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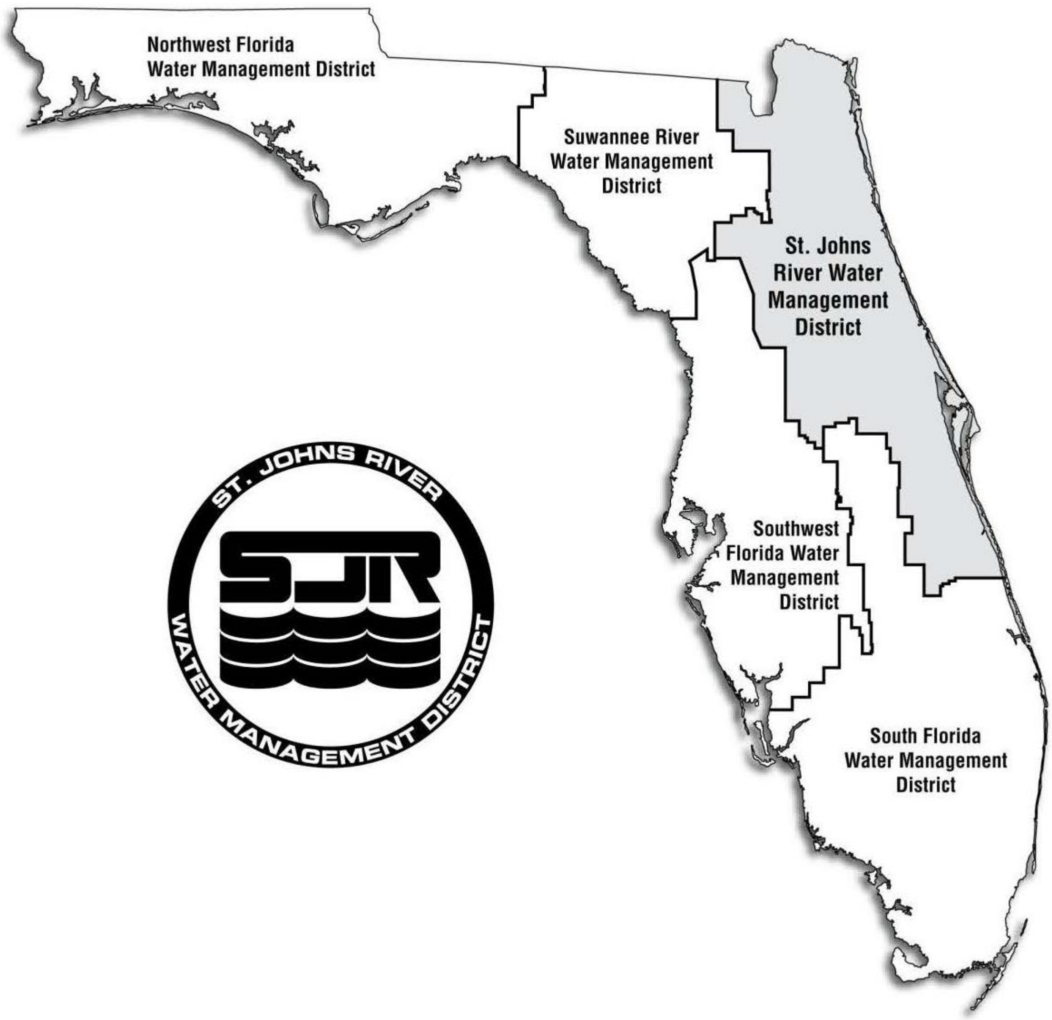

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Lake Apopka soil Remediation Project

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ABSTRACT

In fall 1998, the North Shore Restoration Area (NSRA) at Lake Apopka became shallowly flooded due to the termination of pumping of the fields and rainfall after the St. Johns River Water Management District (District) took possession of these properties. Unfortunately, fish-eating birds associated with the NSRA died in significant numbers during fall 1998 and winter 1999. The United States Fish and Wildlife Service (USFWS) released a statement in February 1999 indicating its opinion that the cause of the bird deaths was organochlorine pesticide (OCP) poisoning. Initial cost estimates to excavate the OCP impacted areas were $800,000,000 ($100,000/acre). The District proceeded with an investigation into alternative remediation techniques to reduce the exposure of avian species to OCPs within an approximately 8,000-acre area that would eventually be restored to a wetland habitat. Several other alternatives were evaluated, including capping, blending, land-farming, incineration and inversion. The most feasible remedial option was an inversion technique that uses four 52-inch disk blades on a Baker Plow to invert the top 10 inches of OCP contaminated soil into a ~3.5 ft furrow, ultimately creating an in-situ capping. Inversion of approximately 4,000 acres was completed in May 2009. Reductions of OCPs within the inverted fields averaged 68%. The final cost for this project was approximately $10,000,000.

INTRODUCTION

In 1996, the Florida Legislature enacted the Lake Apopka Restoration Act, Section 373.461, *Florida Statutes*, to provide that the St. Johns River Water Management District (District) accelerate the restoration of the Lake Apopka Basin by acquiring certain agricultural lands impacting Lake Apopka, along with their related facilities. The District closed on the 3,000-acre Duda property in 1997 and purchased essentially all parcels in the 6,000-acre Zellwood Drainage and Water Control District (ZDWCD) Unit 2 area in 1998. Acquisition continued with an additional 2,000 acres in Unit 1. Currently the District owns approximately 20,000 acres in the Lake Apopka Basin. The U.S. Natural Resources Conservation Service (NRCS) provided federal funding for part of the acquisition.

