryant Building	Tallahassee	FL	32399-1600	(904) 488-1960	
Mr.	Webber	Chuck		WPEC-TV Channel 12	1100 Fairfield Drive	West Palm Beach	FL	33407	(561) 881-0737	
Mr.	Webster-Demo	Patrick		Florida Department of Transportation	3400 W Commercial Blvd.	Ft Lauderdale	FL	33309-3421		
Mr.	Wedgworth	Dennis		Wedgworth Farms Inc.	P.O. Box 2076	Belle Glade	FL	33430-2076		
Mr.	Weissman	Mark		City of Parkland	6500 Parkside Drive	Parkland	FL	33067-1638		
Mr.	Welch	John			2151 NW 399th Street	Okeechobee	FL	34972	(863)357-1581	jcwelch@strato.net
Ms.	Whirls	Tracy		The Clewiston News	626 West Sugarland Highway	Clewiston	FL	33440	(863) 983-9148	
Mr.	Whitby	Bob		New Times	P.O. Box 14128	Ft. Lauderdale	FL	33302-4128	(954) 233-1600	
Mr.	Whitesides	Douglas			514 Cottonwood Drive	Sebring	FL	33872		
Mr.	Whitfield	Estus			602 North Lakeshore Drive	Tallahassee	FL	32312		
Mr.	Wickstrom	Karl	Editor	Florida Sportsman	2700 S. Kanner Highway	Stuart	FL	34994		
Mr.	Wilcox	J. Ross	Environmental Administrator	Martin County	2401 SE Monterey Road	Stuart	FL	34996	561-288-5508	Rwilcox@martin.fl.us
Mr.	Wilcox	Ben		Florida Public Radio	1600 Red Barber Plaza	Tallahassee	FL	32310-3194	(850) 487-3194	
Ms.	Williams	Dorothy		State Library of Florida-RA-Gray Bldg.	500 S. Bronough Street	Tallahassee	FL	32399-0250		
Ms.	Wilson	Janet	Assistant Editor	WINK-TV Ch-11	2824 Palm Beach Blvd.	Fort Myers	FL	33916		
Mr.	Winters	William		Lake Worth Drainage District	13081 S. Military Trail	Delray Beach	FL	33484-1105		
Mr.	Womble	Gary			2828 NW 46th Ave.	Okeechobee	FL	34972		
Mr.	Womer	C.			4814 Alhambra Ave.	Sebring	FL	33870		
Mr.	Woodley	Michael		Woodley Groves	163 Woodley Road	Frostproof	FL	33843		
Mr.	Worth	Larry		U.S. Sugar Corporation	P.O. Drawer 1207	Clewiston	FL	33440-1207		

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Mr.	York	J.			1819 SW Crane Creek Ave.	Palm City	FL	34990-2215		
Ms.	Zaneski	Cyril		The Miami Herald	One Herald Plaza	Miami	FL	33132		
Mr.	Zebuth	Herb		Florida Department of Environmental Protection	P.O. Box 15425	West Palm Beach	FL	33416-5425	(561) 681-6703	HERBERT.H.ZEBUTH@dep.state.fl.us
Mr.	Ziminski	Mark	Planning Division	U.S. Army Corps of Engineers	P.O. Box 4970 PD-ES	Jacksonville	FL	32232-0019		
Mr.	Zivojnovich	Mark			P.O. Box 367	Ocala	FL	34478-0367		
		Public Affairs Office		National Oceanic and Atmospheric Administration	Department of Commerce	Washington	D.C.	30230		
			Area Engineer	U.S. Army Corps of Engineers	525 Ridge Lawn Road	Clewiston	FL	33440-5372		
			Editor	City Link	P.O. Box 14426	Fort Lauderdale	FL	33302	(954) 356-4943	
				SN Knight & Sons, Inc.	P.O. Box 730	Belle Glade	FL	33430		
			Managing Editor	Community Newspapers	9660 West Sample Road	Coral Springs	FL	33065	(954) 752-7474	
			Town Clerk	Town of Sewall's Point	1 S Sewall's Point Road	Stuart	FL	34996-6736		
				Central County Water Control District	HC61 Box 155	Clewiston	FL	33440		
				Pahokee Chamber of Commerce	115 E. Main Street	Pahokee	FL	33476-1805		
			City Desk	Boca Raton News	5801 North Congress Avenue	Boca Raton	FL	33487	(561) 893-6617	
				Talisman Sugar Corp	P.O. Box 814	Belle Glade	FL	33430		
				C.M. Payne & Son Inc.	9410 Payne Road	Sebring	FL	33872		
				Indiantown Chamber of Commerce	P.O. Box 602	Indiantown	FL	34956-0602		
			Environmental Director	Okeelanta Corporation	P.O. Box 86	South Bay	FL	33493		
				Syfrett Groves	501 SW 28th Terrace	Okeechobee	FL	34974-3957		
			Water Management Engineer	USDA Soil Conservation Service	P.O. Box 248	Labelle	FL	33935-0248		
				USDA Natural Resource Conservation Service	5700 Lake Worth Road, Suite 100	Lake Worth	FL	33463		
Ms.	Valentine	Twila C.	Environmental Reporter	Okeechobee News	107 SW 17th Street, Suite D	Okeechobee	FL	34973	(863) 763-3134	
				National Marine Fisheries Services	11420 N. Kendall Drive, Suite 103	Miami	FL	33176		
				USDA Natural Resources Conservation Service	1895 E Irlo Bronson Memorial Highway	Kissimmee	FL	34744-3725		
				Miccosukee Tribe of Indians of Florida	P.O. Box 440021, Tamiami Station	Miami	FL	33144-0021		
				Martin County Public Library	2351 SE Monterey Road	Stuart	FL	34996		
				Devil's Garden Water Control District	P. O. Box 338	LaBelle	FL	33935		
			Town Manager	Town of Magonia Park	1755 E. Tiffany Drive	Magonia Park	FL	33407		
				Everglades Coordinating Council	16700 SW 68th Street	Fort Lauderdale	FL	33331		
				Palm Beach County Office, South Florida Business Journal	1800 South Australian Avenue, #102	West Palm Beach	FL	33409	(561) 909-0125	
				The Sun Sentinel-Community News Group	9660 West Sample Road	Coral Springs	FL	33065	(954) 752-7474	
