# EVALUATION OF ECONOMIC BENEFITS OF D'OLIVE WATERSHED RESTORATION PROJECTS

Prepared For

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## 1.0 INTRODUCTION

The mission of the Mobile Bay National Estuary Program (MBNEP) is to promote the wise stewardship of water quality and living resources of Alabama's estuaries. MBNEP's purpose is to catalyze actions of estuary stakeholders, build community organizational capacity for sound resource management, and leverage commitment and investment to ensure the estuary's sustainability. MBNEP's objectives: 1) engage estuary stakeholders in the development of a comprehensive conservation and management plan (CCMP); 2) expand resources and involvement in the implementation of the CCMP; and 3) promote how to best protect this nationally-significant ecological, economic, and cultural resource to ensure its conservation into perpetuity.

The current CCMP includes a five-year strategy to protect and improve management of: Access to the water and open spaces (for recreation and vistas); Beaches and Shorelines (protection, economy, beauty); Fish (fish and wildlife habitats, abundance, livelihood); Heritage and Culture (protecting the legacy); Environmental Health/Resiliency (ensuring community ability to weather storms and changing climates); and Water Quality (drinking water quality and quantity, rivers, creeks, bay- fishable, swimmable, drinkable). The work of many stakeholders involved in implementing this CCMP is focused on improving the management of what has been determined by a group of scientists to be the Alabama coast's three most stressed habitats: freshwater wetlands, riparian buffers, and intertidal marshes and flats. The methodology used to do this is through the development and implementation of watershed management plans and in building the capacity of local communities to better manage coastal Alabama lands and water.

Progressive and sustainable growth and development is the lead initiative of almost every community in our country. Over time, however, the natural and manmade infrastructure and systems that support our communities demonstrate they have finite capacities with which to absorb the cumulative impacts following rapid growth. As communities' natural systems are converted to impervious surfaces in the form of buildings, streets, and parking lots, their capacity to assimilate, safely displace, and effectively convey increases in stormwater runoff is reduced. These systems no longer are capable of absorbing increased volumes and velocities of runoff associated with growth without risk to surrounding manmade infrastructure. As a result, effective management and adaptation of the natural and built systems needed to carry this increased demand will be essential to every Gulf Coast community's success.

For Coastal Alabama, given over five feet of hard rain this area experiences on a yearly basis, many communities grapple with the impacts of increased stormwater runoff including drainage ditch degradation, stream and creek degradation, sanitary sewer overflows, and neighborhood flooding. Not only do these impacts reduce the quality of life for residents, but water quality downstream and in receiving waters is also degraded due to excessive sediment transport and loading.

Nowhere is this more acute than in the D'Olive Bay Watershed, a drainage area of approximately 7,700 acres encompassing parts of the cities of Daphne and Spanish Fort as well as unincorporated Baldwin County, Alabama (see Figure 1). Due to a combination of steep slopes and highly erodible soils coupled with intensive residential and commercial development, the natural systems of creeks and streams used to convey stormwater runoff have become severely degraded. As a result, this watershed is currently on the State of Alabama's list of impaired streams, indicating it is not meeting its designated use for propagation of fish and wildlife.

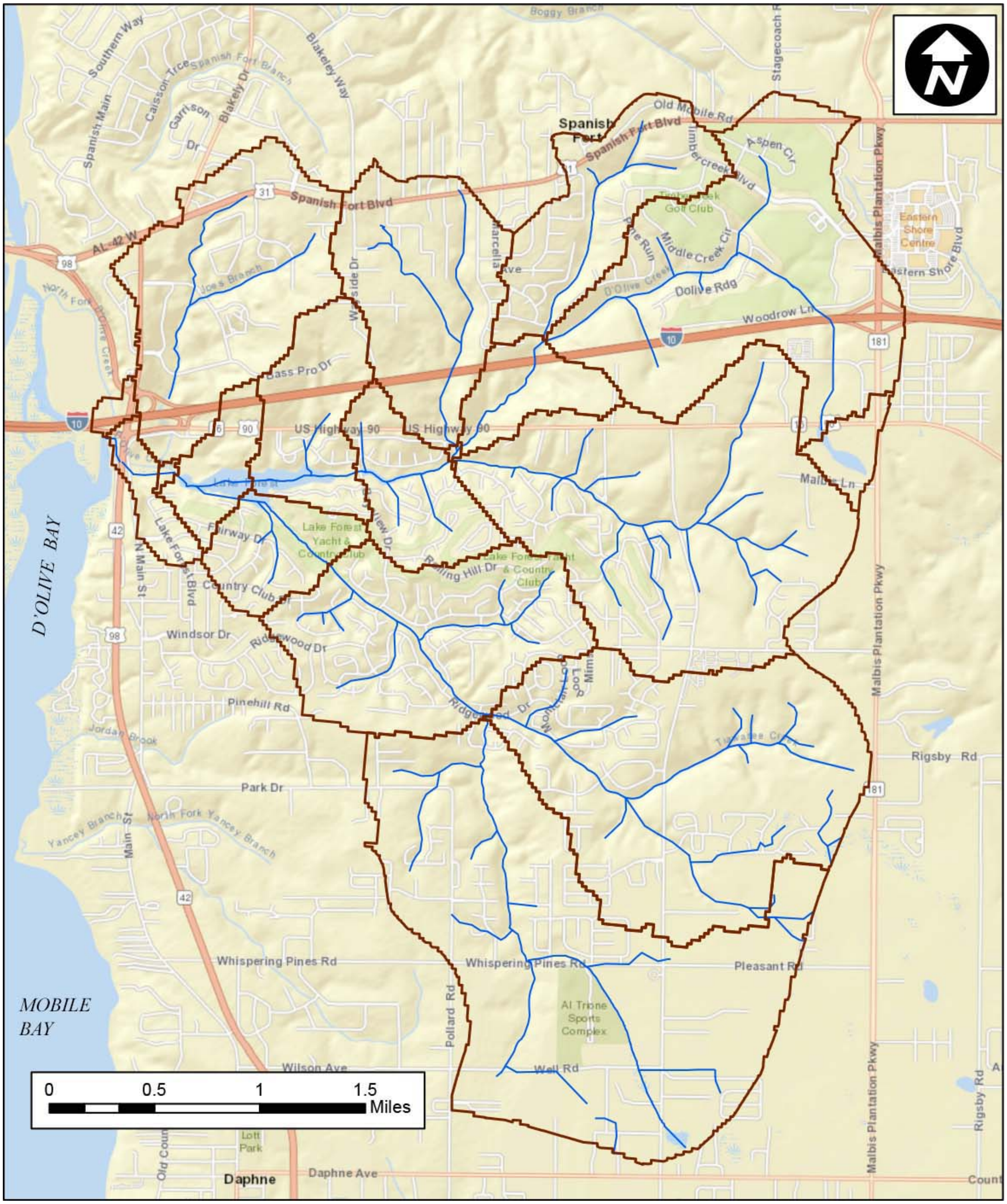

**Figure 1. The D'Olive Bay Watershed.**

In 2006, the Mobile Bay National Estuary Program (MBNEP) joined the Cities of Daphne and Spanish Fort and several other key watershed stakeholders to develop a strategy for addressing sediment impacts in the D'Olive Watershed and downstream in D'Olive Bay. A first step was to conduct a sediment analysis to determine the origin of the sediment sources. From there, the MBNEP and its partners developed a comprehensive watershed management plan. Once the plan was published, the MBNEP was asked to act as lead in applying for funding to address severe erosion stemming from an active head cut in a tributary to Joes Branch in Spanish Fort. MBNEP was successful in being awarded funding and this initial project was completed in 2013. As the BP Oil Spill related restoration funds began to flow, the State identified D'Olive Watershed restoration as a high priority. Given the existence of a comprehensive watershed management plan and one successful project already complete, the State approached the MBNEP about putting forth a "landscape scale restoration" project for National Fish and Wildlife Foundation Gulf Environmental Benefit (NFWF-GEBF) funding. MBNEP has received almost $12 million dollars in NFWF-GEBF funds to improve stormwater management and habitat function throughout Daphne and Spanish Fort. With leveraged funds from other sources, the total funding received for stormwater-related stream stabilization/enhancements in the watershed have totaled nearly $14 million dollars.

To improve local municipalities' and counties' abilities to manage natural resources and the associated infrastructure supporting a healthy estuary AND community growth, the MBNEP identified a need to determine the economic impact, both direct and indirect, of the restoration and stormwater management investments being executed in the D'Olive Watershed. MBNEP commissioned this D'Olive Watershed Restoration Valuation Study for this purpose.

<u>Goals and Objectives</u>

The specific goals of the D'Olive Watershed Restoration Valuation Study are as follows:

(1) To determine the economic benefits, both direct and indirect, of the environmental restoration and stormwater management investments that have been and are currently in progress in the D'Olive Watershed;
(2) To determine how improved environmental management and protection efforts affect property values, infrastructure costs, and revenue generating activities for the public and private sectors; and
(3) To identify the value added by the MBNEP in terms of project identification, management, and funding.

<u>Project Team</u>

MBNEP contracted with Barry A. Vittor & Associates, Inc. (Vittor & Associates) to perform this study. Tim Thibaut served as project manager and Barry Vittor provided senior consultation and quality assurance review. Other Vittor & Associates staff involved with the project included natural communities specialist Howard Horne and GIS technician Nicole Mackey. Principal subconsultant support to the Vittor & Associates Team included Wade Burcham (Integrated Science and Engineering Inc.) and Emery Baya (Baya Consulting LLC).

# 2.0 METHODOLOGY

## 2.1 Overview of Valuation of Environmental Benefits

The *Federal Resource Management and Ecosystem Services (FRMES) Guidebook* (National Ecosystem Services Partnership. 2016) provides excellent discussion on monetary valuation of ecosystem services. The *FRMES Guidebook* is a collaborative effort of the National Ecosystem Services Partnership (NESP) created to fulfill the expressed need of federal agencies for common, credible approaches to incorporate ecosystem services concepts into natural resource management, planning, and decision making. The FRMES Guidebook provides an introduction to the economic techniques used to measure changes in social welfare and describes which methods may be most appropriate for use in valuing particular ecosystem services. It establishes that the valuation of ecosystem services is grounded in a long history of non-market valuation and discusses how ecosystem services valuation can be conducted within established economic theory and techniques. The following discussion highlights selected topics of the guidebook.

### Economic Valuation

Valuation often quantifies economic value using individuals' or groups' *willingness to pay* (WTP) for an additional unit of ecosystem goods or services, given the quality of the good or service, the availability of substitutes, and other context variables that affect demand relative to supply. Drawing from the above definition of value, WTP measures the amount of money or some other commodity that an individual or group would be willing to give up to obtain a specified quantity of an ecosystem service, compared to a given baseline quantity. Value may also be quantified in terms of *willingness to accept* (WTA), defined as the minimum amount that a person or group would be willing to be compensated in order to give up a specified quantity of an ecosystem service that they already have or would otherwise get in the future under business as usual. WTP and WTA are alternative inputs into the calculation of benefits. These distinct ways to measure economic value are appropriate to use in different circumstances because they make different assumptions about who has the right to a good or service.

Other metrics that are frequently used as proxies for welfare changes, such as prices, avoided costs, or replacement costs have weaker (or no) ties to social welfare within economic theory. These metrics can still prove useful, because they are relatively easy to measure and can sometimes provide information similar to economic benefit metrics. However, the use of these metrics, which do not directly measure economic benefits, must be applied with caution.

The difficulty of putting a dollar value on all ecosystem services is well understood among practitioners and is the reason that assessments should monetize what is possible to monetize, quantify what cannot be monetized, and describe what can be neither monetized nor quantified. Economic value measures are only meaningful for changes in ecosystem services from a known baseline.

Economists use the concept of Total Economic Value (TEV) to reflect the fact that changes in ecosystem services can simultaneously affect many different types of values, including both *use* and *non-use* (also known as *passive use*) *values*. That is, in the context of ecosystem service valuation, TEV is used by economists to emphasize that a total or complete value measure must incorporate the full range of the *types* of value and people, including user and nonuser groups, affected by a change. Like all economic values, TEV is only meaningful when well-defined changes from a known baseline are considered.

A typology of ecosystem services values can be used to define TEV (Figure 2). Use values are those that result from direct use (e.g., bird-watching or hunting on site) or indirect use (e.g., flood risk mitigation from proximal wetlands) of ecosystem services or related resources. *Non-use values*, in contrast, are values that do not require observable use or consumption of the service. More broadly, non-use values for ecosystem services are associated with protecting natural assets (e.g., species or ecosystems) because people value the pure existence of these assets, want to pass these assets along to future generations, or think that these assets ought to be protected regardless of human use.