As part of the due diligence process during the acquisition of these properties, Phase I Environmental Site Assessments (ESA) were conducted on all 32 properties in accordance with the current ASTM 1527 standard. Twenty-six of these Phase I ESAs resulted in Phase II ESAs to investigate possible contamination. Eighteen of these Phase II ESAs confirmed contamination and were followed by Phase III Remedial Action Plans and Phase IV Remedial Action Reports. The subsequent remediation activities removed approximately 24,000 tons of contaminated soil from former petroleum storage areas and mix / load sites and 20,000 tons of solid waste.

In 1997, concurrently with the ESA process, an Environmental Risk Assessment (ERA) was conducted to examine the risk to wildlife posed by restoration of the former agricultural areas. Approximately 400 soil samples were collected and analyzed for organochlorine pesticides (OCP) as part of the risk assessment. The ERA concluded that soil pesticide residues did not present an acute toxicity risk to wetland fish and wildlife (ATRA 1998). However, there was concern for potential long-term, sub-lethal effects of DDT residuals on growth or reproduction of top-level predatory birds. The reports recommended, and District staff concurred, that long-term monitoring of the site was necessary when the restoration flooding commenced. In 1998, the ERA Addendum evaluated the Site Remedial Action Levels (SRAL) proposed by the District. The Addendum concluded the remediation of any “hot spots” to these levels would result in overall averages in OCPs that would fall below the Ecological Protection Values (EPV) determined by the 1997 report. The Florida Department of Environmental Protection (FDEP) concurred with the ERA and provided oversight for the due diligence process during the acquisition of the NSRA properties.

In fall 1998, the North Shore Restoration Area (NSRA) became shallowly flooded due to rainfall and the termination of pumping of the fields. The area was not drained in order to prevent soil oxidation and the growth of vegetation. The diversity of habitats presented by the NSRA resulted in an enormous response by bird populations. Unfortunately, fish-eating birds associated with the NSRA died in significant numbers during fall 1998 and winter 1999. The species most affected was the American white pelican. The U.S. Fish and Wildlife Service (USFWS) released a statement in February 1999 indicating its opinion that the cause of the bird deaths was organochlorine pesticide poisoning.

With the support from a 13-agency Technical Advisory Group, NRCS and the District proceeded with an investigation into the cause of the bird mortality. Other objectives of this investigation were to further evaluate the background OCP levels in the soils and/or canals of the NSRA, attempt to locate any “hot spots” that may have contributed to the bird mortality, and evaluate implications for future restoration planning.

In summer 1999, a large-scale soil sampling project began at the NSRA. Soil samples were collected from approximately 1,500 locations and analyzed for OCPs by EPA Method 8081, RCRA 8 Metals plus Copper and Total Organic Carbon (TOC). A stratified, random sampling grid was designed with weighting determined by prior data for the areas. The former Duda farm, the western part of the NSRA, was sampled at the lowest density and Unit 2, the southern part of the NSRA, was sampled at the highest density. The former Duda Farms has historically had lower OCP levels than the eastern part of the NSRA. This background sampling was completed in 2001. The results of this investigation produced better definition of OCP concentrations within the fields of the NSRA. Table 1 includes a summary of these sample results compared to FDEP guidance levels.

Table 1. Summary of Sample Results Compared to FDEP Guidance Levels

Units: mg/kg	Residential SCTL	SQAG TEC	SQAG PEC	Average	Max
4,4'-DDD	4.2	0.0049	0.028	**0.816**	**8.8**
4,4'-DDE	2.9	0.0032	0.031	**1.842**	**16**
4,4'-DDT	2.9	0.0042	0.063	**1.398**	**62**
Dieldrin	0.06	0.0019	0.062	**0.423**	**3.3**
Toxaphene	0.9	0.0001	0.032	**14.268**	**150**

SCTL: Soil Cleanup Target Level
SQAG: Sediment Quality Assessment Guidelines
TEC: Threshold Effects Concentration
PEC: Probable Effects Concentration

Concurrently with the large-scale soil sampling project, the District's Division of Environmental Sciences (ES) researched appropriate Bio-Sediment Accumulation Factors (BSAF) for the high TOC content typical of the NSRA. Due to the uncertainty of the rate of bioaccumulation of weathered OCPs from soils/sediment through the food chain to fish and then birds, three additional phases of study were initiated during spring 2001. These three additional phases were: 1) laboratory microcosms, 2) field-scale mesocosms, and 3) bird feeding studies. "Safe levels" of OCPs in the soil were determined by these studies and used as guidance for eventual remedial activities at the NSRA. Two Expert Review Groups were convened to review and critique specific aspects of the study. The Expert Review Group comments were incorporated and the Safe Levels have been adjusted according to these comments and according to more current data from the field-scale mesocosm studies.

Remediation Plan

Preparation of a viable Remediation Plan for the NSRA was contingent on discovering a remedial option that was capable of reducing the OCP concentrations in the top foot of soil (exposure zone), and was cost effective as well as achievable within a reasonable amount of time. MACTEC Engineering & Consulting, Inc. (MACTEC) produced a Feasibility Study in January 2005 to compare remedial alternatives for the NSRA.

MACTEC used the 1999–2001 data to address site specific requirements for remedial options. The best estimate target levels (BETL) were calculated from trigger values in fish tissue provided to the District by USFWS in its consultation on the former Duda Farms. Conservative target levels (CTL) are one half of the BETL. These values are expressed as TOC normalized values in order to account for the transference of the OCPs from the TOC content of the soil to the lipid content of the fish.

MACTEC divided the 8,000 acres of Unit 1 and 2 into 70 distinct fields based upon previous land ownership and some natural boundaries such as ditches or canals. The percent reductions of OCP concentrations required to meet the BETLs and CTLs were calculated for each field. A list of 23 potential remedial options were evaluated and reduced to 12 remedial alternatives that would best reduce or remove exposure to OCPs. These 12 remedial action alternatives were screened against Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) based criteria and cost estimates were developed for each alternative. Each alternative was also assigned a percentage reduction in OCPs that could be expected. Remedial options assessed ranged from the "No Action Alternative" to "Excavation and Off-site Disposal." The result of this Feasibility Study was a menu of options to explore for remedial alternatives for specific fields.

