Nutrient Control Technologies
Standards of Comparison

Establishing Standards of Comparison
for application in
Cost and Benefit, Cost Effectiveness and
Life Cycle Cost Analysis

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1.0 Nutrient Control Technologies Standards Of Comparison (NCTSOC)

To meet nutrient load reduction requirements associated with Total Maximum Daily Loads (TMDLs), decision makers and stakeholders require accurate information regarding available nutrient reduction technologies so as to accurately assess and compare the various alternatives.

Available in the literature are reports and on-line databases that document costs and treatment performance associated with a wide variety of water treatment technologies and best management practices (BMPs) designed to reduce nutrient loads to surface and ground waters. However, to accurately compare these widely varying water treatment technologies or BMPs, it is critical that there be a standardization of assumptions and methods employed relative to any given comparison.

As there are no mandated guidelines for conducting economic analysis of costs and benefits associated with nutrient pollution control, it the responsibility of interested decision-makers and stakeholders to evaluate and compare published treatment costs with a full understanding of factors that affect cited costs and benefits. For agencies personnel and others responsible for requesting treatment technology Cost and Benefit Analysis, opportunity exists to specify the economic analysis to be applied.

While pollutant removal costs are often presented in the literature in terms of a cost and benefit relationship such as $/lb of pollutant removed, the design conditions, cost accounting or economic analysis methodologies and assumptions used in the calculations are often so varied that accurately comparing reported costs is virtually impossible. Often, assumptions and design conditions used in conjunction with the calculation of pollutant removal costs and benefits are not provided when costs are referenced. Accordingly, the reader is often left unable to accurately compare technology treatment costs.

To accurately compare various nutrient control technologies, it is critical that water treatment technologies or pollutant reduction alternatives are evaluated against the same set of criteria. To assure evaluation against the same criteria, a Standards of Comparison (SOC) should be applied when calculating pollutant removal costs.

Standardization guidelines should address all of the following factors when possible or applicable:

- Economic Analysis Methodology Selection
- Design Conditions and Assumptions
- Cost Categories and Elements (i.e. Design, Permitting, Construction, etc.)
- Unit Costs [i.e. Concrete ($/cy); Earthwork ($/cy), Erosion control, etc.]

In addition to the above listed items which have direct impact on calculated costs and benefits, it may also be beneficial to provided standardization guidelines, or at least document information and assumptions relative to the items listed below.

- Treatment Performance Quantification Methods (Measured or Assumed)
- Load Reduction Geographic Correlation (Direct or Indirect)

Only through standardization can an accurate comparison of alternative technologies and pollutant reduction approaches be made.

Provided in Appendix A is an example of a Standards of Comparison approach to comparing alternative technologies is provided in the August 1999 document entitled *Technical Memorandum Bases for Cost Estimates of Full Scale Alternative Treatment (Supplemental) Technology Facilities* as prepared by PEER Consultants/Brown and Caldwell under Contract C-E008-A12 with the South Florida Water Management District. In the referenced document a clearly defined Standardization approach was provided to allow for an accurate comparison of highly variable phosphorus control technologies that included biological, physical and chemical treatment systems for application in the Everglades.

2.0 Economic Analysis

2.1 Methodology Discussion

In reviewing the literature, multiple economic analytical approaches have been applied for the calculation of costs and benefits related to nutrient control technologies. Cost calculation approaches vary widely - ranging from the simple calculation of current year operations and maintenance (O&M) costs to detailed Life Cycle Cost Analysis (LCCA). The net result is that without standardization or use of the same analytical method, cost values for alternative nutrient control technologies reported in the literature typically cannot accurately be compared.

Within the literature economic analytical approaches typically cited include (i) Cost Effectiveness Analysis (CEA), (ii) Cost-Benefit Analysis (CBA) also known as Benefit-Cost Analysis (BCA), or (iii) a hybrid Cost and Benefit Analysis, also know as Benefit and Cost Analysis. For clarification, a brief description of CEA and CBA are provided below.

Cost-Effectiveness Analysis (CEA) is an economic analysis that compares the relative costs and benefits or effects of two or more alternatives. Cost effectiveness analysis is appropriate whenever it is unnecessary or impractical to consider the dollar value of the benefits provided by the alternatives under consideration.

A cost-effectiveness (CE) ratio can be obtained by dividing costs by units of effectiveness:

$$\text{Cost-Effectiveness Ratio} = \frac{\text{Total Cost}}{\text{Units of Effectiveness}}$$

Units of effectiveness are defined as a measure of any quantifiable outcome central to a specified objective. Units of effectiveness relative to nutrient control technologies are typically reported as units of pollutants removed.

Accordingly, the Cost Effectiveness Ratio may be reported as:

$$\text{Cost-Effectiveness Ratio} = \frac{\$}{\text{Pounds of Pollutant Removed}}$$

Cost-Benefit Analysis (CBA) or Benefit-Cost Analysis (BCA) is often used by governments and other institutions such as private sector businesses to (i) evaluate the desirability of a given policy or (ii) to compare and rank alternative policies options in terms of the costs and benefits. In CBA, both benefits and costs are expressed in money terms, and are adjusted for the time value of money, so that all flows of benefits and flows of project costs over time (which tend to occur at different points in time) are expressed on a common basis in terms of their "net present value." Both tangible and intangible costs and benefits should be recognized. The concept was originally developed more than 150 years ago by the French engineer Jules Dupuit. However, CBA was first employed for widespread use in the United States by the US Army Corps of Engineers for the evaluation of federal water projects in the late 1930s.

Use of CBA or BCA expanded at the federal level beyond the Army Corps in the 1960s, and was formalized as a decisions making tool through multiple Executive Orders and guidance documents (EO 12291 in 1981, EO 12866 in 1993, Circular A-4 (US OMB), Circular A-94, EO 13258 in 2002 and EO13514 in 2009). The guidance provided for CBA however applied principally to the analysis of policies and programs, and therefore some of this guidance is not applicable to an analysis in which benefits are not monetized.

As benefits are not monetized when referring to the removal of a pollutant, the economic approach CBA or BCA in which benefits (effects) are expressed in monetary terms is not fully applicable. However, much of the information related to the proper management of "costs" is applicable. It should also be noted - in the literature authors may provide nutrient control treatment costs relative to a unit of benefit ($/lbs-pollutant removed), and refer to the analysis as a "Cost and Benefit Analysis" or "Benefit and Cost Analysis". These analyses differ from a standard Cost-Benefit Analysis in which benefits are monetized, and thus "Cost and Benefit Analysis" are more closely related to CEA.

Whether the economic method applied is referred to as a Cost-Effectiveness Analysis (CEA) or Benefit and Cost Analysis, it is important that the method applied be consistent or standardized for all nutrient control alternatives to be compared.

As discussed previously, every economic analysis requires multiple assumptions, detailed calculations and careful analysis by the reviewer. To assist in this effort, provided below are eight steps associated with developing a Cost Effectiveness Analysis.

2.2 Steps in Developing a Cost and Benefit Analysis/Cost Effectiveness Analysis

1. Define analysis time frame or useful life
2. Identify costs and benefits to be quantified
3. Identify benefits to be quantified
4. Standardize Unit Costs
5. Project costs over the defined life
6. Project benefits over the defined life
7. Cost Valuation
8. Quantify benefits in terms of units of effectiveness
9. Discount costs to obtain present values
10. Compute a cost-effectiveness ratio

In conjunction with the steps identified above, it is recommended that a Life Cycle Cost Analysis (LCCA) be performed to quantify costs for each nutrient control technology.

The use of LCCA has proven most helpful to the engineering and planning communities for long-term cost comparisons of available, competing technologies and system processes. LCCA is an economic technique that allows comparisons of investment alternatives having different costs streams. The process involves estimating the costs and timing associated with each cost over the selected analysis period or time frame. These costs are then converted to economically comparable values considering the time-value of money. The Present Worth Cost (PWC) is the sum of all costs associated with a given alternative discounted to today's dollars.

There are many established guidelines and computer based programs that effectively support Present Value LCC analyses. The National Institute of Standards and Technology (NIST) has prepared the Life Cycle Costing Manual for the Federal Energy Management Program (NIST Handbook 135) http://fire.nist.gov/bfrlpubs/build96/PDF/b96121.pdf

2.2.1 Define Analysis Time Frame

To complete the economic analysis it is necessary to define the time frame over which the nutrient control technology will be analyzed. While the length of time may be any time selected, the time frame is typically measured in years for these analyses, though the analyst may also use any other unit of time that is reasonable.

Most CEA/Cost and Benefit analyses use a time frame in the range of five to fifty years. Often a key factor to deciding on the time frame relates to the useful life of the technology being measured. As multiple technologies may be compared when considering nutrient control technologies, it is recommended that the time frame be sufficient to capture the majority of costs and benefits associated with the technologies in consideration. Typically in the wastewater and stormwater sectors cost and benefit time frames range from 20 to 50 years.

2.2.2 Identify Costs to be Quantified

As a component of the standardization process, efforts should be made to list those cost elements that should be included within the CEA/Cost and Benefit Analysis. Requiring standardization will allow a more accurate comparison of technologies. For technologies that do not require an identified or specified cost element, the cost is identified as zero. However, by providing a master list of cost elements, greater accuracy is provided by assuring that the majority of major costs items are included within the analysis. Additionally, providing this information allows others who may use published cost analysis data a greater understanding of assumptions and cost elements that were included within said analysis.

As previously mentioned, costs should be calculated as a Life Cycle Cost (LCC) which calculates the total cost of ownership over the defined analysis time frame (Section 2.2.1). Initial costs associated with the implementation of the technology and all subsequent expected costs are included in the calculation as well as disposal (or residual) value and any other quantifiable benefits to be derived.

Cost Categories should address at a minimum all of the following if applicable:

- Site Selection and Land Costs
- Engineering
- Permitting
- Capital Costs
- Operating Costs
- Replacement Cost
- Salvage Costs/Residual Value

Within each cost category, specific cost elements may be defined. A sample list of possible costs elements is provided below.

- Site Selection and Land Costs
    - Site Selection Labor Cost
    - Land Costs
- Engineering
    - Site Engineering
    - System Design Engineering
- Permitting
    - Local Permits
    - Stormwater Permits
- Capital Costs
    - Earthwork ($/cy)
    - Pumping ($/unit flow)
    - Concrete ($/cy)
    - Piping
    - Equipment
    - Electrical Controls
    - Electrical Distribution
    - Contingency
- Operating Costs
    - Labor
    - Energy
- Replacement Costs
    - Materials and Labor or Percentage
    - Energy
- Salvage Costs/Residual Value

In addition to identifying cost elements, it should also specified if a contingency cost is to be included within the cost analysis. If contingency costs are to be included, a percentage value should be specified.

The stakeholder or decision maker conducting the CEA/Cost and Benefit Analysis should also consider if “Indirect Costs” are to be considered. Examples include costs to government (labor, etc) associated with implementing and potentially monitoring the nutrient control technology, lost tax revenue to the municipality, or lost value to the property owner associated with down zoning. Typically indirect costs are not included when evaluating nutrient control technologies.

2.2.2 Identify Benefits to be Quantified

It is expected that the benefits to be recognized relative to a CEA/Cost and Benefit Analysis of nutrient control technologies will be reduction of the macronutrients nitrogen or phosphorus. These reductions are typically associated with a regulatory requirement or mandate or non-regulatory objective designed to protect or improve water quality.

Dependent on the project/program objectives, it is possible that the desired benefit may (i) define a specific nutrient to be reduced (i.e. total nitrogen or total phosphorus, (ii) define a specific species of nutrient to be reduced (i.e. nitrate-nitrogen or ortho-phosphorus), or (iii) more than one benefit is deemed important (i.e. reduction of nitrogen and phosphorus).

If more than one benefit is desirable, separate cost effectiveness ratios should be calculated for each benefit or pollutant removed.

2.2.3 Standardize Unit Costs

Alternative nutrient control technologies often include similar cost elements (i.e. land costs, site and system design engineering, earthwork, concrete, etc.). To allow for an accurate comparison, unit costs should be standardized or specified for a given project when possible.

It is also important that unit costs be accurately correlated with treatment system size to factor in economies of scale. If all treatment system alternatives are of similar scale, then a standard cost unit may be applicable. However, if treatment system sizes vary significantly, careful consideration should be given to specification of unit costs. If possible, application of cost curves may provide a solution to unit costs that may vary in relation to treatment system size.

Examples are provided below that illustrate cost elements in which fixed unit costs may not be optimal when comparing technologies of significantly different scale.

Example 1. *Engineering and Permitting*. Design engineering and permitting a are often site specific and thus costs associated with a small system may be disproportionately higher than costs for larger systems.

Example 2. *Earthwork and Concrete*. Unit costs (i.e. $/cy) for work performed in small systems are typically significantly higher than large systems as mobilization costs are significantly greater.

Example 3. *Pump Stations*. Unit costs for water delivery systems often vary with system size as illustrated in Figure 1 [Excerpted from the *Basis for Cost Estimates of Full Scale Alternative Treatment (Supplemental) Technology Facilities* (Peer Consultants et al., 1999) (See Appendix A)]

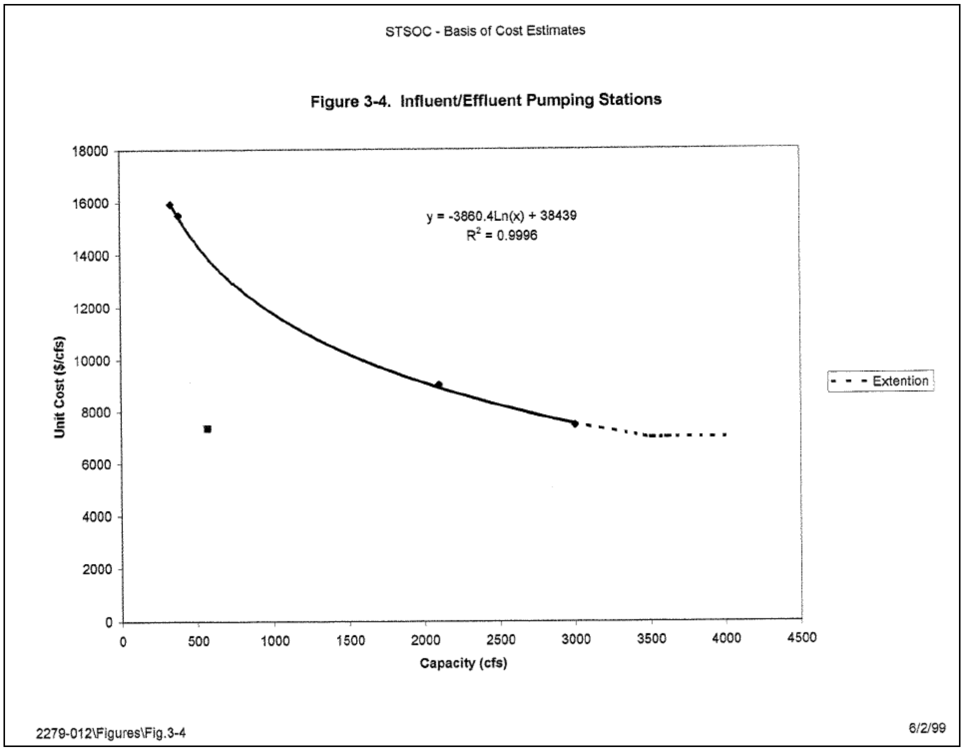

Figure 1. Pumping Station Cost Curves

Examples of sample Unit Cost Worksheets are included in Appendix B.

If the entity requesting treatment cost data does not provide standardized unit costs, it is recommended that the number of units and unit costs for each cost element be provided for the CEA/Cost and Benefit Analysis so that standardization can be provided at a later date if desired.

2.2.4 Define Design Conditions and Assumptions

Project or program design conditions and assumptions can significantly affect the calculation of nutrient control costs and benefits, and therefore should be standardized or specified when possible.

Important design conditions and assumptions that should be specified include the following:

- Specify Water Quality Conditions or Range of Conditions.

Pollutant removal rates are significantly impacted by the concentration of the pollutant in the source water specified for treatment. Accordingly, it is important that pollutant treatment costs from a CEA/Cost and Benefit Analysis be correlated with key factors such as water quality conditions. Assumed water quality conditions (i.e. nitrogen or phosphorus concentration) should be, standardized for all treatment alternatives if applicable, or at a minimum, be specified within the analysis.

For the CEA/Cost and Benefit Analysis , the analyst must also determine if it is to be assumed that each individual nutrient control activity is independent of other nutrient reduction activities within the watershed. Thus, are nutrient reduction estimates based on current conditions projected to remain the same over the defined analysis time frame? If source water quality changes are to be assumed over time, then the analyst may elect to propose a range of source water conditions for which to quantify benefits (pollution reduction).

- Specify Treatment Requirements (Load Vs Concentration)

Pollutant removal rates and thus the corresponding treatment costs for various treatment technologies are also impacted by the design objectives for the project. As an example, systems optimized for pollutant load reduction often achieve lower treatment costs than systems that are required to meet specified outflow treatment concentrations for the same source water. Accordingly, design water treatment objectives should be specified.

- Source Water Flow Rate and Frequency (if applicable)

Treatment technologies typically are impacted by design flow rates and flow frequency for intermittent flows. To assure that that treatment costs are based on application to the same set of design conditions, flow rates and frequency should be specified is applicable. If technologies to be compared may applied to different source waters with varying flow rates and flow frequencies, rates and frequencies used in the cost analysis should be reported.

2.2.5 Quantify Costs over the Defined Life

After defining the analysis time frame (Section 2.2.1), identifying those costs to be quantified per Section 2.2.2, and taking into consideration the specified design conditions per Section 2.2.4, the next step in the CEA/Cost and Benefit Analysis is to assign each required cost element a dollar value.

For each cost element, it is important to (i) clearly describe the element, (iii) how it is measured, and (iii) any assumptions made in the calculations. Those assumptions need to be made clear to decision makers and may be subjected to a sensitivity analysis to determine to what extent the outcome of the analysis is controlled by the assumptions made.

After the aforementioned information on costs is provided, quantified costs should employ the standardized unit costs as discussed in Section 2.2.3 if applicable.

Additional information pertaining to calculation of Life Cycle Costs can be found in the "*Guide to Computing and Reporting the Life Cycle Cost of Environmental Management Projects*" provided at the link below.

http://www.em.doe.gov/pdfs/LLCA_Guide_NIST-IR6968.pdf

2.1.6 Quantify Benefits over the Defined Life

In the case of CEA or a Cost and Benefit Analysis relating to nutrient control technologies, the analyst must quantify the level of effectiveness of the benefit or benefits identified in Section 2.2.2 over the specified time frame of the analysis. If more than one benefit (i.e. both nitrogen and phosphorus) is deemed important; separate cost effectiveness ratios may be calculated.

Benefits (i.e. pounds of pollutants removed) should be calculated over the time frame of the analysis, and the benefits should be annualized.

Quantification of future nutrient control benefits for any given technology may be based on (i) literature cited performance data, (ii) performance model projections or (iii) general estimates of performance. If the performance data used to quantify future benefits is not from a project within the source water or watershed of interest data, providing a projected range of benefits rather than a single value may be preferred.

Of critical importance in assessing the cost-effectiveness of a nutrient control technology is the reliability (probability) of meeting the projected treatment levels in any given year recognizing that the magnitude of flows and pollutant loads occurring in a given year are dependent on the many variable factors for technologies in which removal is correlated to source waters of varying flow and water quality.

2.2.7 Discount Costs to Obtain Present Values

LCC calculations are most easily performed when all estimates of future costs are made in current dollars and are discounted to their present value using a nominal discount rate. This avoids the complexity inherent in attempting to accurately predict future costs. The key economic assumption therefore in the LCCA is the value selected for the discount rate (time value of money).

The choice of an appropriate discount rate is critical for the analyst using LCCA in a CEA/Cost and Benefit Analysis; however, there is considerable debate as to the appropriate rate.

While in some public sector situations regulation or law may mandate the discount rate, there is no single correct discount rate for all situations. Regretfully, this lack of a standardized value can lead to confusion.

Circular A-94 of the Office of Management and Budget titled Guidelines and Discount Rates for Benefit Cost Analysis of Federal Programs provides guidelines on conducting benefit-cost and cost effectiveness analysis. Section 4 specifically addresses the Scope of said Circular. However, specifically exempted from the scope of Circular A-94 are decisions concerning water resource projects (See Section 4.b (1).

Accordingly, for the purposes of evaluating regional water supply and water quality projects, an appropriate option for a discount rate to be used is the current Rate for Federal Water Projects per Section 80, Water Resource Development Act 1974 (Public Law 93-251), published by the United States Department of Agriculture, Natural Resources Conservation Service at:

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/econ/prices/?&cid=nrcs143_009685

The 2012 published discount rate is 4.000% per year.

2.2.8 Compute a Cost-Effectiveness Ratio

The last step involves developing a Cost and Benefit or Cost Effectiveness Ratio that brings together system costs and benefits in a defined ratio. These values can be calculated as either (i) annualized present value costs and benefits or (ii) total present value of costs and total units of effectiveness over the specified analysis time frame to calculate a CE ratio. The CE ratio applies to only a single benefit (i.e. pounds of nitrogen removed). As opposed to using total costs, this ratio uses the present value of these costs. It should be noted however, that often in the literature the cost is presented without identifying said cost as a present value cost, even though the cost may have been discounted in the present value calculation.

$$\text{Cost-Effectiveness Ratio} = \frac{\text{Present Value Cost}}{\text{Units of Effectiveness}}$$

The resulting Cost and Benefit Ratio or Cost Effectiveness Ratio is expressed in “dollars per pound of pollutant removed”.

3.0 Geographic Correlations to Benefits

Spatial or Location Effects

Decision makers may also consider spatial or location effects when comparing various pollutant removal technology alternatives.

The rationale for considering spatial or location effects relates to the fact that the location of a given pollutant discharge affects the magnitude that said discharge has on the designated impaired receiving water. For example, for a nutrient impaired surface water such as a lake, reductions in nutrient pollutant discharges far upstream may have less of an benefit on the impaired surface water than an equivalent load reduction either downstream or directly from impaired source water because nutrients discharged upstream may be removed through existing natural processes as the water flows downstream.

As nutrient treatment technologies may be employed throughout the watershed, comparisons of treatment costs and specified benefits (load reductions) may be adjust for these spatial or location effects.