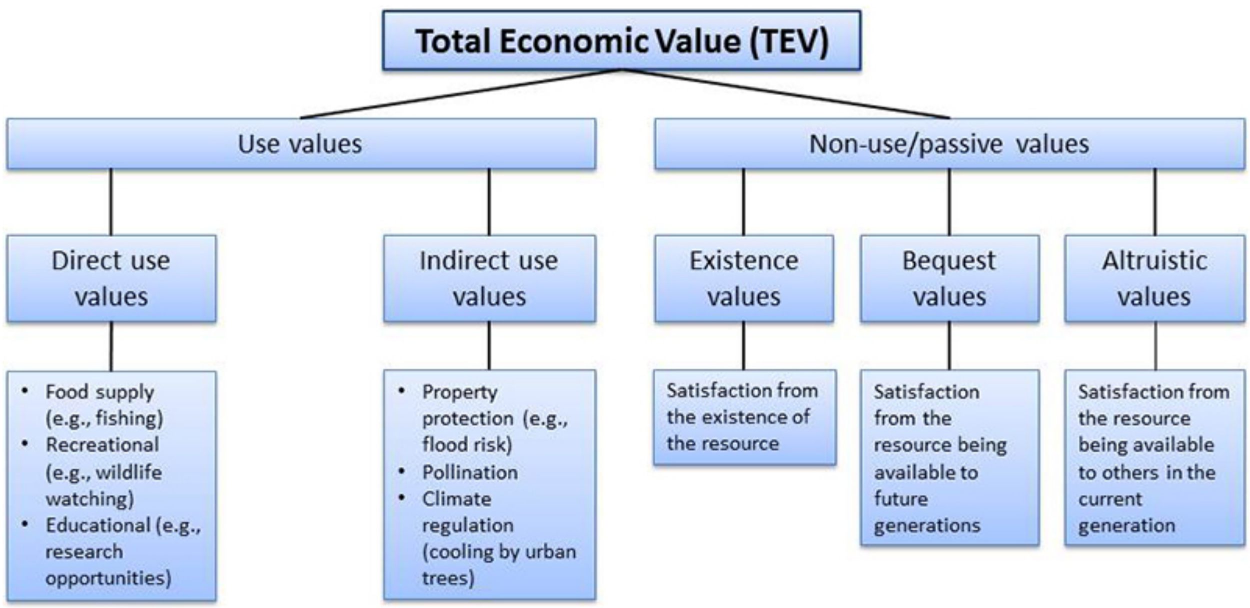


**Figure 2. Components of total economic value and relevant valuation methods.**
*Source: FRMES Guidebook* (National Ecosystem Services Partnership. 2016) as adapted from *Turner, Georgiou, and Fisher. 2008.*

An extensive economic literature addresses theoretical and empirical approaches to valuation of benefits derived from ecosystems. The major primary approaches are summarized below using a common typology and selected examples (Table 1).

**Table 1. Primary valuation methods applied to ecosystem services.**

| | Valuation Method | Description | Examples of Ecosystem Services Valued |
|---|---|---|---|
| Market Valuation | Market Analysis and Transactions | Derives value from household's or firm's inverse demand function based on observations of use | Fish<br>Timber<br>Water<br>Other raw goods |
| | Production Function | Derives value based on the contribution of an ecosystem to the production of marketed goods | Crop production (contributions from pollination, natural pest control)<br>Fish production (contributions from wetlands, seagrass, coral) |
| Revealed Preferences | Hedonic Price Method | Derives an implicit value for an ecosystem services from market prices of goods | Aesthetics (from air and water quality, natural lands)<br>Health benefits (from air quality) |
| | Recreation Demand Methods | Derives an implicit value of an on-site activity based on observed travel behavior | Recreation value (contributions from:<br>Water quality and quantity<br>Fish and bird communities<br>Landscape configuration<br>Air quality) |
| Defensive and Damage Costs Avoided | Damage Costs Avoided | Value is inferred from the direct and indirect expenses incurred as a result of damage to the built environment or to people. | Flood protection (costs of rebuilding homes)<br>Health and safety benefits (treatment costs) |
| | Averting Behavior / Defensive Expenditures | Value is inferred from costs and expenditures incurred in mitigating or avoiding damages | Health and safety benefits (e.g., cost of an installed air filtration system suggests a minimum willingness-to-pay to avoid discomfort or illness from polluted air) |
| | Replacement / Restoration Cost | Value is inferred from potential expenditures incurred from replacing or restoring an ecosystem services. | Drinking water quality (treatment costs avoided)<br>Fire management |
| | Public Pricing | Public investment serves as a surrogate for market transactions (e.g., government money spent on purchasing easements). | Non-use values (species and ecosystem protection)<br>Open space<br>Recreation |

**Table 1 (continued). Primary valuation methods applied to ecosystem services.**

| | Valuation Method | Description | Examples of Ecosystem Services Valued |
|---|---|---|---|
| Stated Preference | Contingent Valuation (open-ended and discrete choice) | Creates a hypothetical market by asking survey respondents to state their willingness-to-pay or willingness-to-accept payment for an outcome (open-ended), or by asking them whether they would vote for or choose particular actions or policies with given outcomes and costs (discrete choice). | Non-use values (species and ecosystem protection), Recreation Aesthetics |
| | Choice Modeling / Experiments | Creates a hypothetical market by asking survey respondents to choose among multi-attribute bundles of goods with associated costs and derives value using statistical models. | Non-use values (species and ecosystem protection), Recreation Aesthetics |

*Source: FRMES Guidebook* (National Ecosystem Services Partnership. 2016) as adapted from Table 4.8 in *Turner, Georgiou, and Fisher. 2008.*

Valuation methods fall into two main categories: primary valuation and benefit transfer. Primary methods include market value approaches, non-market revealed preference approaches, and non-market stated preference approaches, including contingent valuation and choice experiments. Defensive and avoided damage costs are presented as a separate category, even though they include revealed preference approaches, because they are more weakly grounded in economic welfare theory and include techniques that do not necessarily derive values solely from individual preferences.

Benefit transfer approximates economic values for one or more policy sites (where proposed changes will occur) using data or models generated and published for other, similar locations with similar goods (referred to as study sites). Benefit transfer is the use of information from primary studies at one or more study sites to estimate welfare estimates such as WTP or related information at unstudied policy sites. Although the use of primary research to estimate values is generally preferred, the realities of the policy process often dictate that benefit transfer is the only feasible option for estimating ecosystem services values. Benefit transfer is most often used when time, funding, or other constraints prevent primary research and is the most commonly applied valuation technique. Although benefit transfer enables many ecosystem services benefits to be valued for many sites, the value estimates generated by this method are subject to errors not present in primary value estimates. The size of these errors depends on many factors, including the type of transfer methods applied and the similarity of study and policy sites.

**Assessing the value of a stream of future benefits**

It is standard practice to apply a *discount rate* to understand the *present value* of a future stream of ecosystem goods and service benefits. This practice enables current and future values to be compared and aggregated within consistent terms. The discount rate is a function of multiple factors that one can calculate in multiple ways. As a simplification of this complex topic, one can think of the discount rate as reflecting both the change in the value of money (or a valued commodity) over time and the willingness of current generations to forgo current consumption to obtain future consumption.

**Considerations for Valuation of Ecosystem Services**

Ecosystem services are commonly defined as the benefits people receive from ecosystems. These benefits are thought to contribute to human wellbeing (MA, 2005). While there is broad support for the notion that ecosystem services influence our wellbeing, the means to measure such an effect remain elusive (Villamagna and Giesecke, 2014). In practice, conflicting definitions and *ad hoc* approaches to measuring ecosystem services have created confusion regarding how to rigorously link ecological change to changes in wellbeing (Wainger and Mazzotta, 2011). Wellbeing is not a simple concept that can be easily defined and measured to see how environmental restoration is affecting people (Palmer Fry *et al*., 2015).

Natural services are defined as the direct benefits of restoration to people in the watershed, even if property owners generally aren't aware these services provide value. No urban market exists for functions such as wildlife habitat, sediment stability, or scenic beauty. Many of the more commonly referenced intermediate ecosystem services, such as regulation of water quality and quantity, and natural areas, may not be particularly relevant to communities (Yee *et al*., 2016). Moreover, stakeholders at different spatial scales, such as relative proximity to a stream, can have very different interests in ecosystem services (Hein *et al*., 2006). Although many challenges remain in applying ecosystem service assessment and valuation to environmental management, investments in conservation, restoration, and sustainable ecosystem use are increasingly seen as generating substantial ecological, social and economic benefits (de Groot *et al*., 2010).

## 2.2 Technical Approach for This Study

The D'Olive Watershed restoration projects represent infrastructure improvements to drainage and stormwater management systems within the cities of Daphne and Spanish Fort. The costs of implementing these improvements, or alternative measures accomplishing similar objectives, may be considered a measure of the direct benefits of the infrastructure improvements and are examined.

It was apparent at the outset of this study that significant indirect economic benefits of the restoration program had resulted from avoided future damages to infrastructure (i.e., roadways, utilities and/or building structures). For example, the first restoration project implemented as part of MBNEP's program (Joe's Branch Phase 1) corrected a severely-eroded drainage path that was threatening both U.S. Highway 31 and private residential structures at the Westminster Village retirement community in Spanish Fort. Had the MBNEP restoration project not been performed, subsequent corrective actions by others would have been required at some point in the future. This study has conducted a damage cost avoidance analysis to estimate such benefits at all restoration sites. Information was developed by the project team and consultation with design engineers, contractors, and others to catalog potential infrastructure protection/repair projects that would likely have occurred if MBNEP had not performed the restoration program, and an Engineer's Opinion of Probable Cost (OPC) was developed for these potential repair projects. Recognizing limitations of damage cost analysis for economic valuation, a conservative approach was employed, only including potential damages that were considered likely to have occurred, and a reasonable estimation of their costs (i.e., not a worst-case scenario).

Another indirect economic benefit considered was possible increased property values, both at properties where the actual improvements were located and/or at downstream properties. This was evaluated by literature review to identify similar studies allowing estimation by "benefits transfer" relevant to this study. The scope also included consultation with a property appraiser.

The primary objectives of the D'Olive Watershed Restoration Program are to reduce sediment loadings, improve water quality (e.g., reduced turbidity), and protect and/or improve habitats that had been adversely impacted within the watershed and D'Olive Bay. Where feasible, benefit transfer valuation techniques are utilized to estimate economic values of related ecosystem services.

The degree of success in achieving restoration program objectives is an important factor influencing the valuation. MBNEP, with guidance from its Science Advisory Committee (SAC), has implemented a comprehensive monitoring program intended to measure environmental improvements and the ecological success of the restoration efforts. Existing monitoring information has been considered by coordination with MBNEP and its consultants who are involved with the effort. It was recognized, however, that the monitoring is a "work in progress" and definitive conclusions may not yet be available throughout the watershed. Therefore, available monitoring information was supplemented by field reconnaissance of selected previously-impacted wetland and riparian buffer habitats at or near the restoration projects.

A GIS database of watershed land cover types and habitats was produced to assist with analysis of the effectiveness and scale of restoration projects for adjacent areas and within the catchments (sub-watersheds) comprising the broader watershed. The Baldwin County Wetland Advanced Identification Map (Baldwin County Planning and Zoning Department, 2005) was updated in ArcGIS 10.3 using 2016 aerial ortho imagery, 2010 LiDAR elevation data, and supplementary field observations to aid in the analysis.

## 3.0 Description of D'Olive Watershed Restoration Program

### 3.1 General

The D'Olive Watershed has experienced tremendous land use change over the last several decades. Large areas of farm lands are now subdivisions and commercial developments. Development in upland areas of the D'Olive Watershed has resulted in an increased volume of stormwater runoff from impermeable surfaces; flashy hydrology; loss of natural wetlands and riparian areas; inadequate natural floodplains; and threats to aquatic and wildlife species survival and habitat. This change in land use has increased volume and velocity of urban stormwater flows which has resulted in severe downstream channel degradation in D'Olive Creek, Tiawasee Creek, Joe's Branch, and their tributaries. Severe erosion and mass wasting occur with every significant rainfall event, as the flowing water seeks to create a stable floodplain at a lower elevation. The sediment generated during this process deposits in wetlands located in downstream floodplains, resulting in alterations to stream morphology and hydrologic function; destruction of native vegetation and wildlife habitat in the area; and the proliferation of invasive plant species.

Since 2008, the Alabama Department of Environmental Management (ADEM) has included D'Olive Creek, Tiawasee Creek, and Joe's Branch (as well as certain unnamed tributaries) on the Clean Water Act (CWA) Section 303(d) List of Impaired Waters. ADEM identifies the cause of water quality impairment as siltation (habitat alteration) from land development. The basis for the listing was data obtained by the Geological Survey of Alabama (GSA) from a study that they conducted in 2007. The publication *Analysis of Sediment Loading Rates and Impacts of Land-Use Change on the D'Olive and Tiawasee Creek Watersheds, Baldwin County, Alabama 2007* (Cook, 2007) discusses their findings. GSA sampled a total of 11 sites for the overall D'Olive Watershed. These sites were located on D'Olive Creek, Joes Branch, and Tiawasee Creek and some of their tributaries. The GSA report noted "if the land use in the D'Olive Creek watershed continues to change from rural to urban without treatments for increased storm-water runoff, sediment loads will increase due to increased stream discharge and flow velocity that cause erosion and stream channel degradation." The GSA conducted further studies the following year to better define water quality conditions and evaluate loading rates and presented their findings in *Analysis of Water Quality, Sediment Loading Rates, Biological Resources, and Impacts of Land-Use Change on the D'Olive and Tiawasee Creek Watersheds, Baldwin County, Alabama, 2008* (Cook and Moss, 2008). The highest sediment loading rates found (in D'Olive Creek) were attributed to massive stream channel erosion upstream.