Following the production of the Feasibility Study, it was determined that the 1999–2001 data was insufficient to adequately address the requirements for remediation of the individual fields. A resampling effort commenced during spring 2007. Sample densities within the MACTEC field designations were standardized based on size and on an existing agreement with the USFWS. Fields 50 acres or less had five soil samples collected. Fields with more than 50 acres and 200 acres or less had 10 soil samples collected. Fields larger than 200 acres had 15 samples collected. Sample points from the 1999–2001 data set were used, with additional points added spatially as needed. During this sampling event, the depth of the muck layer was also determined by continuing the soil boring to the end of the muck layer or 4 feet, whichever came first. If the end of the muck layer was found, then the soil type beneath the muck was documented. This information was useful in the success of the final remediation option.

Pilot studies were conducted for several of these remedial options. A reduction in DDE was the determining factor for the most effective remedial option. ES studies indicated that DDE has a chronic toxicity and bio-accumulates at a higher rate than the other OCPs. A 50% or greater reduction of the average DDE concentration was used as the indicator of success in the following pilot studies.

Pilot Studies

Fiscal Year (FY) 2003/2004

The first pilot study compared DDE reduction using two different pieces of normal farming equipment. Three one-acre plots were prepared (mowed). Twelve soil samples were collected from within each plot and analyzed for OCPs by EPA Method 8081. Soil samples were collected at the same locations and analyzed for OCPs subsequent to the project activities. The southern most plot acted as the Control plot, no mechanical manipulation of the soil occurred in this plot. The northernmost plot was tilled by District Operations staff on a weekly basis for a six-month period. The weekly tilling was accomplished using a Case 7230 tractor pulling a 12-inch wide 24-inch Rome disc for a tilling depth of approximately 10 to 12 inches. The middle plot was inverted to a depth of 18–24 inches by Allen Machines & Equipment of Roscoe, Texas using a 36-inch Square Bottom switchblade plow (Figure 1).

Figure 1: 36-inch Square Bottom switchblade plow

Soil samples were collected in the inverted plot immediately after inversion. Soil samples were collected from the tilled plot after three months of tilling and again at the end of the six-month project. The control plot was sampled at the end of the six-month period. Average results for DDE for each plot were compared for samples collected at the beginning of the project to samples collected at the end of the project. (Figure 2). The inversion plot showed the biggest reduction in average DDE concentration and the control plot showed an increase in average DDE concentration. The increase in average DDE concentration in the control plot may be a result of a decrease in the moisture content in the soil. A Moisture Study conducted by the District in 2005 has demonstrated that OCP concentrations in these high organic muck soils can be influenced by the moisture content of the soil, with the greatest concentrations occurring around a moisture content of 45%. Graphing moisture content versus OCP concentration developed a bell shaped curve with the apex around 45-48%. The average moisture content in the control plot changed from 69.5% to 52%, which may have skewed the DDE results in the final samples. The other two plots did not show as significant a change in moisture content and remained in the 60 percentiles. One of the biggest challenges for the inversion project was the very wet field conditions at the time of the inversion.

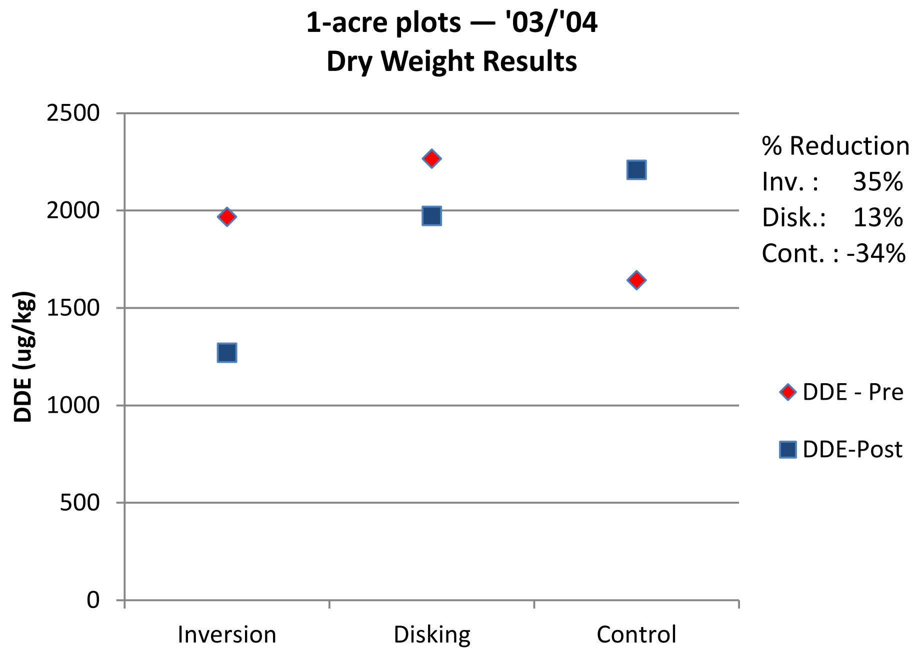

Figure 2. 1-acre plots — '03/'04, dry weight results

FY 2005/2006

Following the completion of the MACTEC Feasibility Study, a second pilot study was conducted to compare the inversion efficiency to a blending technique. A Mobile Injection Treatment Unit — Large Volume Remediator (MITU-LVR) (Figure 3) was used to vertically blend contaminated soil with underlying uncontaminated soil to a depth of 3–4 feet for this project. For this project, Allen Machines modified its plow and used a bi-directional moldboard plow (Figure 4) to invert the top 2–3 feet of soil. Three five-acre plots were prepared for this pilot study and 12 soil samples were collected from within each plot and analyzed for OCPs by EPA Method 8081 and Total Organic Carbon (TOC). Soil samples were collected at the same locations and analyzed for OCPs and TOC subsequent to the project activities. TOC was analyzed for each sample in order to calculate a carbon normalized result. In order to carbon normalize the data, the dry weight laboratory results are divided by the percentage of TOC. The northernmost plot was blended to a depth of approximately 3.5 feet. The blending was limited to a two-day period, and only 1.5 acres were completed of the 5-acre plot. The southern most plot acted as the Control plot, no mechanical manipulation of the soil occurred in this plot. The middle plot was inverted to a depth of approximately 2.5 feet.