			City Manager	City of Cape Coral	P.O. Box 150027	Cape Coral	FL	33915-0027		
			Manager	East County Water Control District	601 E County Lane	Lehigh Acres	FL	33936		
				Florida Fish & Wildlife Conservation Commission	620 S. Meridian Street	Tallahassee	FL	32399-1600		
				Florida Audubon Society	1331 Palmetto Ave, Suite. 110	Winter Park	FL	32789		
				Florida Lime & Avocado Commission	18710 SW 288 Street	Homestead	FL	33030		
		Editor		WAFC-AM	116 Commercio Street	Clewiston	FL	33440	(863) 983-6160	
		Assignment Desk		WBBH-TV/ Channel 20 NBC	3719 Central Avenue	Ft. Myers	FL	33901	(941) 936-6458	
		Assignment Desk		WEAT-FM	701 Northpoint Parkway, Suite 500	West Palm Beach	FL	33407	(561) 686-9505	
		Station Manager		FGCU	8111 College Park	Ft. Myers	FL	33919	(941) 432-5580	
		Assignment Desk		WINK-AM/FM	2824 Palm Beach Blvd.	Ft. Myers	FL	33916	(941) 337-2346	
		Assignment Desk		WINK- Channel 11 CBS	2824 Palm Beach Blvd.	Ft. Myers	FL	33916	(941) 334-1131	
		Assignment Desk		WJNO-AM	3071 Continental Drive	West Palm Beach	FL	33407	(561) 616-6758	
		Assignment Desk		WOKC AM	3101 South Highway 441	Okeechobee	FL	34973	(863) 763-3181	
				Governor's Commission for the Everglades	1550 Madruga Ave, Suite 412	Coral Gables	FL	33146		
Mr.	Peterson	Dave		WPTV	622 North Flagler Drive	West Palm Beach	FL	33401	(561) 653-5711	
		Assignment Desk		WQCS-FM Ft. Pierce (NPR)	3209 Virginia Avenue	Ft. Pierce	FL	34981	(561) 462-4747	
				Hendry County Engineering	P.O. Box 1607	Labelle	FL	33975		
		Station Manager		WXEL-FM/TV	3401 South Congress Avenue	Boynton Beach	FL	33426	(561) 737-8000	
		Assignment Desk		WZVN-Channel 26 ABC	3719 Central Blvd.	Ft. Myers	FL	33901	(941) 936-6458	
				C. M. Payne & Son Inc.	9410 Payne Road	Sebring	FL	33872-9716		
				Hillsborough River State Park	15402 U.S. Hwy 301 N.	Thonotosassa	FL	33592		
Mr.	Henderson	Kevin		St. Lucie River Initiative		Stuart	FL	34994	(561) 223-1005	egreen@gate.net
Mr.	Murray	Brent	Vice President	Environmental Quality, Inc.	135 Lighthouse Drive	Teqesta	FL	33469	(561) 624-5747	eqibcm@aol.com
Ms.	Charles	Angie		U.S. Army Corps of Engineers	525 Ridgelawn Road	Clewiston	FL	33440	(863) 983-8101	Angie.L.Charles@usace.army.mil
Mr.	Todd, P.E.	Kenneth S.	Water Resources Manager	Palm Beach County	P.O. Box 16097	West Palm Beach	FL	33401	(561) 355-4600	ktodd@co.palm-beach.fl.us
Mr.	Mitnik	John		Florida Department of Environmental Protection	400 North Congress Avenue	West Palm Beach	FL	33406	561-681-6709	john.mitnik@dep.state.fl.us
Ms.	Case-O'Bourke	Nancy		Case O'Bourke Engineering	3550 Biscayne Blvd.	Miami	FL	33137	(305) 572-9960	Nancy@caseobourke.com
Mr.	Barry	Robert		Palm Beach Community College	4200 Congress Avenue	Lake Worth	FL	33461	(561) 434-5129	barryr@pbcc.cc.fl.us
Ms.	Daromb	Samica		University of Florida	3200 East Palm Beach Road	Belle Glade	FL	33430	(561) 993-1593	sdaroub@mail.ifas.ufl.edu
Mr.	Walsh	Joe		Florida Fish & Wildlife Conservation Commission	255 154th Avenue	Vero Beach	FL	32968	(561) 778-5094	walshj@gfc.state.fl.us
Mr.	Hornung	Lewis		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406	561-682-2007	lhornun@sfwmd.gov
Mr.	Havens, Ph.D.	Karl	Senior Scientist, Lake Okeechobee	South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406	(561) 682-6534	khavens@sfwmd.gov
Mr.	Veach	Bill	City Manager	City of Okeechobee	55 SE Third Avenue	Okeechobee	FL	34974	(863) 763-3372	bveach@cityofokeechobee.com
Mr.	James	R. Thomas	Senior Supervising Environmental Scientist	South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406	(561) 682-6356	tjames@sfwmd.gov

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Mr.	Erskine	James	Water Quality Manager	Miccosukee Tribe	P.O. Box 40021	Miami	FL	33144	(305) 233-8380 x22	jameserskine@earthlink.net
Mr.	Jin	Kang-Ren		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406	(561) 682-6529	kjin@sfwmd.gov
Ms/	Shooshani	Margaret	President	MSAI	P.O. Box 970125	Boca Raton	FL	33497	(561) 483-0603	mshoosh@icanect.net
Mr.	Hewett, III	Earnest J.		University of Florida, EREC	3200 East Palm Beach Road	Belle Glade	FL	33430	(561) 993-1596	ejhiii@ufl.edu
Mr.	Woelhke	Carl		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406	(561) 682-6659	lwoehlk@sfwmd.gov
Commissioner	Bolton	Linda	Commissioner	City of Wellington	1986 S. Club	Wellington	FL	33414	(561) 798-6534	BOLTONLL@aol.com
Mr.	Scott	Sherry B.		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406	(561) 682-6803	sscott@sfwmd.gov
Mr.	Barry	James		Palm Beach County, DERM	3323 Belvedere Road, Bldg. 502	West Palm Beach	FL	33406	(561) 233-2400	
Mr.	Wright	Bishop, Jr.	President	Everglades Coordinating Council	15439 94th Street North	West Palm Beach	FL	33412	(561) 795-1375	