Following the GSA studies referenced above, MBNEP and project partners developed a comprehensive watershed management plan (WMP) with the primary goals of: reducing sediment inputs into the Lake Forest Lake/D'Olive/Tiawasee system; reducing outgoing loads into D'Olive Bay and the Mobile Bay estuary; remediating and restoring past effects of these sediment loads; and mitigating future impacts of development in the watershed. The WMP was finalized in August 2010 (Thompson Engineering, 2010). The WMP identified a broad range of conceptual measures that can be applied to more effectively manage stormwater and urban development within the D'Olive Watershed. Among the recommended management measures was implementation of a programmatic stream restoration approach for a sustained effort to halt the active head-cutting and channel erosion processes. Soon after the WMP was published, severe erosion stemming from an active head cut in a tributary to Joes Branch in Spanish Fort was identified as the highest priority for stream restoration efforts. The erosion posed an imminent threat to public and private infrastructure. The sediment from this site was being deposited downstream causing negative impacts to water quality in Daphne, however, the problem was located in Spanish Fort. Both communities needed a neutral third party to act on their behalf. MBNEP was asked to act as lead in applying to ADEM for EPA Section 319 (non-point source) funding to address the problem. The funding was approved in 2012, and this initial project was completed in 2013. The State subsequently identified D'Olive Watershed restoration as a high priority for "BP Deepwater Horizon" restoration funds and approached the MBNEP about putting forth a "landscape-scale restoration" project for NFWF-GEBF funding. The MBNEP funding request was approved, representing among the first use of these oil spill related funds in the state of Alabama. With this funding, MBNEP began restoration activities throughout the entire D'Olive Watershed. Planning and design of NFWF-funded projects began in 2014, with construction beginning in 2015. The restoration program is still ongoing but is nearing completion at this time.

### 3.2 Project Descriptions and Metrics

The D'Olive Watershed Restoration Program has included stream restoration/stabilization projects at priority locations throughout the watershed. The program has also included the development of Stormwater Management Facilities (SWMFs) at selected areas. Stream restoration and stormwater management projects have included:

- Joe's Branch Phase 1 (JB1)
- Joe's Branch Phase 2 (JB2, JA, J41, J42, J-SWMF, JB-SWMF)
- D'Olive Creek D4-D6
- D'Olive Creek DA3
- D'Olive Creek DAE
- D'Olive Creek DAF, DAF1
- D'Olive Creek DAF-1A (Melanie Loop)
- Tiawasee Creek TC1-TC2, TC2 Trib.
- D'Olive SWMF (Lake Forest Lake- preliminary planning and investigations)

Figure 3 presents a location map of these projects. Table 2 summarizes project metrics for those projects which have been constructed, are underway, or have had construction funds obligated. Project profiles with narrative descriptions, project maps, and additional information are included in Appendix A.

As displayed on Table 2, the Restoration Program to date includes restoration/stabilization of 11,283 linear feet of streams with an associated 27.6-acre riparian area. The restoration projects have also restored 3.1 acres wetlands (not including wetlands incidental to stream restoration) and protected approximately 58.3 acres of threatened wetlands. Additionally, stormwater facilities associated with the projects have increased retention/detention capacity of 123,900 cubic feet (not including the capacity added by stream restoration itself).

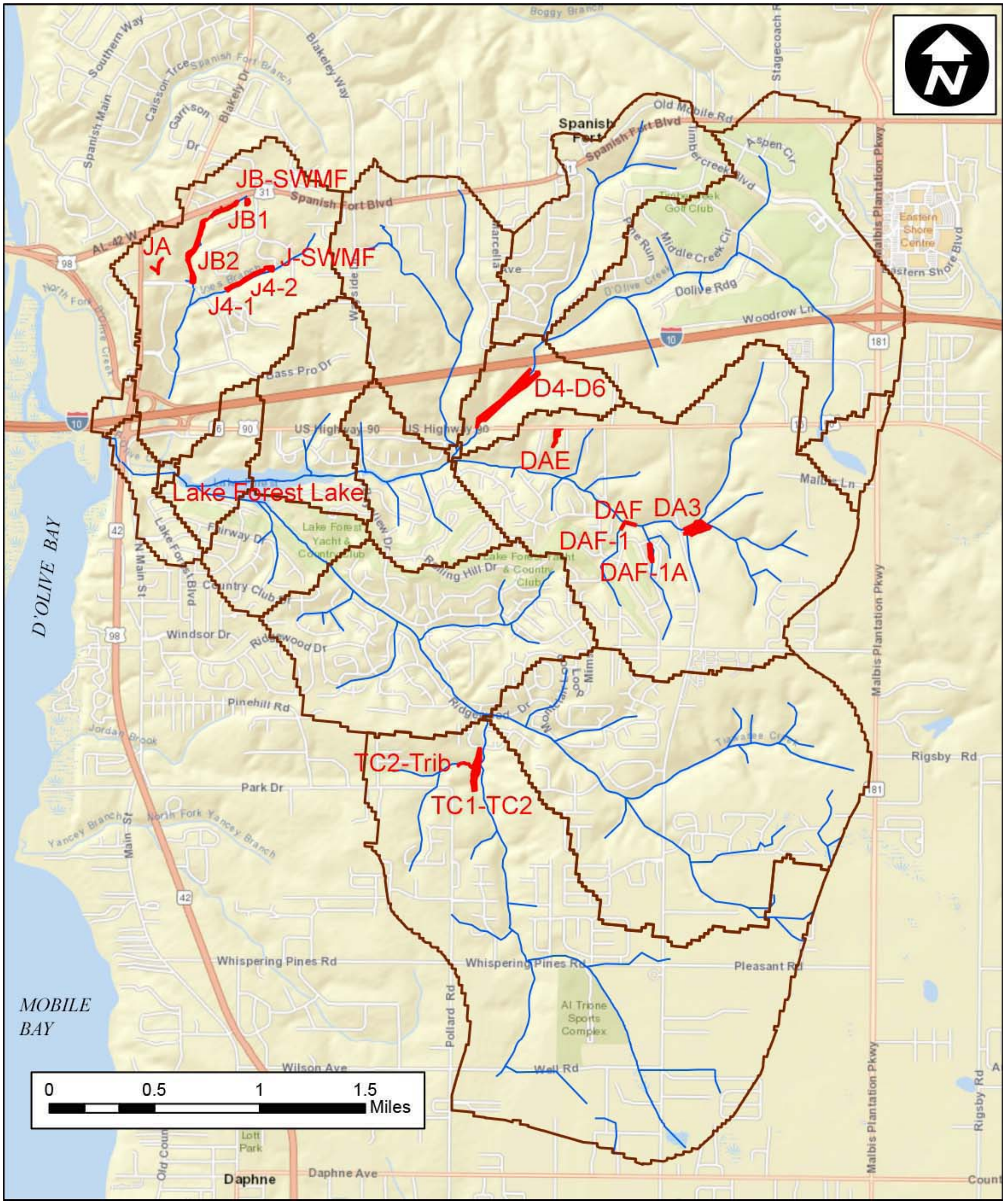


**Figure 3. D'Olive Watershed restoration projects.**

**Table 2. Metrics for restoration and stormwater management projects completed or underway (funds encumbered) prior to end of 2018.**

| Project Name | Construction Start | Construction Substantial Completion [Note 1] | Stream Restoration Length (linear feet) | Floodplain Riparian Area (acres) | Wetlands Restored (acres) [Note 2] | Wetlands Protected (acres) [Note 3] | SWMF Area (acres) | SWMF Retention / Detention Volume (cubic feet) |
|---|---|---|---|---|---|---|---|---|
| Joe's Branch Phase 1 | Oct. 2012 | Apr. 2013 | 1,000 | 2.2 | 0.5 | 13.7 | | |
| Joe's Branch Phase 2 | Apr. 2015 | Nov. 2016 | 3,300 | 7.0 | | | | |
| J-SWMF | | | | | | | 0.4 | 35,000 |
| JB-SWMF | | | | | | | 0.5 | 53,400 |
| D4-D6 | May 2016 | Sep. 2016 | 2,714 | 9.0 | | 5.6 | | |
| DA3 | Oct. 2016 | Feb. 2017 | 1,100 | 2.2 | 1.6 | 0.5<br>19.3 upstream | | |
| DAE | Apr. 2017 | Sep. 2017 | 420 | 1.2 | | 0.5 | | |
| DAF, DAF1 | Jan. 2019 (sched.) | Mar. 2019 (sched.) | 535 | 0.5 | | | | |
| DAF-1A (Melanie Loop) | Apr. 2018 | May 2018 | 490 | 1.6 | | 0.5 | | |
| TC1-TC2, TC2 Trib. | Jan. 2016 | Sep. 2017 | 1,724 | 3.9 | 1.0 | 18.4 upstream | 0.3 | 35,500 |
| ***Restoration Projects Totals*** | | | ***11,283*** | ***27.6*** | ***3.1*** | ***58.5*** | ***1.2*** | ***123,900*** |

1. Construction project contracts typically include a 2-year maintenance period following Substantial Completion.
2. Restored wetlands do not include those incidental to stream restoration.
3. Protected wetlands include those downstream which are now receiving reduced sediment loadings, and those upstream (as noted) that are protected by halting advance of a head-cut.

### 3.3 Restoration Program Management

MBNEP has provided overall administrative oversight and direction to ensure that the restoration projects are implemented in a timely manner, within the prescribed workplan budgets, and in compliance with requirements of the grant agency. MBNEP has partnered with a mix of stakeholders to leverage overall resources and facilitate public knowledge and acceptance. This has been extremely important since all but one of the projects have been located on private property and have required landowner permissions. The City of Daphne, in particular, has assisted with overall project management and public outreach. The City of Daphne directly managed one project (TC1-TC2 and TC2 Trib.) that was located on land owned by them.

Using qualifications-based selection procedures, MBNEP contracted with several engineering firms for design and construction oversight of the restoration projects. All engineering firms have a local presence, and have included Goodwyn Mills & Cawood, Integrated Science & Engineering, Mott McDonald, Thompson Engineering, and Volkert. Firms performing construction of the restoration projects have been selected by competitive bidding among companies meeting specified stream restoration pre-qualification requirements. Two construction firms have performed the construction: North State Environmental and Southern Excavating (now Streamline Environmental). MBNEP also contracted with a stream restoration consultant (Greg Jennings, PhD, PE) to provide technical oversight and guidance for all projects. Additionally, Hydro-Engineering Solutions has been contracted to provide specialized hydrological/hydraulic modeling for certain projects.

### 3.4 Monitoring

GSA performed sediment and water quality monitoring for the initial restoration project constructed in 2012 – 2013 (Joe's Branch Phase 1). The assessment employed three monitoring sites, one upstream of the restoration site and two downstream, one of which was immediately below the constructed step pool storm conveyance (SPSC) system and another farther downstream below the restored wetlands. The GSA findings compared post-restoration with pre-restoration data and are presented in a report entitled *Phase II Post-Restoration Analysis of Discharge and Sediment Transport Rates in Tributaries of Joe's Branch in Spanish Fort, Baldwin County, Alabama* (Cook *et al.*, 2014). This monitoring showed the restoration project to be highly effective in reducing erosion and sediment transport, with a 90% reduction in total sediment loads downstream of the project.

In concert with the NFWF-funded restoration program, MBNEP implemented a broader monitoring program to assess watershed conditions and the effectiveness of the restoration program. Similar sediment and water quality monitoring has continued under the direction of Marlon Cook (now retired from GSA), utilizing six of the same locations sampled in 2007 and/or 2008, plus an additional two locations not previously monitored. Additionally, five data-logging sondes were deployed in 2016 to continuously collect water quality parameters (including turbidity) at selected locations. Mr. Cook issued an interim report of this monitoring for data collected in 2015 – 2016 (Cook, 2017). However, the monitoring is still ongoing and overall synthesis of the results has not been finalized.

In addition to the sediment and water quality monitoring discussed above, additional studies include:

- Downstream water quality in D'Olive Bay is being measured by Dr. Ken Heck's DISL laboratory. Primary parameters include TSS, chlorophyll a, and CDOM (Colored Dissolved Organic Matter), but also DO, temperature, and salinity.
- MBNEP contracted Wetlands Resources to conduct functional assessments of restoration site wetlands using Wetland Rapid Assessment Procedures (WRAPs) and floristic assessments using a Floristic Quality Index (FQI).
- The University of West Florida has been contracted to monitor stream stability and riparian habitat using a Riparian Habitat Health Level Evaluation ((RipHLE) they developed for use in riparian forests in urban watersheds.
- Vittor & Associates is evaluating the success of the restoration projects by reviewing the water quality monitoring data and assessing the quality of wetland, stream, and riparian buffers at the restored sites and throughout the broader watershed.

### 3.5 Funding and Costs

Funding for the D'Olive Watershed Restoration Program has totaled $13.75 million, not including in-kind services match. Table 3 provides an itemization of funding sources and amounts. Primary funding for the program has come from NFWF-GEBF ($11.74 million) followed by EPA/ADEM Section 319 funds ($1.18 million). Additional leveraged funding sources totaling $0.84 million have come from the Alabama Department of Transportation (ALDOT), the Coastal Impact Assistance Program (CIAP), and other sources.