Figure 3: MITU- LVR

Figure 4: Bi-directional moldboard plow

Soil samples were collected in the three plots after the inversion and blending were complete. Average results for DDE for each plot were compared for samples collected at the beginning of the project to samples collected at the end of the project. (Figure 5) Carbon normalized sample results were also compared (Figure 6). The blending plot showed the biggest reduction in average DDE concentration in the dry weight results and the inversion plot showed the biggest reduction in the carbon normalized results. The control plot showed a slight increase in average DDE concentration for both dry weight and carbon normalized results. Both machines had some difficulty with wet conditions. The blending machine was more successful in lower TOC areas, but these are not typical to the NSRA. At optimum field conditions, the MITU-LVR could complete one acre per day. Allen Machines expressed interest in further modifying its plow and performing additional field prep in order to get a more successful inversion. Under optimal field conditions, Allen Machines estimated inversion of at least 10 acres per day.

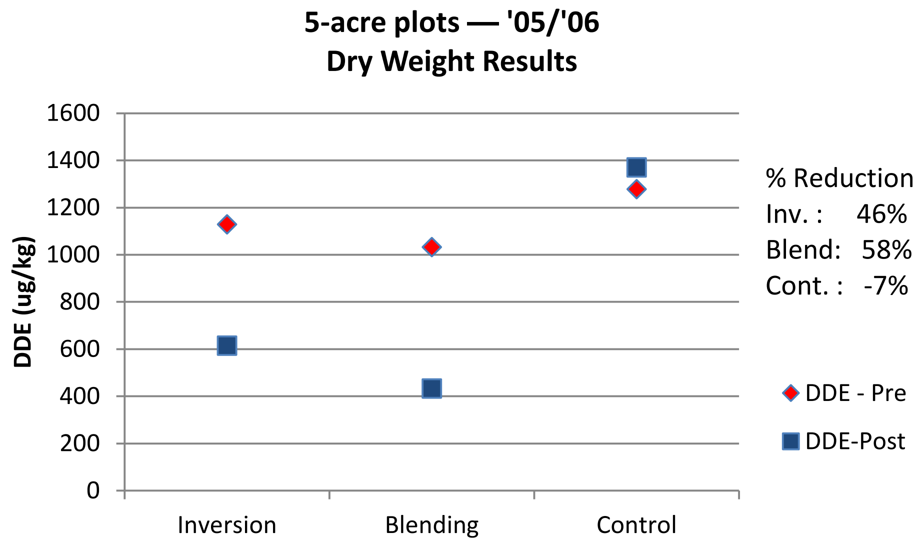

Figure 5. 5-acre plots – '05/'06 dry weight results

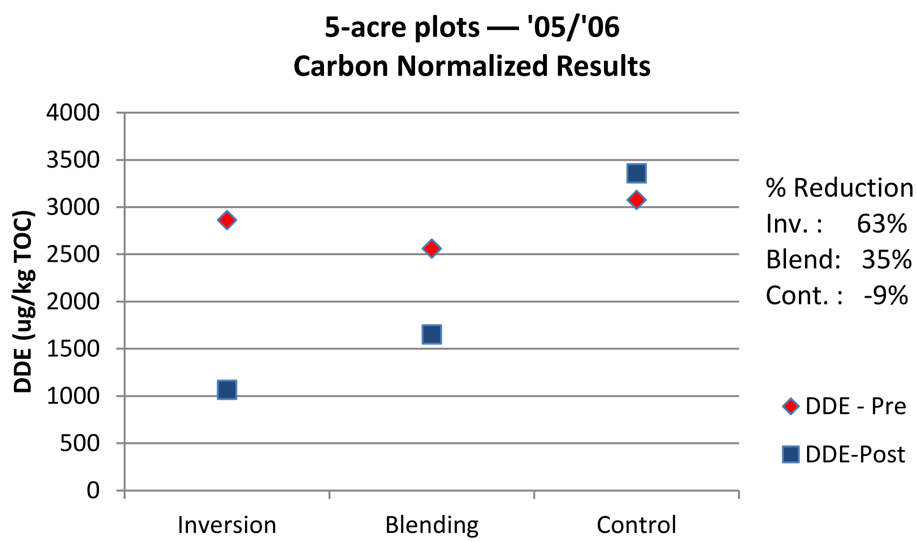

Figure 6. 5-acre plots – '05/'06 carbon normalized results

FY2006/2007

Pilot projects assessing two different remedial options were implemented with very limited success. These techniques were not further assessed due to difficulty in implementation and a relatively higher cost compared to the other successful remedial options.

The first project consisted of applying a muck cap layer over the contaminated soil. A local trucking company involved in hauling excavated material from construction sites contacted the District to offer the fill material at a reasonable cost. Unfortunately, by the time the District analyzed the fill material for suitability, the material was not available. After several attempts, this project was not pursued further. Although the cap material was at a nominal cost, the cost to spread the material was prohibitive to use on a large scale project.