Appendix A. Technical Memorandum Bases for Cost Estimates of Full Scale Alternative Treatment (Supplemental) Technology Facilities (PEER Consultants et al., 1999)

TECHNICAL MEMORANDUM

Basis for Cost Estimates of Full Scale Alternative Treatment (Supplemental) Technology Facilities

Contract No. C-E008 – A12

Presented to:

South Florida Water Management District

Prepared by:

PEER Consultants, P.C./ Brown and Caldwell
A Joint Venture

August, 1999

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LIST OF ACRONYMS AND ABBREVIATIONS

CMP	Corrugated Metal Pipe
CCB	Construction Criteria Base
cfs	cubit foot per second
c/s	cross-section
cy	cubic yard
District	South Florida Water Management District
DoD	Department of Defense
DPRT	Demonstration Project Research Team
ECP	Everglades Construction Program
EFA	Everglades Forever Act
ENR	Everglades Nutrient Removal
FDEP	Florida Department of Environmental Protection
FEB	Flow Equalization Basin
FPL	Florida Power and Light
lf	linear foot
LS	Lump sum
MCACES	Micro-Computer Aided Cost Engineering System
OMD	Operations and Maintenance – South Florida Water Management District
O&M	Operations & Maintenance
PCD	Project Controls Division – South Florida Water Management District
PS	Pumping Station
PSTA	Periphyton Stormwater Treatment Area
R^2	Coefficient of Correlation
SAV	Submerged Aquatic Vegetation
sf/lf	square foot/linear foot
STA	Stormwater Treatment Area
STSOC	Supplemental Technology Standard of Comparison
USACE	United States Army Corps of Engineers
WCA	Water Conservation Area

BASIS FOR COST ESTIMATES OF FULL-SCALE ALTERNATIVE TREATMENT (SUPPLEMENTAL) TECHNOLOGY FACILITIES

1.0 INTRODUCTION

The 1994 Everglades Forever Act (EFA; Section 373.4592, Florida Statutes) mandates that the Florida Department of Environmental Protection (FDEP) and the South Florida Water Management District (District) design and carry out the Everglades program, a series of research, regulation and construction activities to restore the Everglades. The Everglades Program is designed to achieve interim ecosystem restoration goals and to identify and subsequently achieve long-term water quality and management goals. The Everglades Forever Act specifies that stormwater treatment areas (STAs), coupled with the use of on-farm best management practices to reduce phosphorus loading at the source, currently are the best available strategies for treating discharges from agricultural basins, for achieving interim water quality, and for accomplishing hydroperiod restoration goals. STAs are being designed to reduce phosphorus discharges to a long-term, flow-weighted, mean concentration of 50 parts per billion (ppb), which is the Phase I water quality improvement goal of the Everglades Program.

Currently, the program is focused on identifying technologies that, when used alone or in combination with STAs, can reduce phosphorus concentrations from approximately 150 ppb to approximately 10 ppb. Phase II of the Everglades Program is focused on identifying, demonstrating and implementing water treatment technologies to achieve these legislated standards.

To accomplish the Phase II goals of the Everglades Program, the District will identify, demonstrate, and design systems of water treatment technologies that can be used with constructed wetlands (i.e., STAs), to ensure that waters discharged from the Everglades Agricultural Area to the Everglades Protection Area will meet Florida water quality standards by December 31, 2006. The Everglades Program Phase II work will be orchestrated through the Alternative Treatment Technology Program to meet specifically legislated requirements of the Everglades Forever Act.

Eight alternative water treatment technologies along with stormwater treatment areas that have the potential to meet the objectives of the Everglades Program, alone or coupled in treatment trains, have been identified by District studies and the United States Army Corps of Engineers (USACE) 404 Dredge and Fill Permit for the Everglades Construction Project. The nine technologies that have been identified include:

1. Chemical Treatment - Direct Filtration
2. Chemical Treatment - High-Rate Sedimentation
3. Chemical Treatment - Dissolved Air Flotation/Filtration
4. Chemical Treatment - Microfiltration
5. Low Intensity Chemical Dosing of Wetlands
6. Managed Wetlands
7. Submerged Aquatic Vegetation (SAV)/Limerock
8. Periphyton-based Stormwater Treatment Areas (PSTAs)
9. Wetlands (STAs)

1.1. Supplemental Technology Standard of Comparison (STSOC)

A process identified as the STSOC was established to enable the District to compare demonstrated alternative treatment (supplemental) technologies to each other and with candidate technologies classified by those studies. Primary objective of the STSOC is to provide a scientifically defensible basis for comparative evaluation of the various technology demonstrations. To accomplish this, it is necessary that all demonstration projects be conducted to collect data in a similar fashion. A methodology is then needed to evaluate and compare these technologies. The above task was divided into three phases:

Phase One - A Standard of Comparison was developed that provided an unbiased approach to comparing the effectiveness of one Alternative Treatment Technology to another. Phase One included a concept letter report that proposed 12 evaluation concepts and a Contract Document (PEER Consultants, P.C./Brown and Caldwell, 1998a) (Appendix A) that listed data collection requirements that the alternative treatment technology demonstration project research teams (DPRTs) would follow.

Phase Two - Phase Two included: 1) development of an evaluation methodology for a comparative evaluation of alternative treatment technology demonstration projects (PEER Consultants, P.C./Brown and Caldwell, 1998b) (Appendix A), and 2) development of a comprehensive STSOC database. An evaluation methodology was developed, which consisted of both quantitative and qualitative concepts. The STSOC database serves as a repository for storing DPRT research data and is also a STSOC evaluation methodology tool.

Phase Three- To properly evaluate the cost estimates of a full-scale treatment facility for the diverse Everglades Program alternative treatment technology demonstration projects, it is necessary that all such cost estimates be prepared in a manner that allows valid comparisons to be made. Contract requirements were developed in Phase One for data collection by the DPRTs, which also includes requirements to develop full-scale cost estimates including capital, O&M, and present worth costs. Phase Three uses the guidelines established in the contract requirements for development of the basis for cost estimates that are likely to be used by each of the alternative treatment technologies.

It is the development of the basis for cost estimates of full-scale alternative treatment technology treatment facilities that is documented in this technical memorandum. The purpose of this document is to facilitate the STSOC as developed by the District for evaluating one alternative treatment technology against another. This basis for costs is not intended to provide an engineer's estimate nor a basis of comparison for any particular project that may be bid by the District. Therefore, components that are unique to a particular technology are not considered in this basis for costs. The purpose is to develop a "level playing field," for comparison of alternative treatment technologies and to assist in the review of cost estimates provided to the District by DPRTs.

2.0 RESEARCH OF AVAILABLE COST DATA

Certain items, such as land, levees, pump stations (PS), etc. will be used by most of the alternative treatment technologies. To facilitate the comparison of costs, unit costs for these items will be standardized. These documented standardized costs will be utilized in the development of cost estimates for each technology. The unit costs are based upon available data from recognized sources. These sources include:

- Everglades Construction Projects (STAs, WCAs)
- Everglades Nutrient Removal Test Cell Construction
- Past Alternative Treatment (Supplemental) Technology Research/Evaluation Projects (PEER Consultants, P.C./Brown and Caldwell, 1996)
- On-going/Completed DPRT Research
- District's Operations and Maintenance Department (District-OMD) records obtained through personal communications.
- Standard Cost Estimating Books (Means, Walker, Craftsman)
- Department of Defense (DOD), Micro-Computer Aided Cost Engineering System (MCACES)
- National Building Institute's, Construction Criteria Base (CCB).

The District has been involved in the construction of water management projects since its' inception in the 1940's as the Central and Southern Flood Control District. This has involved continuous construction activities such as dredging of canals, construction and maintenance of levees, construction and operation of pump stations and construction of support facilities. This experience with working in the unique Everglades environment has led to a detailed understanding of the specific risks and special situations that can arise during construction projects.

The District has let bids and begun or completed construction on a number of EFA Phase I construction projects, such as: STA-1W, STA-1W works and distribution, STA-2, STA-5 and STA-6. In addition, the detailed design of STA-3/4, the largest of the STAs, has begun. As each of these projects is bid and constructed, updated information regarding costs are obtained. An internal cost tracking system for all construction projects is being maintained by the District's Project Controls Division (PCD). Engineers' estimates and PCD cost information for the above mentioned projects were obtained through personal communications to be used in this basis for costs.

Various studies have been conducted by the District and others as alternative treatment (supplemental) technologies are being developed and implemented. The Desktop Study (PEER Consultants, P.C./Brown and Caldwell, 1996) laid the groundwork for implementing these technologies. The Modified Water Deliveries to Everglades National Park report (USACE, 1992) provides extensive cost information on canal, levee, pumping station and control structure construction, with respect to the Everglades construction. Other similar reports, evaluating cost alternatives for the Everglades projects, were also considered in this basis for costs.

Standard cost estimating references such as Means, R.S. (1999), Walker, F. (1995), Craftsman (1999) were also researched. Construction/Engineering databases such as MCACES, CCB were also used in developing this basis for costs.

Certain alternative treatment technologies, such as Microfiltration have already developed costs following the STSOC. The costs developed by Conestoga-Rovers and Associates (1998) for the Microfiltration demonstration project were also included in this analysis of basis for costs. A detailed list of references and documents used in the preparation of this basis of costs is presented in the References section.

3.0 COST COMPONENTS

The cost components for which the basis for costs has been developed, can be grouped under four categories:

- Capital Costs
- O&M Costs
- Salvage/Demolition/Replacement Costs
- Lump Sum/ Contingency Items

The items considered under each of the above categories do not include all of the items/tasks that are required for the development of full-scale cost estimates. Table 3-1 provides a complete list of items/tasks that are to be considered for the economic evaluation of the alternative treatment technologies, including items that are project specific and are not included in this basis of costs. Unit costs for items that have been evaluated in this document are also provided in Table 3-1.

Apart from the above major cost categories, certain individual components such as excavation, concrete, and corrugated metal pipe (CMP) for culverts, are also evaluated. A basis for costs for these items is provided to help develop detailed estimates, if necessary, at a later stage in the STSOC.

In developing the unit costs for the above items, data from various sources, identified in Section 2.0, were evaluated together to obtain the most representative cost numbers. The following assumptions hold in developing the unit costs:

1. Where possible, a generic average number for the unit cost was developed. However, in some cases the unit costs varied according to the capacity/size of the item. In such instances relationship curves were developed, to aid in identifying the appropriate unit cost for the item. A correlation coefficient (R^2) is provided to show the significance of the relationship.

2. All of the capital cost items (except Flow Equalization Basins (FEB's) and Roads), discussed in this document are actual construction costs as allocated to the contractor. Therefore, the 20% contingency, as stipulated in the Contract Documents (PEER Consultants, P.C./Brown and Caldwell, 1998a) may not be applied to these items.

3. Most of the data obtained is considered recent. Therefore, no attempt was made to convert the available numbers to present day dollars. In cases where older data was used, a cross check to current numbers revealed that the changes were not significant. For example, O&M costs for pumping stations as obtained from OMD (1999b) was compared to the Desktop Study (PEER Consultants, P.C./Brown and Caldwell, 1996) and the difference was insignificant. For the purposes of STSOC all numbers presented in this document will be considered as 1998 dollars.

4. In cases where an average number or a relationship could not be developed, a detailed explanation of the methodology to be used in evaluating the costs for these items is given. An example of this is the estimation of costs for flow control structures.

5. Statistical and/or engineering judgement was applied in developing the relationship curves in inclusion/elimination of data points to obtain a valid relationship curve.

6. Lump Sum/Contingency items are assumed to be similar to all technologies and are expected to be applied uniformly to all technologies. Modifications to these numbers will be at the discretion of the District STSOC project managers or an independent cost estimating entity selected by the District, whichever might be the case.

3.1. Capital Costs

The Contract Documents (PEER Consultants, P.C./Brown and Caldwell, 1998a) require the research teams to develop capital cost estimates for full-scale treatment facilities, which include all construction, equipment, design and land costs. The following items have been found to be generic for all technologies to be included in this basis for costs:

- Land
- Canals
- Levees
- Flow Equalization Basins (FEBs)
- Influent/Effluent Pumping Stations (Flow Equalization Basin and Treatment Plant)
- Flow Equalization Basin Seepage Pumping Station
- Control Structures, and
- Roads (gravel access roads).

Table 3-2 summarizes the capital cost items, the unit costs and the primary references used in obtaining these costs. A detailed discussion of these items is included in the following sections.

Land. Land acquisition costs are to be computed at $3500/acre. In all cases, the land required is to be estimated as the actual land required for water conveyance and treatment, plus an additional 10 percent for easements, right-of-ways, and buffers (PEER Consultants, P.C./Brown and Caldwell, 1996).

Canals. Canals may be required by the technologies for water conveyance to the flow equalization basin or the treatment plant itself. To estimate the construction costs of canals, costs estimates from various District construction projects were collected and analyzed. As was seen from this analysis the unit cost for canal construction varied from $1.37 per cubic yard ($/cy) to $6.17/cy ($26.13 per linear foot ($/lf) to $233.37/lf) depending on the cross-section (c/s) of the canal (for cross section of 200 to 1800 square feet) and the type of excavation required (whether blasting is included). Canals requiring blasting are considered separate from canals constructed by general excavation. A relationship between unit cost ($/lf) and cross-sectional area was developed (blasting not included) with an R^2 of 0.9255 (Figure 3-1). For an average inflow canal of size 1460 sf/lf (eg. STA 1W Inflow canal), the unit cost would be $150/lf. For canals requiring blasting the unit cost would be $6.17/cy ($233.37/lf) of excavation required. The data analysis for canal construction costs is presented in Appendix B (Table B-1).

In estimating canal costs, it must be noted that supply canal construction also includes the construction of the levees along the canal. Therefore, additional costs for levee construction may not be included.

Levees. To estimate the construction costs of levees (perimeter and internal levees), costs estimates from various District construction projects were collected and analyzed. As was seen from this analysis the unit cost for levee construction varied from $2.47/cy to $6.57/cy ($36.32/lf to $94.46/lf) depending on the cross-section of the levee (for a cross section of 300 to 530 sf) and the type of excavation required (whether blasting is included). Perimeter levees/interior levees will most likely be constructed of borrowed fill and will not include blasting. Average unit price for levee construction (blasting not included) is estimated to be $60.83/lf (Figure 3-2) or $3.95/cy (Figure 3-3). Unit cost for levee construction including blasting is $6.22/cy ($94.46/lf). The data analysis for canal construction costs is presented in Appendix B (Table B-2).

Unit price for perimeter levees to be constructed in STA 3/4 is estimated to be $108/lf or $571,000/mile (Burns and McDonnell, 1999). This estimate is outside the range ($36.32/lf to $94.46/lf) observed in this Basis of Costs. This higher unit price is attributed to the anticipation of significant amount of blasting involved in the construction of STA 3/4 levees.

Flow Equalization Basin (FEB) Construction. Flow equalization basins required by the alternative treatment technologies are different than those required by typical wastewater applications. For the purposes of STSOC it is assumed that the flow equalization basins would be constructed in a manner similar to that of STAs, except with higher levees of 12 to 15 feet. Flow equalization basins are also estimated to have greater seepage than STAs and hence enhanced seepage control is required for flow equalization basin levees. Considering the higher levees and greater seepage volume, the base construction cost of flow equalization basins amounts to 80% increase over a base construction cost for STAs. Based on a construction cost of $4583/acre for STA's, flow equalization basin construction cost would be $8250/acre (PEER Consultants, P.C./ Brown and Caldwell, 1996). A 20% construction contingency factor needs to be applied to this estimate. This cost does not include the cost of any pumping stations, engineering or land acquisition costs.

Influent/Effluent Pumping Stations. A number of pumping station cost estimates related to the ECP were obtained from the PCD. However, all these costs are for pumping stations that are related to STAs, WCAs or re-pumping stations. According to the Contract Documents (PEER Consultants, P.C./Brown and Caldwell, 1998a) DPRT's are required to develop cost estimates for full-scale facilities designed for flows from STA 2. Therefore, additional STA pumping stations will not be included in the full-scale cost estimates.

Development of flow equalization basin and treatment plant influent/effluent pumping station costs, will however, be required by each technology. flow equalization basin influent/effluent pumping station costs are estimated to be higher by 10% and treatment plant influent/effluent pumping station costs are estimated to be higher by 25% when compared to STA influent/effluent pumping station costs for the same capacity, to account for the higher head pumping requirements (PEER Consultants, P.C./Brown and Caldwell, 1996, Conestoga-Rovers and Associates, 1998).

For the purposes of this basis for costs, available (Burns and McDonnell, 1999, Conestoga-Rovers and Associates, 1998, PEER Consultants, P.C./Brown and Caldwell, 1996, PCD, 1999) influent/effluent pumping station unit costs, in dollars per cubic feet per second ($/cfs) were plotted against capacity with a relationship curve of $R^2 = 0.9996$. This curve is presented in Figure 3-4. The data based on which this curve was developed, is presented in Table B-3 under Appendix A. Given the capacity of the influent/effluent pumping stations, the unit costs for that pumping station could be interpolated from this curve. Some unit costs for typical pumping station sizes are presented in Table 3-2.

Flow Equalization Basin Seepage Pumping Stations. STA/WCA seepage pumping station costs, as available from the various sources (Burns and McDonnell, 1999, Conestoga-Rovers and Associates, 1998, PEER Consultants, P.C./Brown and Caldwell, 1996, PCD, 1999), averaged approximately $9154/cfs. Comparable flow equalization basin seepage pumping station (serving the same acreage) can be expected to cost twice as much to account for the higher seepage (PEER Consultants, P.C./Brown and Caldwell, 1996). Total construction cost for each station was converted into unit cost of $/acre, based on the acreage covered by each station. In the case of STAs/WCAs served by more than one station, the acreage was estimated on a capacity proportional basis. Average cost per acre of STA seepage pumping stations is $351/ac. Based on this cost flow equalization basin seepage pumping station costs can be expected to be $702/ac. Figures 3-5 ($/cfs vs. capacity) and 3-6 ($/ac vs. acreage) show the plots of seepage pumping station unit costs. Details of the data used in plotting these figures are presented in Appendix B (Table B-3).

Roads. Gravel access roads, (6-inch thick) can be estimated to cost about $2.59/sf (PCD).

Control Structures. Flow control structures related to the STAs and WCAs vary in size, type and purpose. These structures include simple corrugated metal pipes (CMP), single to multi gated control structures and gated spillway structures. The type of control structures to be used is project specific and cannot be predicted at this time. Gated spillway structure costs can be estimated using the equation

$$\text{Cost} = (1.000339)^{X}\ (664{,}237), \text{ where } {}^{X} = \text{spillway capacity (cfs)},$$

for capacities of 560 cfs to 3600 cfs (Burns and McDonnell, 1999). Simple CMP culvert costs can be estimated using the individual cost component prices for CMP, trench excavating and concrete, as given in Table 3-3.

3.2. O&M Costs

The DPRT Contract Documents (PEER Consultants, P.C./Brown and Caldwell, 1998a) require the research teams to develop O&M cost estimates for full-scale treatment facilities, which include all labor, material, energy, utilities, and chemical costs required for the operation and maintenance of all facilities included in the capital cost estimate. The following items have been found to be generic for all technologies to be included in this basis for costs:

- Maintenance of Canals,
- Maintenance of Levees,
- Maintenance of Flow Equalization Basin,
- O&M of Influent/Effluent Pumping Stations (Flow Equalization Basin and Treatment Plant), and
- O&M of Flow Equalization Basin Seepage Pumping Stations.

Table 3-4 summarizes the O&M cost items, unit costs and the primary references used in obtaining these costs. A detailed discussion of these items is included in the following sections.

Maintenance of Canals. Based on the information obtained from the OMD (1999b), this cost is estimated to be about $500/acre mainly for chemical control. This cost is applicable 2 to 3 years after the construction of the canal, once the submerged aquatics have been established. An alternative to chemical control is the use of grass carp. The use of carp requires the designer to contain the fish within the canal. The cost of this design feature must be factored in the original cost should this option be exercised. The District prefers the use of this option over chemical control but realizes that escape of carp into adjacent marsh areas is unacceptable. (OMD, 1999b). For the purposes of STSOC, chemical control costs may be used for canal O&M.

Maintenance of Levees. This cost is estimated to be about $1530/mile and mainly involves mowing and maintenance of grass along levees (OMD, 1999b).

Maintenance of Flow Equalization Basin. Flow equalization basins are assumed to be constructed similar to STAs, except with higher levees. OMD (1999b) estimates $22/acre for maintenance of STAs for levee/wetland maintenance and chemical control. To account for larger levees and greater seepage associated with flow equalization basins, it is assumed that flow equalization basin maintenance would be twice that of STA's or $44/acre.

O&M of Influent/Effluent Pumping Station. The following breakdown for O&M of typical large pumping stations (such as G335, rated at 3040 cfs) in the ECP was provided by OMD (1999b):

- Labor - $173,000/year
- Overtime - $12,900/year
- Diesel - $0.80 /acre-foot
- Equipment - $23,000/pumping unit
- Structure Maintenance - $55,000/year.

Based on these numbers, O&M costs for two typical pumping stations G-335 (3040/244 cfs, STA 2) and G-370 (1860/223 cfs, STA 3/4) have been developed and are included in Table 3-4. Annual O&M cost estimates of pumping stations with other average daily flows can be assumed to vary from these estimates on a flow proportional basis. A more detailed breakdown of these estimates is provided in Appendix B (Table B-4).

Flow equalization basin influent/effluent pumping station O&M can be estimated to be about 10% higher than STA pumping stations delivering similar flows, to account for the increased head pumping requirements. (PEER Consultants, P.C./Brown and Caldwell, 1996). Similarly treatment plant pumping stations O&M can be estimated to be about 20% higher to account for higher head pumping requirements.

O&M of Flow Equalization Basin Seepage Pumping Stations. OMD estimates $110,000/year in O&M costs for STA seepage pumping stations. This cost is found to be representative of G-337 serving STA 2 of 6430 acres. Annual O&M costs for other seepage pumping stations were assumed to be proportional to this estimate on the basis of STA treatment area served. An additional base cost of $10,000 per year can be added to each estimate to account for costs not related to the size of the seepage pumping station (PEER Consultants, P.C./Brown and Caldwell, 1996). Because flow equalization basin seepage pumping stations are expected to have greater seepage pumping requirements the O&M cost can be estimated to be 1.5 times that of STA seepage pumping station serving the same acreage.