Costs (expended and encumbered) for the Restoration Program to date are $12.21 million and are itemized in Table 4. Certain costs (such as engineering and construction) are tracked for individual projects; whereas programmatic costs (such as professional technical services, monitoring, MBNEP staff, and other indirect) are not assigned to projects. Subtotals are provided for the restoration projects that have reached the construction phase and for the programmatic costs.

**Table 3. Funding summary (sources and amounts, not including in-kind services match)**

| Title/Description | EPA/ ADEM 319 | NFWF-GEBF | Other | Subtotal | Comments |
|---|---|---|---|---|---|
| Joe's Br Phase 1 | $645,600 | | $200,000 | $845,600 | other: ALDOT |
| Joe's Br Phase 2 | $77,050 | $2,959,982 | | $3,037,032 | |
| D4-D6 | | $2,860,426 | | $2,860,426 | |
| DA3 | | $1,142,432 | | $1,142,432 | |
| DAE | $54,965 | $338,469 | $60,000 | $453,434 | other - ALDOT |
| DAF, DAF1 | | $1,576,499 | | $1,576,499 | |
| DAF-1A (Melanie) | | $582,824 | | $582,824 | |
| TC1-TC2, TC2 Trib. | $398,961 | $550,000 | $512,925 | $1,461,886 | other: CIAP (State) - $250,000; CIAP (County) - $250,000; City of Daphne - $12,925 |
| D'Olive SWMF | | $467,176 | | $467,176 | |
| Professional Technical Services | | $375,000 | | $375,000 | |
| Travel | | $32,500 | | $32,500 | |
| Monitoring – Joe's Branch Phase 1 | | | $63,806 | $63,806 | Monitoring pre-construction 2012 - EPA funding - $15,903, GSA - $15,903; Monitoring during construction - ADCNR - $16,000; GSA - $16,000 |
| Monitoring - NFWF (contractual) | | $226,984 | | $ 226,984 | |
| Monitoring – NFWF (equipment) | | $54,016 | | $54,016 | |
| Salaries & Fringe | | $143,428 | | $143,428 | |
| Other | | $428,382 | | $428,382 | |
| | | | | | |
| **TOTALS** | **$1,176,576** | **$11,738,118** | **$836,731** | **$13,751,425** | |

Note: Information sources:

- Joe's Branch Phase 1 (Step Pool Storm Conveyance) – MBNEP contract records
- MBNEP – Expenses & Encumbrances spreadsheet 3.31.2018 (modified to add construction bid amounts for D'Olive DAF, DAF1 and D'Olive DAF-1A Melanie Loop)
- Tiawasee Creek Restoration (TC1-TC2 and TC2 Trib.) - City of Daphne, Tiawasee Restoration Project as of 8/09/2016 (TC1-TC2) and ADEM Invoice 9/20/2017 (TC2-Trib.). (Ashley Campbell, pers. comm. 5/9/2018)

**Table 4. Costs summary (expenditures and encumbrances)**

| Title/Description | Engineering | Construction | Other | Subtotal | Comments |
|---|---|---|---|---|---|
| *Costs allocated to projects that have reached the construction stage: Joe's Branch Phase 1, Joe's Branch Phase 2, D'Olive D4-D6, D'Olive DA3, D'Olive DAE, D'Olive DAF, DAF1, D'Olive DAF-1A (Melanie Loop), Tiawasee TC1-TC2, TC2 Trib.* | | | | | |
| ***Total Costs Allocated to Projects*** | ***$2,632,777*** | ***$8,121,579*** | ***$70,000*** | ***$10,824,356*** | other – Hydrologic/Hydraulic modeling |
| *Programmatic costs not allocated to projects* | | | | | |
| D'Olive SWMF (Lake Forest Lake) | $32,300 | | $40,000 | $72,300 | other - Lake Forest POA |
| Professional Technical Services | | | $375,200 | $375,200 | Stream Restoration Consultant - $315,000 Hydrologic/Hydraulic modeling - $60,200 |
| Travel | | | $17,384 | $17,384 | |
| Monitoring Joe's Branch Phase 1 | | | $63,806 | $63,806 | |
| Monitoring NFWF (contractual) | | | $194,995 | $194,995 | |
| Monitoring NFWF (equipment) | | | $53,980 | $53,980 | |
| Salaries & Fringe | | | $151,236 | $151,236 | |
| Other | | | $455,749 | $455,749 | Permitting - $10,010; MESC Indirect - $445,739 |
| ***Total Programmatic Costs*** | ***$32,300*** | | ***$1,352,350*** | ***$1,384,650*** | |
| | | | | | |
| **TOTALS** | **$2,665,077** | **$8,121,579** | **$1,422,350** | **$12,209,006** | |

Note: Information sources:

- Joe's Branch Phase 1 (Step Pool Storm Conveyance) – MBNEP contract records
- MBNEP – Expenses & Encumbrances spreadsheet 3.31.2018 (modified to add construction bid amounts for D'Olive DAF, DAF1 and D'Olive DAF-1A Melanie Loop)
- Tiawasee Creek Restoration (TC1-TC2 and TC2 Trib.) - City of Daphne, Tiawasee Restoration Project as of 8/09/2016 (TC1-TC2) and ADEM Invoice 9/20/2017 (TC2-Trib.). (Ashley Campbell, pers. comm. 5/9/2018)

## 4.0 FINDINGS AND RESULTS

### 4.1 Direct Benefits of Improved Drainage and Stormwater Management Systems

The D'Olive Watershed restoration projects represent infrastructure improvements to drainage and stormwater management systems within the cities of Daphne and Spanish Fort. Besides environmental benefits (e.g., water quality and habitat enhancement), the projects provide for safe conveyance of stormwater and erosion protection of adjacent properties. Effective drainage systems and stormwater management are typical objectives of urbanized communities and usually fall within the realm of public responsibility. However, budget limitations and the fact that drainage conveyances in many locations are on private property constrain Daphne and Spanish Fort from the implementation of stormwater improvements. These constraints have been overcome by the work of MBNEP to plan and implement the Restoration Program. MBNEP with its collaborative partnerships competed for and secured funding from outside sources, thus saving local resources for other priorities of the communities. It is not likely that the infrastructure improvements would have been implemented otherwise, except for limited and piecemeal responses to "emergency" situations (roadway washouts, sewer line breaks, etc.). There is a "pay me now, pay me later" aspect to this – eventually, the worsening degradation of drainage systems will require response actions. Such "emergency" responses are costlier and less effective than a well-planned program aimed at addressing priority problem areas before catastrophic failure occurs.

As previously presented in Table 4, costs of the Restoration Program to date are approximately $12.2 million. The costs allocated to projects that have reached construction stage subtotals $10.8 million. Adding the programmatic costs of technical services (stream restoration consultant and hydrologic/hydraulic modeling) brings the amount to $11.2 million. With the restored stream length being 11,283 linear feet (lf), the unit cost translates to nearly $1,000 per linear foot[1]. By comparison, stream restoration costs in Maryland (Schwarzmann, 2013) have been referenced as ranging from $500 to $1,200 per linear foot in the City of Baltimore (2011) and as $404 to $816 per linear foot in Anne Arundel County (2013).

In the past, if drainage improvements are performed strictly for channel stabilization, many have used conventional construction techniques (where flexible or rigid channel and bank linings such as riprap, ECA, Gabions, CIP concrete, or sheetpile are required). A planning level cost range for such "hard construction stabilization" techniques was given as $700 to $1,000 per linear feet in the D'Olive WMP (Thompson Engineering. 2010). This translates to an expected cost range of $7.9 to 12.4 million had conventional channel stabilization been employed (not including stormwater detention / retention facilities or wetlands restoration).

It cannot be said for certain whether or not infrastructure improvements to drainage and stormwater management systems in the D'Olive Watershed would have been implemented anyway had the MBNEP restoration program not been undertaken. The constraints noted before would probably have restricted improvements only to "emergencies." However, both Daphne and Spanish Fort are subject to Municipal

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[1] Note: A more rigorous estimate to arrive at the unit cost of the stream restoration/stabilization alone would exclude the cost of associated wetland restoration and SWMFs.

Separate Storm Sewer System (MS4) permits regulated by ADEM. Given that D'Olive Watershed streams in both municipalities are on ADEM's list of impaired waters for "siltation (habitat alteration)" from "land development," it is indeed possible that ADEM could have required regulatory actions necessitating stream stabilization improvements. Instead, ADEM has acted as a proactive partner with MBNEP and the regulated municipalities to advance solutions to the underlying problems on a voluntary basis. A goal of the Restoration Program is the eventual removal of the streams from the impaired waters list. Such delisting will provide benefits of reduced MS4 permit compliance costs for the regulated municipalities. If not delisted, ADEM will be required to determine the Total Maximum Daily Load (TMDL) for the pollutant causing impairment, i.e., siltation (habitat alteration) caused by land development. A TMDL is defined as the sum of the individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background. Point sources are minimal in the D'Olive Watershed, thus TMDL development must focus on nonpoint sources (i.e., sediment loadings). Imposition of a TMDL for the D'Olive Watershed could require the municipalities to adopt additional development controls that could increase costs to achieve orderly and sustainable growth.

### 4.2 Avoided Damages to Infrastructure

A damage cost avoidance analysis has been conducted to estimate such benefits at the restoration sites. Information was developed by the project team and consultation with design engineers, contractors, and others to catalog potential infrastructure protection/repair projects that would likely have occurred if MBNEP had not performed the Restoration Program. Appendix B presents results of the analysis in an Engineer's Opinion of Probable Cost (OPC) prepared for these potential infrastructure repair projects. The report describes the cost descriptions and assumptions used to develop the OPC. Assumptions include the future timeframe that a possible infrastructure repair would likely have occurred, and the cost estimates are adjusted to Present Value using a discount rate of 2.75 %. The report uses a conservative approach, only including potential damages that were considered likely to have occurred had MBNEP not implemented the Restoration Program. The estimated damage avoidance costs are reasonable assumptions of probable response actions that one would take, and not "worst case" scenarios. For example, the OPC assumes that sewer main repairs would be performed before a break occurs, and spill response and cleanup costs are not included.

The types of potential damages evaluated primarily include highways and roadways, utilities (water, sewer, gas, and fiber optics), building structures, and drainage / stormwater. The team reviewed preliminary estimates for water and sewer with representatives of Daphne Utilities, and estimates of potential highway damages with the Alabama Department of Transportation (ALDOT).

The avoided damages to infrastructure analysis resulted in an Engineer's Opinion of Probable Cost (OPC) totaling approximately $4.0 million, with a recognized uncertainty range for this level of estimate at -20% to +30% (i.e., an Engineer's OPC range of $3.2 million to $5.2 million).

### 4.3 Property Values

An indirect economic benefit considered was possible increased property values, both at properties where the actual improvements were located and at downstream properties. This was evaluated by literature review to identify similar studies allowing estimation by "benefits transfer" relevant to this study. The scope also included consultation with a property appraiser.

The literature review identified several studies where property values are linked to water quality. One study (Braden and Poor, 2004) noted that aesthetic improvements to a stream or lake can add 3 – 15% to the value of adjacent land. The higher end or the range was for waterside residences where clarity of the water quality is significantly improved. They also noted that increases are much less for improvements that are less visible, undeveloped properties, and properties not adjacent to the watercourse. Most of the other literature reviewed used hedonic price methods in an attempt to isolate changes in housing prices due to a recognized change in a water quality attribute. Many of the studies calculated benefits related to water clarity as measured by Secchi disc readings in lakes. Secchi disk readings relate to the perceived quality of water versus the actual biological quality of water since the readings are based on water clarity. Most of the studies reviewed identified positive correlations with property values and higher Secchi disc readings. One obtains Secchi disk readings by the distance below the surface a Secchi disk can be seen. It is a common general parameter used in water quality studies of open water bodies (with minor current velocities). Secchi disc is probably found so often in hedonic valuation studies because of a large amount of data available. However, Secchi disc measurement is rarely applicable to studies of flowing water streams. A more common measurement that reflects water clarity is turbidity, which is a parameter measured in ongoing monitoring of the restoration program. Our literature review found no studies that related property values directly to turbidity measurements. Although it might be possible to make a general relationship between Secchi disc and turbidity, ongoing monitoring data has not yet been fully synthesized to allow definitive conclusions of water quality (turbidity) improvements. Because of this limitation, and the differences in reviewed literature studies and the Restoration Program (lakes vs. streams, Secchi disc vs. turbidity) benefit transfer of literature values for property value increase are not considered applicable.

The team consulted with a local property appraiser (Joey Vegliacich, MAI, AL-GRS, Premier Appraisals – Gulf Coast) to research and analyze potential economic impacts of restoration projects throughout the D'Olive Watershed on real estate values in surrounding areas. The scope of work included inspecting multiple restoration project sites throughout the watershed and determining their impact on property values of adjacent properties, proximate properties, and properties downstream and throughout the watershed. Mr. Vegliacich visited project sites, then viewed and researched surrounding properties. He reviewed multiple publications and studies as well as real estate sales volume and transaction data. Mr. Vegliacich also interviewed local market participants, buyers, sellers, brokers, and appraisers. His findings and conclusions are summarized as follows:

1. Improved Water Quality affects a relatively small number of properties. Although studies indicate potential increased home values of 9% − 16% per each additional foot of water clarity, there are a very limited number of properties that actually have a view of D'Olive Bay or Lake

Forest. The tree cover along D'Olive Bay blocks the view for almost all the properties along US 98. Also, the streams that feed these two bodies of water are generally not visible by anyone.