Ms.	Villapando	Odi		South Florida Water Management District	205 Parrott Ave, Suite 201	Okeechobee	FL	34972	(863) 462-5260 x30	rvillap@sfwmd.gov
Ms.	Foster	Tanya		Kimley-Horn	2400 SE Federal Highway, # 302	Stuart	FL	34994	(561) 286-2190	tfoster@kimley-horn.com
Mr.	Nelson	Wayne		Fishermen Against the Destruction of the Everglades	P.O. Box 16061	West Palm Beach	FL	33416	(863) 357-7144	
Mr.	Grezelka	Michael		Kinley-Horn	2400 SE Federal Highway, #302	Stuart	FL	34994	(561) 286-2190	mgrzelka@kimley-horn.com
Mr.	Zhu	Dongwei		MacVicar, Fredrico & Lamb	4524 Gun Club Road, Suite 201	West Palm Beach	FL	33415	(561) 689-1708	zhu@mfl-inc.com
Mr.	Ingram	Kevin		Chemical Lime Company	31 Inverness Parkway, #425	Birmingham	AL	35242	(808) 605-7783	kevin.ingram@chemicallime.com
Mr.	Collins	Jim		EA Engineering, Science, and Technology, Inc.	15500 New Barn Road	Miami Lakes	FL	33014	(305) 819-2212	
Ms.	Head	Caroll		Friends of Lake Okeechobee	2252 SW 22nd Circle	Okeechobee	FL	34974	(863) 763-3568	chead@ircc.net
Ms.	Barletto	Missie		South Florida Water Management District	205 Parrott Avenue, Suite #201	Okeechobee	FL	34972	(863) 462-5260 x 30	mbarlett@sfwmd.gov
Mr.	Muricci	Frank		Fast Break	1505 Highway 78 West	Okeechobee	FL	34974	(863) 467-4300	
Mr.	Hoover	Sorrel		Orion, Inc.	3642 Lothair Ave.	Boynton Beach	FL	33436	(561) 731-0122	orion-inc@mindspring.com
Mr.	Price	Rick		Lockhart Ag Technologies	1385 Riverside Circle	Wellington	FL	33414	(561) 792-1052	Agman@earthlink.net
Mr.	Dwinell	Bill	President	Friends of Istopoga Lake Association, Inc.	P.O. Box 155	Lorida	FL	33857	(941) 490-0140	
Mr.	Barnett	Earnest	Director of Ecosystem Planning and Coordin	Florida Department of Environmental Protection	3900 Commonwealth Boulevard (MS-45)	Tallahasee	FL	32399-3000	(850) 488-4892	Earnie. Barnett@dep.state.fl.us
Mr.	Best	Ronnie G.	Branch Chief & Supervisory Ecologist	USGS Biological Resources Division	FIU, University Park OE Bldg, Room 148	Miami	FL	33199	(305) 348-3095	Ronnie_Best@USGS.gov
				National Research Council	2101 Constitution Avenue, NW	Washington	D.C.	20418	(202) 334-3422	
Mr.	Bradford	Mark	Office of Trust Responsibilities	Bureau of Indian Affairs	1849 C Street NW, MS-4513, Main Interior Building	Washington	DC	20240	(202) 208-3598	mark_bradford@ios.doi.gov
Mr.	Brown	Bradford E.	Director, Southeast Fisheries Service	NOAA, US Department of Commerce	75 Virginia Beach Drive	Miami	FL	33149	(305) 361-4284	brad_brown@noaa.gov
Mr.	Causey	Billy D.	Sanctuary Superintendent, Florida Keys Nat	NOAA, US Department of Commerce	P.O. Box 500368	Marathon	FL	33050	(305) 743-2437	
Mr.	Daltry	Wayne E.	Executive Director	Southwest Florida Regional Planning Council	4980 Bayline Drive, 4th Floor	North Fort Myers	FL	33918	(941) 656-7720	
Mr.	Thornton	Harkley	Governing Board Member	South Florida Water Management District	P.O. Box 700665	St. Cloud	FL	34770	(407) 296-0411	
Mr.	Gutierrez, Jr. E	Nicolas	Governing Board Member	South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406	(305) 373-0300	
Ms.	Williams	Trudi K.	Governing Board Member	South Florida Water Management District	TKW Engineering - 12553 New Brittany Blvd. # 32	Ft. Myers	FL	33907	(941) 278-1992	
Mr.	Lindall	Lenhart E.	Governing Board Vice Chair	South Florida Water Management District	LBFH, Inc. 2090 Palm Beach Lakes Blvd. Suite 600	West Palm Beach	FL	33409	(561) 684-3375	
Mr.	Gleason	Patrick J.	Governing Board Member	South Florida Water Management District	Camp Dresser & McKee, 1601 Belevedere Road, Suite 211	West Palm Beach	FL	33406	(561) 689-3336	
Mr.	English	Hugh	Governing Board Member	South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406	(561) 686-8800	
Ms.	Brooks-Thomas	Pamela	Governing Board Member	South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406		
Mr.	Fernandez	Gerraldo B.	Governing Board Member	South Florida Water Management District	14201 SW 248th Street	Redlands	FL	33023	305-662-1927	
Mr.	Schoeder	Richard		BP Technology, Inc.	4035 NW 56th Way	Gainesville	FL	32606	(352) 367-1235	gnvfieldofc@msn.com
Ms.	Degraffenreidt	Carol E, A.		US Attorney's Office - Civil Division	99 NE 4th Street, Room 330	Miami	FL	33132-2111	(305) 961-9930	
Mr.	Duke	Frank M.	Director	Palm Beach County Planning Department	100 Australian Avenue, 5th Floor	West Palm Beach	FL	33406	(561) 233-5300	fduke@co.palm-beach.fl.us
Mr.	Truman	Eugene Duncan	Water Resources Director	Micosukee Tribe of Indians of Florida	P.O. Box 440021, Tamiami Station	Miami	FL	33144	(305) 223-8380	duncan2u@aol.com