OMD estimate (1999) of $110,000/year matches the basis of the estimates used in the Desktop Study (1996), indicating no significant change in these numbers from 1996 to 1999. A relationship between flow equalization basin area and flow equalization basin seepage pumping station O&M costs was obtained (Figure 3-7) with $R^2 = 0.916$. Given the size of flow equalization basin required by the technology, the seepage pumping station O&M costs can be interpolated from this curve. The basis for this plot is presented in Appendix B (Table B-5).

3.3 Salvage/Demolition/Replacement Costs

The following salvage/demolition/replacement cost items are included in this basis for costs to aid in the development of 50-year present worth costs; demolition costs, restoration of levees, restoration of flow equalization basins, clearing and grubbing, replacement items.

Demolition Costs. Demolition costs of large structures such as pumping stations and treatment plants can be estimated at 20% of capital cost (excluding contingency).

Restoration of Levees. Levee demolition was estimated to be $300,000/mile for STA levees (USACE, 1992, PEER Consultants, P.C./Brown and Caldwell, 1996).

Restoration of Flow Equalization Basins. Flow equalization basin restoration includes demolition of levees to return flow equalization basin land to its original state. Based on the above estimate of $300,000/mile for STA levees, flow equalization basin levee demolition is estimated to be $400,000/mile, to account for large levees. Considering only the perimeter levees, flow equalization basin restoration costs were developed for various technologies (PEER Consultants, P.C./Brown and Caldwell, 1996). Plotting these restoration costs (Figure 3-8) gives a means to develop the flow equalization basin restoration costs based on the acreage of flow equalization basin required by the technology. Details of the numbers forming the basis for this relationship are included in Appendix B (Table B-6).

Clearing and Grubbing. Typical clearing and grubbing of land for construction purposes is estimated to range between $250 to $2500/acre (R.S. Means, 1999, PEER Consultants, P.C./Brown and Caldwell, 1998a, Walker, F., 1995 and USACE, 1992) depending on the density of the brush and size of trees to be cleared. For the purposes of STSOC, clearing and grubbing will be limited to agricultural areas with light density brush. Therefore, a unit price of $630/acre will be used for clearing and grubbing (R.S. Means, 1999 and Sverdrup/PMA, 1997a, 1997b).

Replacement Items. If the economic life of equipment or facilities is projected to be less than 50 years, rehabilitation or replacement must be accounted for in the present worth calculations. (PEER Consultants, P.C./Brown and Caldwell, 1998a). The Contract Documents stipulate the economic life of various equipment/facilities to be used. OMD estimates 30 year life cycle for major equipment (Contract Documents stipulate 25 years) and 20 years for minor equipment. Based on these economic lives the following assumptions will hold good for estimating replacement costs:

- Flow equalization basin-Influent/Effluent pumping stations – 25% of costs being replaced once at 25 years.
- Seepage pumping stations – 50% of costs being replaced once at 25 years.
- Treatment Plant Influent/Effluent pumping stations – 50% of costs being replaced once at 25 years.
- Chemical Feed Systems – 60% of costs replaced every 10 years.
- Treatment plant equipment – 25% of plant cost replaced at 20th and 40th year.

3.4. Lump Sum/Contingency Items

The following lump sum items are suggested to be included in the cost estimates (PCD):

- Telemetry - $4500 (Sverdrup/PMA, 1997)
- FPL Improvements – project specific
- Administrative Facilities – project specific
- Sampling and Monitoring – project specific

3.5. Individual Cost Components

Apart from the major item unit costs as developed above, certain individual unit cost components were identified during the research into the cost estimates. These unit costs are provided in Table 3-3 for use in developing detailed full-scale estimates at later stages in STSOC.

4.0 USE OF THIS MEMORANDUM

The cost basis developed herein can be used in different ways. In the case of alternative treatment demonstration projects completed, this cost basis can be used to make a comparison against cost estimates provided by the DRPT. In the absence of cost figures developed by an individual DRPT, the District (or the individual "cost estimating entity") can utilize this document in developing their own costs. The costs will then be comparable to others developed under the STSOC. This document can also be distributed as an attachment to the RFPs (along with the contract documents) for the alternative treatment technology research. This will ensure that the alternative treatment technology cost estimates are developed in accordance with the STSOC – Evaluation Methodology. An example worksheet is presented in Appendix C to demonstrate the use of this document in developing full-scale cost estimates for a "Test Case Technology".

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TABLES

Table 3-1. Cost Components Master List

	Item/Task	Unit cost	Source	Comments/Explanation
1	**Capital costs**			
1.1.1	Equipment (process)	N/A	N/A	Project Specific
1.1.2	Equipment (residuals management)	N/A	N/A	Project Specific
1.2	Freight	N/A	N/A	Project Specific
1.3	Installation	N/A	N/A	Project Specific
1.4	Instrumentation	N/A	N/A	Project Specific
1.5	Electrical controls	N/A	N/A	Project Specific
1.6	Civil works- Control structures	See Text	Burns and McDonnell, 1998, Sverdrup/PMA, 1997a, 1997b.	Project Specific. See also text under Capital Costs/Control Structures.
1.7.1	Canals (no blasting)	See Fig. 3-1	District PCD, 1999	Plot obtained from actual construction costs per PCD records. Valid for cross-sections of 200 to 1800 sf/lf. (See Table A-1 for actual data)
1.7.2	Canals (incl. Blasting)	$6.17/cy	District PCD, 1999	Typical of Cell 5 canals.
1.8.1	Levees (No blasting)	$3.95/cy ($60.83/lf)	District PCD, 1999	Plot obtained from actual construction costs per PCD records. Valid for cross-sections of 300 sf to 530 sf. (See Table A-2 for actual data)
1.8.2	Levees (Incl. Blasting)	$6.22/cy	District PCD, 1999	Typical of Cell 5 levees.
1.9.1	Pumping stations- Influent/effluent	See Fig. 3-4	Burns and McDonnell, 1999, CRA, 1998, District PCD, 1999, PEER/BC, 1996	Plot obtained from actual construction costs and estimated/projected costs.

Table 3-1. Cost Components Master List
(continued)

	Item/Task	Unit cost	Source	Comments/Explanation
1.9.2	Pumping stations- Seepage	$702/ac	Burns and McDonnell, 1999, CRA, 1998, District PCD, 1999, PEER/BC, 1996	Total construction costs converted to $/ac based on an estimate of acreage of the STA/WCA area covered by each station. In the case of STAs/WCAs stations served by more than one station, the acreage was estimated on a capacity proportional basis.
1.10	Flow Equalization Basins (FEB)	$8250/acre	PEER/BC, 1996	FEB construction is estimated to be 2 times STA base construction (which is $4583/acre)
1.11	Land	$3500/acre	PEER/BC, 1998a, PEER/BC, 1996	Unit cost to be used as required by the contract documents.
1.12	Roads	$2.59/sf	Sverdrup/PMA, 1997a, 1997b	Cost estimate for typical gravel access road, 6-inch thick.
2	**Operating costs**			
2.1	Labor (operation and maintenance)	N/A	PEER/BC, 1998a	District OMD to be used as the source to obtain labor rates for different personnel, as required by the contract documents.
2.2.1	Maintenance (spare parts, equipment)	N/A	N/A	Project specific
2.2.2	Maintenance –Civil work	N/A	N/A	Project specific
2.2.3	Maintenance – Canals	$500/acre	District OMD, 1999b	Chemical control

Table 3-1. Cost Components Master List
(continued)

	Item/Task	Unit cost	Source	Comments/Explanation
2.2.4	Maintenance – Levees	$1530/mile	District OMD, 1999b	Mowing and maintenance of grass.
2.2.5	Maintenance - FEBs	$44/acre	District OMD, 1999, PEER/BC, 1996	Based on $22/acre for STA O&M and assume FEB O&M to be twice.
2.2.5	Maintenance- Seepage pumping stations	See Fig. 3-7	District OMD, 1999b, PEER/BC, 1996	Plot obtained based on estimates presented in the Desktop Study (PEER/BC, 1996). Basis for these estimates compared with District OMD PS maintenance costs to confirm validity.
2.2.6	Maintenance- Influent/effluent pumping stations	See Table 3-3	District OMD, 1999b	Values for two typical pumping station sizes, based on unit maintenance costs obtained from District OMD, converted to costs per pumping station using station specifications (acre-foot pumped, # of pumping units etc.)
2.2.7	Maintenance- Sludge treatment	N/A	N/A	Project specific
2.4	Chemicals	See Table 3-3	PEER/BC, 1996, CRA, 1998.	Typical chemicals anticipated to be used by supplemental technologies.
2.5	Solids disposal	$50/ton	PEER/BC, 1998a	As stated in the contract documents. Does not include transportation costs to the landfill.
	T. Plant sampling & monitoring.			

Table 3-1. Cost Components Master List
(continued)

	Item/Task	Unit cost	Source	Comments/Explanation
3	**Salvage/Demolition/Replacement costs**			
3.1	Demolition costs	20% of construction costs	PEER/BC, 1996, PEER, 1998.	For large structures such as Pumping Stations.
3.2	Restoration of levees	$300,000/mile	USACE, 1992, PEER/BC, 1996	
3.3	Restoration of FEBs	See Fig. 3-8	USACE, 1992, PEER/BC, 1996	Based on FEB levee restoration cost of $400,000/mile and considering only the demolition of perimeter levees.
3.4	Clearing and grubbing	$630/acre	R.S. Means, 1999, Sverdrup/PMA, 1997a, 1997b	Light brush clearing.
3.5	Replacement Items	See Text	District OMD, 1999b, PEER/BC, 1998a, PEER/BC, 1996	Economic life of equipment as estimated by District OMD and replacement costs to be estimated as discussed in the contract documents.
4	**Lump sum/Contingency items**			
4.1	Telemetry	$4500 LS	Sverdrup/PMA, 1997	As estimated for STA 1W project costs.
4.2	FP&L Improvements	N/A	N/A	Project Specific
4.3	Administrative Facilities	N/A	N/A	Project Specific
4.4	Sampling and Monitoring	N/A	N/A	Project Specific

STSOC – Basis for Cost Estimates
Table 3-2
Capital Cost Components

Item		Unit	Cost	Source	Comments
Land		AC	$3,500.00	PEER/BC, 1998a, PEER/BC, 1996	As stipulated in the Contract Documents
Levees				District PCD, 1999	Plot obtained from actual construction costs of various levees
	No blasting	CY (LF)	$3.95 ($60.83)		See Figure 3-2 and 3-3. Does not include blasting
	Includes blasting	CY	$6.22	District PCD, 1999	Includes blasting
Canals					Plot obtained from actual construction costs of various canals
	No blasting	LF	See Figure 3-1	District PCD, 1999	Does not include blasting
	Includes blasting	CY	$6.17	District PCD, 1999	Includes blasting
Flow equalization basin (FEB)		Acre	$8,250.00	PEER/BC, 1996	See explanation in text. Does not include contingency
Influent/ Effluent Pumping Station				Burns and McDonnell, 1999; CRA, 1998; District PCD, 1999; PEER/BC, 1996	Influent/Effluent (unit cost/max cfs). See Figure 3-4
	3600/292 cfs	cfs	$7,000.00		STA Flows (max/avg cfs)
	2111/719 cfs	cfs	$9,017.00		10 yr POR Flow (2111/719 cfs)
FEB Seepage Pumping Stations	Acreage	AC	$702.00	Burns and McDonnell, 1999; CRA, 1998; District PCD, 1999b; PEER/BC, 1996	See Figure 3-5
	Capacity	cfs	$9,154.00	District PCD, 1999	See Figure 3-6
ROADS		sf	$2.59	District PCD, 1999	6-inch thick gravel access road

STSOC – Basis for Cost Estimates
Table 3-3
Individual Unit Cost Components

Item	Unit	Cost	Source	Comments
Excavation (Canal/levees)	CY	$1.82	Sverdrup/PMA, 1997a, 1997b; PMA, 1997	Median Number
Trench Excavation for Pipe	CY	$3.38	Sverdrup/PMA, 1997a, 1997b; PMA, 1997	Typical for 18 to 74-inch CMP.
Concrete			Sverdrup/PMA, 1997a, 1997b; PMA, 1997	
Structures	CY	$565		Baffles, Weirs etc.
Base Slab	CY	$273		USACE - $265 (USACE, 1992 converted to 1996 dollars)
Walls, Platforms	CY	$350		
Seeding	AC	$1179	Sverdrup/PMA, 1997a, 1997b; PMA, 1997	Minimal fertilization
Disking Fields	AC	$60	Sverdrup/PMA, 1997a, 1997b; PMA, 1997	
CMP	lf-in	$2.36	Sverdrup/PMA, 1997a, 1997b; PMA, 1997	Average number for 18 to 72-inch CMP

STSOC – Basis for Cost Estimates
Table 3-4
O and M Cost Components

Item		Unit	Cost	Source	Comments
Levees		Mile	$1,530.00	District OMD, 1999b	See text
Canals		Acre	$500.00	District OMD, 1999b	See text
FEB		Acre	$44.00	District OMD, 1999b	See text
Influent/ Effluent Pumping Stations				District OMD, 1999b	See Table A-5 for more details
G335	3040/244 cfs	Year	$520,000		See text for FEB and treatment plant PS O&M estimates
G370	1860/223 cfs	Year	$439,000		
FEB Seepage Pumping Stations		See Figure 3-7			See text and Table A-6
Chemicals					
	Bleach	Gal	$0.75	CRA, 1998	
	Ferric Sulfate	Dry ton	$150.00	CRA, 1998	
	Ferric Chloride	Dry Ton	$180.00	PEER/BC, 1996	
	Alum	Dry ton	$150.00	CRA, 1998	
	Polymer	Lb	$2.00	PEER/BC, 1996	
	Citric Acid	Lb	$0.90	CRA, 1998	
	Lime	Ton	$66.00	PEER/BC, 1996	

FIGURES

Figure 3-1. Canal Unit Cost Curve

For C/s of 200 to 1800 sf

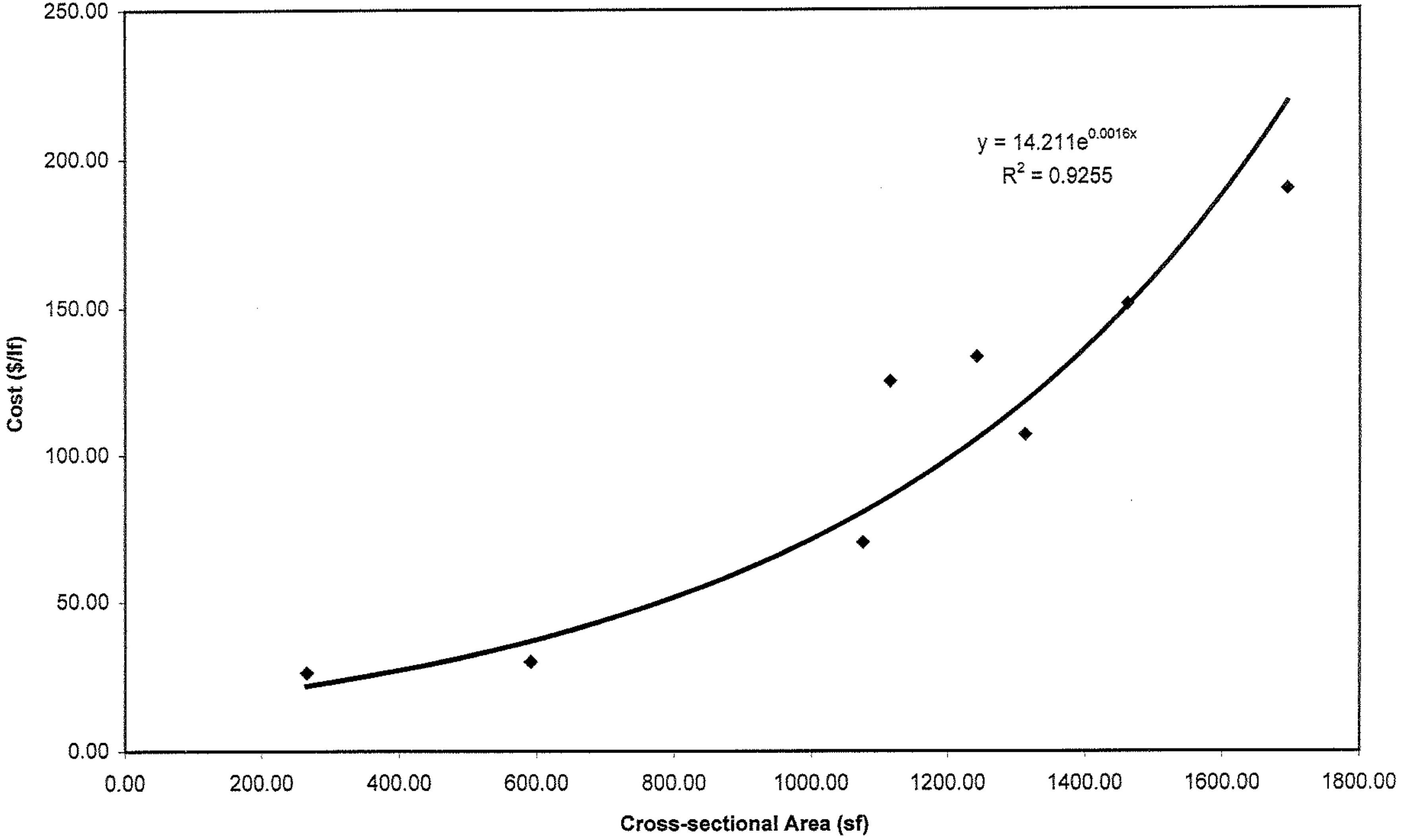


Figure 3-2. Levee Unit Cost (Length)

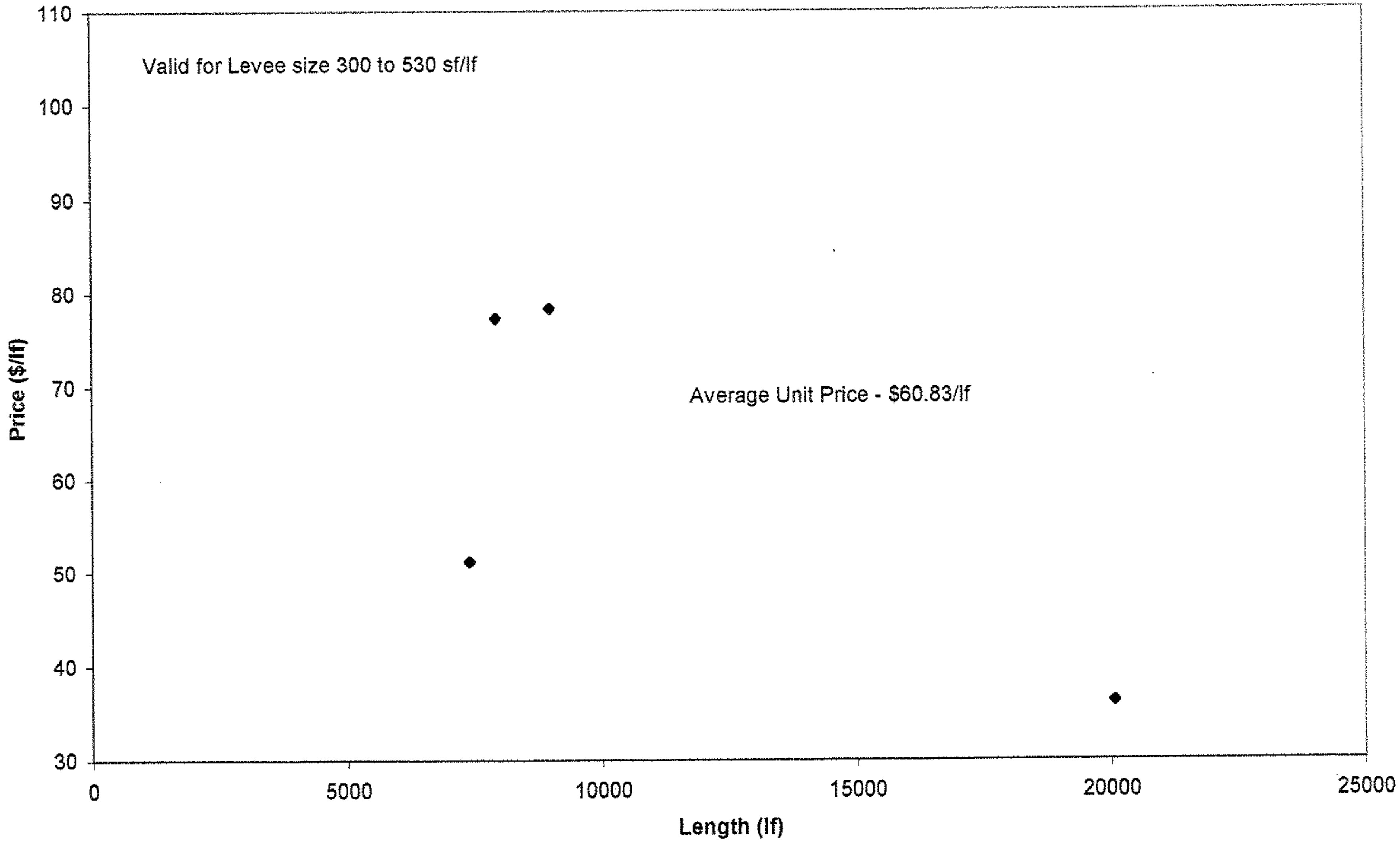


Figure 3-3. Levee Unit Cost (Volume)