2. While the projects may be saving infrastructure (roads and sewer), the marketplace simply does not show increased values for properties that are now better protected from catastrophe. The reality is that buyers and sellers expect their infrastructure to remain in place, and no measurable price increases or decreases have occurred at direct or indirect result of the investigated projects.

3. Appraisers in the local market make very small adjustments of 0% to 5% for waterfront properties versus non-waterfront properties on Lake Forest and its feeder streams.

His concluding opinion was that there are currently no measurable benefits to property values within the D'Olive Watershed as a result of the projects.

### 4.4 Sediment Loading Reductions

One of the primary objectives of the Restoration Program is to reduce sediment loadings to watershed streams, Lake Forest Lake, and the D'Olive Bay/Mobile Bay estuary. Monitoring of the initial restoration project constructed in 2012 – 2013 (Joe's Branch Phase 1) showed the restoration project to be highly effective in reducing erosion and sediment transport. However, monitoring at other sites constructed later is still ongoing, and it is too early to draw conclusions about the effectiveness of the restoration projects in improving water quality and habitats in the watershed and in D'Olive Bay.

Reducing sediment inputs to Lake Forest Lake could provide economic benefits, and were considered in this project. In the absence of final monitoring results with actual estimates of sediment load reductions, the team considered calculations of erosion reduction at each project site. These calculations were performed by MBNEP's stream restoration consultant, Dr. Greg Jennings, utilizing modeling methods described in *Chesapeake Bay Partnerships Urban Stormwater Work Groups Recommendations of the Expert Panel to Define Removal Rates of Individual Stream Restoration Projects Final Report (December 6, 2012)*. The erosion estimates were provided in a spreadsheet from MBNEP in April 2018. Table 5 summarizes erosion reduction estimates for projects upstream of Lake Forest Lake.

**Table 5. Erosion reduction estimates for projects upstream of Lake Forest Lake.**

| **Project** | **Erosion Reduction (tons/year)** |
|---|---|
| D'Olive Creek D4-D6 | 1,800 |
| D'Olive Creek DA3 | 600 |
| D'Olive Creek DAE | 300 |
| D'Olive Creek DAF, DAF1 | 200 |
| D'Olive Creek DAF-1A (Melanie Loop) | 250 |
| Tiawasee Creek TC1-TC2, TC2 Trib. | 500 |
| ***Total*** | ***3,650*** |

These data were used for a preliminary analysis of possible economic benefits from reduced sediment inputs to the lake as discussed in the avoided damages report contained in Appendix B. Reduced sediment inputs to the lake will lessen the quantity of sediments that will require removal when and if the lake is dredged to maintain its capacity as a sediment trap and/or for other purposes. Making several assumptions (percentage of erosion reduction realized as reduced sediment input, cost of dredging, when dredging would occur, etc.) a present value of the benefit of sediment prevention to Lake Forest could be on the order of $1.1 million. However, the overall economic benefit valuation given in the Engineer's OPC does not include the value of prevented lake sediment input due in part to the lack of completed monitoring results documenting the actual reduced sediment loadings, and also because plans for maintenance (dredging) of the lake are uncertain.

### 4.5 Improved Stormwater Attenuation (Detention / Retention)

The Restoration Program has included Stormwater Management Facilities (SWMFs) that provide stormwater detention and/or retention. Additionally, several of the stream restoration projects have increased stormwater attenuation (detention/retention) by reconnecting the stream channel with their floodplains (that is, during a storm event, improved floodplain connectivity provides improved storage). Many publications document that stormwater attenuation can reduce flood risk and there are recognized valuation methodologies (usually avoided damages techniques) for estimating these benefits. However, existing flood risk in the locations of the restoration projects are minimal and flood protection was not an objective of the program. Stormwater attenuation also provides environmental benefits by helping restore natural watershed hydrology which, by reducing runoff rate, volume, and duration, provides erosion control and improves water quality. Also, increased infiltration in floodplain areas can increase low flows and enhance aquifer recharge.

Estimates of the detention/retention volume at facilities were made based on design plans and topographic features (existing grades vs. proposed grades). The team considered the difference between the post-restoration volume compared to pre-restoration volume during a 1-percent Annual Exceedance Probability Storm (from pre/post HEC-RAS and other models) to estimate the magnitude of stormwater attenuation at stream restoration sites.

Estimated stormwater detention and/or retention volumes at various projects were calculated as shown below:

- JB SWMF 53,400 CF
- J SWMF 35,000 CF
- TC2 SWMF 35,500 CF
- JB Phase 1 9,200 CF
- JB2 65,700 CF
- JA 6,700 CF
- D4-D6 77,600 CF
- DAE 20,300 CF

TOTAL 303,400 CF

One approach considered for estimating the economic value of stormwater attenuation provided by these projects could be to estimate the cost of a conventional dry detention basin to provide the same level of detention. A preliminary analysis was conducted (see Appendix B) and suggests a present value on the order of $870,000. However, because there are no regulations requiring such detention facilities, and it is considered doubtful that they would be constructed, the potential economic benefits of stormwater detention and/or retention were not included in the Engineer's Opinion of Probable Cost.

### 4.6 Habitat Improvements – Riparian Floodplains and Wetlands

Another of the primary objectives of the Restoration Program is to improve watershed habitats that had been adversely impacted and/or were threatened by stream erosion and altered hydrology. Significantly, the program was implemented to halt the impairment and destruction of these natural areas, to maintain their provision of environmental services and benefits.

In terms of ecosystem services provision, floodplains and their associated river channels are among the world's most valuable resources (Costanza *et al*., 2014). Floodplains provide broad areas to spread out and temporarily store floodwaters, reduce flood peaks and velocities, and reduce the potential for erosion, allowing additional time for runoff to infiltrate and recharge available groundwater aquifers. Riparian zones are comprised of vegetation adjacent to and along the length of streams and rivers, and are transitional areas between aquatic and upland terrestrial habitats. Vegetation in the riparian corridor benefits water quality and habitat by regulating temperature, adding organic matter, assisting in pollution reduction, stabilizing streambanks, and providing wildlife habitat (Marczak *et al.*, 2010; Semlitsch and Bodie, 2003).

It is widely recognized that wetlands, estuaries, and forests are the most valuable ecosystems in terms of the services and benefits they provide (Costanza *et al*., 2006; Costanza *et al*., 2014). The primary wetland habitats in the watershed are forested floodplain systems associated with perennial streams and intermittent drainageways. Major ecological services of bottomland forest systems include sediment stabilization and soil retention, water quality enhancement, and wildlife habitat (Barbier *et al*., 2011). Cultural services and benefits (Costanza *et al*., 1997) include aesthetic, bequest, educational, and scientific values. Biodiversity support, water quality improvement, flood abatement, and carbon sequestration are key functions that are impaired when wetlands are lost or degraded (Zedler and Kercher, 2005). Land use and hydrologic alteration can negatively affect the ecological quality of nearby wetland and riparian habitats (Gergel *et al.*, 2002; Mack, 2007; Falcone *et al.*, 2010; Rooney *et al.*, 2012; Stapanian *et al*., 2018). Undisturbed riparian zones and wetland buffers with natural vegetation help maintain highly diverse and functional aquatic communities.

The estimated amounts of restored and protected wetlands in the D'Olive Watershed have been presented in Table 2. Restored wetlands are those directly included as part of the restoration project. Protected wetlands are those either downstream of the project (protected by reduced sedimentation) or upstream of the project (protected by halting the advance of a head-cut).

Protected wetlands include 13.7 acres in Spanish Fort Town Center downstream of Joe's Branch Phase 1 and 2. These wetlands were assessed in 2010 as being heavily impacted and remain at least moderately impacted today due to the pre-restoration erosion and sedimentation. This protected wetland area is significant, as it represents 43% of the total current wetland acreage in the Joe's Branch sub-watershed.

Site D4-D6 lies between upstream poor quality wetlands and a downstream area of higher quality wetlands. The upstream area is within the Timber Creek subdivision, which was assessed in 2010 as having heavily impacted wetlands with cleared and dead canopy trees and heavy sedimentation. The downstream area was assessed as high quality wetlands, located at the confluence of D'Olive Creek and its two major tributaries, and these remain relatively un-impacted today. A 5.6-acre portion of this downstream wetland area is now considered protected due to the adjacent D4-D6 project.

Site DAE is a small drainageway bounded by Hwy 90 on the north, upstream of a small drainageway south to D'Olive Creek. A 0.5-acre area of downstream wetland is being protected by the DAE restoration. To the east of DAE, the DAF-1A restoration is also providing 0.5 acre of downstream wetland protection.

Site DA3 is located on the east side of CR13, south of Hwy 90. A 0.5-ac area of downstream wetlands, although partially degraded, is now protected by the DA3 project. Prior to restoration, the two tributary streams flowing toward DA3 were head-cutting into high quality wetlands. These head cuts were halted by the restoration, and a total of 19.3 acres of wetlands are now considered protected.

The TC1-TC2, TC2 Tributary project halted a head-cut that was advancing upstream at a rate of over 100 feet per year. Had that erosion continued the head cut would have reached Whispering Pines Road within 50 years. A total of 18.4 acres of wetlands are now protected by the TC1-TC2, TC2 Tributary restoration. This protected wetland area represents 36% of the total current wetland acreage in the TC sub-watershed.

The approach for estimating the economic value of riparian floodplains and wetlands in the watershed is to apply appropriate dollar value estimates to the total area of habitats restored and protected by the D'Olive projects. The use of a benefit transfer method to estimate habitat monetary values is challenging, due to region- and location-specific ecological and socioeconomic factors that do not necessarily correspond with other geographic areas or current conditions (Woodward and Wui, 2001; Himes-Cornell *et al.*, 2018).

Forested wetlands generate relatively little revenue, but have very high value due to their underlying ecosystem services (Schmidt *et al*., 2014). An acre of forestland in a riparian area has a much greater impact on water quality and quantity than an acre of non-riparian forest, and higher per acre values generally come from forested wetlands or riparian forests in urban areas (Moore *et al*., 2011). There is substantial potential for ecosystem services provision by forests in urban green spaces (Ziter and Turner, 2018). In urbanized areas where natural wetlands are relatively sparse features within the broader landscape of a watershed, such as in D'Olive, habitat scarcity can increase monetary values (Mitsch and Gosselink, 2000).

Floodplains and forested wetlands have been estimated to provide as much as $10,397 per ac/yr ($12,658 in 2018 dollars) in ecosystem services (Constanza *et al*., 2014). In a study of Georgia forests, Schmidt *et al*. (2014) determined that total economic value of riparian forests in suburban and rural locations ranges from $11,841 to $13,202 per ac/year ($12,626 to $14,078 in 2018 dollars).

In a meta-analysis of 190 wetland valuation studies, water quality improvement was found to be valued higher than other identified wetland services (Brander *et al.*, 2006). Since a primary objective of the Restoration Program is to reduce sediment loadings to improve water quality in watershed streams and D'Olive Bay, we focus on a water quality enhancement service. For the purposes of this evaluation, a per-acre/yr value for both floodplains and wetlands is based on a range using lower and upper estimates.

For an upper bound estimate, Moore *et al.* (2011) determined that forested wetlands in urban and suburban areas provide as much as $3,479 per acre/yr ($3,904 in 2018 dollars) in pollution treatment. Woodward and Wui (2001) performed a meta-analysis of wetland valuation studies to determine the relative value of individual wetland services. The mean value for water quality service was determined to be $417 per acre/yr ($805 in 2018 dollars), and this is adopted as the lower bound estimate. Table 6 presents the estimated range of water quality enhancement values for floodplains and wetlands in the watershed.

**Table 6. Range of estimated annual water quality enhancement values for acres of floodplains and wetlands restored and protected in the D'Olive Watershed.**

| | Floodplain Riparian Areas Restored | Wetlands Restored | Wetlands Protected |
|---|---|---|---|
| Acreage Total | 27.6 | 3.1 | 58.5 |
| Per Acre/Yr Value | $805 - $3,904 | $805 - $3,904 | $805 - $3,904 |
| Total Value/Yr | $22,218 - $107,750 | $2,496 - $12,102 | $47,093 - $228,384 |
| All Habitats | $71,807 - $348,236 | | |

Translating the above estimated annual values of restored and protected wetlands and floodplains to a present value of benefits directly attributable to the Restoration Program is complicated. Firstly, restored areas will require a period of years before they are established and fully providing associated ecosystem services. Also, an allowance would be needed for the pre-existing ecosystem services of these areas in their pre-restoration condition. Likewise, downstream and upstream wetlands that are considered protected by the restoration projects would not have been immediately and totally lost had the restoration not been implemented; rather, they would have gradually become more and more degraded over time. The timeframes and extent of such degradation are uncertain. Because of these complications and uncertainties, estimation of the present value of associated environmental benefits has not been attempted.