Mr.	Evink	Gary	State Ecologist	Florida Department of Transportation	MS 37, 605 Suwannee Street	Tallahassee	FL	32399	(850) 487-2781	gary.evink@dot.state.fl.us
Ms.	Finnery	Maureen	Superintendent, Everglades National Park	National Park Service, U.S. Department of the Interior	40001 State Road 9336	Homestead	FL	33034	(305) 242-7710	maureen_finnerty@nps.gov
Mr.	Forsythe	Stephen	Florida State Supervisor	U.S. Fish and Wildlife Service	P.O. Box 2676	Vero Beach	FL	32960	(561) 778-0896	stephen_forsythe@fws.gov
	Public Opinion			Okeechobee News						
Mr.	Boyd	John	Director, Engineering	Palm Beach County Solid Waste Authority	7501 North Jog Road	West Palm Beach	FL	33412	(561) 640-4603	
Ms.	Coulon	Myrtle			1301 SW Avenue C Place	Belle Glade	FL	33430	(561) 996-5893	
Ms.	Chamblee	Sandra		Glades Health Initiative	136 S. Main Street	Belle Glade	FL	33430	(561) 996-0500	
Ms.	Kendall	Mary			324 NW Avenue D	Belle Glade	FL	33430	(561) 995-4490	
Ms.	Laramore	Cynthia		ACTION	417 NW 16th Street/ PO Box 16	Belle Glade	FL	33450	(561) 993-9100	laramore@aol.com
Ms.	Bell-Spence	Barbara			740 SE 1st Street	Belle Glade	FL	33430	(561) 996-1628	
Mr.	Royal	Al			1401 NW F Place	Belle Glade	FL	33430	(561) 992-1900	
Dr.	White	George			601 SW 12th Street	Belle Glade	FL	33430	(561) 996-3855	
Ms.	Moore-Williams	Autrie			401 SE 2nd Street	Belle Glade	FL	33430	(561) 992-9500	
Ms.	Mc Donald	Paula			P.O. Box 2885	Belle Glade	FL	33430	(561) 992-4855	
Ms.	Walker	Shirley		L.S.F./PEPPI Head Start	200 SW 9th Street	Belle Glade	FL	33430	(561) 996-1718	
Ms.	Brown	Sandra			P.O. Box 422	South Bay	FL	33493	(561) 996-9487	
Mr.	Augusting	Blunzell		Palm Beach County Health Department	38754 State Road 80	Belle Glade	FL	33430	(561) 996-1600	
Mr.	Harris	J.R.			P.O. Box 167	Belle Glade	FL	33430	(561) 993-3479	
Mr.	Canales	Joe			340 S.E. 4th Street	South Bay	FL	33493	(561) 996-9493	
Ms.	Allen	Mary			270 SW 7th Avenue	South Bay	FL	33493	(561) 996-0661	
Mr.	Allen	Paul			33 NE Avenue I	Belle Glade	FL	33430	(561) 992-7093	
Mr.	Kyles	Joe			275 SW 9th Avenue	South Bay	FL	33493	(561) 996-6324	
Mr.	Ramos	Jose		Florida Fish and Wildlife Conservation Commission	P.O. Box 2403	Belle Glade	FL	33430	(561) 924-5123	
Mr.	Singletary	Roy	Mayor	City of Pahokee	171 North Lake Avenue	Pahokee	FL	33476	(561) 924-5534	

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Mr.	Bronson	Charles	Commissioner	Department of Agriculture & Consumer Services	PL 10 Capitol	Tallahassee	FL	32399	(850) 488-3022	
Ms.	Knox	Carol	Office of Environmental Services	Florida Fish & Wildlife Conservation Commission	255 154 Avenue	Vero Beach	FL	32968	(561) 778-5094	
Mr.	Fistikelli	Freddi		ECC	16700 SW 68th Street	Ft. Lauderdale	FL	33331	(954) 434-7841	
	Public Meeting Attendee									
	Public Meeting Attendee			Public Comment						
Mr.	Thompson	Curt	Public Outreach Specialist	U.S. Army Corps of Engineers	3301 Gun Club Road	West Palm Beach	FL	33405	(561) 683-2651 #29	curt.thompson@usace.army.mil
Mr.	Schubert	Steve T.		U.S. Fish & Wildlife Service	1339 20th Street	Vero Beach	FL	32960	(561) 562-3909 X24	Steve_Shubert@FWS.gov
Ms.	Silver	Vicki		Palm Beach County Planning Division	100 Australian Avenue	West Palm Beach	FL	33406	(561) 233-5313	vsilver@co.palm-beach.fl.us
Ms.	Orsenigo	Mary			101 SE 9th Street North	Belle Glade	FL	33430	(561) 996-5198	
Commissioner	Jones	K.S. Butch	Commissioner	Glades County Commission	P.O. Box 10	Moore Haven	FL	33471	(863) 946-2140	gladescomgr@ictransnet.com
Mr.	Hopple	Clyde	Civil Engineer	U.S. Army Corps of Engineers, Jacksonville District	400 W. Bay Street	Jacksonville	FL	32223	(904) 232-1678	clyde.f.hopple@usace.army.mil
Mr.	Cook	David C.		South Florida Conservancy	P.O. Box 896	Belle Glade	FL	33430	(561) 996-2940	dcwater@gate.net
Commissioner	Barry	Esther	Commissioner	City of South Bay	335 SW 2nd Ave	South Bay	FL	33493		
Mr.	Wilson	Charles		U.S. Sugar Corporation	380 US Hwy 27	South Bay	FL	33493	(561) 993-9702	cwilson@ussc.com
Mr.	Feddersen	Jamie		Florida Fish & Wildlife Conservation Commission	3200 TM Goodwin Road	Fellsmere	FL	32948	(321) 726-2862	fedderj@gfc.state.fl.us
Mr.	Ellison	Todd		City of Belle Glade	1016 W. Canal St South	Belle Glade	FL	33430	(561) 996-5876	belleglade_w@yahoo.com
Mr.	Hess	John C.		U.S. Army Corps of Engineers	P.O. Box 4970	Jacksonville	FL	32202	(904) 899-5013	john.c.hess@usace.army.mil
Mr.	Patino	Jorge	Project Manager	South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL		(561) 686-8800	jpatino@sfwmd.gov
Mr.	Dennis	Duke		U.S. Army Corps of Engineers	400 West Bay Street	Jacksonville	FL	32332		dennis.r.duke@usace.army.mil
Mr.	Tate	Houston L.	Assistant Director of Public Service	City of Belle Glade	2050 S Canal	Belle Glade	FL	33430		