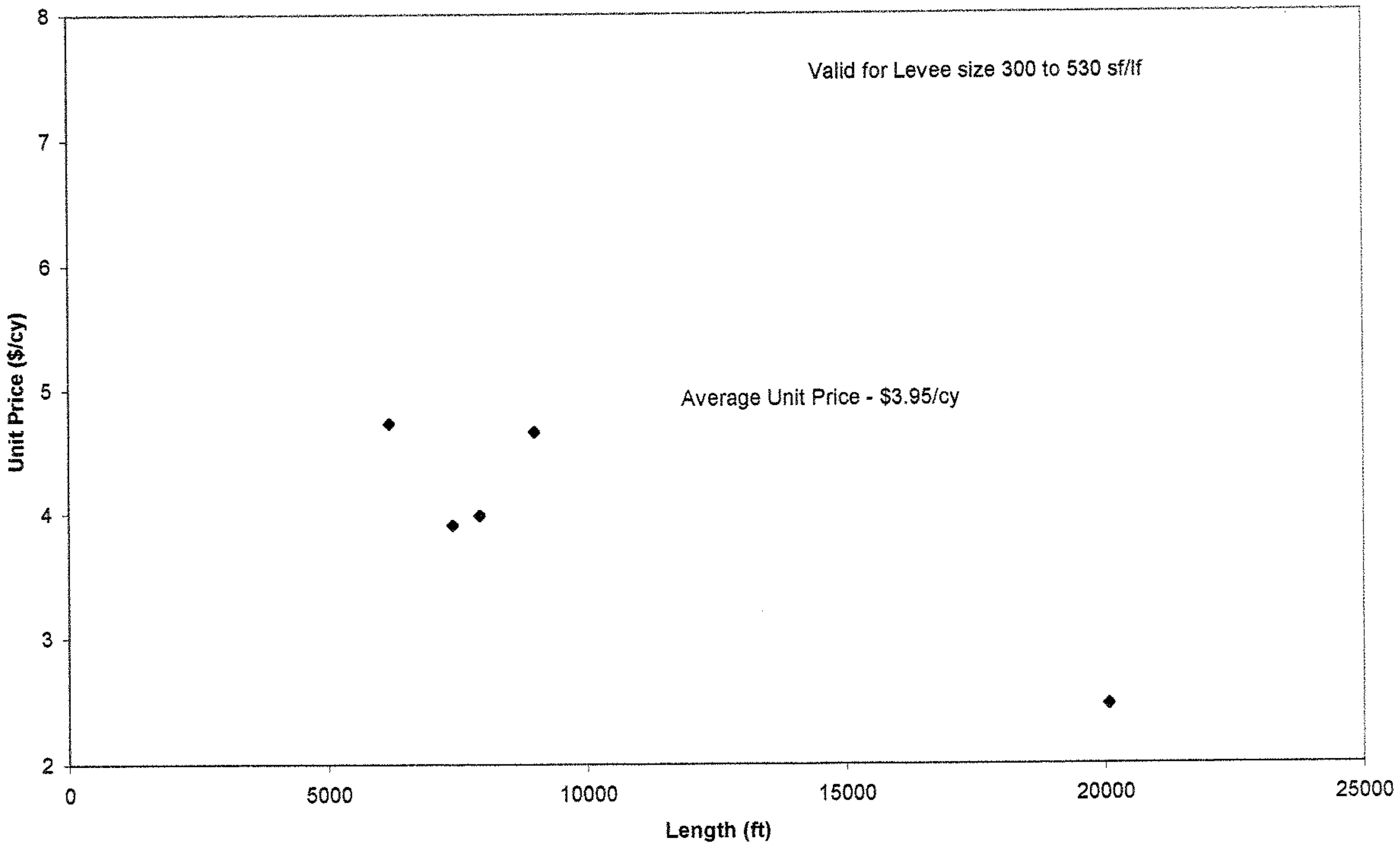


Figure 3-4. Influent/Effluent Pumping Stations

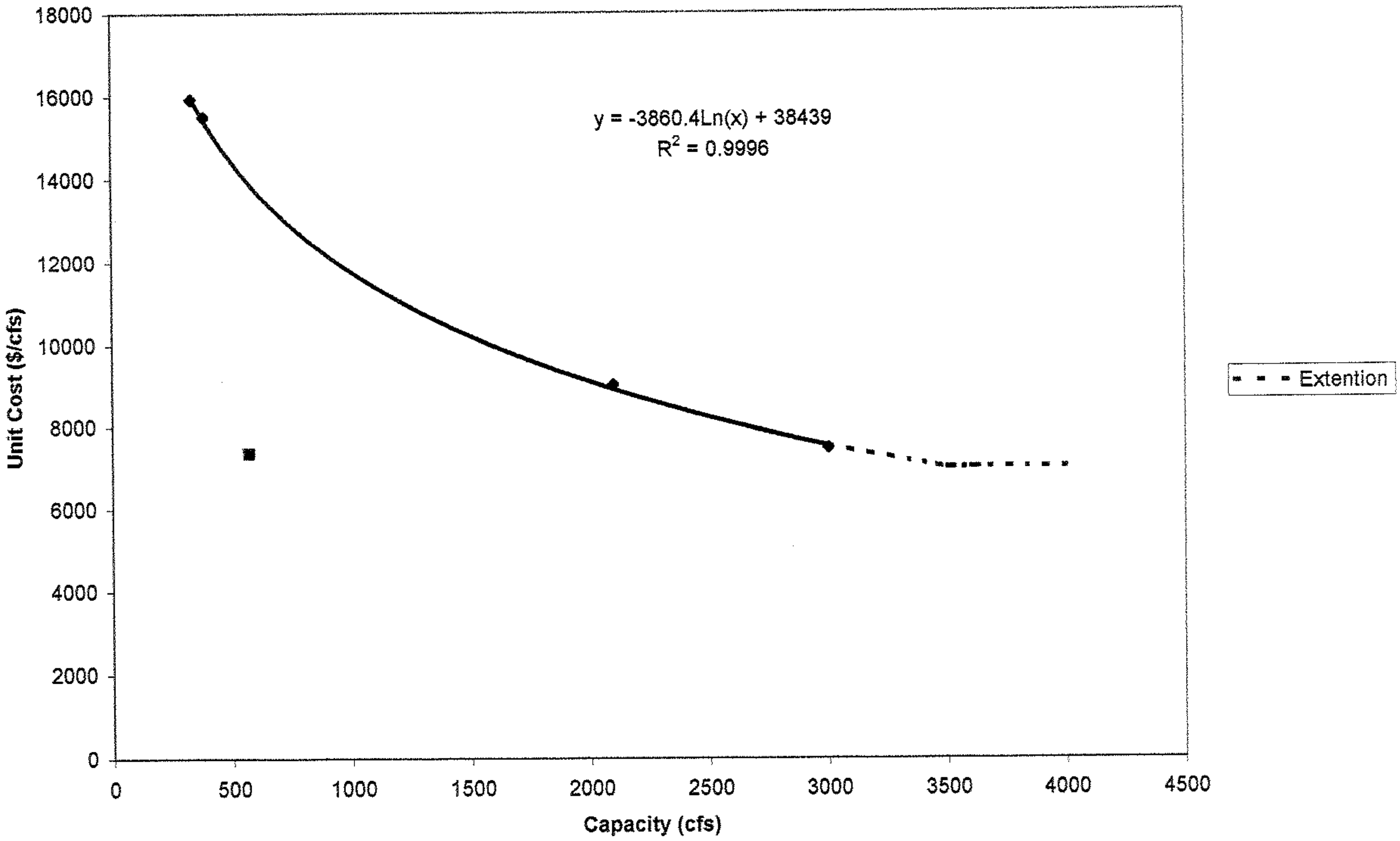


Figure 3-5. STA Seepage Pumping Stations (Capacity)

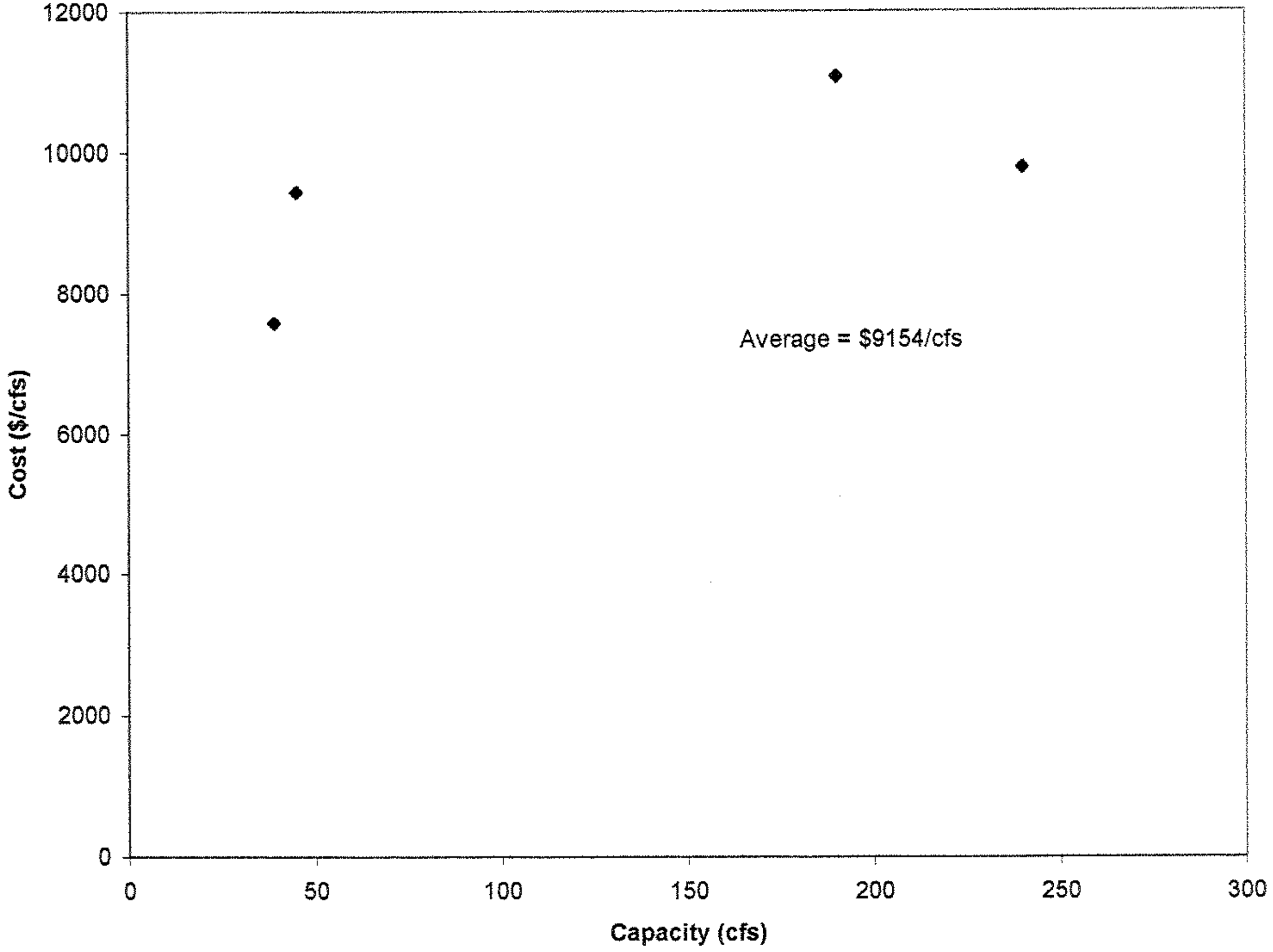


Figure 3-6. Seepage Pumping Station Unit Costs (Area)

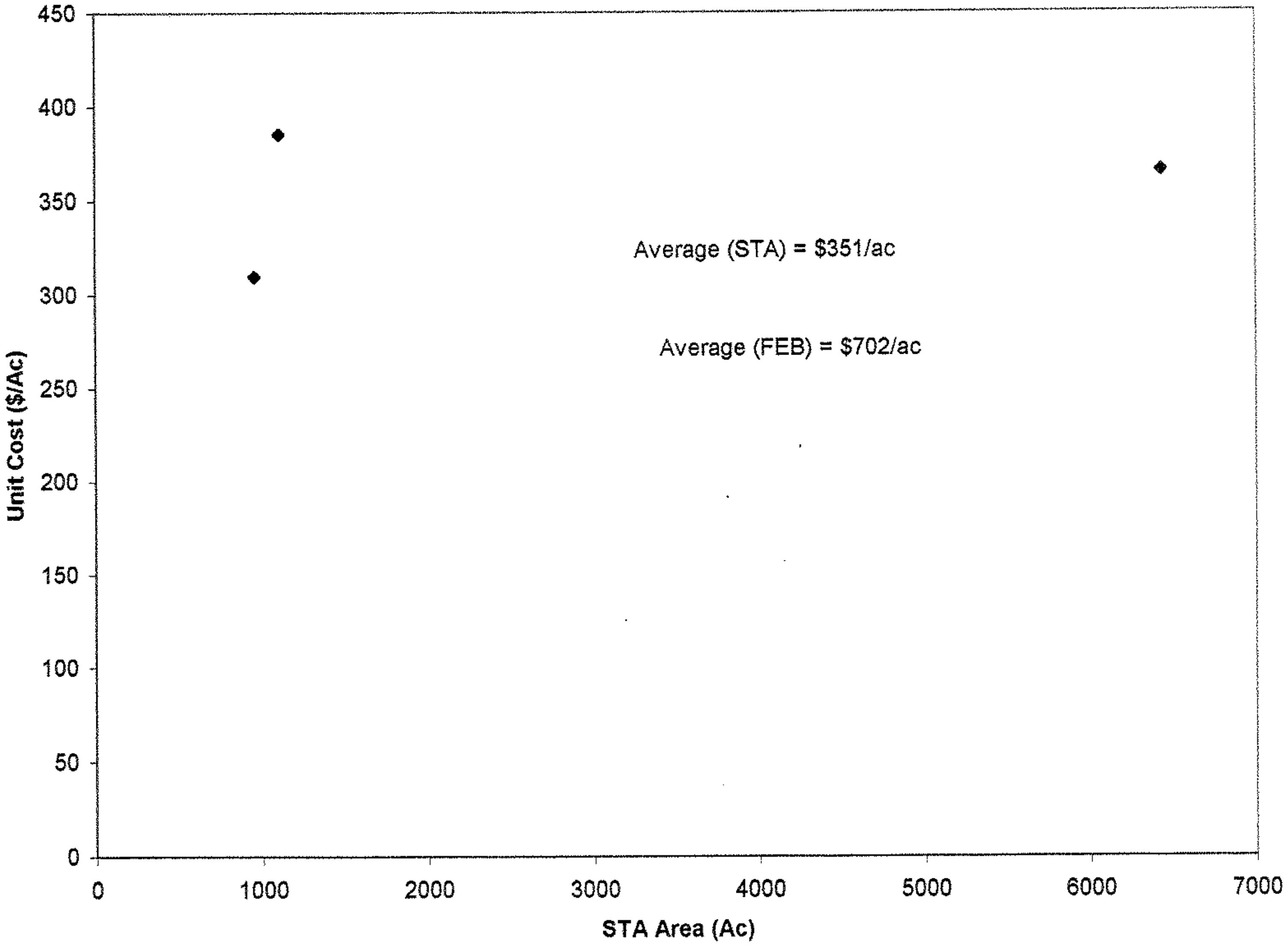


Figure 3-7. Flow Equalization Basin Seepage Pumping Station O&M Costs

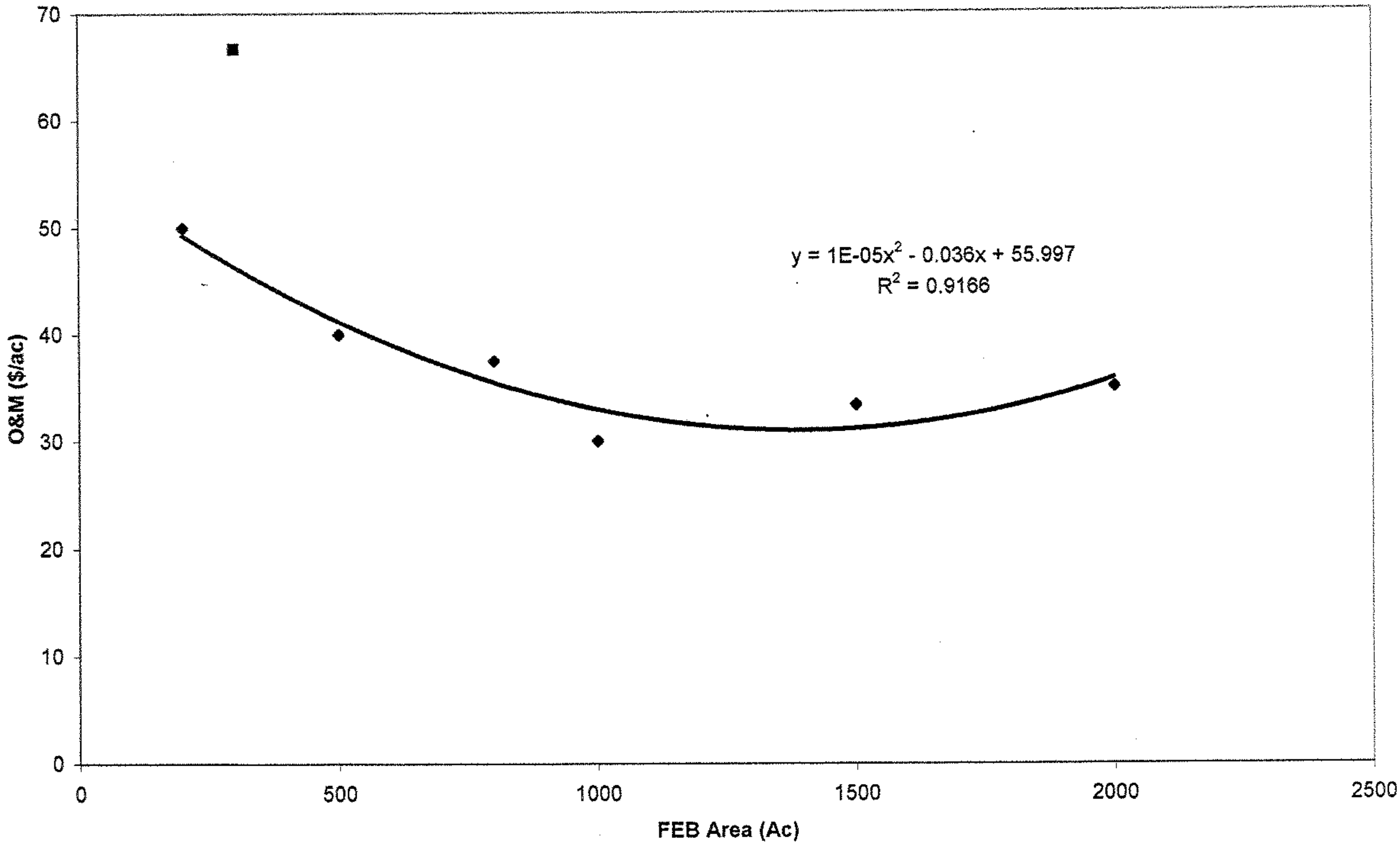
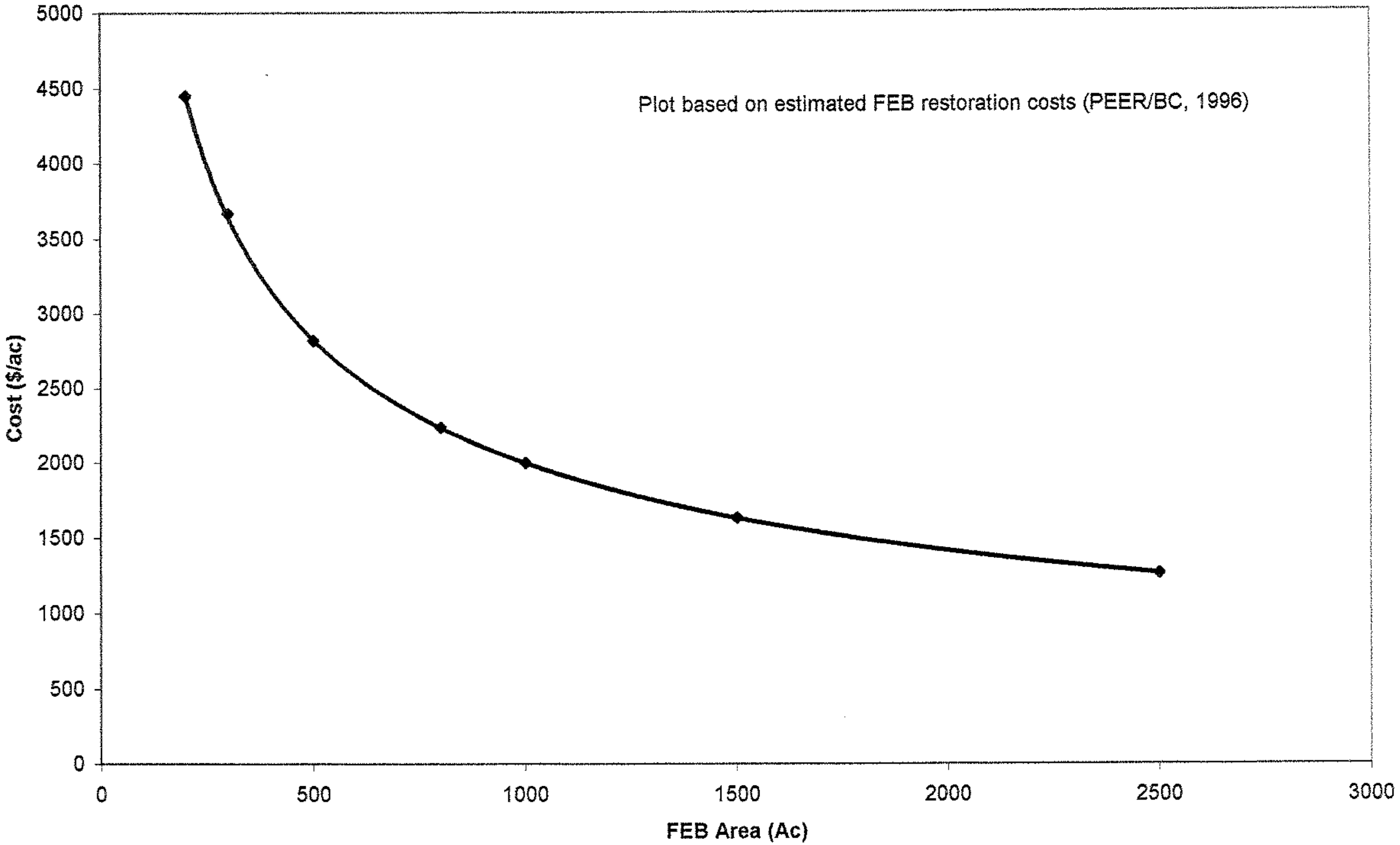


Figure 3-8. Restoration Costs for Flow Equalization Basins



APPENDIX A

STSOC Evaluation Methodology (includes contract documents as an attachment)

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

CONTRACT C-E0008 A9B Phase Two

EVALUATION METHODOLOGY FOR COMPARISON OF SUPPLEMENTAL TECHNOLOGY DEMONSTRATION PROJECTS

EXECUTIVE SUMMARY

The Florida Department of Environmental Protection (FDEP) and the South Florida Water Management District (District) are working together to determine the most appropriate technologies to supplement and/or replace the stormwater treatment areas (STAs) to provide additional treatment to agricultural runoff from the Everglades Agricultural Area. A number of research programs are underway to determine the most suitable supplemental technologies for treatment of runoff to achieve the water quality objectives of the Everglades Forever Act.