### 4.7 Habitat Improvements – D'Olive Bay and Mobile Bay

The Restoration Program is intended to improve habitats within D'Olive Bay that had been adversely impacted by sedimentation and increased turbidity stemming from degradation of streams and wetlands in the watershed. The bay system, including the lower reaches of D'Olive Creek, supports submerged aquatic vegetation (SAV) and tidal marshes, two of our most biologically productive coastal habitats.

There has been a long-term decline in SAV in coastal areas, believed to be principally a result of increasing inputs of sediments and nutrients into estuarine waters. Increased turbidity and reduced light availability necessary for plant growth and survival is a major cause of the reduced SAV extent along the Alabama coast. Sedimentation in upper D'Olive Bay has reduced water depths in proximity to D'Olive Creek. This sedimentation has resulted in some expansion of emergent marsh but has also created shallower conditions that impede migration of aquatic fauna, hinder boat navigation, and reduce natural current flows.

Major ecological services of SAV and tidal marshes include coastal protection, erosion control, nutrient cycling, water quality enhancement, and wildlife habitat. These submerged and intertidal plant communities provide nursery habitat for more than 95% of the recreational and commercially important fish and shellfish species found in the Gulf of Mexico, including brown and white shrimp, blue crab, speckled trout, and redfish.

Biodiversity support is high in the SAV and marshes of the upper Mobile Bay and lower Mobile-Tensaw Delta. These habitats provide food and habitat for a diverse wildlife community, including fish, amphibians, reptiles, and hundreds of bird species. SAV is a preferred food item for the endangered Alabama red-bellied cooter (*Pseudemys alabamensis*) and endangered West Indian manatee (*Trichechus manatus*), both of which commonly occur in upper Mobile Bay and the lower Mobile-Tensaw Delta.

Cultural services and benefits provided by the estuarine wetlands include aesthetic, bequest, educational, and scientific values. Natural, open areas not only provide beauty and solitude, they have always been an integral part of coastal life and cultural heritage. Pre-European inhabitants of the Mobile Bay area, including at D'Olive Creek (Curren, 1978), had an estuary-oriented mixed economy, adapted to their needs for deltaic horticulture and seasonal hunting and gathering (Knight, 1984). Today, people still enjoy these natural areas for fishing and hunting, bird watching, photography and art, and education, among other uses.

Because of their ecological and socioeconomic values, research and monitoring of SAV and tidal marshes are an integral part of MBNEP's program for assessing estuarine status and trends. Conservation and restoration of these coastal resources are a major focus of the MBNEP and NFWF-GEBF funded projects, including the Restoration Program.

Since 2009 there has been expansion of SAV extent in Mobile Bay and the lower Mobile-Tensaw Delta, including D'Olive Bay. However, SAV expansion due to improvements in water clarity as a result of the restoration projects, if any, is yet to be determined. Monitoring in D'Olive Bay is ongoing, and results are still being analyzed.

Regardless, vegetated estuarine habitats provide direct and indirect societal benefits. The approach for estimating the economic value of SAV and marshes in D'Olive Bay is to apply appropriate dollar value estimates to the total area of these habitats.

There is sparse information on market-based and non-market ecosystem services provided by marshes and SAV for the Gulf coast region. Most monetary estimates of SAV and tidal marsh ecosystem service values have been determined using market price methods or benefit transfer, using a single site or set of sites to describe broad habitat types across large geographic scales (Himes-Cornell *et al.*, 2018). Tidal marsh as a global biotope has been estimated to provide as much as $78,479 per acre/year ($95,548 in 2018 dollars) in total ecosystem services (Constanza *et al*., 2014).

Most marsh valuation studies have focused on discrete geographic regions and specific services. Commonly analyzed coastal wetland services are related to fish and food production, and recreation, since these are market services. There are no available data for the size and quality of fisheries in D'Olive Bay, so published values were reviewed to identify a range to apply to D'Olive marsh and SAV acreage.

Costanza *et al*. (1989) estimated the total value of an average acre of tidal wetlands in Louisiana at $2,429 to $6,400 per acre/yr ($6,156 to $16,221 in 2018 dollars), based on a valuation of commercial fisheries, trapping, recreation, and storm protection. Bell (1997) determined the economic value of recreational fishing per acre/yr of wetlands on the west coast of Florida was $981 ($2,383 in 2018 dollars).

In Alabama, O'Higgans *et al*. (2010) analyzed the extent and value of emergent salt marsh for redfish, speckled trout, and blue crab fishery habitat in Weeks Bay, located about 14 miles south of D'Olive Bay. The authors determined a fisheries value of black needlerush (*Juncus roemarianus*) at $5,600 per acre/yr ($6,483 in 2018 dollars), and smooth cordgrass (*Spartina alterniflora*) marshes at $9,400 per acre/yr ($10,882 in 2018 dollars).

The fisheries value of D'Olive tidal wetlands, with a lower salinity regime and different vegetative community than Weeks Bay, likely differs from values determined for the salt marsh fish production. But given the proximity to D'Olive Bay, the relatively recent valuation by O'Higgans *et al*. (2010) for black needlerush ($6,483) is used here as the upper bound of the range for fishery habitat. The wetland meta-analysis performed by Woodward and Wui (2001) determined a mean wetland value for recreational fishing at $357 per acre/yr ($690 in 2018 dollars), and this value is used as the lower bound of the range.

Fishery production is significantly greater in marshes and SAV compared to non-vegetated bay waters. In locations where marshes and SAV occur, there is some degree of synergy between them because fishery populations will occur across both habitats. The value range for tidal marsh ($690 to $6,483) is adopted also for SAV in D'Olive Bay. Table 7 presents the estimated range of fishery values for marsh and SAV in D'Olive Bay.

**Table 7. Range of estimated annual fishery values for tidal marshes and SAV in the D'Olive Bay system.**

| | Tidal Marsh | SAV |
|---|---|---|
| Acreage Total | 251.2 | 90.1 |
| Per Acre/Yr Value | $690 - 6,483 | $690 - 6,483 |
| Total Value/Yr | $173,328 - $1,628,530 | $62,169 - $584,118 |
| All Habitats | $235,497 - $2,212,648 | |

The annual fishery values above represent an estimate of the total value of tidal marshes and SAV in the D'Olive bay system. To evaluate corresponding benefits attributable to the Restoration Program, it would be necessary to quantify the changes in these habitats that have directly resulted from the watershed restoration. This is not currently possible. As previously noted, even though there has been expansion of SAV extent since 2009, SAV expansion due to improvements in water clarity as a result of the restoration projects, if any, is yet to be determined.

### 4.8 Other Environmental Benefits Considered

In addition to those discussed in preceding sections, other environmental benefits considered included recreation and education. Although there are recognized valuation techniques for such direct use values, monetizing such benefits has not been attempted herein for the reasons summarized below.

Recreation (hiking, bird-watching, etc.) oftentimes provides significant benefits from open space public lands in urban settings. However, because the restoration projects are mostly on private properties, recreational opportunities are limited.

The restoration projects have provided educational benefits to high school and college students, environmental and engineering professionals, and others. It has been estimated by MBNEP and the City of Daphne that site tours and workshops utilizing the restoration sites have totaled over 1,000 contact hours between 2015 and 2018. The amount of use of the sites for educational purposes in future years is uncertain. While simplifying assumptions could be made to allow monetization, a wide range of uncertainty would exist and therefore attempts at monetizing education benefits are felt to be premature at this time.

As presented in Section 2.1 and Figure 2, there are other indirect use values (e.g., climate regulation) and non-use/passive values (existence, bequest, altruistic) attributable to ecosystem services as may be provided by the restoration sites. Attempting to assign monetary values to such benefits was beyond the scope of this study.

## 5.0 CONCLUSIONS

Direct Benefits of Improved Drainage and Stormwater Management Systems

The D'Olive Watershed restoration projects represent infrastructure improvements to drainage and stormwater management systems within the cities of Daphne and Spanish Fort. Besides environmental benefits (e.g., water quality and habitat enhancement), the projects provide for safe conveyance of stormwater and erosion protection of adjacent properties. Effective drainage systems and stormwater management are typical objectives of urbanized communities and usually fall within the realm of public responsibility. However, budget limitations and the fact that drainage conveyances in many locations are on private property constrain Daphne and Spanish Fort from the implementation of stormwater improvements. These constraints have been overcome by the work of MBNEP to plan and implement the restoration program. MBNEP with its collaborative partnerships competed for and secured funding from outside sources, thus saving local resources for other priorities of the communities.

Costs of the D'Olive Watershed Restoration Program to date are approximately $12.2 million. It cannot be said for certain whether or not infrastructure improvements to drainage and stormwater management systems in the D'Olive Watershed would have been implemented anyway had the MBNEP restoration program not been undertaken. However, the constraints noted before would probably have restricted improvements only to "emergencies." Nevertheless, both Daphne and Spanish Fort are subject to Municipal Separate Storm Sewer System (MS4) permits regulated by ADEM. Given that D'Olive Watershed streams in both municipalities are on ADEM's list of impaired waters for "siltation (habitat alteration)" from "land development," it is indeed possible that ADEM could have required regulatory actions necessitating stream stabilization improvements. Instead, ADEM has acted as a proactive partner with MBNEP and the regulated municipalities to advance solutions to the underlying problems on a voluntary basis. A goal of the D'Olive Watershed Restoration Program is the eventual removal of the streams from the impaired waters list. Such delisting will provide benefits of reduced MS4 permit compliance costs for the regulated municipalities.

Avoided Damages to Infrastructure

A damage cost avoidance analysis was conducted to estimate benefits from avoided damages to infrastructure at the restoration sites. Information was developed by the project team and consultation with design engineers, contractors, and others to catalog potential infrastructure protection/repair projects that would likely have occurred if MBNEP had not performed the restoration program. The types of potential damages evaluated primarily include highways and roadways, utilities (water, sewer, gas, and fiber optics), building structures, and drainage / stormwater. Assumptions included the future timeframe that a possible infrastructure repair would likely have occurred, and the cost estimates are adjusted to Present Value using a discount rate of 2.75 %. The avoided damages to infrastructure analysis resulted in an Engineer's Opinion of Probable Cost (OPC) totaling approximately $4.0 million, with a recognized uncertainty range for this level of estimate at -20% to +30% (i.e., an Engineer's OPC range of $3.2 million to $5.2 million).

Property Values

An indirect economic benefit considered was possible increased property values, both at properties where the actual improvements were located and at downstream properties. This was evaluated by literature review to identify similar studies allowing estimation by "benefits transfer" relevant to this study. The scope also included consultation with a property appraiser.

Although the literature review identified several studies where property values are linked to water quality, "benefit transfer" of reported property value increases was not considered applicable to due to several differences between the literature studies compared to characteristics of (and data available for) the D'Olive Watershed. The property appraiser consultant issued similar findings, concluding that there are currently no measurable benefits to property values within the D'Olive Bay Watershed as a result of the restoration projects.

Sediment Loading Reductions

One goal related to sediment loadings is reduction of sediment inputs to Lake Forest Lake. Reducing these inputs could provide economic benefits since reduced sediment inputs to the lake will lessen the quantity of sediments that will require removal when and if the lake is dredged to maintain its capacity as a sediment trap and/or for other purposes. Although preliminary consideration of such benefits were on the order of $1.1 million (present value), these were not included in the Engineer's OPC due in part to the lack of completed monitoring results documenting the actual reduced sediment loadings, and also because plans for maintenance (dredging) of the lake are uncertain.

Improved Stormwater Attenuation (Detention / Retention)

The D'Olive Watershed Restoration Program has included Stormwater Management Facilities (SWMFs) that provide stormwater detention and/or retention. Additionally, several of the stream restoration projects have increased stormwater attenuation (detention/retention) by reconnecting the stream channel with their floodplains (that is, during a storm event, improved floodplain connectivity provides improved storage). In total, it is estimated that the projects provide over 300,000 cubic feet of improved stormwater attenuation.

Stormwater attenuation can reduce flood risk and there are recognized valuation methodologies (usually avoided damages techniques) for estimating these benefits. However, existing flood risks in the locations of the restoration projects are minimal and flood protection was not an objective of the program. Stormwater attenuation also provides environmental benefits by helping restore natural watershed hydrology which, by reducing runoff rate, volume, and duration, provides erosion control and improves water quality. Also, increased infiltration in floodplain areas can increase low flows and enhance aquifer recharge.

One approach considered for estimating the economic value of stormwater attenuation provided by these projects could be to estimate the cost of a conventional dry detention basin to provide the same level of detention. A preliminary analysis suggests a present value on the order of $870,000. However, because there are no regulations requiring such detention facilities, and it is considered doubtful that they would be constructed, the potential economic benefits of stormwater detention and/or retention were not included in the Engineer's OPC.

Habitat Improvements – Riparian Floodplains and Wetlands

A primary objective of the Restoration Program is to improve watershed habitats that had been adversely impacted and/or threatened by stream erosion and altered hydrology. A benefit transfer approach was used to estimate the economic value of wetlands and riparian floodplains in the D'Olive watershed. A range of water quality enhancement dollar value estimates was taken from published studies. The total area of restored and protected habitats was multiplied by the monetary values to estimate annual ecosystem services values ranging from $71,807 to $348,236. An assumption in the analyses was that water quality enhancement values do not differ across habitats of varying condition.