Mr.	Blackwelder	Brion		Environmental Land Use Law Center, Inc.	3305 College Ave	Ft. Lauderdale	FL	33430	(954) 262-6135	blackwelderb@nsu.law.nova.edu
Mr.	Maharrey	Byron		Florida Sportsmen Conservation Association	329 Emerson Circle	Palm Springs	FL	33461	(561) 967-7134	
Mr.	Flinchum	Mitch		University of Florida, IFAS	3200 East Palm Beach Blvd.	Belle Glade	FL	33430	(561) 993-1523	dmflinchum@mail.ifas.ufl.edu
Ms.	Webb	Eva		Florida Farm Bureau	16700 West Epson Drive	Loxahatchee	FL	33470	(561) 795-6169	evawebb@aol.com
Mr.	Jackson	Michael E.	City Manager	City of South Bay	335 SW 2nd Avenue	South Bay	FL	33493	(561) 996-6751	southbaycm@aol.com
Mr.	Cone	Tommy	Director, Public Services	City of Belle Glade	110 SW Avenue E	Belle Glade	FL	33430	(561) 792-1636	
Mr.	Lopez	Pepe		U.S. Sugar Corporation	P.O. Box 1207	Clewiston	FL	33440	(561) 993-3713	plopez@ussugar.com
Ms.	Whalen	Benita		South Florida Water Management District	3301 Gun Club	West Palm Beach	FL	33406	(561) 686-8800	bwhalem@sfwmd.gov
Mr.	Houck	Russel	Sr. Project Engineer I	Blasland, Bouck & Lee, Inc.	6723 Towpath Road	Syracuse	NY	13214-0066	(315) 446-2570 X37	ren@bbl-inc.com
Mr.	Fowler	Alan	Vice President	Blasland, Bouck & Lee, Inc.	100 Cummings Center, Suite 324 J	Beverly	MA	01915-6112	(978) 921-0442	af@bbl-inc.com
Dr.	Pollman, Ph.D.	Curt		Tetra Tech, Inc.	408 West University Avenue	Gainesville	FL	32608	(352) 379-2757	cpollman@worldnet.att.net
Mr.	Mohan	Ram K.	Principal Engineer	Blasland, Bouck & Lee, Inc.	326 First Street, Suite 200	Annapolis	MD	21403-2678	(410) 295-1205	rkm@bbl-inc.com
	Public Meeting Attendee									
Mr.	Waldon	Michael G.	Sentior Hydrologist	U.S. Fish & Wildlife Service, ARM Loxahatchee National Wildlife Ref	10216 Lee Road	Boynton Beach	FL	33437	(561) 732-3684 x 11	waldon@members.asce.org
Ms.	Mendendez	Brenda	Intergovernmental Coordination	Florida Department of Community Affairs	2555 Shumard Oaks Blvd.	Tallahassee	FL	32399	(850) 922-1829	b.menendez.dca.state.fl.us
				The Okeechobee News						
				The Okeechobee News						
				The Okeechobee News						
				The Okeechobee News						
				The Okeechobee News						
Ms.	Childress	Allyn		South Florida Ecosystem Restoration Task Force	1430 Washington Street	Hollywood	FL	33020		
Ms.	Ackerman-Whi	Danna		Lake Worth Drainage	13081 Military Trail	Delray Beach	FL	33484		
Ms.	Ball	Christine		Everglades Foundation	P.O. Box 1915	Islamorada	FL	33036		
Ms.	Barley	Mary		Everglades Foundation	P.O. Box 1915	Islamorada	FL	33036		
Mr.	Bogardus	David		World Wildlife Fund	1909 Harrison Street #207	Hollywood	FL	33020		
Mr.	Bauer	Mike		Audubon of Florida	375 Sanctuary Road	Naples	FL	34120		
Mr.	Ames	Edward		Mary Flagler Cary Charitable Trust	122 East 42nd Street Room 3505	New York	NY	10168		
Ms.	Baughman	Kathy		The Trust for Public Land	306 N. Monroe	Tallahassee	FL	32301		
Mr.	Bonner	Richard		U.S. Army Corps of Engineers	P.O. Box 4970	Jacksonville	FL	32232		
Mr.	Ammon	Kenneth		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406		
Ms.	Briggs	Sandy		Arthur R. Marshall Foundation	525 S. Flagler Suite 456	West Palm Beach	FL	33401		
Mr.	Appelbaum	Stu		U.S. Army Corps of Engineers	P.O. Box 4970	Jacksonville	FL	32232		
Ms.	Bausch	Joan		Martin County Florida Native Plant Society	20 South Sewall's Point Road	Sewall's Point	FL	34996		
Ms.	Brooks-Thomas	Pamela		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406		
Mr.	Armstrong	Thomas		U.S. Geological Survey	12201 Sunrise Valley MS-150	Reston	VA	20192		
Ms.	Bundrick-Hamr	Ellen		Clean Water Action	4455 Connecticut Ave	Washington	DC	20008		
Ms.	Austin	Alison		Audubon of Florida	444 Brickell Ave #850	Miami	FL	33131		
Mr.	Bermuda	Navis		NRDC	40 West 20th Street	New York	NY	10011		
Mr.	Burgess	Donald		Broward County DPEP	218 SW First Ave	Ft. Lauderdale	FL	33301		
Ms.	Bague	Irela		Audubon of Florida	444 Brickell Ave #850	Miami	FL	33131		
Mr.	Berry	Len		Center for Environmental Studies - FAU	3932 RCA Blvd #3210	Palm Beach Gardens	FL	33410		
Ms.	Burzycki	Gwen		Miami Dade DERM	33 SW 2nd Ave	Miami	FL	33130		
Ms.	Best	Ronnie		USGS Everglades Science Program	15631 SW 48th Street	Miami	FL	33185		
Mr.	Bushey	Randy		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406		
Ms.	Balbin	Maribel		South Florida Water Management District	172 West Flagler Street	Miami	FL	33130		

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Mr.	Bilello	Louis		CDM	8659 Baypine Road	Jacksonville	FL	32256		
Ms.	Carroll	Patricia		Broward County DPEP	218 SW First Ave	Ft. Lauderdale	FL	33301		
Ms.	Daneri	Celia		Miccosukee Tribe of Florida	P.O. Box 440021	Miami	FL	33144		