This document is part of a process to develop a method with minimal bias to evaluate the research results of the supplemental technology research programs and select the most appropriate technologies to supplement the STAs. The first phase of the development of a Supplemental Technology Standard of Comparison (STSOC) was completed for the District by the joint venture firm PEER Consultants, P.C./Brown and Caldwell in late 1997. The first phase STSOC work included a concept letter report that proposed 12 evaluation concepts and a contract requirements document that listed data collection requirements for adherence by the supplemental technology demonstration project research teams. The concept letter report and the Contract Requirements Document were developed through an iterative review process involving the District, DEP, Everglades Technical Advisory Committee (ETAC), and the public. The contract requirements document was distributed to all the active supplemental technology demonstration research teams and will be made available to new supplemental technology demonstration project teams.

This second phase of the STSOC includes development of an evaluation methodology for a comparative evaluation of supplemental technology demonstration projects. Based on discussions with ETAC the original twelve evaluation concepts have been modified and reduced to ten concepts. Five concepts are considered primary and five are considered ancillary. The evaluation methodology will include a quantitative analysis of the primary concepts and a qualitative analysis of the ancillary concepts. This methodology will evaluate a technology in achieving a given objective, such as phosphorus removal efficiency, effluent phosphorus concentration, cost effectiveness, timeliness, etc. The following process will be used:

- Demonstration project research teams conduct their research consistent with the contract requirements document, and the written plan approved by the District. This will ensure that data sets developed by the technologies are comparable.
- Demonstration project research teams develop a conceptual design and model phosphorus removal for a 10-year period of record (POR) for the phosphorus and flow data set provided by the District.

- Final reports are provided to the District from the supplemental technology research teams.
- The District applies the Standard of Comparison Evaluation Methodology depending upon the available information on the results of Nutrient Threshold Research, STA optimization, and enhanced BMPs.
- The most promising technologies are selected for further consideration.
- Conceptual design cost estimates are developed for all six STAs by one District Contractor.

This document provides a description of the proposed evaluation methodology for each evaluation concept.

1.0 BACKGROUND

The Everglades Forever Act mandates that the Florida Department of Environmental Protection (FDEP) and the South Florida Water Management District (District) design and carry out the Everglades Program, a series of research, regulation, and construction activities to restore the Everglades. The Everglades Program is designed to achieve interim ecosystem restoration goals and to identify and subsequently achieve long-term water quality and management goals. Six Stormwater Treatment Areas (STAs) have been or will be designed to treat agricultural and residential runoff prior to discharge to the Water Conservation Areas (WCAs). The STAs, coupled with on-farm Best Management Practices (BMPs) will reduce the Total Phosphorus (TP) concentration in runoff from approximately 150 ppb[1] to 50 ppb TP on a long term basis. The Everglades Forever Act (EFA) mandates that additional treatment strategies be considered to reduce the TP concentration to a numeric phosphorus criterion. However, the TP concentration shall be 10 ppb, if FDEP does not adopt a numeric phosphorus criterion by rule by December 31, 2003. Supplemental technology research efforts are currently underway to determine the phosphorus removal capabilities of nine technologies:

1. Chemical Treatment - Direct Filtration
2. Chemical Treatment - High Rate Sedimentation
3. Chemical Treatment - Dissolved Air Floatation
4. Chemical Treatment - Microfiltration
5. Low Intensity Chemical Dosing of Wetlands
6. Managed Wetlands
7. Submerged Aquatic Vegetation - Limestone Treatment
8. Periphyton Stormwater Treatment Areas (PSTAs)
9. Wetlands (STAs)

Because of the different types of nutrient removal mechanisms and previous performance histories of these supplemental technologies, the District has begun the development of a Standard of Comparison that would have minimal bias. This standard is intended to be applied evenly to all technologies to provide a reasonable analysis of the potential of each technology. The first phase of the development of a STSOC was completed for the District by the joint

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[1] ppb = parts per billion

venture firm PEER Consultants, P.C./Brown and Caldwell in late 1997. The first phase STSOC work included a concept letter report that proposed 12 evaluation concepts and a contract requirements document that listed data collection requirements for adherence by the supplemental technology demonstration project research teams. The concept letter report and the Contract Requirements Document were developed through an iterative review process involving the District, DEP, ETAC, and the public. The contract requirements document was distributed to all the active supplemental technology demonstration research teams and will be made available to the new supplemental technology demonstration project research teams. The contract requirements will be incorporated into research contracts for supplemental technology research sponsored by the District and FDEP. The contract requirements document is presented in Appendix A.

2.0 OBJECTIVES

The objectives of this second phase of the STSOC includes: 1) development of an evaluation methodology for a comparative evaluation of supplemental technology demonstration projects, and 2) development of a comprehensive STSOC database.

The evaluation methodology will have quantitative and qualitative methods to compare the ten supplemental technologies. These methods would rank the technologies from most feasible to least feasible in achieving a given objective, such as phosphorus removal efficiency, effluent phosphorus concentration, cost effectiveness, timeliness, etc. This document provides a description of the proposed evaluation methodology for each evaluation concept. The development of a comprehensive STSOC database is not within the scope of this document. The STSOC database will be developed after finalization of the evaluation methodology described herein.

The steps for developing an evaluation methodology are:

I. Formulate Conceptual Approach
II. Prepare Preliminary Draft Methodology
    A. Rate within each STSOC Concept
    B. Obtain District and ETAC Comments
III. Review Comments and Prepare a Draft Methodology
    A. Revise Preliminary Draft Methodology
    B. Obtain District and ETAC Comments
IV. Prepare the Final Evaluation Methodology

This document describes steps I, II, and IIIA.

3.0 DEVELOPMENT OF STSOC EVALUATION METHODOLOGY

3.1 Formulate Conceptual Approach

The conceptual approach for evaluating supplemental technology demonstration projects is a comparison to evaluation concepts that were developed in Phase I of the STSOC and subsequently modified based on comments received from ETAC, FEDP, and District members. The revised list of concepts is:

1. The level of phosphorus concentration reduction achievable by the technology (based on experimental data)
2. The level of phosphorus load reduction achievable by the technology (based on model data)
3. Cost-effectiveness of the technology
4. Evaluation of the potential toxicity of the technology
5. Implementation schedule
6. Feasibility and functionality of scaled-up design and cost estimates
7. Operational flexibility
8. Sensitivity of technology to fire, flood, drought and hurricane
9. Level of effort required to manage, and the potential benefits to be derived from, side streams generated by the treatment process
10. Other water quality issues.

Concepts 1 through 5 are considered primary concepts and will be evaluated quantitatively, by developing a scoring system for each concept. Concepts 6 through 10 are considered ancillary concepts and will be evaluated qualitatively. The quantitative data will be entered into a supplemental technology standard of comparison database and the qualitative information will be provided by the research teams as written summaries. There are no plans to generate a single score or rating of the technologies. The selection of the most promising supplemental technologies for further evaluation will be made by the District. The combined evaluation methodology will be presented to ETAC and will be modified as necessary. **This document is the second step in the development of a screening tool that will be used to select the most promising technologies from the list of potential supplemental technologies for further evaluation.**

3.2 Preliminary Evaluation Methodology Scoring System with STSOC Concepts

The method of evaluating STSOC concepts is summarized in Table 1 (presented at the end of the document). Additional explanation of the methodology for each evaluation concept is presented below.

Evaluation Concept 1 - The Level of Phosphorus Concentration Reduction Achievable by the Technology (based on experimental data)

The purpose of this evaluation concept is to evaluate technologies according to their ability to produce effluent with low phosphorus concentrations and the efficiency with which they can achieve phosphorus reduction. The data to be used for this evaluation will be results from the pilot test verification phase. Two measures will be used to evaluate this concept, average effluent TP concentration, and overall TP reduction efficiency.

- *1A – Concentration*

TP effluent concentration will be evaluated by the average effluent TP concentration observed during the experimental verification phase. The average effluent TP concentration will be calculated by using data from all the samples collected during experimental verification testing at the expected design conditions (e.g. hydraulic retention time, depth, treatment cell geometry, etc).

- *1B – Efficiency*

Phosphorus removal efficiency will be calculated using the average of all TP reduction percentages over the experimental verification phase.

$$TP\ Removal\ Efficiency = \frac{\left\{\sum\left[\left(\frac{p_{in} - p_{out}}{p_{in}}\right)\times 100\right]\right\}}{n}$$

where:

$$p_{out} = \frac{\left(p_{effluent} \times Q_{effluent}\right) + \left(p_{seepage} \times Q_{seepage}\right)}{Q_{effluent} + Q_{seepage}}$$

p_{in} = Influent TP for the technology
$p_{effluent}$ = Effluent TP for the technology
$Q_{effluent}$ = Effluent flow
$p_{seepage}$ = Seepage TP for the technology
$Q_{seepage}$ = Seepage flow
n = Number of data sets (p_{in} and p_{out})

Assume the following hypothetical data:

Supplemental Technology	Calculated Evaluation Measures		
	Average Influent TP Conc., µg/l.	Average Effluent TP Conc., µg/l	***Average Removal Efficiency***
A	20	10	***49.8%***
B	17.9	12	***32.8%***
C	25	14	***43.6%***
D	22	16	***27.3%***
E	16	8	***49.8%***

Technology E has lowest *average effluent* TP concentration, however, its *average* TP removal efficiency is *49.8%* which is the same as that of technology A.

Evaluation Concept 2 - The Level of Phosphorus Load Reduction Achievable by the Technology (based on model data)

The objective of this evaluation concept is to give a higher rating for a technology with a higher TP load reduction capability. The predicted average TP removal based on the 10-year POR phosphorus data set, with 0%, 10% and 20% diversion volume will be used in this evaluation. *The flow equalization storage required for the technology will be determined by the research team.* TP removal will be modeled at supplemental technology effluent TP concentrations of 10 and 20 ppb, as shown below:

Effluent TP	No Diversion	10% Diversion	20% Diversion
10 ppb	X	X	X
20 ppb	X	X	X

Note: The percent diversion is calculated based on the 10-year volume. The 10 ppb effluent concentration target is for the water not diverted around the supplemental technology. The percent removal should be based on the supplemental technology effluent load divided by the total influent load including the diverted TP load.

The predicted removal will be based on the optimal design for the supplemental technology that is consistent with the STA's hydraulic and geotechnical design assumptions presented in the 1994 Conceptual Design (Burns and McDonnell, 1994). Development of the conceptual design for the supplemental technology is summarized in Chapter 4 of the Contract Requirements Document (See Appendix A). This evaluation concept will be applied to the average TP load reduction for a 10-year POR flow and TP concentration data set for STA 2. This data set was provided to the research teams by the District. The load reduction will be based on an empirical model of phosphorus removal for the supplemental technology for the conceptual design developed by the research team, as described in Appendix A. *The outflow load will include discharges at the STA weirs and discharges to groundwater.*

This evaluation concept is tested using the hypothetical data shown below:

Supplemental Technology	Predicted Average Daily Effluent TP Load Reduction Over 10 – year POR, %
A	67
B	60
C	53
D	40
E	70

The technology with the highest load reduction for the 10-year POR might or might not be the same technology with the lowest effluent TP concentration during demonstration testing. The load reduction evaluation requires that demonstration project research teams plot TP load reduction vs design parameters such as hydraulic retention time, depth, etc. This information will be used for additional qualitative evaluation of the technologies being demonstrated.

Evaluation Concept 3 - Cost-effectiveness of the technology

To evaluate the cost effectiveness of the technology, the 50-year present worth value will be considered for six full-scale facility scenarios. These facilities will achieve flow weighted, average effluent TP concentrations of 10 and 20 ppb TP with 0%, 10%, and 20% diversion (peak shaving, not continuous) of the 10-year POR flow volume. This approach will result in a total of six cost estimates for each technology, shown below in the table.

Effluent TP	No Diversion	10% Diversion	20% Diversion
10 ppb	X	X	X
20 ppb	X	X	X

Initial information that may be included in an evaluation of costs and benefits will be generated as a part of this effort.

The six cost estimates will be reported as the total present worth for the 50-year analysis period <u>and</u> the average cost of TP removal in dollars per pound of TP removed. The average cost of TP removal will be calculated by dividing the equivalent average annual cost of full scale treatment facility by the average annual quantity of TP removed over the 10-year POR.

$$CostEffectiveness,\frac{\$}{lb}=\frac{C_A}{TP_{Removed}}$$

where: C_A = Equivalent average annual cost of implementing technology A calculated by summing all projected costs over the 50-year period and dividing by 5, \$

$TP_{Removed}$ = Predicted TP removed for the 10 year POR, lb
TP removed shall not include the TP load discharged through seepage.

To ensure that the costs obtained are representative of the optimal conditions for the supplemental technologies, cost estimates will be developed through a coordinated effort between the District and a District consultant.

The above equation was tested with the following hypothetical data:

Supp Tech	50-year Present Worth (in millions of $)						Average Annual 10 year POR TP Removal (in hundreds of lb)					
	10 ppb			20 ppb			10 ppb			20 ppb		
	0%	10%	20%	0%	10%	20%	0%	10%	20%	0%	10%	20%
A	150	123	111	39	31	28	96.0	86.4	76.8	48.0	43.2	38.4
B	90	72	63	24	18	9	120.0	108.0	96.0	72.0	64.8	57.6
C	45	27	18	9	3	3	144.0	129.6	115.2	96.0	86.4	76.8
D	135	117	90	36	30	27	168.0	151.2	134.4	120.0	108.0	96.0
E	36	27	18	9	3	3	192.0	172.8	153.6	144.0	129.6	115.2

Supp. Tech	Cost Effectiveness ($/lb)					
	10 ppb			20 ppb		
	0%	10%	20%	0%	10%	20%
A	3,125	2,847	2,891	1,625	1,435	1,458
B	1,500	1,333	1,313	667	556	313
C	625	417	313	188	69	78
D	1607	1,548	1,339	600	556	563
E	375	313	234	125	46	52

Calculating cost effectiveness for the 10 ppb, 0% diversion condition:

$$\text{Cost Effectiveness of A} = \left[\left(\frac{150 \times 1000000}{5}\right) \times \left(\frac{1}{96 \times 100}\right)\right] = 3{,}125 \ \$/\text{lb}$$

Other scenarios are evaluated similarly.

Evaluation Concept 4 – Evaluation of Potential Toxicity of the Technology

Comparison of technologies according to this concept will be based upon FDEP's evaluation of each technology's effluent and, as necessary, sidestream waters with respect to FDEP's Phase I Procedures Document (FDEP, 1997) to assess each technology's potential effects on water quality, flora and fauna. Evaluations will consist of the following:

- Evaluation of toxicity test results – comparison of effluent (and sidestream) waters results with influent results;
- Comparison of physical and chemical parameters of potential concern measured in effluent and sidestream waters with influent concentrations of those parameters and with State of Florida Class III numeric criteria. In the absence of such numeric criteria, comparison will be made with the best available and applicable toxicity information of the parameter.

At a minimum, each technology demonstration research project team will test influent, effluent, and, as necessary, sidestream waters for each of the parameters listed in Table 1 of FDEP's Phase I document (FDEP, 1997, see Attachment B) and for toxicity as described in that document. Additional parameters to be tested may be added on a technology-specific basis (refer to paragraph 1 of Section 1 of the Phase I document). Evaluation of this concept based on the water quality and toxicity data from each technology will be conducted as described below. A table denoting the evaluation methodology for this concept is provided in Attachment C.

Toxicity Tests:

For this evaluation, influent, effluent and, as necessary, sidestream waters will be tested for chronic toxicity using *Cyprinella leedsi, Ceriodaphia dubia,* and *Selenastrum capricornutum* as described in FDEP's Phase I document. Statistical analyses of the toxicity tests will be conducted to compare influent vs. effluent (and sidestream), control vs. influent and control vs. effluent (and sidestream). Using the results of these analyses, FDEP will assign each technology a score of 0 if the technology is determined to produce toxicity or a score of 1 if the technology is not determined to produce toxicity. This score will be multiplied by the water quality score described below. In this way, a score of 0 for toxicity will result in an overall score of 0 for this evaluation concept and a score of 1 will not affect the water quality score.

In the event that a technology is determined to reduce toxicity with respect to the influent waters, the technology also will be assigned a toxicity test score of 1, and reduction of toxicity will be noted as part of ancillary concept 10 and will be included in a qualitative analysis of the technology.

Water Quality Parameters:

Several of the physical and chemical parameters listed in Table 1 of the FDEP's Phase I document were included based on concerns for potential toxicity related to potential addition to or removal of parameters from Everglades waters (i.e., dissolved oxygen, pH, specific conductivity, un-ionized ammonia, dissolved aluminum and iron, reactive silica and additional parameters which may be present in chemical additions). Total mercury samples collected by SFWMD and analyzed by FDEP for each technology also will be included in this analysis. The other parameters listed in Table 1 are for purposes of providing information about technology performance, which is evaluated in other concepts, or are necessary to the toxicity tests described above. For the parameters of potential concern from a toxicity standpoint, evaluation of this concept will consist of statistical comparison of effluent (and sidestream) to influent concentrations. Those concentrations of parameters that are shown to be statistically different from influent will then be compared to State of Florida Class III numeric criteria or the best available and applicable toxicity information where numeric Class criteria are not available. If the concentration of a parameter is determined to have changed significantly with respect to influent concentrations and, as a result, to have exceeded the applicable Class III criterion or best available toxicity information, then the parameter will be given a score of 0. For those parameters which are not significantly different in effluent concentration with respect to influent concentrations, the parameter will be given a score of 1, to be multiplied with other parameter scores. Finally, for those parameters which are determined to have changed significantly in concentration with respect to influent concentrations and to have resulted in improved water quality, the parameter will be given a score of 1, and the result will be noted as an ancillary concept to be included in a qualitative analysis of the technology under ancillary Concept 10.

Overall Evaluation Concept 4 Score:

As described above, the toxicity test and physical/chemical parameter portions of the evaluations can result in scores of 0 or 1 for toxicity and 0 or 1 for each parameter of potential concern from a toxicity standpoint. A score of 0 on toxicity tests or on parameter evaluations will result in a score of 0 for this concept. Stated differently, all scores must be 1 for this concept to be given an overall score of 1. *If a technology gets a score of 0 on this evaluation concept, it will be necessary to evaluate the cause of toxicity or potential toxicity. If the cause for toxicity or potential toxicity can be identified and eliminated, the technology could be permittable,* *depending on results from other evaluation concepts. However, all the individual scores (for each parameter and for toxicity tests) will be reported in the STSOC database.*

Evaluation Concept 5 - Implementation Schedule

Full-scale implementation of the technology should be possible within the timeframes established in the Everglades Forever Act. Information obtained from the research teams regarding the time required for full-scale implementation of the technology will be used as an evaluation factor for this concept. The information will be used for a quantitative assessment of the technology. Time in years from January 1, 1999 required for the operation of a stable treatment system at design flow for STA-2, and final completion date will be the criterion used for comparing the technologies under this concept.

Evaluation Concept 6 – *Uncertainty Assessment of Full Scale Construction, Operations, and Scale-up (Ancillary)*

The history and confidence level for the scale-up of a technology will be qualitatively assessed as an ancillary issue. Some of the parameters used to evaluate this concept are history of previous applications, differences between the Everglades Construction Project (ECP) and the previous applications, history of success or failure, assumptions made during the scale-up design, and factors considered to require additional study. *The research teams shall make an assessment of uncertainty for construction and operations parameters (e.g., harvesting, sludge disposal/reuse) that has a significant effect on cost.*

Evaluation Concept 7 - Operational Flexibility (ancillary)

Operational flexibility will be qualitatively assessed as an ancillary issue by determining the ability of the technology to add operational flexibility to the South Florida hydraulic conveyance system and the Everglades water conservation areas, while still meeting treatment objectives. Factors such as peak flow attenuation, available storage capacity, effect on green space and wildlife habitat will be qualitatively assessed for each technology under this concept. The demonstration project research team shall present a short summary discussion documenting the ability of the supplemental technology to affect the factors listed above.

Evaluation Concept 8 - Sensitivity to Fire, Flood, Drought and Hurricane (ancillary)

Sensitivity of a technology to fire, flood, drought and hurricane will be qualitatively assessed by determining the ability of the technology to re-establish design effluent conditions following such events. This concept will be evaluated as an ancillary issue that will compliment the primary objective of TP reduction. Information regarding the frequency and severity of the four phenomena will be provided to the research teams to assist them in identifying potential impacts to their technology. Information to be provided by the research teams includes:

- Description of effect on the treatment facilities from fire, flood, drought and hurricane
- Time to re-establish design effluent conditions following such events
- Cost to re-establish design effluent conditions following such events

Evaluation Concept 9 - Level of effort required to manage side streams (ancillary)

The level of effort required to manage side streams is dependent upon various factors such as volume of side streams, type of side stream (sludge, residual solids, harvested vegetation) and method of disposal. This concept is considered an ancillary issue and will be evaluated qualitatively. The demonstration project research team shall list the annual volume of the side streams generated (including seepage losses) and their characteristics. The team shall also list likely, worst case, and best case disposal and reuse options for the side streams. Seepage losses shall be reported as a percentage of annual TP inputs.

Evaluation Concept 10 – Other Water Quality Issues

Some aspects of water quality evaluation based on the information to be provided per FDEP's Phase I document do not lend themselves to a quantitative (scoring) analysis. These issues will be evaluated qualitatively based on the information to be provided by the demonstration project research team. These issues include the following:

Toxicity Tests:

As noted under Evaluation Concept 4, in the event that a technology is determined to reduce toxicity with respect to the influent waters, the technology also will be assigned a toxicity test score of 1 for Concept 4, and reduction of toxicity will be included in a qualitative analysis of the technology under ancillary Concept 10.