For the second project, a District contractor leased a CAT RM300 (Figure 7), a rotary trenching machine capable of mixing to a depth of 20 inches, to test the feasibility of using it for mixing the contaminated soil with the underlying clean soil. A 36-acre plot was prepared for this pilot study and 10 soil samples were collected and analyzed for OCPs and TOC. The CAT was leased for one week. The machine had difficulty getting stuck in wet muck and some vegetation managed to break the hydraulic line. By the end of the week, the Contractor only mixed the areas where six of the soil samples were taken. Reduction of DDE was significant, but the cost in time and equipment failure was prohibitive for use on a large scale. Modifications would need to be made for the machine to run more efficiently at this site.

Figure 7. CAT RM300

Allen Machines returned in spring 2007 for a 300-acre pilot project. Samples collected during the 2007 sampling event were used for the pre-inversion samples. In addition, the information on the subsurface conditions obtained during the 2007 sampling was used to select fields with varying subsurface conditions — muck, clay, sand and/or rock.

Five different fields were identified for this project to test the redesigned four-bottom bi-direction plow with 52-inch disks (Figure 8). Allen Machines was responsible for all field prep.

Figure 8. Four-bottom bi-direction plow with 52-inch disks

Figure 9. Fields 5 and 8 — post inversion

The percent reduction of DDE in the individual fields ranged from 54%–98% for the dry weight results (Figure 10) and from 13%–94% for the carbon normalized results (Figure 11). The 13% reduction in carbon normalized results for Field 5 (Figure 9) was attributed to the very low TOC resulting from inverting the rocky subsurface. The other field carbon normalized reductions were above 50%. Based on these results, a performance-based contract was awarded to Allen Machines for a large scale remediation project at the Lake Apopka NSRA.

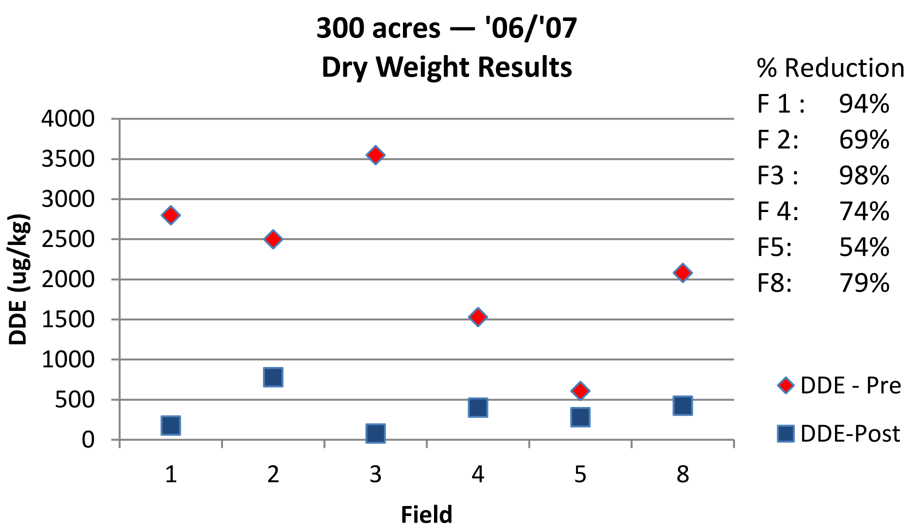

Figure 10. 300 acres — '06/'07 dry weight results

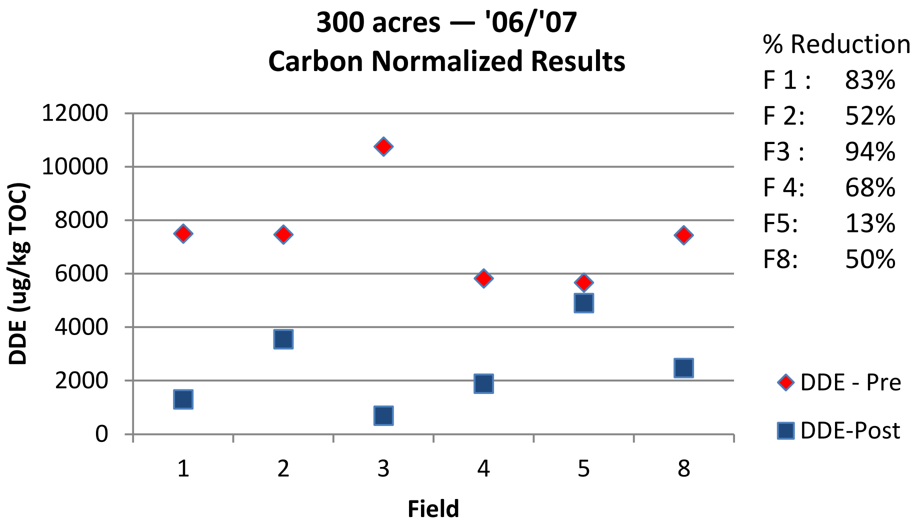

Figure 11. 300 acres – '06/'07 carbon normalized results

FY 2007/2008

A pilot project to assess the potential for bioremediation of the OCP contaminated soil was implemented by a District consultant and subcontractor. This pilot project consisted of the application of a protein factor amendment to the soil that would assist the existing microbes in dechlorinating the OCPs. The District considered this alternative for low TOC areas where the inversion had not shown to be as successful. The protein factor amendment was added to the soil and the areas were disked every two weeks for the five months of the project. Two 1.5-acre plots were prepared for application of the amendment, TA1 and TA2 (twice the rate of TA1) (Figure 12). One-acre plot was designated as the control, which would be disked, but have no amendment added.

Another one-acre plot was designated as background, where no activity occurred. Eight soil samples were collected from each of the treatment plots and five soil samples were collected from the control and background plots before the application, and at two and five months after the application. All soil samples were analyzed for OCPs and TOC. The consultant also monitored moisture and pH every two weeks and the plots were watered if necessary. TA2 showed the most reduction in DDE in dry weight (60%) (Figure 13) and carbon normalized results (43%) (Figure 14), but the Control plot had similar results (52% and 40%). It was unclear how much of the reduction could be attributed to the addition of the amendment. The cost of this alternative was also significantly higher, so further assessment of this alternative was not pursued.