Mr.	Duke	Dennis		U.S. Army Corps of Engineers	400 West Bay Street	Jacksonville	FL	32232		
Mr.	Duncan	Truman		Miccosukee Tribe of Florida	P.O. Box 440021	Miami	FL	33144		
Mr.	Dunne	Robert		U.S. Army Corps of Engineers	400 West Bay Street	Jacksonville	FL	32232		
Ms.	Castillo	Selene		Miccosukee Tribe of Florida	P.O. Box 440021	Miami	FL	33144		
Mr.	Dean	Henry		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406		
	Eller	Tambour		U.S. Army Corps of Engineers	P.O. Box 4970	Jacksonville	FL	32232		
Mr.	Clark	Ronald		Big Cypress National Preserve	HCR 61 Box 110	Ochopee	FL	34141		
Mr.	Erskine	James		Miccosukee Tribe of Florida	P.O. Box 440021	Miami	FL	33144		
Mr.	Collins	Michael		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406		
Ms.	Estenoz	Shannon	Director	World Wildlife Fund	1909 Harrison Street #207	Hollywood	FL	33020		
Ms.	Curtis	Jennifer		World Wildlife Fund	102 Pine Street	Carrboro	NC	27510		
Mr.	Duck	Jim		U.S. Army Corps of Engineers	400 West Bay Street	Jacksonville	FL	32259		
Ms.	Eustis	Christine		U.S. Fish and Wildlife	1875 Century Blvd	Atlanta	GA	30345		
Ms.	Daigle	Stephanie		EPA / OPEI	1200 Pennsylvania Ave NW Rm 3513 AR	Washington	DC	20460		
Ms.	Duerr	Naomi		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406		
Ms.	Evoy	Jean		Miami Dade DERM	33 SW 2nd Ave	Miami	FL	33130		
Mr.	Farrell	Chris		Audubon of Florida	444 Brickell Ave #850	Miami	FL	33131		
Dr.	Gray, Ph.D.	Paul N.	Lake Okeechobee Watershed Science Coor	Audubon of Florida	100 Riverwood Circle	Lorida	FL	33857	863-467-8497	audubon@okeechobee.com
Mr.	Feeney	Rory		Miccosukee Tribe of Florida	P.O. Box 440021	Miami	FL	33144		
Ms.	Greene	Juanita		Friends of the Everglades	7800 Red Road	South Miami	FL	33143		
Mr.	Groat	Charles		U.S. Geological Survey	100 National Center	Reston	VA	20192		
Ms.	Finnerty	Maureen		National Parks Service	400001 State Road 9336	Homestead	FL	33034		
Mr.	Guest	David		Earth Justice	P.O. Box 1329	Tallahassee	FL	32302		
Mr.	Hamilton	Sam		U.S. Fish and Wildlife	1875 Century Blvd	Atlanta	GA	30345		
Ms.	Harrison	Debra		World Wildlife Fund	8075 Overseas Highway	Marathon	FL	33050		
Mr.	Leary	William		Council on Environmental Quality	722 Jackson Place	Washington	DC	20503		
Mr.	Horning	David		U.S. Fish and Wildlife	1875 Century Blvd.	Atlanta	GA	30345		
Mr.	Leketa	Anthony		U.S. Army Corps of Engineers, South Atlantic Division	60 Forsyth Street SW - Room 9M15	Atlanta	GA	30303-8801		
Ms.	Klee	Ann		U.S. Department of the Interior	1849 CSTNW	Washington	DC	20240		
Mr.	Koch	John		Sierra Club - Loxahatchee Group	4303 Barbridge Road	West Palm Beach	FL	33406		
Ms.	Lange	Barbara		Sierra Club	3198 Via Abitare	Coconut Grove	FL	33133		
Ms.	Lynch	Sarah		World Wildlife Fund	1250 24th Street NW	Washington	DC	20037		
Ms.	Marshall	Barbara		The Trust for Public Land	7900 Red Road #25	Miami	FL	33143		
Ms.	Munson	Mary		National Parks Conservation Association	1909 Harrison Street #207	Hollywood	FL	33020		
Mr.	Mooney	Bob		U.S. Geological Survey	3301 Gun Club Road	West Palm Beach	FL	33406		
Ms.	Payton	Nancy		Florida Wildlife Federation	2590 Golden Gate Pkwy #109	Naples	FL	34105		
Mr.	Parks	Paul		Florida Wildlife Federation	P.O. Box 6870	Tallahassee	FL	32314		
Mr.	Salt	Rock		U.S. Department of the Interior	FIU OE 148	Miami	FL	33199		
Mr.	Reed	Nathaniel			P.O. Box 1213	Hobe Sound	FL	33475		
Ms.	Siebodnik	Kathleen		League of Women Voters	32 Pebble Beach Blvd	Naples	FL	34113		
Ms.	Teel	Susan		Environmental Protection Agency	400 N. Congress Ave	West Palm Beach	FL	33401		
Ms.	Sorenson	Kathy		Miami Dade County	111 NW First Street	Miami	FL	33128		
Mr.	Strahl	Stuart		Audubon of Florida	444 Brickell Ave #850	Miami	FL	33131		
Ms.	Tinsley	Joanne		Nova Environmental Law Clinic	6630 SW 39th Street #36	Davie	FL	33314		
Mr.	White	David		The Ocean Conservancy	449 Central Ave #200	St. Petersburg	FL	33701		
Ms.	Wilcox	Joan		Environmental & Land Use Law Center	95 South River Road	Stuart	FL	34996		
Ms.	Williams	Trudi		South Florida Water Management District	3301 Gun Club Road	West Palm Beach	FL	33406		
Ms.	Woody	Theresa		South Florida Ecosystem Restoration Task Force	FIU Main Campus OE-148	Miami	FL	33199		
Ms.	Chandler	Maria		Okeechobee News		Okeechobee	FL			
	Okeechobee News			Okeechobee News		Okeechobee	FL			
Mr.	Eng	David		Top Performance Marine, LOBOS	4375 Highway 441 South	Okeechobee	FL	34974		
Mr.	Ferguson	Dave		Fergie's Restaurant, LOBOS	11295 Martin Blvd	Moore Haven	FL	33471		
Mr.	Ford	Charlie		LOBOS	3513 SE 26th Street	Okeechobee	FL	34974		
Mr.	Ford	Harvey		LOBOS	2102 S.E. 29th Street	Okeechobee	FL	34974		
Mr.	Foy	Matthew		Taylor Creek Condos, LOBOS	3124 Highway 441 S.E.	Okeechobee	FL	34974		