Water Quality Parameters:

Per the FDEP Phase I document, samples for analysis of sulfate are to be collected and analyzed by the demonstration project research team. These analyses are to provide some information about the potential for mercury methylation from potential increases in sulfate concentrations from addition of metal sulfates. However, issues of potential mercury methylation cannot be quantitively addressed during Phase I screening, and if potentially applicable to a project, should be addressed as part of longer-term projects or during Phase II screening process. Thus, sulfate concentrations in effluent (and sidestream) waters will be compared with influent concentrations, and will be evaluated as part of this ancillary concept during this phase of project demonstration to be included in a qualitative analysis of the technology.

Finally, for those parameters evaluated under Evaluation Concept 4 which are determined to have changed significantly in effluent concentration with respect to influent concentrations and to have resulted in improved water quality, the parameter will be given a score of 1 for Concept 4, and the results will be described in a qualitative analysis of the technology under ancillary Concept 10.

3.3 Summary of Evaluation Concepts

The evaluation parameters or criteria for each concept and the definition of the variables are summarized in the Table 1.

REFERENCES

Burns and McDonnell (1994). *Everglades Protection Project, Palm Beach County, Florida Conceptual Design*, February 15, 1994.

FDEP, 1997. Phase I Procedures for Evaluating the Potential for Effects to Everglades Biota from Discharges from Pilot Testing of Supplemental Technologies. Everglades Technical Series Number 1. Everglades Technical Support Section, Division of Water Facilities, November 26, 1997.

Table 1. Evaluation Concepts and Potential Evaluation Methods for Use in the Supplemental Technology Standard of Comparison

Evaluation Concept	Parameters to Evaluate Concept	Comment or Explanation of Variables
1. The level of phosphorus concentration reduction achievable by the technology.	• Average Effluent TP concentration during verification phase of demonstration testing • TP removal percentage during verification phase of demonstration testing	
2. The level of phosphorus load reduction achievable by the technology.	Load reduction over the 10-year POR for 10 and 20 ppb effluent TP with 0, 10, and 20% diversion	Percentage of average daily effluent TP load reduction
3. Cost-effectiveness of the technology.	$CostEffectiveness,\frac{\$}{lb}=\frac{C_A}{TP_{Removed}}$	C_A = Equivalent average annual cost of implementing technology A calculated by summing all projected costs over the 50-year period and dividing by 50, \$ $TP_{Removed}$ = Predicted TP removed for the 10 year POR, lb
4. Compliance with Florida Class III Water Quality Standards and compatibility of treated water with natural population of aquatic flora and fauna in the Everglades.	FDEP methodology (Appendix B and C)	
5. Implementation schedule.	Time in number of years (including fractions) to full operation from January, 1999.	
6. Scale-up confidence assessment.	Scale-up history, assumptions made in scale-up design, etc.	Qualitative

Evaluation Concept	Parameters to Evaluate Concept	Comment or Explanation of Variables
7. Operational flexibility.	Provide a written discussion of the ability of the technology to affect peak flow attenuation, water storage, green space, and wildlife habitat.	Qualitative
8. Sensitivity of technology to fire, flood, drought and hurricane.	Provide information on effect of treatment facilities from fire, flood, drought, and hurricane. Predict: Time to re-establish design conditions following complete destruction of processes and or facilities and Cost to re-establish design conditions following complete destruction of processes and or facilities for technology A.	Qualitative
9. Level of effort required to manage, and the potential benefits to be derived from, side streams generated by the treatment process.	List volume and characteristics of sidestreams, including seepage, (gal/day) generated for the technology, and most likely, worst case, and best case for disposal/reuse. List percentage of TP influent discharged to groundwater.	Qualitative
10. Other water quality issues	Provide information on reduction of toxicity of influent, and sulfate concentrations	Qualitative

Attachment A

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
CONTRACT C-E0008-A9A

DEMONSTRATION PROJECT CONTRACT REQUIREMENTS

(Italicized text represents modifications made to reflect the current STSOC evaluation methodology, September, 1998)

1.0 INTRODUCTION

To properly evaluate the results of diverse Everglades Program supplemental technology demonstration projects, it is necessary that the data obtained from all such demonstration projects be collected in a manner that allows scientifically valid comparisons to be made. Presented below is guidance for sampling and testing programs, reporting of data, and assessments to be performed by all Demonstration Project Research Teams. This information will be used by the District to evaluate and compare the capabilities of the various supplemental technologies to achieve the water quality objectives of the Everglades Program, according to a Supplemental Technology Standard of Comparison. This Supplemental Technology Standard of Comparison is intended for research projects sponsored by the District, however this document should serve as a general guideline for independent supplemental technology research projects sponsored by other groups, since these projects will be subjected to peer review by the District, ETAC, and other member of the scientific community.

The research work plans for the supplemental technologies will include process trials to identify phosphorus removal mechanisms and to determine general conceptual design information. Following the preliminary process trials, additional research will be conducted to refine basis of design information. The final step of the trials will be to conduct process verification testing where the supplemental technology is operated at optimum design. It is important to emphasize that the Supplemental Technology Standard of Comparison, and hence the guidance contained herein, applies only to the process verification phase of each demonstration project. This phase of testing shall be conducted after a recommended process design has been selected and optimum operating parameters have been defined based on experimental data from preliminary process trials. Data requirements for these preliminary trials shall be determined by the individual Demonstration Project Research Teams. Data collection for verification of the recommended process, however, shall be as specified in Section 3.0 below.

2.0 TECHNOLOGY BACKGROUND REQUIREMENTS

General information regarding the technology shall be provided to the District. A comprehensive review of previous applications of the technology shall be conducted. This information shall include the following:

- Summaries of previous applications of the technology or other previous research activities.
- Discussion of the phosphorus removal mechanisms used by the technology.
- Discussion of the various experimental trials that were performed during demonstration testing.
- All available flow and TP concentration data associated with the mass balance performance of the treatment facility should be provided.
- Discussion of the recommended treatment process to be used in the conceptual design of a full-scale treatment facility.

The technology background will not be used directly in the comparison of demonstration project results, but will be useful in helping evaluators interpret the experimental data.

3.0 EXPERIMENTAL DATA REQUIREMENTS

The following paragraphs define the minimum requirements for compilation of experimental data during verification testing of the recommended treatment process. In addition to documenting the treatment performance capability of the technology, a primary objective of the sampling and testing program is to compile sufficient data on which to base water and chemical mass balances. Experimental data requirements for investigation of preliminary process options shall be as recommended by the Demonstration Project Research Team and the District.

3.1 Flow Streams to be Sampled

At a minimum, the demonstration project shall include sampling of the inflow to and the outflow from the recommended treatment process. If seepage or evapotranspiration are important components of the hydrologic budget for the treatment process (>20% of the inflow), then these flows shall also be sampled. Residual waste streams that are not recycled back into the treatment process shall also be sampled, including liquid side streams, sludge streams, and vegetation that require harvesting.

3.2 Flow Measurement

Surface water inflows and outflows shall be measured continuously using approved techniques. Liquid/sludge side stream flows shall be measured at a sufficient frequency to conduct mass balances. Flow calibration records shall be provided to document accurate flow measurements. Velocity meters should be calibrated according to the manufacturers instructions. If velocity is not measured directly, documentation of accurate stage/discharge relationships shall be provided. Stage/discharge relationships shall be checked periodically throughout the verification period to verify that the stage/discharge relationship has not shifted. Copies of the QA check of the stage/discharge relationship shall be provided. Seepage flows shall be determined through a well monitoring program designed and constructed in a manner adequate to quantify seepage. The frequency of seepage flow measurements shall be sufficient to allow accurate water and chemical mass balances to be derived.

3.3 Sampling Methodology for each Flow Stream

Sampling methodologies shall be as specified in Comprehensive Quality Assurance Plans (CompQAP) for the research laboratories and the Site-Specific Quality Assurance Plans (QAPP) established for each research project. These documents specify procedures for collection of grab and composite water quality samples and flow measurements. Sampling methodologies for parameters with short holding times or special bottle/preservation requirements shall be as specified in the CompQAPs.

The sampling point for the influent stream shall be such that the sample represents the mean concentration. If possible, effluent samples shall be collected where the flow can be concentrated into a uniform stream. If the sample must be collected across a broad crested weir or a broad channel, then sampling studies shall be conducted to determine the location(s) of sampling points resulting in the most representative sample.

Daily (24-hour) composite samples shall be collected for selected parameters identified in Table 3-1. The composite samples shall be collected for both influent and effluent samples. The number of composite samples required shall be adequate for statistical analysis of the data. Nominally, approximately 40 samples shall be collected during each verification testing period. The final number of composite samples required and the number of discreet samples per composite shall be determined through the development of the work plan in cooperation with the District. Samples shall be flow-weighted unless the flow is constant, in which case time-weighted composites are acceptable. Note, however, that the sampling program identified for the Supplemental Technology Standard of Comparison is required only for the process verification phase of the demonstration project.

3.4 Sampling Parameters and Frequency for Each Flow Stream

The sampling parameters and frequency required for influent, effluent, and side streams are summarized in Table 3-1. Sampling frequency to evaluate design parameters during mesocosm experiments (e.g. HRT, depth, influent P concentration, etc.) shall be determined by each Demonstration Project Research Team. Sampling frequency for process trials shall be sufficient to establish that the desired TP removal is achievable using the treatment process. The sampling frequency during verification of the recommended treatment process shall be as summarized in Table 3-1. Residual solid side streams that require off-site disposal shall be sampled for the parameters listed in Table 3-1. The solids content of residual solids requiring off-site disposal shall be determined for each sample subjected for chemical analysis.

3.5 Analytical Methods

Analytical methods for each parameter shall be determined by the Demonstration Project Research Teams and shall be described in a FDEP approved CompQAP. Detection limits for parameters are listed in Tables 3-2, 3-3 and 3-4. The Demonstration Project Research Team laboratory shall document its participation in the Everglades round-robin laboratory program conducted by FDEP. Any modification of a method shall be documented in a validation package and approved by FDEP.

3.6 Sampling and Laboratory QA/QC Requirements

The laboratory used by each Demonstration Project Research Team shall have a CompQAP approved by FDEP. Sampling and laboratory QA/QC requirements shall be documented in an approved QAPP for each demonstration project. The QAPP shall indicate the frequency and number of trip blanks, equipment blanks, field duplicates and field blank samples to be collected. Data quality objectives for precision and accuracy shall meet those of the CompQAP. Any deviations from these quality assurance targets shall be specified in the QAPP. If the Demonstration Project Research Team laboratory loses their laboratory certification, the District shall be immediately notified and a corrective action plan shall be developed and implemented.

For supplemental technology research efforts that are not District-sponsored, the research team should review their sampling and laboratory QA/QC program with the District and FDEP to assure the maximum amount of consistency possible.

3.7 Units to be Used in Reporting Data

The units and detection limits for reporting each parameter shall be as provided in Tables 3-2, 3-3 and 3-4. Parameters for water samples shall be reported in units of milligrams per liter (mg/l), except for metals, which shall be reported in µg/l. Parameters for solid samples shall be reported in units of milligrams per kilogram (mg/kg) dry weight, except for metals, which shall reported in µg/Kg. Reportable units for field parameters shall be as specified in Table 3-4.

3.8 Format for Data Reports

Supplemental Technology Standard of Comparison data shall be provided in ASCII and Microsoft Excel 6.0 format and reports shall be provided in Microsoft Word format to allow compatibility with all District standard software. Electronic data files shall also be compatible with Oracle. The format for Supplemental Technology Standard of Comparison data reports shall be provided by the District prior to initiation of demonstration testing.

The data reports shall be compatible with the District year 2000 database standards.

3.9 Standard of Comparison Plan

The Demonstration Project Research Team shall provide the District a written plan detailing how information and data will be collected and provided to the District for use in the STSOC. This written plan shall be provided 60 days prior to verification testing of the supplemental technology.

Table 3-1. Water and Sidestream Quality Parameters and Sampling Frequencies for the Recommended Treatment Process

Parameter	Influent/Effluent	Sidestream[b]
Total Phosphorus	Composite	Three times
Soluble Reactive P	Composite	Three times
Total Dissolved Phosphorus	Composite	Three times
Total Suspended Solids	Every 3rd Composite	Three times
Total Organic Carbon	Every 3rd Composite	Three times
Alkalinity	Every 3rd Composite	Three times
Total Dissolved Solids	Every 3rd Composite	Three times
Sulfate	Every 3rd Composite[a]	Three times
Reactive Silica	Five times	Three times
Chloride	Every 3rd Composite[a]	Three times
Metals		
Dissolved Aluminum	Composite[a]	Three times
Dissolved Iron	Composite[a]	Three times
Dissolved Calcium	Five times	Three times
Dissolved Magnesium	Five times	Three times
Dissolved Potassium	Five times	Three times
Dissolved Sodium	Five times	Three times
TKN	Every 3rd Composite	Three times
Nitrate	Every 3rd Composite	Three times
Nitrite	Every 3rd Composite	Three times
Ammonia	Every 3rd Composite	Three times

TCLP (Full suite)	None	Once

Notes:

a If added during treatment, otherwise analyze five samples

b Residual solid and/or liguid shall be sampled.

Table 3-2. Water Quality Monitoring Parameters with Reportable Units and Required Detection Limits

Parameter	Units	Required Detection Limit
Total Phosphorus	mg/l as P	0.004
Soluble Reactive Phosphorus	mg/l as P	0.004
Total Dissolved Phosphorus	mg/l as P	0.004
Total Suspended Solids	mg/l	3.0
	mg/l	4.0*
Total Organic Carbon	mg/l	1.0
Alkalinity	mg/l as $CaCO_3$	1.0
Total Dissolved Solids	mg/l	9.0
	mg/l	13.0*
Sulfate	mg/l	1.0
Reactive Silica	mg/l	1.0
Chloride	mg/l	0.5
Metals		
Dissolved Aluminum	µg/l	5.0
Dissolved Iron	µg/l	1.0
Dissolved Calcium	mg/l	0.5
Dissolved Magnesium	mg/l	0.5
Dissolved Potassium	mg/l	0.5
Dissolved Sodium	mg/l	0.5
TKN	mg/l as N	0.1
Nitrate	mg/l as N	0.015
Nitrite	mg/l as N	0.01
Ammonia	mg/l as N	0.015

* Small Volume Sample (100 ml)

Table 3-3. Monitoring Parameters For Solids With Reportable Units and Required Detection Limits

Parameter	Units	Required Detection Limits
Metals		
Total & Dissolved Aluminum	mg/kg dry wt.	250
Total & Dissolved Iron	mg/kg dry wt.	2.5
Dissolved Calcium	mg/kg dry wt.	21
Dissolved Manganese	mg/kg dry wt.	1
Dissolved Magnesium	mg/kg dry wt.	6
Dissolved Potassium	mg/kg dry wt.	13
Dissolved Sodium	mg/kg dry wt.	2.5
Ammonia-N	mg/l	0.02
TKN	mg/kg	1000
TCLP (Full suite)	µg/l	Consult with District

Table 3-4. Field Parameters to be Monitored and Required Detection Limits

Parameter	Units	Required Detection Limits
Conductivity	µs/cm	50
Dissolved Oxygen	mg/l	0.1
pH	pH unit	0.1 (PR)
Temperature	°C	1 (PR)
Turbidity	NTU	1.0
Color	CU	1.0

PR - Precision range

4.0 ASSESSMENTS TO BE PERFORMED

The following paragraphs define the assessments to be performed on the technology using data during the verification testing of the recommended treatment process.

4.1 Minimum Effluent TP Concentration Achievable

All effluent TP data collected during the verification phase of the demonstration testing shall be reported. In addition, the flow-weighted mean effluent TP concentration, calculated over a period at least 5 times the hydraulic retention time (HRT), shall be reported for the recommended treatment process. If removal is affected by temperature or other environmental variables, averages should be provided for each season and/or environmental condition. Individual TP influent, effluent, and flow data used to calculate the mean concentration shall be provided as required in Table 3-1. The minimum, maximum, and standard deviation associated with the mean shall be reported. If the data are not normally distributed, the 10, 25, 50, 75, and 90% rank-order exceedance values shall be reported for the effluent TP data.

4.2 Variability of TP Removal Efficiency

TP removal efficiency shall be reported for each composite sample result generated throughout the verification of the recommended treatment process. Removal percentages shall be plotted as a function of factors affecting the TP removal performance. Predictive equations and/or plots for removal efficiency as a function of HRT, depth, etc. shall be determined and reported, where applicable.

4.3 Residual Solids

4.3.1 Quantity of Solids Reported per Unit of Inflow Treated. Residual solids that require off-site disposal shall be quantified. The residual solids may be generated on a continual basis (e.g. chemical treatment processes) or on an episodic basis (e.g. annual cleaning of biological treatment cells). The volume and mass of residual solids shall be reported per unit of flow. Units shall be cubic feet and wet and dry tons per MGD of flow, respectively. The frequency of solids generation shall be reported. All procedures and methods associates with disposal of residual solids shall be described. A predictive model for solids removal shall be developed. In cases of technologies requiring harvesting of vegetation, the frequency of harvesting and the phosphorus load associated with it shall be determined and reported.

4.3.2 Physical and Chemical Characteristics. The physical and chemical characteristics of the residual solids shall be determined. The parameters and frequency of sample analysis are given in Table 3.1.

4.4 Liquid Side Streams

4.4.1 Quantity of Side Stream Flow per Unit of Inflow Treated. Liquid side streams that require off-site disposal shall be quantified. This shall also include side streams that are intended for discharge directly to adjacent wetlands (i.e. not routed through the system nor collected for disposal elsewhere). The liquid side streams may be generated on a continual basis or on an episodic basis. The volume of liquid side streams shall be reported per unit of flow. Units shall be gallons per day per MGD of flow. All procedures and methods proposed for disposal of liquid side streams shall be described.

4.4.2 Chemical Characteristics. The chemical characteristics of the liquid side stream shall be determined. The parameters and frequency of sample analysis are given in Table 3-1.

4.5 Time to Achieve Design Effluent TP Concentration

The time required to achieve the design effluent TP concentration following process start-up shall be determined and reported based upon demonstration project test data and recommended treatment process verification data. The time required to achieve the design treatment goal shall include time required *and final completion date* to meet specific design criteria, establishing necessary vegetation in biological treatment cells, obtaining steady state conditions, and any other required conditions or operations necessary to establish desired TP removal rates.

4.6 Effluent Compatibility with FDEP Phase 1 Testing Protocol

FDEP has established a Phase I testing protocol that describes the physical and chemical parameters of potential concern, and biological testing requirements of supplemental technology influent and effluent. The basic intent of this protocol is to provide preliminary information regarding the appropriateness of discharges from supplemental technologies to the Everglades ecosystem. The list of physical and chemical parameters for monitoring from the Phase I document is incorporated into Table 3-1. In addition to monitoring for those physical and chemical parameters, the Demonstration Project Research Team shall incorporate sampling and analysis of influent, effluent and, as appropriate, side streams (e.g. if liquid side streams are being considered for discharge to the Everglades) for the toxicity tests described in the Phase I protocol. The minimum desired number of toxicity tests will vary from technology to technology and shall be determined through discussion with FDEP and the District.

4.7 Conceptual Design of Full Scale Treatment Facility

Based upon the demonstration test results for the recommended treatment process, conceptual designs for full-scale treatment facilities shall be prepared by the Demonstration Project Research Team. Conceptual designs shall be prepared assuming post-BMP and/or post-STA inflow streams, whichever is applicable to the demonstration project being evaluated, and effluent total phosphorus (TP) goals of 20 and 10 parts per billion (ppb). If it is not possible for the technology being evaluated to achieve an effluent TP concentration of 10 ppb, conceptual design shall be based on the lowest effluent TP concentration achieved on a sustained basis during demonstration testing. The conceptual design shall be consistent with the STA design concept described in the STA Conceptual Design (Burns and MacDonnell, February, 1994.

The basis for development of the conceptual designs shall be two data sets identifying daily flows and TP concentrations into and out of STA-2 over a 10-year period of record. These data sets shall be made available by the District in ASCII or Microsoft Excel 6.0 format. TP removal performance shall be predicted for this data set. The Demonstration Project Research Team shall document any periods when by-pass is required and the magnitude of by-pass. Designs shall be provided for *0%, 10% and 20% flow diversion. The mass of TP associated with each diversion shall be reported.*

At a minimum, each conceptual design shall include the following elements; separately explained and listed in the design project table of contents:

- **Basis of design** information including number, type, size (or capacity), operating range , and other applicable design parameters for each primary project component. Special issues on scale-up to develop the basis of design shall be documented.
- **Mass balances** for water, TP, and other constituents, such as treatment chemicals, on an average annual basis over the 10-year period of record.
- Estimates of **energy and chemical utilization** on an average annual basis over the 10-year period of record.
- Estimates of **residual solids and liquid waste streams** volumes requiring disposal on an average annual basis over the 10-year period of record.
- Modeling of daily **process performance** to estimate the percentage of time during the 10-year period of record that the effluent TP concentration goal will be exceeded and the maximum duration and incremental TP load associated with such exceedances. Due to the uncertainties associated with this assessment, it is expected that the development of the process performance model will require some best engineering judgment.

- A **staffing plan** for operation and maintenance of the full scale treatment facility, including a breakdown of the number of staff positions within professional, technical and administrative labor categories to be provided by the District.

- A hypothetical **site plan** for the full scale facility, identifying the land area required and the proposed general arrangement of project components.

- Assumptions used to develop the conceptual design shall be documented and listed in the description of the conceptual design.

- *Uncertainty assessment of construction and operations parameters (e.g., harvesting, sludge disposal/reuse) that have a significant effect on cost.*

The concept design developed by the Demonstration Project Research Teams shall be subjected to peer review by the District, ETAC, and other members of the scientific community as appropriate for the supplemental technology being investigated. The Demonstration Project Research Team shall make a presentation to ETAC to explain the information submitted for the Standard of Comparison.

4.8 Cost Estimates of Full Scale Treatment Facility

The Demonstration Project Research Team shall develop cost estimates for the operation of a full scale treatment facility. The size and operational conditions of the full scale facility shall be as developed under section 4.8. Cost estimates shall include capital costs, operations and maintenance (O&M) costs and present worth. To assure reasonableness and consistency across all demonstration projects, the costs estimates shall be subjected to an independent peer review by a contractor selected by the District.