Habitat Improvements – D'Olive Bay and Mobile Bay

The Restoration Program is intended to improve habitats within D'Olive Bay that had been adversely impacted by sedimentation and increased turbidity stemming from degradation of streams and wetlands in the watershed. Monitoring of habitats and water quality improvement in D'Olive Bay is ongoing, and results are still being analyzed.

A benefit transfer approach was used to estimate the total fisheries value of tidal marshes and SAV in D'Olive Bay. A range of dollar value estimates was taken from published studies. The total area of marshes and SAV was multiplied by the dollar values to estimate potential annual fishery values ranging from $235,497 to $2,212,648. Because fishery populations occur in both marsh and SAV, an assumption in the analyses was that these habitats have equal values.

The annual fishery values above represent an estimate of the total value of tidal marshes and SAV in the D'Olive Bay system. To evaluate corresponding benefits attributable to the Restoration Program, it would be necessary to quantify the changes in these habitats that have directly resulted from the watershed restoration. This is not currently possible since monitoring is ongoing and results are still being analyzed.

Other Environmental Benefits Considered

Recreation (hiking, bird-watching, etc.) oftentimes provides significant benefits from open space public lands in urban settings. However, because the restoration projects are mostly on private properties, recreational opportunities are limited and monetization of such benefits was not attempted.

The restoration projects have provided educational benefits to high school and college students, environmental and engineering professionals, and others. It has been estimated by MBNEP and the City of Daphne that site tours and workshops utilizing the restoration sites have totaled over 1,000 contact hours between 2015 and 2018. The amount of use of the sites for educational purposes in future years is uncertain. While simplifying assumptions could be made to allow monetization, a wide range of uncertainty would exist and therefore attempts at monetizing education benefits are felt to be premature at this time.

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# APPENDIX A
# RESTORATION PROJECT PROFILES

Project I.D.: **Joe's Branch Phase 1 (JB Project 1)**

Project Name: Joe's Branch Unnamed Tributary JB, Step Pool Stormwater Conveyance (SPSC) Project, D'Olive Watershed, Spanish Fort, Alabama

Location:

Latitude/Longitude (approx. center): 30$^o$40'12.8" N; 87$^o$54'16.0" W

Descriptive location: Spanish Fort, Alabama - south of US Hwy 31 and west of Westminster Drive

General Project Information:

**Landowner(s):**

- Special Care Facilities Financing (aka Westminster Village)

**Engineer: Thompson Engineering, Inc.**

**Contractor: Southern Excavating LLC**

Date of start of construction: October 2012

Date of Substantial Completion of construction: April 2013

Date of completion of maintenance period: March 2015 (supplemental funding for plants)

Landowner(s):

- Special Care Facilities Financing (aka Westminster Village)

Project Metrics:

For stream restoration / stabilization project:

Length of stream restored / stabilized (linear feet): 1,000

Riparian area modified, floodplain/wetlands (acres): 2.2

Wetlands restored (acres): 0.5

Wetlands protected (acres): 13.7 (downstream)

Downstream wetlands have been protected by the Joe's Branch projects (Phases 1 and 2). The wetlands in the Spanish Fort Town Center complex (approximately 13.7 acres) were noted as severely impacted by sedimentation in the 2010 D'Olive Watershed Management Plan. The reduced sediment loadings from the Joe's Branch restoration projects are believed to have substantially lessened the continued impacts from sedimentation on the downstream wetlands.

Project Description:

In 2010, officials with the City of Daphne discovered highly turbid waters entering D'Olive Creek. The origin of the muddy water was traced to a 20-foot-deep headcut and a severely eroded channel in an unnamed tributary (designated as "JB") of Joe's Branch, within the D'Olive Watershed in Baldwin County, Alabama. Joe's Branch is included on ADEM's Section 303(d) list of impaired waters because of siltation and habitat alteration caused by land development. This headcut, the result of excessive stormwater runoff, required immediate attention because it threatened the stability of residences at the adjacent Westminster Village Retirement Community and the heavily traveled U.S. Highway 31.

On behalf of a multi-jurisdictional project team, the Mobile Bay National Estuary Program (MBNEP) secured USEPA Section 319 funding for the project from the Alabama Department of Environmental Management (ADEM), and also matching funds from the Alabama Department of Transportation (ALDOT), to address the problem. The project represented the first step in the plan to rehabilitate Joe's Branch and remove it from the impaired waters list and was an initial effort to implement management recommendations of the D'Olive Creek Watershed Management Plan prepared by Thompson Engineering for MBNEP in 2010.

The restoration technique used is called a Step Pool Storm Conveyance (SPSC) system. The SPSC system is an aesthetically-pleasing approach that uses a porous sand/woodchip mixture beneath the primary flow channel to retain and filter stormwater during lower flow events. The system's flow path itself is constructed by a network of rock riffles and pools to stabilize the eroded channel and dissipate energy during higher flow events. The project also included restoration of the degraded wetlands severely impacted by sedimentation from the prior erosion immediately downstream of SPSC rock structures.

The construction of this first-of-its-kind project in Alabama was completed in 2013. Since installation, the SPSC project has:

- Restored the severely eroded 1,000-ft. slope to more natural conditions, remediating the effects of erosion and sedimentation and improving water quality in water bodies located downstream of the SPSC project
- Removed the threat of damaging erosion to nearby highway and housing infrastructure
- Stabilized steep slopes, provided wildlife habitat and minimized the potential for erosion with natural vegetation
- Restored wetland areas, preserved habitats and reduced threats to aquatic and wildlife species
- Demonstrated through water quality monitoring performed by the Geological Survey of Alabama (GSA) that, following construction, an order-of-magnitude reduction for turbidity and total suspended solids had occurred. In GSA's Open File Report 1408, post-restoration total sediment loadings downstream of the restoration site, as compared to pre-restoration rates, were found to be 90% lower.

In April 2014, the project area withstood a "100-year rainfall event" of more than 13-inches with minimal problems.

The SPSC project represents the first restoration measure initiated from implementation of a comprehensive Watershed Management Plan prepared for the D’Olive Bay watershed in 2010. Its success helped justify funding from the National Fish and Wildlife Foundation (NFWF) Gulf Environmental Benefit Fund for a broader program to address similar problems throughout the watershed.

An educational outreach video, The Restoration of Joe’s Branch, was produced by the MBNEP to introduce the project to municipal leaders and others. It was created not only as an educational tool for this type of project, but also to emphasize the importance of a collaborative approach among various entities to address such problems. In addition to MBNEP, ADEM, ALDOT, and Thompson Engineering, other project partners included the Alabama Department of Conservation and Natural Resources (ADCNR), Geological Survey of Alabama (GSA), City of Daphne, City of Spanish Fort, and Westminster Village (the landowner). In 2015, the USEPA Gulf of Mexico Program awarded the project a 1st Place Gulf Guardian Award in the Partnerships category.

Project Maps:

**Project I.D.:** **Joe's Branch Phase 2 (JB Project 2, JA, J4-1, J4-2, J-SWMF, JB-SWMF)**

Project Names and Locations:

**JB2 - Joe's Branch Unnamed Tributary JB, Project 2,** Stream Restoration Downstream of Step Pool Storm Conveyance (SPSC) System, D'Olive Watershed, Spanish Fort, Alabama

Location: *JB Project 2* Latitude/Longitude (approx. center): 30°40'3.5" N; 87°54'22.8" W

Descriptive location: Spanish Fort, Alabama - south of US Hwy 31 near Spanish Fort United Methodist Church

**JA - Joe's Branch Unnamed Tributary JA**, D'Olive Watershed, Spanish Fort, Alabama

Location: *JA* Latitude/Longitude (approx. center): 30°39'58.5" N; 87°54'34.1" W

Descriptive location: Spanish Fort, Alabama - south of US Hwy 31 near Piggly Wiggly Shopping Center

**J4-1 – Joe's Branch Upstream of Town Center Avenue**, D'Olive Watershed, Spanish Fort, Alabama

Location: *J4-1* Latitude/Longitude (approx. center): 30°39'54.5" N; 87°54'12.3" W

Descriptive location: Spanish Fort, Alabama - upstream of Town Center Avenue

**J4-2 – Joe's Branch Upstream of J4-1**, D'Olive Watershed, Spanish Fort, Alabama

Location: *J4-2* Latitude/Longitude (approx. center): 30°39'56.7" N; 87°54'6.9" W

Descriptive location: Spanish Fort, Alabama - upstream of J4-1 and downstream of J-SWMF at Westminster Gates Subdivision

**J-SWMF – Joe's Branch Stormwater Management Facility (SWMF)**, D'Olive Watershed, Spanish Fort, Alabama

Location: *J-SWMF* Latitude/Longitude (approx. center): 30°39'58.3" N; 87°54'2.0" W

Descriptive location: Spanish Fort, Alabama - stormwater detention facility for Westminster Gates Subdivision at Maury Court

**JB-SWMF – Joe's Branch Unnamed Tributary Stormwater Management Facility (SWMF)** upstream of Step Pool Storm Conveyance (SPSC) System, D'Olive Watershed, Spanish Fort, Alabama

Location: *JB-SWMF* Latitude/Longitude (approx. center): 30°40'14.5" N; 87°54'8.8" W

Descriptive location: Spanish Fort, Alabama - stormwater management facility south of US Hwy 31 and west of Westminster Drive

General Project Information:

**Landowner(s):**

**JB-2**

- Special Care Facilities Financing (aka Westminster Village)
- Spanish Fort United Methodist Church
- Cypress Spanish Fort Venture LLC

**JA, J4-1, J4-2, J-SWMF, JB-SWMF**

- Special Care Facilities Financing (aka Westminster Village)
- Spanish Fort United Methodist Church
- Cypress Spanish Fort Venture LLC
- Church of His Presence
- Westminster Gates Homeowners Association

**Engineer:** **Thompson Engineering, Inc.**

**Contractors:**

**JB-2** **North State Environmental LLC**

Date of start of construction: April 2015

Date of Substantial Completion of construction: August 2015

Date of completion of maintenance period: August 2017

Project Metrics:

For stream restoration / stabilization project:

Length of stream restored / stabilized (linear feet): 1,600

Riparian area modified, floodplain/wetlands (acres): 3

Wetlands restored (acres): 0 (not including wetlands incidental to stream restoration)

**JA, J4-1, J4-2, J-SWMF, JB-SWMF** **Southern Excavating LLC**

Date of start of construction: February 2016

Date of Substantial Completion of construction: November 2016

Date of completion of maintenance period: November 2018

Project Metrics:

For stream restoration / stabilization projects:

**JA**

Length of stream restored / stabilized (linear feet): 600

Riparian area modified, floodplain/wetlands (acres): 1

Wetlands restored (acres): 0 (not including wetlands incidental to stream restoration)

**J4-1, J4-2**

Length of stream restored / stabilized (linear feet): 1,100

Riparian area modified, floodplain/wetlands (acres): 3

Wetlands restored (acres): 0 (not including wetlands incidental to stream restoration)

For stormwater management facilities (SWMF):

**J-SWMF**

Area (acres): 0.4

Detention/retention storage volume (cubic feet): 35,000

**JB-SWMF**

Area (acres): 0.5

Detention/retention storage volume (cubic feet): 53,400

Wetlands protected (acres): 13.7 (downstream)

Note: The above project metrics display that Joe's Branch Phase 2 projects did not include wetland restoration other than wetlands incidental to stream restoration. However, downstream wetlands have been protected by the Joe's Branch projects (Phases 1 and 2). The wetlands in the Spanish Fort Town Center complex (approximately 13.7 acres) were noted as severely impacted by sedimentation in the 2010 D'Olive Watershed Management Plan. The reduced sediment loadings from the Joe's Branch restoration projects are believed to have substantially lessened the continued impacts from sedimentation on the downstream wetlands.

Project Description:

Subsequent to successful completion of the Joe's Branch Step Pool Storm Conveyance (SPSC) project (Joe's Branch Phase 1), additional funds were received for Joe's Branch Phase 2 from the National Fish and Wildlife Foundation – Gulf Environmental Benefit Fund (NFWF-GEBF), which was among the first use of these "BP Deepwater Horizon" funds in the state of Alabama. With this funding, MBNEP began restoration activities throughout the D'Olive Bay Watershed. This restoration program began with the Joe's Branch sub-watershed.

Initial project activities included a field assessment of stream/watershed conditions in the Joe's Branch sub-watershed, which is comprised of three stream segments: 1) unnamed tributary to Joe's Branch (JA) north of Town Center Avenue and east of US Hwy. 98; 2) unnamed tributary to Joe's Branch (JB) north of Town Center Avenue and located south of the completed SPSC Project; and 3) Joe's Branch proper, east (and upstream) of Town Center Avenue through a wooded wetland area upstream to headwater residential and commercial developed areas. The field team adopted the Unified Stream Assessment (USA) approach for the evaluation. The USA is a rapid technique to locate and evaluate problems and restoration opportunities within stream corridors.

The following were designed and constructed for Joe's Branch Phase 2 restoration:

1) JA Subwatershed:

- Gully erosion repair for three gullies in JA Lower Reach (western area near Hwy. 98) which included installation of vegetated wall systems / Flex MSE ditch checks.
- Installation of a 50-ft x 100-ft. plunge pool with an outfall.
- Installation of 300 LF of 48" diameter Class III RCP pipe to channel stormwater through a non-historic streambed area into the plunge pool. The piping system contained four junction boxes to change direction of flow.