Figure 12. Treatment areas and control area

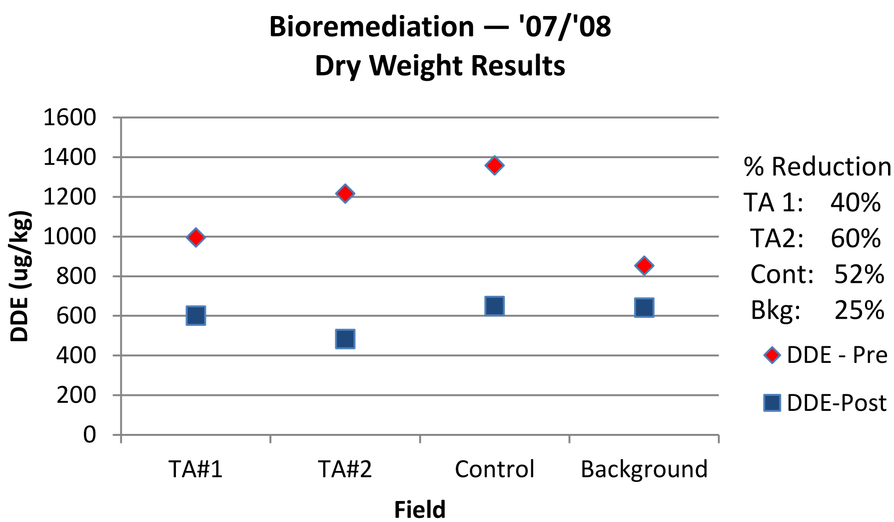

Figure 13. Bioremediation — '07/'08 dry weight results

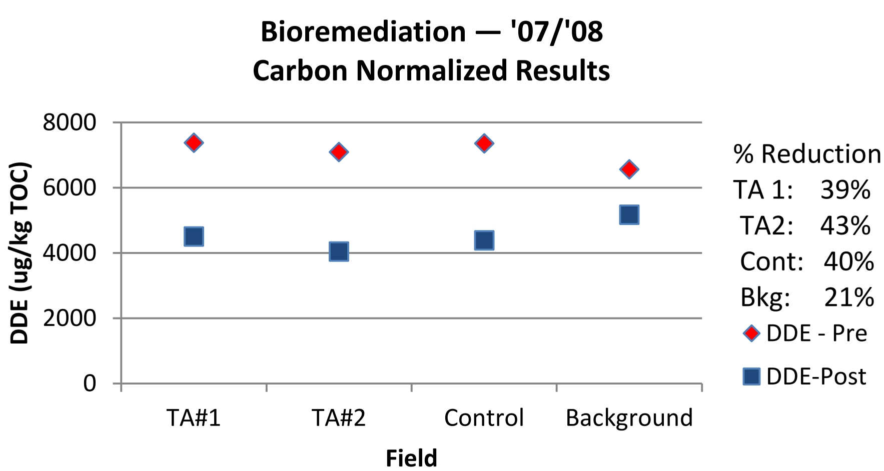

Figure 14. Bioremediation — '07/'08 carbon normalized results

Table 2 summarizes the results of the Pilot Studies and estimates the cost and duration for each technique over the presumed 8,000 acres requiring remediation. Inversion proves to be the most successful in terms of cost and duration. Full scale remediation began using inversion. The next challenge was to reduce the cost further by reducing the number of acres requiring remediation.

Table 2. Summary of Pilot Studies

				8,000 acres	
Project	% Reduction DDE	Rate: Acre/Day	Cost: $/Acre	Total Time (Days)	Total Cost
Inversion	79	15	$2,500	533	$20,000,000
Blending	58	1	$2,700	8,000	$21,600,000
Bio-remediation	50	NA	$31,839	NA	$254,712,000
Excavation and disposal	100	0.25	$100,000	32,000	$800,000,000

Full Scale Remediation

Remediation Strategy

Early in the project, DDE concentrations were the driving force in determining remediation requirements. Data from the 2007 sampling event were compared to ES's Safe Levels to decide which fields required remediation. Requirements were further refined by evaluating DDE concentrations spatially within the fields. Within fields, there were areas that exhibited DDE concentrations lower than Safe Levels. A Remediation Strategy was developed to standardize the method for determining how much of a field would be remediated. The steps are outlined below followed by an example.

<u>Step 1: Determination of fields requiring remediation:</u>

The results of the 2007 data set have been carbon normalized and the 95% Upper Confidence Limits (UCL 95) of the field averages have been determined and compared to proposed "Safe Levels" concentrations for DDE (5,275 ug/kg TOC). Fields that have a UCL 95 above the Safe Levels are targeted for remediation.

Step 2: Determination of specific blocks within fields requiring remediation:

Individual points within each field are evaluated against the Safe Level for DDE. Smaller fields (defined by canal or ditch boundaries) within these fields are targeted for remediation based on the presence of individual sample points with concentrations above Safe Levels. The smaller fields are combined to create a block. The total acreage for the block of smaller fields will be at least 25% of the total acreage of the field. The block is delineated on an aerial map and the locations are confirmed in the fields for Allen Machines to complete the inversion.

The UCL 95 is also calculated for the proposed non-inverted portion of the field. Sample density within the non-inverted portion must follow the same sample density used for the 2007 sampling effort. The UCL 95 for the proposed non-inverted portion must be less than the Safe Level.

Step 3: Post-inversion sampling of the block:

Once the inversion has been completed, the block is resampled at the locations that were previously sampled. These new sample results replace the pre-remediation 2007 sample results to determine a new UCL 95 for the total field.

Example: Field 4 (152 acres)

Step 1: Determination of fields requiring remediation:

Figure 15 shows that the UCL 95 for DDE in Field 4 is above the Safe Level.