Mr.	Fraser	John		Clewiston Public Library, LOBOS	120 W. Osceola Ave	Clewiston	FL	33440		
Mr.	Freed	Charles		LOBOS	2995 Highway 441 S.E.	Okeechobee	FL	34974		
Mr.	Frisby	Scott		Tropical Breeze Marina, LOBOS	2345 Highway 441 S.E.	Okeechobee	FL	34974		
Mr.	Glennon	Robert		LOBOS	1494 N.W. 43rd Ave	Okeechobee	FL	34972		
Ms.	Goodyear	Jeanne		Pier II, LOBOS	2200 Highway 441 S.E.	Okeechobee	FL	34974		
Mr.	Gray	Paul		Audubon Society & LOBOS	100 Riverwoods Circle	Lorida	FL	33857		
Mr.	Griffin	Sam		LOBOS/ Fishermans Heaven	P.O. Box 1496	Moore Haven	FL	33471	863-946-3441	

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Ms.	Groves	Janice		LOBOS	P.O. Box 2518	LaBelle	FL	33975		
Mr.	Hall	Jim		Treasure Island Plaza & LOBOS	3651 Highway 441 S.E.	Okeechobee	FL	34973		
Mr.	Harper	Charles		LOBOS	P.O. Box 505	Canal Point	FL	33438		
Mr.	Harris	Larry		LOBOS	12836 Longford Road	North Palm Beach	FL	33408		
Mr.	Hazellief	David		Okeechobee County BCC & LOBOS	1200 S. Parrott Ave	Okeechobee	FL	34974		
Ms.	Hooks	Lynne		Okeechobee County Emergency Management & LOBOS	9892 Highway 441 S.E.	Okeechobee	FL	34974		
Mr.	Horner	Joe		LOBOS	Rt. #2, Box 925	Clewiston	FL	33440		
Mr.	Horner	Mike		LOBOS	Rt. #2, Box 925	Clewiston	FL	33440		
Mr.	Jones	Pete		LOBOS	Rt. #8, Box 809	Okeechobee	FL	34974		
Mr.	Krattizer	Russell		LOBOS	9308 SE 69th Drive	Okeechobee	FL	34974		
Mr.	Krattizer	Wayne		Reptile Supply & LOBOS	9892 Highway 441 S.E.	Okeechobee	FL	34974		
Ms.	Kennington-Ko	Judi		LOBOS	P.O. Box 2340	LaBelle	FL	33975		
Ms.	Letz	Anna		LOBOS	531 County Road 721 Loop	Moore Haven	FL	33471		
Mr.	Liftman	Dan		Congressman Alcee Hastings Office & LOBOS	5725 Corporate Way, Suite 208	West Palm Beach	FL	33407		
Mr.	Machek	Richard		State Representative, District 78 & LOBOS	4188 Okeechobee Blvd, #87	Ft. Pierce	FL	34947		
Mr.	MacLean	Greg		Okeechobee Fishing HQ &LOBOS	3235 Highway 441 S.E.	Okeechobee	FL	34974		
Ms.	Powers	Gail	President	LOBOS & Gail's Bait Pail	13500 Highway 441 S.E.	Okeechobee	FL	34974	863-357-6525	
Mr.	Hardy	Rondo	Vice President	LOBOS	2821 S.E. 33rd Drive	Okeechobee	FL	34974		
Ms.	Cannon	Sherry	Treasurer	Tropical Breeze & LOBOS	2345 Highway 441 S.E.	Okeechobee	FL	34974		
Mr.	Murchie	Rob	Regional Representative	LOBOS	4500 Joe Overstreet Road	Kenansville	FL	34734		
Mr.	Simmons	Harry	Regional Representative	LOBOS	148 Chobee Street	Okeechobee	FL	34974		
Mr.	Corbin	Charlie	Regional Representative	LOBOS	P.O. Box 250	Belle Glade	FL	33430		
Ms.	Martin	Mary Ann	Regional Representative	LOBOS	920 E. Del Monte	Clewiston	FL	33440		
Mr.	Bedell	Ed	Regional Representative	LOBOS	114 Florida Ave	Moore Haven	FL	33471		
Mr.	Abney	John		Okeechobee County BCC & LOBOS	P.O. Box 700	Okeechobee	FL	34973		
Mr.	Agnew	Keith		LOBOS	7545 Highway 441 S.E.	Okeechobee	FL	34974		
Ms.	Avery	Debbie		Glades Co. EDC, Inc.	P.O. Box 1003	Moore Haven	FL	33471		
Mr.	Beahl	Donald		LOBOS	13500 Highway 441 S.E.	Okeechobee	FL	34974		
Mr.	Bennett	Ross		LOBOS	455 East State Road 78	Lakeport	FL	33471	863-946-0011	
Ms.	Boyer	Betty		LOBOS	P.O. Box 2465	Belle Glade	FL	33430		
Mr.	Britt	Gene		LOBOS	52 Maple Street	Okeechobee	FL	34974		
Mr.	Buenaventura	Italo		Big Lake Marina & LOBOS	964 Highway 441 S.E.	Okeechobee	FL	34974		
Mr.	Challancin	Mike		LOBOS	P.O. Box 2225	Belle Glade	FL	33430		
Ms.	Clark	Carolyn		LOBOS	215 E. State Road 78	Lakeport	FL	33471		
Mr.	Cockroft	Lee		LOBOS	913 Eden Drive	St. Cloud	FL	34771		
Mr.	Cowart	Wendall		Knot's Landing RV Park & LOBOS	5300 Highway 441 S.E.	Okeechobee	FL	34974		
Mr.	Crossman	Larry		Wanta Linga Motel & LOBOS	3225 Highway 441 S.E.	Okeechobee	FL	34974		
Mr.	Davina	Ray		LOBOS	8480 Highway 441 S.E.	Okeechobee	FL	34974		
Mr.	Drake	Ron		Royal Palm Tours & LOBOS	P.O. Box 60079	Ft. Myers	FL	33906		
Mr.	Emrick	Dennis		LOBOS	607 Eden Drive	St. Cloud	FL	34771		
Ms.	Bryant	Anita	Director	Glades County Chamber of Commerce	P.O. Box 490	Moore Haven	FL	33471	863-946-0440	
Mr.	Echols	Russell			P.O. Box 56	Moore Haven	FL	33471	863-946-1610	
				Glades County Abstract Company	P.O. Box 69	Moore Haven	FL	33471	863-946-0727	
Mr.	Burk	Stephen		Carolyn Thomas Realty	P.O. Box 267	Moore Haven	FL	33471	863-946-0505	
Mr.	Daltry	Wayne		SWFRPC	4980 Bayline Drive, 4th Floor	N. Ft. Myers	FL	33918-3455	941-656-7720	
				Johnson-Prewitt & Associates, Inc.	P.O. Box 1029	Clewiston	FL	33440	863-983-9188	
Mr.	Jones	Scott			11295 Martin Blvd	Moore Haven	FL	33471	863-946-1750	
Mr.	Ferguson	Dave			11295 Martin Blvd	Moore Haven	FL	33471	863-946-1750	
Ms.	Ramey	Carolyn			840 SE 7th Ave	Pompano Beach	FL	33066	954-782-8286	
Mr.	Watson	Dave		Cheeky Chew's BBQ,	P.O. Box 1102	Moore Haven	FL	33471	863-946-1811	