4.8.1 Capital Costs. Capital costs shall include all permitting, design, construction, equipment and land costs required for full scale implementation of the technology as required by the conceptual design. Capital cost estimates shall be presented as follows:

4.8.1.1 Construction Costs. Construction costs shall be presented for all major project components, including levees, canals, basins, pumping stations, treatment plants, and other significant facilities that may be required as part of the conceptual design. Allowances shall also be made for site development (access roads, drainage, utilities, administrative facilities, etc.) and extension of power to the site, if necessary. Unit costs shall be based on existing cost estimates for similar facilities, recently prepared for the District during detailed design of other Everglades Program projects. Equipment costs shall be based upon planning level estimates supplied by vendors in the business of manufacturing such equipment.

All construction cost estimates shall include reasonable allowances for contractor overhead and profit. The sources of all construction cost estimates, as well as any assumptions made in preparing the estimates, shall be clearly documented in the cost estimate submittal.

4.8.1.2 Construction Contingency Costs. A construction contingency allowance shall be included in each capital cost estimate to cover construction items unforeseen in the conceptual design. The construction contingency allowance for technologies typically shall be computed at 20 percent of the construction cost estimate developed in section 4.9.1.1. If the construction cost estimates for a technology are developed based on laboratory testing or mesocosm scale testing, then the contingency allowance may be computed at a higher percentage as determined by the cost estimator.

4.8.1.3 Permitting, Design and Construction Management Costs. Permitting and design costs shall be computed at 15 percent of total construction costs, including construction contingencies.

4.8.1.4 Land Costs. Land costs shall be computed at an average unit cost of $3500 per acre of land purchased. The land area to be purchased shall be the actual land area required for water conveyance and treatment plus an additional 10 percent for easements, right-of-ways, buffers etc..

4.8.2 Annual O&M Costs. Annual O&M costs shall be estimated based upon the conceptual design of the full scale facility developed under section 4.7. The O&M cost estimates shall include all labor, material, energy, utilities and chemical costs required for the operation and maintenance of all facilities included in the capital cost estimate. An allowance for laboratory analyses associated with process control and regulatory compliance shall also be included.

Labor requirements shall be based upon the recommended staffing plan included in the conceptual design. Average labor rates shall be as provided by the District for the different categories of personnel required to staff the recommended facilities. Energy costs, such as electrical power, diesel fuel, etc. shall also be computed based upon unit costs to be provided by the District. *Costs for disposal of residual solids shall be based on a uniform cost of $50/ton plus transportation costs, for landfill disposal.*

All other O&M cost components, including the cost of chemicals and other materials, shall be calculated using data from similar projects and current market costs for the materials required. In all cases, the basis of the annual O&M cost component and the source of the unit cost data used to compute it, shall be clearly documented in the cost estimate submittal.

4.8.3 Present Worth. Present worth calculations shall be performed based on the capital and O&M cost estimates. The present worth shall be calculated over a period of 50 years using an interest rate of 6.8 percent less an inflation rate of 2.8 percent (net interest rate of 4.0 percent).

In addition to capital and O&M costs, present worth calculations shall also include replacement costs and salvage value/cost of the capital components of the technology. If the economic life of equipment or facilities is projected to be less than 50 years, rehabilitation or replacement must be accounted for in the present worth calculations. Typical economic life to be used for rehabilitation or replacement of various equipment/facilities shall be:

- Pumps - 20 years
- Pipelines, Canals - 50 years
- Wetlands Vegetation/ Soil Matrix - 25 years
- Earthen Basins - 50 years
- Electrical Equipment - 20 years
- Major mechanical treatment equipment - 20 years
- Concrete structures - 50 years

Present worth calculations shall also include salvage value/costs. The basis for calculation of the salvage value/cost shall be that the site has to be returned to its original condition without structures. The various individual components included in the salvage value computations shall be:

- Demolition costs for structures such as pumping stations and treatment plants.
- Restoration costs for the levees and canals and sludge *management* sites.
- Land value at original purchase price.

The total present worth shall be computed as a sum of capital costs plus present worth of O&M costs, plus the present worth of the replacement costs, minus the present worth of the net salvage value/cost.

4.8.4 Unit Cost. The present worth costs for the technology shall be converted into unit costs, based on the gallons treated and the total pounds of P removed over a 10-year period of record. The unit costs shall be presented as the following:

- average annual cost, $/million gallons treated, and
- average annual cost, $/pound of P removed

4.9 Implementation Schedule

A detailed schedule for full-scale implementation of the recommended treatment process, as represented by the conceptual design developed in section 4.8, shall be prepared and submitted to the District. The implementation schedule shall include separate time durations for the following:

- Additional research and/or process verification testing.
- Selection of technology for implementation by the District.
- Engineering, design, and permitting.

- Bidding and construction contract award.

- Construction.
- Process start-up and time to achieve design treatment goals.
- *The final completion date for full-scale operation of the technology shall be reported.*

Based on the implementation schedule, an assessment shall be made as to whether or not the technology can be implemented within the District's current schedule for satisfying the requirements of the Everglades Forever Act.

ATTACHMENT B

Phase I Procedures for Evaluating the Potential for Effects to Everglades Biota from Discharges from Pilot Testing of Supplemental Technologies

Everglades Technical Series
Number 1

Everglades Technical Support Section
Division of Water Facilities
November 26, 1997

Introduction

The Everglades Forever Act (Section 373.4592, Florida Statutes) requires the District and the Department to implement a research and monitoring program to optimize the design and operation of the Stormwater Treatment Areas (STAs) and to identify other treatment and management methods and regulatory programs that are superior to STAs in reducing phosphorus loads and concentrations from Everglades Agricultural Area (EAA) runoff.

To identify and evaluate treatment technologies or combinations of technologies, the District retained the services of PEER Consultants/Brown and Caldwell. As a part of the PEER Consultants/Brown and Caldwell evaluation (August, 1996, desktop evaluation), a concern was raised regarding potential adverse impacts the technologies might have on the biota of Everglades Protection Area marshes resulting from changes in water quality in addition to phosphorus concentration reductions. The purpose of this document is to provide a minimum set of guidelines for examining the potential adverse impacts of the effluent waters generated by pilot testing of supplemental technologies for the reduction of phosphorus from EAA runoff on the biota of Everglades Protection Area marshes. These guidelines should be incorporated by project managers as part of the demonstration of each of those supplemental technologies.

Procedure

The determination of the potential effects to biota from the effluents from technologies will be based on a phased approach. Phase I, or the screening phase, will include an evaluation of the effluent on both a physical and chemical-specific basis and a whole effluent basis (algal assays and toxicity testing) to determine potential effects on the biota of Everglades Protection Area marshes. Phase I screening is the primary focus of this document.

Phase II will build on the results from Phase I. Phase II evaluations may include, but are not limited to: additional toxicity testing; examination of micro element deficiencies; description of treatment potential (efficiencies, costs, etc.); and identification of additional relevant studies or analysis. Decisions regarding the efficiency, costs, Phase I toxicity screenings, and the resulting proposed/planned use of the treatment technologies will be used in the determination of whether and how Phase II evaluations should be conducted. For those technologies selected for scale-up or additional study subsequent to Phase I, project managers should contact Department and District staff to develop plans for Phase II evaluations and should incorporate those plans, and the cost for same, into the demonstration of the project.

Phase I Procedures

I. Physico-chemical testing

At a minimum, surface water influent and effluent samples should be analyzed for the physical and chemical parameters expected to potentially influence the biota of Everglades Protection Area marshes and presumed to be present in the effluent (Table 1). Sampling and analysis for such parameters should be incorporated by project research teams into the plans for demonstration of each supplemental technology. Additional parameters may be added to the demonstration if the Department or District has reason to believe the technology will add or remove such parameters. To this end, project research teams must provide information to Department and District staff describing chemical formulation of all chemical additions to be made during the course of the project and/or Material Safety Data Sheets or certificates of analysis for all the chemicals must be provided.

During Phase I, results of the analysis of effluent waters should be compared to applicable State water quality criteria as defined in Rule 62-302.530, Florida Administrative Code, and to the quality of concurrently collected samples of influent waters. Project Managers should consult with Department and District staff regarding appropriate comparisons. If the effluent waters are statistically different from the influent waters, based on statistical evaluations to be conducted as part of the supplemental technology standard of comparison, further evaluation on the part of the project research team may be needed, including additional sampling, biological testing and a literature survey to determine potential effects of these statistically significant water quality differences.

At a minimum the following parameters should be sampled at frequencies to be determined by the Department and the District for each technology under evaluation. The frequency of sampling will depend on the nature of treatment and will vary from project to project.

Table 1

Nutrients	Metered Parameters	Dissolved Ions	Misc. Parameters	Metals
Total Phosphorus (TP)	Dissolved Oxygen	Sulfate	Alkalinity	Dissolved Iron
Total Dissolved Phosphorus (TDP)	Temperature	Silica		Dissolved Aluminum
Soluble Reactive Phosphorus (SRP)	pH	Chloride		
Total Kjeldahl Nitrogen (TKN)	Specific Conductance	Calcium		
Ammonia Nitrogen (NH_3-N)	Turbidity	Magnesium		
Nitrate-Nitrite Nitrogen (NOx-N)	Color	Sodium		
		Potassium		

During Phase I screening, a limited number of samples for analysis of total mercury will be collected by District staff and analyzed by Department staff to investigate potential changes in ultra-trace total mercury concentration from influent to effluent. Project Managers should consult with Department and District staff at the beginning of project initiation to determine a sampling schedule. Since typical methods of sample collection and analysis are not likely to yield useful information regarding mercury, the collection and analysis of such samples by the project research team as part of routine project monitoring is not recommended for Phase I.

Issues of potential mercury methylation cannot meaningfully be addressed during Phase I screening, and if applicable, should be addressed as part of longer-term projects or during Phase II screening process. For those technologies selected for longer-term studies or scale-up, project managers should contact Department and District staff to develop plans for addressing this issue, as necessary, and project managers should be prepared to incorporate the costs (potentially large) of this and other Phase II demonstrations judged necessary by Department and District staff into costs for demonstration of the selected projects.

II. Toxicity testing

It is the Department's position that *in-situ* studies would not be feasible during the screening phase of supplemental technologies. The complexity of *in-situ* studies necessitates employing extreme scientific rigor to successfully generate results that would provide assurance that the receiving water would be protected. There are numerous logistical and methodological obstacles to overcome before reliable results may be obtained using *in-situ* tests.

However, it is the Department's experience that laboratory toxicity testing provides very sensitive indications of toxicity, the results of which have proven to be indicative of receiving-water effects. Not finding toxicity in the laboratory testing should be protective of the receiving water, but more elaborate toxicity testing may be required during Phase II. The results of the laboratory toxicity tests will be used in conjunction with information on phosphorus removal performance, cost and other feasibility determinations for a treatment technology in deciding whether additional testing of the technology, and thus Phase II studies, will be warranted. If needed, *in-situ* testing in Phase II will require extensive experimental controls and replication, as well as an understanding of the background variability in order to yield results having sufficient statistical power to provide assurance that the receiving water is being protected.

Thus, as part of the pilot demonstration of supplemental technologies, whole effluent and influent samples should be collected and tested for chronic toxicity in accordance with Department and EPA guidelines (EPA, 1978; EPA, 1991; EPA, 1994). The Department's position that the whole effluent approach should be used in Phase I screening is based on the capabilities of the techniques. Chronic toxicity testing measures sub-lethal effects such as changes in growth or rates of reproduction, as well as organism mortality. These measures are determined during sensitive life stages of the test species. The use of the laboratory test species reduces variability in the test results, thereby enabling the test to detect low-level effects. This results in a more sensitive test compared to those using non-EPA/DEP approved native or non-native test organisms. Mechanisms of toxicity are not species specific, so any toxicity found would indicate the likelihood of effects on receiving water species. Testing with multiple species of different trophic levels (vertebrate, invertebrate, alga) is intended to minimize the risk of 'missing' a type of toxicity. The principal capabilities are (EPA, 1991):

The aggregate toxicity of all constituents in a complex effluent or influent is measured.

Toxicity can be measured even if: 1) any toxic compounds present are commonly not analyzed for in chemical tests; or 2) the substances are toxic at levels below the detection limit of the analytical method.

The bioavailability of the toxic constituents is assessed, and the effects of interactions of constituents are integrated. Additivity, synergism, and antagonism between compounds in an effluent or influent are addressed implicitly by whole effluent toxicity.

The toxicity of the effluent or influent is measured directly for the species tested.

The Department has identified three test species, a vertebrate, an invertebrate, and an alga, as representative species for the toxicity testing for the supplemental technologies to be evaluated. These species, or close relatives, are found in the Everglades. The species were chosen for following reasons:

The background testing and data associated with these species are extensive, providing assurance that the species are sensitive to a wide range of toxic substances.

Quality assurance issues associated with the use of non EPA/DEP approved native species include: (1) assurance that test specimens are all of the same species and life stage; (2) effects of seasonal variations in populations, habitat requirements, and health of the test organisms on test results; and (3) availability of baseline information on the species sensitivity to standard reference toxicants. Studies of sufficient rigor and duration to yield such quality assurance are not within the scope of the Phase I screening, but may be addressed, if Phase II screening is deemed appropriate.

The three test species to be used for chronic toxicity testing under Phase I screening are:

Cyprinella leedsi (bannerfin shiner)	EPA/600/4-91/002 method 1000.0
Ceriodaphnia dubia (water flea)	EPA/600/4-91/002 method 1002.0
Selenastrum capricornutum (green alga)	EPA/600/4-91/002 method 1003.0

The minimum number of chronic toxicity tests to be conducted during Phase I screening of each technology will be determined by the Department and the District, and will depend on the nature of treatments and duration of the project. Chronic screening toxicity testing should be performed on influent and effluent samples for each treatment technology to be evaluated. Samples for chronic toxicity testing must be collected at the same time that water samples are collected for the determination of all the physical and chemical demonstration parameters for a technology (e.g., Table 1). All tests must be performed in accordance with Department and EPA guidelines.

Screening toxicity tests expose test organisms to full-strength sample and a control water. These tests show the presence of toxicity, but provide little information on the magnitude of that toxicity. Definitive toxicity tests expose the organisms to a series of concentrations of the test water and, while more complex to conduct, provide a measure of the amount of toxicity present. If screening tests identify toxicity of the effluent in excess of that which may be present at the influent of the treatment technology, chronic definitive assays may need to be performed on the effluent sample using laboratory water as a diluent. Department and District staff shall be consulted at that point to determine how best to proceed.

NOTE: All sampling protocols are subject to Department evaluation and are subject to modification at the Department's discretion.

Phase II Procedures

Plans for Phase II evaluations will be dependent on the specifics of the technology being tested, and will be determined by the Department and the District for those technologies selected for scaled-up testing. Phase II evaluations may include but are not limited to:

I. Pilot Study Results

Prior to additional testing, the results of the pilot study of the subject technology will be evaluated. These shall include evaluations of technology performance, whether the technology performed as expected, what cost was associated with phosphorus removal, what volume of water could realistically be treated, whether the technology removed anything other than phosphorus, whether the technology added anything to the effluent, and if the technology were to be used full scale, where it would be located in the treatment train.

II. Toxicity Testing

If it is determined that the treatment technology is viable at full scale, additional toxicity analyses may be warranted. These tests may include use of additional test species (including additional indigenous species), additional test methods (e.g., long-term assays, dilutions using Everglades marsh water and/or receiving waters), and/or testing at higher levels of organization (e.g., community-response studies). If the chemical analysis outlined in Phase I identifies that a specific chemical is in excess or deficit, relative to the influent, the most sensitive EPA/DEP approved species to the chemical specific toxicity should be included in any additional toxicity evaluations.

III. Micro Element Deficiency Evaluation

Chemical testing of the effluent should be performed to determine deficiencies of micro elements and other parameters of concern. The results of the test should be compared to the water quality of the receiving Everglades Protection Area marsh waters. If the effluent is statistically different from the receiving marsh waters, further evaluation may follow including additional sampling, biological testing and a literature survey to determine potential effects of these statistically significant water quality differences.

References

EPA, 1991. Technical Support Document for Water Quality-based Toxics Control, EPA/505/2-90-001.

EPA, 1994. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms, 3rd Ed. EPA/600/4-91/002.

EPA, 1978. The *Selenastrum Capricornutum* Printz Algal Assay Bottle Test, EPA-600/9-78-018.

Attachment C

A	B	C	D	E
Parameter	*Effluent Statistically Significantly Different from Influent* (1)	*Class III Water Quality Criterion or Best Available Information*	*Is Change Causing a Violation of Water Quality Criterion or Best Available Toxicity Information* (2)	*Parameter Score* (3)
Class III Criteria or Potential Toxicity Issues				
Toxicity				
Ammonia (un-ionized)		$\leq$ *0.02 mg/L as* NH_3		
Dissolved Aluminum				
Dissolved Iron				
Reactive Silica				
Specific Conductance		*Shall not be increased more than 50% above background or to 1,275 micromhos/cm, whichever is greater.*		
Dissolved Oxygen		*Shall not be less than 5.0 mg/L.*		
pH		*Shall not vary more than one unit above or below natural background, provided that the pH is not lowered to less than 6 units or raised above 8.5 units. If natural background is less than 6 units, the pH shall not vary below natural background or vary more than one unit above natural background. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below natural background.*		
Additional Parameters				
Overall Score				*See Note (4).*

(1) *Yes or No; the statistical procedures to be used will be determined by the Department.*
(2) *Yes or No.*
(3) *If answer in Column D is Yes, the Parameter Score will be 0; if No, the Score will be 1.*
(4) *Overall Score (all parameters) for each technology is the product of individual score for each parameter. Thus, if any of the parameters get a score of 0, then the overall score for that technology will be 0.*

APPENDIX B

Back-up for Cost Estimates

STSOC - Basis for Cost Estimates

Table B-1. Canal Unit Cost Details

Total Cost	Cy	$/cy	Miles	lf	$/lf	Area (sf/lf)	Description	Source	Comment
154,500	58,125	2.66	1.12	5914	26.13	266.00	Access Canal (STA 1W I&D)	District PCD, 1999, Sverdrup/PMA, 1997b	
221,500	161,670	1.37	1.40	7392	29.96	591.00	FPL - Collection Canal (STA 1W)	District PCD, 1999, Sverdrup/PMA, 1997b	
221,500	161,670	1.37	1.40	7392	29.96	591.00	FPL - Spreader Canal (STA 1W)	District PCD, 1999, Sverdrup/PMA, 1997b	
361,920	58,658	6.17	1.90	10032	36.08	158.00	Cell 5 Collection Canal	District PCD, 1999, Sverdrup/PMA, 1997b	Incl. Blasting
1,409,900	801,080	1.76	3.80	20064	70.27	1076.00	North Perim Levee - Sep Canal (STA 1W)	District PCD, 1999, Sverdrup/PMA, 1997b	
1,973,400	897,000	2.20	3.50	18480	106.79	1312.00	Discharge Canal (STA - 1W)	District PCD, 1999, Sverdrup/PMA, 1997b	
112,200	37,200	3.02	0.17	898	125.00	1116.00	G-330 By-Pass Canal (STA 1W I&D)	District PCD, 1999, Sverdrup/PMA, 1997b	
2,531,317	873,908	2.90	3.60	19000	133.23	1241.87	Supply canal total	District PCD, 1999, Sverdrup/PMA, 1997a	see individual nos below
1,192,500	244,365	4.88	1.50	7920	150.57	832.50	STA 1W - Spreader Canal	District PCD, 1999, Sverdrup/PMA, 1997b	Outlier. Not considered
1,355,240	485,749	2.79	1.70	8976	150.98	1462.00	STA 1W - Inflow Canal	District PCD, 1999, Sverdrup/PMA, 1997b	
220,200	75,288	2.92	0.22	1162	189.57	1694.00	G-301 By-Pass Canal (STA 1W I&D)	District PCD, 1999, Sverdrup/PMA, 1997b	
1,466,340	237,656	6.17	1.19	6283	233.37	630.00	Cell 5 Dishcarge Canal	District PCD, 1999, Sverdrup/PMA, 1997b	Incl. Blasting. Outlier not considered

STA 2 - Supply Canal Breakdown								
1,099,317				8000	137.41		STA 2(WcA -2A) - Supply Canal N	District PCD, 1999, Sverdrup/PMA, 1997a
716,000				6000	119.33		STA 2(WcA -2A) - Supply Canal SA	District PCD, 1999, Sverdrup/PMA, 1997a
716,000				5000	143.20		STA 2(WcA -2A) - Supply Canal SB	District PCD, 1999, Sverdrup/PMA, 1997a

Table B-2. Levee Unit Cost Details

$/CY	CY	Area (sf/lf	Miles	Feet	CY/lf	$/lf	Description	Source	Comment
$2.47	294,899	397.00	3.80	20064	14.70	$36.32	North Perim Levee	District PCD, 1999, Harry Pepper, 1997, Sverdrup/PMA, 1997b	
$3.91	97,008	354.00	1.40	7392	13.11	$51.26	FPL Acc. Levee	District PCD, 1999, Harry Pepper, 1997, Sverdrup/PMA, 1997b	
$3.99	174,100	523.50	1.50	7920	19.39	$77.36	Inflow ctrl.levee	District PCD, 1999, Harry Pepper, 1997, Sverdrup/PMA, 1997b	
$4.66	150,923	454.00	1.70	8976	16.81	$78.36	Perim Levee	District PCD, 1999, Harry Pepper, 1997, Sverdrup/PMA, 1997b	
$4.73	116,755	NK	1.17	6178			Separation Levee	District PCD, 1999	
$5.87	161,486	434.50	1.90	10032	16.09	$94.46	Cell 5 Ext. Levee	District PCD, 1999, Harry Pepper, 1997, Sverdrup/PMA, 1997b	Includes Blasting
$6.57	110,170	300.00	1.90	10032	11.11	$73.00	Cell 5 Perim Levee	District PCD, 1999, Harry Pepper, 1997, Sverdrup/PMA, 1997b	Includes Blasting

NK - Not Known

Cost includes contractor O&P, and contractor contingencies. Does not include construction contingencies and design and engineering (to be applied by the estimator)