	DDE (ug/kg TOC)
UCL 95	6,327
Safe Level	5,275

Figure 15. DDE in Field 4

Step 2: Determination of specific blocks within fields requiring remediation:

Three individual farm fields are identified with three points with the highest concentrations of DDE. These fields are defined as a block for remediation. This block consists of 45.4 acres or 30% of the total acreage of Field 4. Allen Machines inverts the block.

The proposed non-inverted portion of the field is 106.6 acres, which would require 10 sampling locations based on the 2007 sampling density. Only five points are within the proposed non-inverted portion, so an additional five points are sampled within the proposed non-inverted portion. The UCL 95 for DDE is calculated using all 10 points and Figure 16 shows that it is below the Safe Level.

	DDE (ug/kg TOC)
UCL 95 – non-inverted portion	4,162
Safe Level	5,275

Figure 16. DDE in non- inverted portions of the field

Step 3: Post-inversion sampling of the block:

The new UCL 95 for the entire Field 4 is below the Safe Levels (Figure 17).

	DDE (ug/kg TOC)
UCL 95 — post-inversion	4,136
Safe Level	5,275

Figure 17. UCL 95 for entire Field 4

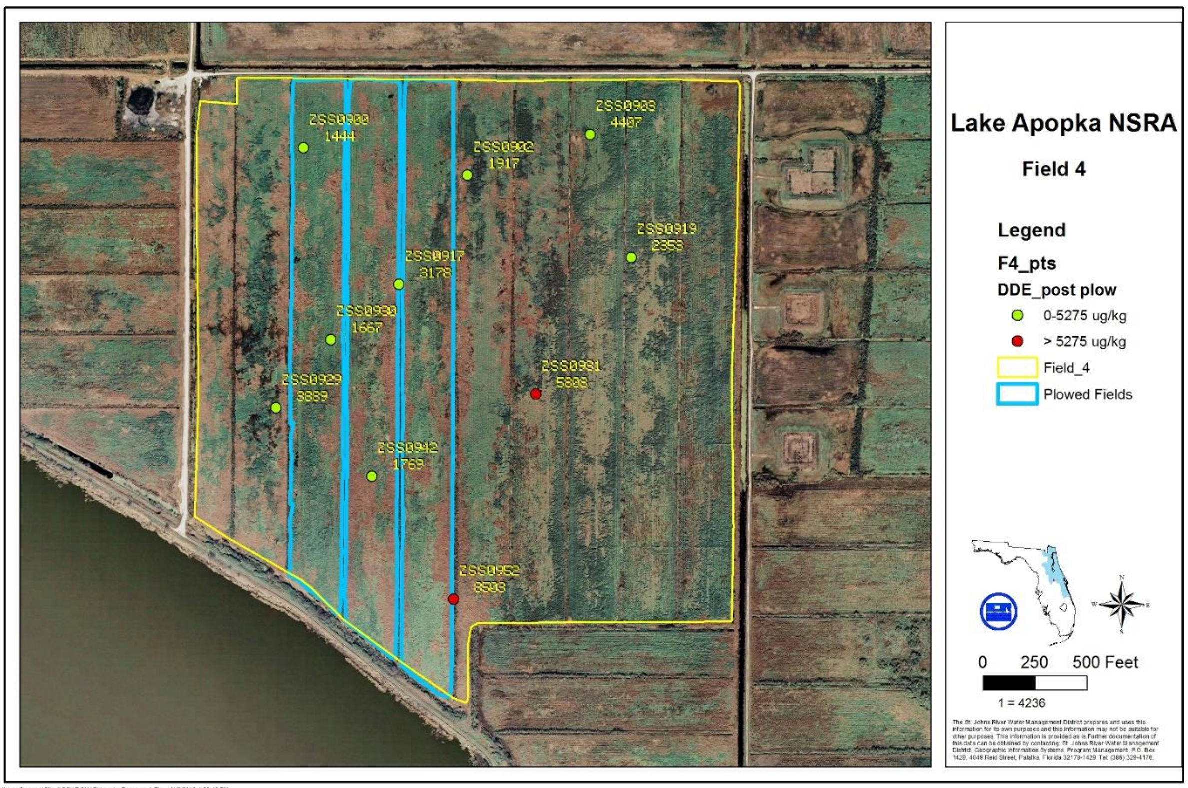

Figure 18. Field 4 of the Example

Implementation of Remediation Strategy

The steps described in the Remediation Strategy are applied to each field. Blocks for remediation are defined within each field. The FY 07/08 contract with Allen Machines originally specified 1,000 acres to be inverted. Due to the success of the inversion early in the fiscal year, another 500 acres were added to the contract. Also, due to the continued success of the inversion on reducing all OCPs within the fields, the Remediation Strategy was altered to include the Hazard Index (HI) as the driving force for the determination of the necessity for remediation within the individual fields. The HI considers the cumulative effects of toxaphene, DDT and its metabolites DDE and DDD, dieldrin, and seven chlordane compounds on potential avian receptors. Some additional acreage was targeted for inversion after evaluation using the HI in addition to the DDE concentrations in the fields. The FY 08/09 Allen Machines contract specified 2,200 acres to be inverted. Four thousand acres were ultimately designated for inversion in the three-year contract.

Inversion process

In order to successfully invert the soil, approximately 10 to 12 passes were necessary across each field. Prior to the inversion, several steps were necessary to prepare the fields. Roller chopping (Figure 20) and shredding the fields (Figure 21) would break up the vegetation to prevent slippage from the vegetation becoming tangled in the disks. After the vegetation was managed, the fields were disked (Figure 22) to a depth of approximately 10 inches to break up the surface material. Rock or other subsurface conditions could necessitate the use of a chisel plow (Figure 23) to break up the subsurface to assist the inversion process. Following each of the field prep techniques, the fields were rolled (Figure 24) to provide a smoother, more compact surface. Once the field was prepped, the Baker plow (Figure 25) would invert the field. The Baker plow created a 2.5–3.5-foot furrow (Figure 19) in which the top one foot of contaminated soil was rolled into and capped with the less contaminated underlying soil. Following inversion, several more passes with the offset disk and roller were necessary to provide a final smooth, more compact surface.