Mr.	Perry	Tommy			P.O. Box 1029	Clewiston	FL	33440	863-983-9188	
				Glades Utility Services, Inc.	P.O. Box 1264	Moore Haven	FL	33471		
				Johnson Engineering, Inc.	P.O. Box 1550	Ft. Myers	FL	33902	941-461-2429	
Mr.	Giesler	Bob	Chairman	Glades County Commissioners	37 Linda Road	Okeechobee	FL	34974	863-763-3983	
Mr.	Harris	Robert G.	Vice Mayor	City of Moore Haven	P.O. Box 392/ 300 Avenue K	Moore Haven	FL	33471	863-983-1484	g82u@skyeone.com
Mr.	Shupe	Chris		1st Federal Savings Bank of the Glades	205 S WC Owen Ave	Clewiston	FL	33440	863-983-6181	
Mr.	Johns	Alex			Rt 6, Box 767	Okeechobee	FL	34974	863-763-5020	
Mr.	Aldrich	Wayne	Superintendent	Glades County School	5549 Frontier Circle	LaBelle	FL	33935	863-946-0323	
Mr.	Tallent	John		Lykes Bros. Inc.	7 Lykes Rd	Lake Placid	FL	33852	863-441-0130	
Ms.	Eby	Cheryl		Rawls Real Estate	10425 Lowery Lane	Moore Haven	FL	33471	863-983-8559	
Mr.	Miller	Cliff	County Manager	Glades County	P.O. Box 1018	Moore Haven	FL	33471	863-946-2140	
Mr.	Rider	Jim	Sheriff	Glades County	P.O. Box 39	Moore Haven	FL	33471	863-946-1600	
Commissioner	Ward	Alvin	Commissioner	Glades County	8700 Wayman Road NW	Moore Haven	FL	33471	863-673-1254	award@agrodist.com
Mr.	Schneider	Jim		c/o Walmarts	1005 W. Sugarland Hwy	Clewiston	FL	33440	863-983-4844	
Mr.	Walter	Merritt			12340 Anchor Lane	Moore Haven	FL	33471	863-675-2398	

Salutation	Last	First	Title	Organization Name	Address	City	ST	ZIP	Work Phone	E-Mail
Mr.	Ogletree	Harry	Mayor	Moore Haven	P.O. Box 572	Moore Haven	FL	33471	863-946-1493	
Mr.	Humphries	Shelly		Cattlemans Association	P.O. Box 549	Moore Haven	FL	33471	863-946-0244	
Ms.	Allen	Jenny		Allen's Repair Service, Inc.	3500 Ortona Locks Road	Moore Haven	FL	33471	863-675-6058	
Mr.	Toole	Steve		Big Lake National Bank	P.O. Box 1010	Moore Haven	FL	33471	863-946-2900	
Ms.	Thomas	Michelle			Rt 6, Box 666	Okeechobee	FL	34974	863-763-4128	
Mr.	Ahern	James		Ahern's Service Center	P.O. Box 176	Moore Haven	FL	33471	863-946-3000	
Mr.	Vinson	Mike		Glades Electric Cooperative	P.O. Box 519	Moore Haven	FL	33471	863-946-0061	
Mr.	Rader	Robert			12240 Schooner Ln SW	Moore Haven	FL	33471	863-675-6073	
Ms.	Storter	Donna		Storter Groves	P.O. Box 2307	LaBelle	FL	33975	863-675-8850	
Ms.	Johnson	Mary Jo			P.O. Box 39	Moore Haven	FL	33471	863-946-1600	
Ms.	Hall	Shannon			2095 Old Lakeport Road	Moore Haven	FL	33471	863-946-3242	
Ms.	Register	Patty		Gatorama	P.O. Box 248	Palmdale	FL	33944-0248	863-675-0623	
Mr.	Estremeras	Julio		Small Business Development Council	24311 Walden Center Drive	Bonita Springs	FL	34134	941-948-4040	
Mr.	Fry	Curtis		Glades County Chamber of Commerce	111 San Benito Street	Clewiston	FL	33440	863-983-9155	
Ms.	Halperin	Christina	Historic Site Specialist	State of Florida Bureau of Archeological Research	500 S. Bronough	Tallahassee	FL	32399-0250	850-245-6444	chalperino@mail.dos.state.fl.us
				Adams Ranch, Inc.						
Ms.	Love	Kimball	Water Resources Management	Martin County	2401 SE Monterey Road	Stuart	FL	34996		klobe@marin.fl.us
Ms.	Powers	Gail		Gail's Bait and Pail					863-357-6525	
Mr.	Jones	Craig	Biochemist	Terra Kenetics Engineering Co.	6008 Indrio Road # C-7	Fort Pierce	FL	34951	561-595-6687	ckjones@bellsouth.net
Mr.	Thomas	K.		City of South Bay	335 S.W. 2nd Avenue	South Bay	FL	33493	561-996-0530	
Mr.	Baker, P.E.	William	Senior Civil Engineer	MacVicar, Federico & Lamb, Inc	4524 Gun Club Road, Suite 201	West Palm Beach	FL	33415	561-689-1708	baker@mfl-inc.com
Mr.	Dupont	Allen	Vice President	Case O'Bourke Engineering, Inc	3350 Biscayne Boulevard, Suite 606	Miami	FL	33137	305-572-9960	adupont@caseobourke.com
Mr.	Fry	S.C.			302 East Alverdez	Clewiston	FL	33400		
Mr.	Owens	Jim		U.S. Army Corps of Engineers	525 Ridgelawn Road	Clewiston	FL	33440	863-983-6964 X-237	
Mr.	Akre	Robert		Terra Kinetics Engineering Co.	1474 SW Locks Road	Stuart	FL	34997	561-560-0764	rakregc@aol.com
Mr.	Shugar	Kim		Florida Department of Environmental Protection	2600 Blairstone Road	Tallahassee	FL	32399	850-921-9395	kimberly.shugar@dep.state.fl.us
Mr.	McCall	Dan		Florida Fish and Wildlife Conservation Commission	3991 27th Court	Okeechobee	FL	34974	863-402-5190	
Mr.	Peck	Ryan	Biologist	U.S. Army Corps of Engineers	525 Ridgelawn Road	Clewiston	FL	33440	863-983-8101 X-251	Ryan.E.Peck@usace.army.mil
Ms.	Avery	Debbie	Executive Director	Economic Development Council, Inc.	PO Box 1003	Moore Haven	FL	33471	863-946-0300	info@gladescountyedc.com
Mr.	Johns	Alex	Brighton Indian Board Member	Brighton Indian Reservation					863-467-0818	
Mr.	Wayne, Sr.	John	Council Member	Brighton Indian Reservation					863-467-0818	