Table B-3. Pumping Stations Capital Cost Details

PS	Capacity (cfs	Type	Cost	Cost/cfs	Description	Source	STA Area (ac)	STA ($/Ac)	FEB Cost ($)*	FEB ($/Ac)	Comment
G-349B	39	Seepage	$296,000	$7,590	STA 5	Burns and McDonnell, 1999, District OMD, 1999a, District, 1998	956	$309.62	$592,000	$619.25	Acreage served estimated on PS capacity proportional basis
G-350B	39	Seepage	$296,000	$7,590	STA 5	Burns and McDonnell, 1999, District OMD, 1999a, District, 1998	956	$309.62	$592,000	$619.25	Acreage served estimated on PS capacity proportional basis
G-349A	45	Seepage	$425,000	$9,444	STA 5	Burns and McDonnell, 1999, District OMD, 1999a, District, 1998	1103	$385.31	$850,000	$770.63	Acreage served estimated on PS capacity proportional basis
G-350A	45	Seepage	$425,000	$9,444	STA 5	Burns and McDonnell, 1999, District OMD, 1999a, District, 1998	1103	$385.31	$850,000	$770.63	Acreage served estimated on PS capacity proportional basis
G-409	190	Seepage	$2,104,286	$11,075	WCA 3A	Burns and McDonnell, 1999, District OMD, 1999a					
G-337	240	Seepage	$2,348,000	$9,783	STA 2	Burns and McDonnell, 1999, District OMD, 1999a, District, 1998	6430	$365.16	$4,696,000	$730.33	Acreage estimated from District, 1998
Plant	333	Infl/Effl.	$5,300,000	$15,935	DPRT-Microfil	CRA, 1998					
Plant	387	Infl/Effl.	$6,000,000	$15,514	DPRT-Microfil	CRA, 1998					
G-404	570	Infl/Effl.	$4,192,494	$7,355	WCA 3A	Burns and McDonnell, 1999, District OMD, 1999a,					
Influent	2096	Infl/Effl.	$18,900,000	$9,016	DPRT-Microfil	CRA, 1998					
G-310	3000	Infl/Effl.	$22,455,869	$7,485	STA 1W	Burns and McDonnell, 1999, District OMD, 1999a, District, 1998					
G-335	3000	Infl/Effl.	$22,455,869	$7,485	STA 2	Burns and McDonnell, 1999, District OMD, 1999a, District, 1998					
FEB	40	Seepage	$800,000	$20,000	DPRT-Microfil	CRA, 1998	3500	$228.57			Capacity of Stn. Guesstimate
Trt.plant	388	Infl/Effl.	$2,410,000	$6,211	STA/DF	PEER/BC, 1996					

Average of STA $351.01 **Average of FEB** $702.01

Notes:

STA 5 Total Acerage 4118

* - FEB Cost Estimated at twice STA cost

Acreage estimated based on capacity proportional basis for STAs served by more than one seepage PS

Only Seepage Stations						
PS	Capacity (cfs)	Type	Cost	Cost/cfs	Description	
G-349A	45	Seepage	425,000	$9,444	STA 5	
G-350A	45	Seepage	425,000	$9,444	STA 5	
G-349B	39	Seepage	296,000	$7,590	STA 5	
G-350B	39	Seepage	296,000	$7,590	STA 5	
G-337	240	Seepage	2,348,000	$9,783	STA 2	
G-409	190	Seepage	2,104,286	$11,075	WCA 3A	Outlier WCA - Do not Consider
FEB		Seepage	800,000		DPRT-Microfil	
			average	$9,154		

Infl/Effluent PS

PS	Capacity (cfs)	Type	Cost	Cost/cfs	Description	Average flows (cfs)
G-404	570	Infl/Effl.	4,192,494	$7,355	WCA 3A	117
G-310	3000	Infl/Effl.	22,455,869	$7,485	STA 1W	200
G-335	3000	Infl/Effl.	22,455,869	$7,485	STA 2	243
Plant	333	Infl/Effl.	5,300,000	$15,935	DPRT-Microfil	271
Plant	387	Infl/Effl.	6,000,000	$15,514	DPRT-Microfil	309
Influent	2096	Infl/Effl.	18,900,000	$9,016	DPRT-Microfil	720

$y = -3860.4Ln(x) + 38439$

$R2 = 0.9996$

Extrapolation

2000	9096.48
3000	7531.22
3500	7000.00
3600	7000.00
4000	7000.00

Table B-4. Influent/Effluent PS O Cost Details

Capacity (cfs)	Average flow(cfs)	Cost ($)	Pumps	Acre-ft	Description	Source
1860	223	$ 439,000	3 @ 620 cfs	161279	G-370 STA3/4	District OMD, 1999a, 199b
3040	244	$ 520,000	2 @ 100 cfs	176400	G-335 STA 2	District OMD, 1999a, 199b
			2 @ 470 cfs			
			2 @ 950 cfs			

Based on following breakdown for large stn's in ECP

Labor	$173,000/year
Overtime	$12,900/year
Diesel	$0.80/acre-foot
Equipment	$23,000/pumping unit
Strucutre Maint.	$55,000/year

From Desktop study

For FEB pumping Stations costs vary flow proportionally and increase by 10% to account for medium head

For treatment plant pumping Stations costs vary flow proportionally and increase by 20% to account for higher head

Table B-5. Seepage PS O Cost Details

Seepage Pumping Station O&M							
STA (ac)	**Sep.Capital**	**Sep O&M**	**Cost/ac**	**capital/ac**	**Source**	**Capacity (cfs)**	**Comment**
7410	$780,000	$120,000	$16.19	$105.26	PEER/BC, 1996		
8965	$950,000	$150,000	$16.73	$105.97	PEER/BC, 1996		
11020	$1,170,000	$180,000	$16.33	$106.17	PEER/BC, 1996		
4040	$430,000	$70,000	$17.33	$106.44	PEER/BC, 1996		
5620	$590,000	$100,000	$17.79	$104.98	PEER/BC, 1996		
7695	$810,000	$130,000	$16.89	$105.26	PEER/BC, 1996		
6430		$110,000	$17.11		District OMD, 1999b, PEER/BC, 1996	240/167	Typical seepage stn. (STA2)

FEB Pumping Stations O&M						
FEB (ac)	**Sep. Capital**	**Sep O&M**	**Cost/ac**	**Capital**	**Source**	**Comment**
500	$110,000	$20,000	$40.00	$220.00	PEER/BC, 1996	
1000	$210,000	$30,000	$30.00	$210.00	PEER/BC, 1996	
1500	$320,000	$50,000	$33.33	$213.33	PEER/BC, 1996	
2000	$530,000	$70,000	$35.00	$265.00	PEER/BC, 1996	
200	$40,000	$10,000	$50.00	$200.00	PEER/BC, 1996	
300	$60,000	$20,000	$66.67	$200.00	PEER/BC, 1996	Outlier do not consider
800	$170,000	$30,000	$37.50	$212.50	PEER/BC, 1996	
3500	$800,000	$200,000	$57.14	$228.57	CRA, 1998	Check. Not included in analysis

From PEER/BC, 1996 Study

Assume FEB Seepage Pumping Station Costs to be Higher by 1.5 times and add $12/ac (or $10,000 per estimate)

Average FEB -900 ac

Average FEB O&M $37.66 per ac. Of FEB

Table B-6. FEB Restoration Cost Details

FEB Restoration Costs			
Area (ac)	**Cost**	**Unit Cost($/ac)**	**Source**
500	$1,410,000	$2,820	PEER/BC, 1996
1000	$2,000,000	$2,000	PEER/BC, 1996
1500	$2,450,000	$1,633	PEER/BC, 1996
2500	$3,160,000	$1,264	PEER/BC, 1996
200	$890,000	$4,450	PEER/BC, 1996
300	$1,100,000	$3,667	PEER/BC, 1996
800	$1,790,000	$2,238	PEER/BC, 1996

From PEER/BC, 1996 Study
Based on Restoration cost for levees for STA'a to be 300,000 /mile (USACE)
For FEB's the restoration cost for levess is $400,000/mile (based on the sheer volume of levees over STA's)

APPENDIX C

Example Worksheet for “Test Case Technology”

Example Worksheet for "Test Case Technology"

Test Case Technology Assumptions:

- Full-scale design based on flows from STA 2 (10-year Period of Record).
- The Test Case plant will be located 2000 feet away from the discharge canal of STA 2. Therefore will require a supply canal of size 1200 sf/lf to covey flows to the plant.
- TP concentration for post-STA are assumed to be 90 ppb (average)and for post-BMP are assumed to be 150 ppb (average). Target effluent concentration of 10 ppb.
- Residual-solids management will be through physical de-watering and disposal to landfill.

Basis of Design	Post - STA	Post-BMP
Influent Pumping Station, (max/avg.),	Not Required	1355/465 mgd (2111/719 cfs)
FEB Area	Not Required	1000 Acres
Treatment Plant capacity (max/avg.)	400/180 mgd (619/279 cfs)	300/150 mgd (464/232 cfs)
Treatment Plant Influent PS (max/avg.)	400/180 mgd (619/279 cfs)	300/150 mgd (464/232 cfs)
Treatment Plant Land area (incl. sludge de-watering facilities)	45 Acres	55 Acres
Effluent PS (max/avg)	Not Required	1355/465 mgd (2111/719 cfs)

Example Calculation:

Based on the above assumptions, an example calculation of full-scale cost estimating using the Basis of Costs (Primarily Table 3-1) is presented in the following table. Present worth calculations are based on a net interest rate of 4% as required by the contract documents

Example Worksheet for "Test Case Technology" (Post- BMP)

	Item/Task	Unit cost	Total Cost ($M)	Contingency (20%)	Actual Cost ($M)	Explanation
1	**Capital costs**					
1.1.1	Equipment (process)	N/A				
1.1.2	Equipment (residuals management)	N/A				
1.2	Freight	N/A				
1.3	Installation	N/A				
1.4	Instrumentation	N/A				
1.5	Electrical controls	N/A				
1.6	Civil works- Control structures	See Text				
Total	Sum of 1.1 through 1.6		$87.00	$104.40	$104.40	Estimate. Includes cost of sludge de-watering facilities
1.7.1	Canals (no blasting)	See Fig. 3-1	$0.19	N/A	$0.19	2000 lf@ $95/lf from Fig 3-1, based on C/s of 1200 sf/lf (80 ft. top width)
1.7.2	Canals (incl. Blasting)	$6.17/cy	N/A	N/A	N/A	N/A
1.8.1	Levees (No blasting)	$3.95/cy ($60.83/lf)	N/A	N/A	N/A	N/A
1.8.2	Levees (Incl. Blasting)	$6.22/cy	N/A	N/A	N/A	N/A
1.9.1	Pumping stations- Influent/effluent	See Fig. 3-4	$38.07	N/A	$38.07	2 Stations (infl and efl.) of 211 1cfs capacity @ $9154/cfs from Figure 3-4.
1.9.2	Pumping stations- Seepage	$702/ac	$0.72	N/A	$0.72	Seepage PS covering an area of 1000 acres @ $702/ac.
1.9.3	Pumping Station – Treatment Plant Influent	See Fig. 3-4	$7.24	N/A	$7.24	464 cfs capacity station @ $15600/cfs from Fig. 3-4
1.10	FEB Construction	$8250/acre	$8.25	$9.90	$9.90	1000 acres @ $8250/acre.
1.11	Roads	$2.59/sf	$0.38	$0.45	$0.45	6000 lf of 24 feet wide gravel roads @ 2.59/sf.
Total	Construction Costs	-	-	-	$160.97	
1.12	Land	$3500/acre	$3.70	N/A	$3.70	1055 acres (1000 FEB + 55 Plant) @ $3500/acre.
Total	**Capital Costs**				**$164.67**	
PW	**50 Yr. PW Capital Costs**				**$164.67**	
2	**Operating costs**					
2.1	Labor (operation and maintenance)	N/A				
2.2.1	Maintenance (spare parts, equipment)	N/A				
2.2.2	Maintenance –Civil work	N/A				
Total	Sum of items 2.1 to 2.2.2 (incl. sludge de-watering facilities)	-	-	-	$0.90	Estimate of plant O&M including sludge de-watering, and all utilities.
2.2.3	Maintenance – Canals	$500/acre	-	-	$0.002	3.67 acres of canal area
2.2.4	Maintenance – Levees	$1530/mile			$0.001	2 levees along the canal of 2000 feet each.
2.2.5	Maintenance - FEBs	$44/acre			$0.04	1000 acres @ $44/acre
2.2.5	Maintenance- Seepage pumping stations	See Fig. 3-7			$0.03	1000 acres @ $33/acre from Fig. 3-7
2.2.6	Maintenance- Influent/effluent pumping stations	See Table 3-3			$0.45	Estimated to be flow proportional based on the O&M estimates given in Table 3-3
2.4	Chemicals	See Table 3-3			$0.30	Estimated chemical usage

Example Worksheet for "Test Case Technology" (Post- BMP)

	Item/Task	Unit cost	Total Cost ($M)	Contingency (20%)	Actual Cost ($M)	Explanation
2.5	Solids disposal	$50/ton			$0.53	10,000/year of de-watered sludge to be hauled to the landfill at transportation cost of $3/ton.
Total	**O&M Costs**				**$2.253**	
50 Yr	**Present Worth**				**$48.39**	
3	**Salvage/Demolition/Replacement costs**					
3.1	Demolition costs	20% of construction costs			$30.04	$20.84M for the plant and $9.2M for the PSs.
3.2	Restoration of levees	$300,000/mile			$0.23	4000 lf of levees along the canal
3.3	Restoration of FEBs	See Fig. 3-8			$2.00	1000 acres FEB @ $2000/acre from Figure 3-8
3.4	Clearing and grubbing	$630/acre			N/A	
Total	**Salvage/Demolition**				**($32.27)**	
PW	**%0 Yr. PW Salvage Items**				**(4.54)**	
3.5	Replacement Items	See Text				
3.5.1	FEB Influent/Effluent Pumping Stations				$9.52	25% of costs replaced at 25 years
3.5.2	Seepage and Treatment Plant PS				$3.98	50% costs replaced at 25 years
3.5.3	Treatment Plant Equipment				$52.2	25% of costs replaced at 20th and 40th year
Total	**Replacement Items**				**$65.70**	
PW	**50 yr. Present Worth**				**$22.40**	
4	**Lump sum/Contingency items**					
4.1	Telemetry	$4500 LS	-	$0.0045	$0.0045	
4.2	FP&L Improvements				$0.07	Estimate
4.3	Administrative Facilities				$2.00	Estimate
4.4	Sampling and Monitoring	$300,000/year			$0.30/year	Estimate
PW	**50yr PW of Lump Sum Items**				**$8.52**	
PW	**Grand Total All Costs**				**$248.52**	

Appendix B. Sample Unit Cost Worksheets

ENGINEERING COST ESTIMATE WORKSHEET

PROJECT: **TBD**
CLIENT:

Orignal Estimate By: 17-Sep-2012
Current Estimate By:
Checked By:

LINE NUMBER	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
	ENGINEERING AND PERMITTING				
	ITEM 1 - SITE SELECTION, REVIEW OF DATA, BASIS OF DESIGN				
	Labor	Hr	$ -	1	$ -
	Expenses	Lump Sum	$ -	0	$ -
	Travel	Miles	$ -	0	$ -
	ITEM 2 - ENVIRONMENTAL & LAND SURVEYING				
	Labor	Hr	$ -	0	$ -
	Expenses	Lump Sum	$ -	0	$ -
	Travel	Miles	$ -	0	$ -
	Topographic and Boundary Survey - Consultant	Lump Sum	$ -	0	$ -
	Biological Survey - Consultant	Lump Sum	$ -	0	$ -
	ITEM 3 - FACILITY DESIGN				
	Labor	Hr	$ -	0	$ -
	Expenses	Lump Sum	$ -	0	$ -
	Travel	Miles	$ -	0	$ -
	ITEM 4 - BUILDING PERMIT_LOCAL				
	Labor	Hr	$ -	0	$ -
	Expenses	Lump Sum	$ -	0	$ -
	Travel	Miles	$ -	0	$ -
	ITEM 5 - CITY & COUNTY_ OTHER PERMIT (ZONING, STORMWATER, ETC.)				
	Labor	Hr	$ -	0	$ -
	Expenses	Lump Sum	$ -	0	$ -
	Travel	Miles	$ -	0	$ -
	ITEM 6 - ELECTRICAL PERMIT				
	Labor	Hr	$ -	0	$ -
	Expenses	Lump Sum	$ -	0	$ -
	Travel	Miles	$ -	0	$ -
	ITEM 7 - STORMWATER PERMIT				
	Labor	Hr	$ -	0	$ -
	Expenses	Lump Sum	$ -	0	$ -
	Travel	Miles	$ -	0	$ -
	ITEM 8 - WATER USE PERMIT				
	Labor	Hr	$ -	0	$ -
	Expenses	Lump Sum	$ -	0	$ -
	Travel	Miles	$ -	0	$ -
	PROJECT BIDDING & CONSTRUCTION MANAGEMENT				
	ITEM 9 - PROJECT BIDDING				
	Labor	Hr	$ -	0	$ -
	Expenses	Lump Sum	$ -	0	$ -
	Travel	Miles	$ -	0	$ -
	ITEM 10 - CONSTRUCTION MANAGEMENT				
	Labor	Hr	$ -	0	$ -
	Expenses	Lump Sum	$ -	0	$ -
	Travel	Miles	$ -	0	$ -

LINE NUMBER	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
	FACILITY CONSTRUCTION				
	ITEM 11 - EARTHWORK AND GENERAL SITE PREPARATION				
	Site Dewatering	Days	$ -	0	$ -
	Clearing & Grubbing (including trees smaller then 12" dia.)	Ac	$ -	0	$ -
	Tree Removal (Larger then 12" dia.)	Ea	$ -	0	$ -
	Debris and Exisiting Structures Removal	Lump Sum	$ -	0	$ -
	Stripping Top Soil	Cy	$ -	0	$ -
	Hauling & Stockpiling Top Soil	Cy	$ -	0	$ -
	Load Haul and Re-Spread Topsoil	Cy	$ -	0	$ -
	Earth Work (excavation, placement, grading and compaction)	Cy	$ -	0	$ -
	Final Grading	Sf	$ -	0	$ -
	Road - 2" Asphalt Conc. Pavement	Sy	$ -	0	$ -
	Road - 6" Limerock Subbase	Sy	$ -	0	$ -
	ITEM 12 - CONCRETE				
	Slab on Grade	Cy	$ -	0	$ -
	Conventional Walls	Cy	$ -	0	$ -
	ITEM 13 - HYDRAULIC STRUCTURES - GATES , VALVES & PIPING				
	Inflow Structure	Lump Sum	$ -	0	$ -
	Outflow Structure	Lump Sum	$ -	0	$ -
	Inflow Piping	Lf	$ -	0	$ -
	Outflow Piping	Lf	$ -	0	$ -
	Stormwater Culverts	Lump Sum	$ -	0	$ -
	Miscellaneous Piping	Lump Sum	$ -	0	$ -
	ITEM 14 - EQUIPMENT				
	TBD	Each	$ -	0	$ -
	ITEM 15 - LANDSCAPING & FENCING				
	Tree Protection	Lf	$ -	0	$ -
	Silt Fence	Lf	$ -	0	$ -
	Floating Turbidity Barrier	Lf	$ -	0	$ -
	Fence - Chain Link	Lf	$ -	0	$ -
	Fence - 5-Strand Barbed Wire (3.5-4" Posts At 14' Centers - DOT Sp	Lf	$ -	0	$ -
	Security Gate	Each	$ -	0	$ -
	Seed & Mulch - DOT Spec	sf	$ -	0	$ -
	Sod	Sf	$ -	0	$ -
	ITEM 16 - ELECTRICAL DISTRIBUTION				
	Electrical Distribution	Mile	$ -	0.0	$ -
	Electrical Equipment & Installation	Lump Sum	$ -	0	$ -
	Electrical Controls - 15% of electrical equipment costs	Lump Sum	$ -	0	$ -
	ITEM 17 - CONTRACTOR MISC COSTS				
	On-Site Trailer	$/mnth	$ -	0	$ -
	Water Truck	Lump Sum	$ -	0	$ -
	Port-O-Lets	Each	$ -	0	$ -
	Dumpster	Each	$ -	0	$ -
	Per Diem	Each	$ -	0	$ -
	Lodging	Each	$ -	0	$ -
	Mileage	miles	$ -	0	$ -
	Surveyor- Site Layout and As-Builts	Lump Sum	$ -	0	$ -
	SUBTOTAL CONSTRUCTION COSTS				
	Mob/Demob			0.0%	
	Contingency			15.0%	
	Land Costs		$ -	0.0	
	Permit Fees			0.0%	
	Bonds			0.0%	
	Insurance			0.0%	
	Sales Tax (Equipment & Materials)			0.0%	
	Contractor Overhead (Materials & Labor)			0.0%	
	Total Construction Costs				

LINE NUMBER	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
	SYSTEM OPERATIONS				
	ITEM 18 - SYSTEM OPERATIONS				
	Labor	Hr	$ -	0	$ -
	Expenses	Lump Sum	$ -	0	$ -
	Travel	Miles	$ -	0	$ -
	Pump - Lubrication, Spare Parts, etc for 0-500 cfs pump	Lump Sum	$ -	0	$ -
	Facilities Maintenance - _______%	Lump Sum	$ -	0	$ -
	Equipment - ____% of Equipment Costs	Lump Sum	$ -	0	$ -
	Road - ______% of Road Costs	Lump Sum	$ -	0	$ -
	Building	Lump Sum	$ -	0	$ -
	ITEM 19 - ENERGY				
	Electricity - Pump System	KW/hr	$ -	0	$ -
	Electricity - Misc	KW/hr	$ -	0	$ -
	Diesel/Gaoline	Gallons	$ -	0	$ -
	ITEM 20 - EQUIPMENT				
	Lawn Maintenance Equipment - Mowers, Trimmers, etc.	$/day	$ -	0	$ -
	ITEM 21 - Plants				
	Replanting	Lump Sum	$ -	0	$ -
	ITEM 22 - CHEMICALS				
	Chemicals	Lump Sum	$ -	0	$ -
	ITEM 23 - RESIDUAL MANAGEMENT				
	Residuals Management	$/cy	$ -	0	$ -
	SUBTOTAL ANNUAL OPERATING COSTS				
	Contingency			15.0%	$ -
					$ -
	Total Annual Operating Costs				$ -