Figure 19. Furrow created by Baker plow

Figure 20. Chopper

Figure 21. Shredder

Figure 22. Offset disk

Figure 23. Ripper / chisel plow

Figure 24. Soil packer / roller

Figure 25. Baker plow with 52” disks

Tractors pulling the Baker plow were equipped with a GPS navigation system. The navigation system aided the operators in guiding the large tractors to the edge of the previous furrow for a more complete inversion. An onboard computer system recorded fuel consumption, depth of furrow and acreage completed (Figure 26). Figure 27 shows a view of the plow from inside the tractor.

Figure 26. Screen for onboard computer system

Figure 27. View from the tractor

Challenges for the inversion process

The greatest challenge for the inversion process was the height of the water table on the site. This area is historic s and can be as much as 6 feet lower in elevation than the surface level of Lake Apopka. Keeping the water table at least 4 feet below land surface (BLS) required vigilant attention to water levels in the canals and rainfall data. Large pumps were available at several locations within the NSRA and smaller portable pumps were moved around as needed. Rainfall of more than one inch a day would shut down the project until the water levels could be managed. Fortunately, the full scale project began after a drought period for the area so the water table was lower than usual. Inversion was scheduled for the winter months that are typically drier. The project was completed by the time that normal rainfall returned to the site.

A second challenge for the inversion process was low TOC soils. These soils typically had much lower dry weight OCP concentration. TOC soils of less than 5% resulted in very high carbon normalized results. One 300-acre field (Field 57) was not inverted due to TOC less than 3% and dry weight OCP concentrations less than FDEP Residential Soil Cleanup Target Levels (SCTLs).

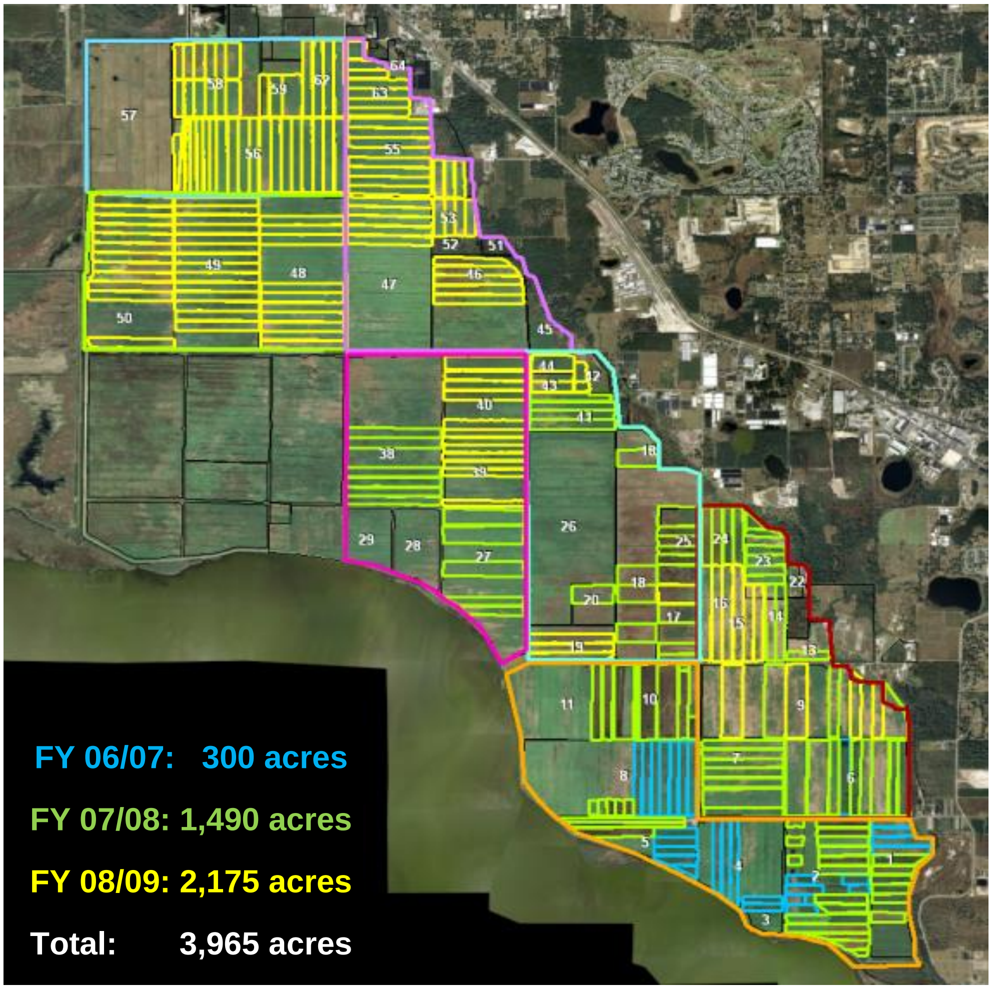

Figure 28. 3,965 acres completed

Project Results

The inversion of 3,965 acres (Figure 28) was completed in spring 2009. By summer 2012, all properties targeted for remediation were scheduled for wetland restoration. As part of the phased flooding, fish are routinely monitored for OCP levels for a year. To date, after the first year of flooding, measured OCP levels in fish were below predicted values. As management goals change from dense wetland vegetation to other options that include open water areas, representative fish species will be sampled and analyzed to verify that OCPs remain at ecologically safe levels. There have been no documented adverse impacts to avian species from exposure to OCPs within the remediated site.

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