2) JB Subwatershed:

JB Project 2 Stream Restoration

- 1,400 linear feet of armored riprap was installed to restore the unnamed tributary flowing to Joe's Branch proper and ultimately draining to the D'Olive creek watershed. The system included log and rock sills at various locations to stem waterflow velocity and provide grade control.
- Three separate stormdrain systems were installed totaling 450 linear feet of 24-inch diameter corrugated stormwater pipe with ten junction boxes for direction change, three outfalls and three plunge pools at various locations.

JB Stormwater Management Facility (JB-SWMF)

- 300-ft. x 75-ft. bio-retention pond that included wetland plants, baffle dike, outfall, and an overflow spillway/dam. The system decreased the velocity of the flow and filtered and treated the water prior to release to the step pool conveyance system.

3) Joe's Branch Subwatershed:

J4-1 and J4-2 Stream Restoration

- J4-1 stream restoration involved redirecting streamflow from an eroded area back into the historic channel and rehydrating the floodplain for roughly 700-ft.
- J4-2 stream restoration involved the installation of 400-ft. of riprap armored naturalized stream stabilization with rock sills for slowing velocity of water.

J Stormwater Management Facility (J-SWMF)

- J-SWMF involved restoring (to its original dimensions) an existing detention pond previously constructed for the Westminster Gates Subdivision

Project Maps:

**Project I.D.:** **D'Olive Creek D4-D6**

Project Names and Locations:

**D'Olive Creek Restoration Project, Segments D4-D6,** Stream Restoration Between I-10 and US Hwy 90, D'Olive Bay Watershed, Daphne, Alabama

Location: Latitude/Longitude (approx. center): 30°39'27.1" N; 87°52'53.7" W

Descriptive location: Daphne, Baldwin County, Alabama. The project extends from Interstate I-10 at the upstream end to US Hwy 90 at the downstream end.

General Project Information:

**Landowner(s):**

- Malbis Plantation

**Engineer:** **Goodwyn, Mills & Cawood Inc. (GMC)**

**Contractors:**

**North State Environmental LLC**

Date of start of construction: May 2016

Date of Substantial Completion of construction: September 2016

Date of completion of maintenance period: September 2018

Project Metrics:

For stream restoration / stabilization project:

Length of stream restored / stabilized (linear feet): 2,714 (D'Olive Creek – 2,236 lf; UT to D'Olive Creek – 478 lf)

Riparian area modified, floodplain/wetlands (acres): 9.0

Wetlands restored (acres): 0 (not including wetlands incidental to stream restoration)

Wetlands protected (acres): 5.6 (downstream)

Downstream wetlands are considered protected due to reduced sediment loadings from the project area.

Project Description:

The D'Olive Creek watershed drains part of the eastern shore of Mobile Bay, including parts of the cities of Spanish Fort and Daphne. Due to continued development, the watershed is transitioning from a mix of forested, agricultural, and residential land uses to primarily residential and commercial land use. With this development comes changes in land cover, most notably an increase in impervious surfaces. The resulting runoff conditions cause increased erosion and stream channel degradation leading to extensive sediment loading and destroyed habitat. These water quality and habitat impacts affect both the D’Olive watershed and the Mobile Bay downstream.

In 2008, severe erosion and downcutting of the D’Olive Creek channel was discovered between Interstate 10 and U.S Highway 90. The erosion was accelerated by excessive rainfall from Tropical Storm Fay, which made landfall near Carrabelle in the Florida Panhandle on August 23, 2008, and Hurricane Gustav, which made landfall in southeastern Louisiana on September 1, 2008 (Cook, Moss 2012). At I-10, concrete culverts under the highway were undermined initiating emergency repairs to the roadway which led to a stream restoration project in 2009.

Watershed development had changed the hydrographic response, increasing flow and associated event peaks. The change in hydrographic response contributed to increased energy within the channel. The design stream of 2009 was not capable of effectively transporting the increased flows without excess scour in both the channel and floodplain. As a result, the channel continued to erode to increase flow capacity; which, in turn, has led to an increase in sediment transport through the system, sediment that is eventually delivered to D’Olive Bay. During a 24-hour, 13.3-inch rain event on April 29-30, 2014, D’Olive Creek was subject to a peak discharge of 3,750 cubic feet per second (cfs) per data provided by Marlon Cook (USGS), the City of Daphne, and John Curry (Hydro Engineering Solutions). As a result of this substantial flow, the stream experienced extreme erosion, departure from the floodplain, floodplain scour, and channel incision which ultimately led to channel degradation and instability. In 2015 it was estimated that the banks within the project area were eroding at an average rate of 1,700 tons per year and that the project reach experienced a net loss of 3,800 cubic yards of material between 2009 and 2015.

This project was supported wholly or in part by Mobile Bay National Estuary Program as part of a grant from National Fish and Wildlife Foundation (NFWF) Gulf Environmental Benefit Fund to address the outlined issues.

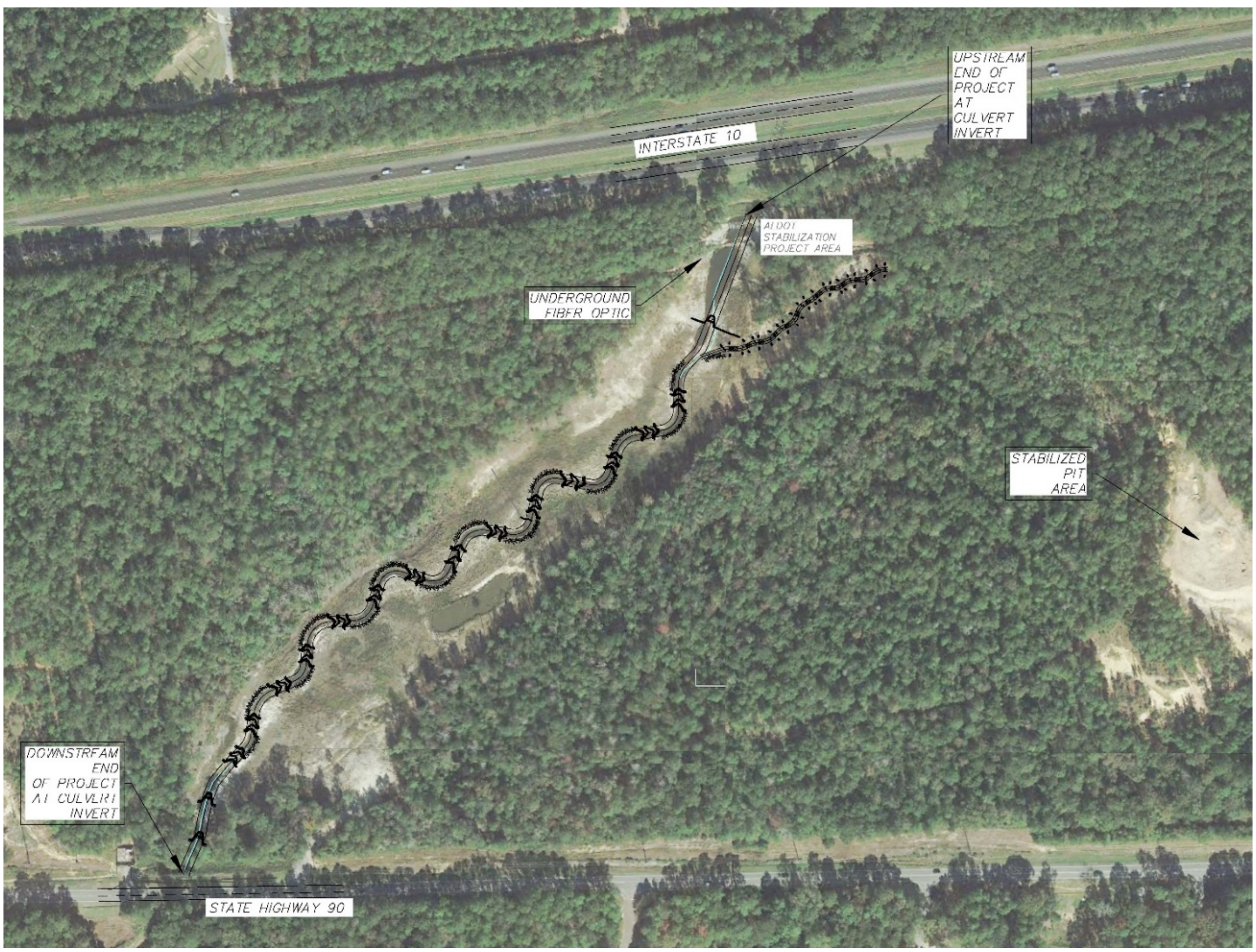
The purpose of this project was to address the instability and accelerated bank erosion that had occurred along the project reach of D’Olive Creek. The design proposed to restore and stabilize the channel through natural channel restoration and best engineering practices. These objectives were met through the design and construction of proper channel dimension, layout, and profile based on reference reach data and instream stabilizing structures. The design also mitigated sediment deposition downstream through channel stabilization and native vegetation installation. The channel and floodplain were designed to support flows similar to those experienced during the April 2014 rain event.

In addition to restoring the channel, the project included stabilization of a borrow pit area. The pit is in an upland area within the creek’s watershed adjacent to the project. The earthen dam of the pit had been compromised from storm events as well as human traffic associated with trespassing onto the property. As a result, excessive sediment was being delivered to the creek. Design and construction of a stabilization project has addressed the problem and has mitigated further erosion and sediment delivery to D’Olive Creek.

Since installation the project has:

- Restored 2714 linear feet of severely eroded channel, including a tributary to the creek
- Removed the threat of damaging erosion to nearby interstate infrastructure; however, an ALDOT-implemented structure at the project interface at I10 addresses this concern.
- Protected an underground fiber optics line.
- Reduced sediment deposition and supply through the project reach
- Improved water quality and aquatic habitat of the stream
- Improved floodplain functions of water storage and habitat
- Improved the riparian buffer functions of stability, habitat, and aesthetics
- Mitigated erosion and sediment delivery from a borrow pit adjacent to the project
- Improved riparian habitat with installation of natural, permanent vegetation.

Project Maps:



**Project I.D.:** **D'Olive Creek DA3**

Project Names and Locations:

**D'Olive Creek Restoration DA3,** D'Olive Bay Watershed, Daphne, Alabama

Location: Latitude/Longitude (approx. center): 30°38'55.1" N; 87°51'59.0" W

Descriptive location: Daphne, Baldwin County, Alabama. The project is located east of County Road 13 approximately 0.5 miles south of US Hwy 90.

General Project Information:

**Landowner(s):**

- Malbis Plantation

**Engineer:** **Volkert, Inc.**

**Contractors:** **North State Environmental, LLC**

Date of start of construction: October 2016

Date of Substantial Completion of construction: February 2017

Date of completion of maintenance period: February 2019

Project Metrics:

For stream restoration / stabilization project:

Length of stream restored / stabilized (linear feet): 1,100

Riparian area modified, floodplain/wetlands (acres): 2.2

Wetlands restored (acres): 1.6

Wetlands protected (acres): 0.5 (downstream)

19.3 (upstream)

Downstream wetlands are considered protected due to reduced sediment loadings from the project area. Upstream wetlands are considered protected by halting the advance of head-cuts.

Project Description:

In 2009, officials with the City of Daphne and with the local branch of NRCS pursued an emergency watershed protection (EWP) project along an unnamed tributary to D'Olive Creek. A progressive headcut, exacerbated by a recent storm in October of 2009 threatened an existing watermain and gas main crossing of the creek. The goal of the EWP project was to stabilize for a minimum of seven (7) years the head cut adjacent to the utilities and prevent loss of function. That project although successful was not scoped with arresting the larger headcut which had moved upstream. In 2015 a larger more complete project was pursued by a dynamic team consisting of the Mobile Bay National Estuary Program (MBNEP), the City of Daphne (Daphne), Volkert, Inc., Hydro, LLC, and Five Smooth Stones Restoration.

The restoration technique focused primarily on the principles of natural stream design (NSD), but supported by threshold channel design and rigorous hydraulic modeling (Hydro). While NSD was favored, site constraints coupled with a desire to restore wetlands along the project reach required additional design methodologies to maximize beneficial uplift. This resulted in an upper reach project utilizing NSD and a lower reach utilizing threshold channel design. To mitigate the impacts to wildlife and aesthetics the threshold channel design was augmented with vegetated riprap. This approach allows for a living buffer of herbaceous plans, grassbeds, and hearty trees to develop within the floodplain and eliminates the “rock canyon” effect typically associated with threshold designs.

The primary goals and accomplishments of this project included:

- Restoration/stabilization of 1,100 linear feet of perennial stream.
- Restoration of wetland connectivity along two branches of D’Olive Creek—an unnamed tributary and Bear Creek which included 1.62 acres of rehydrated wetlands.
- Provided wildlife habitat and minimized the potential for erosion with natural vegetative species.
- Reduced sediment transport within the reach which in turn reduced threats to aquatic species.
- Demonstrated through groundwater monitoring the restoration of wetland hydrology post construction – results were almost immediate for the project reach.

Project Maps:


DA-3 Restoration
Project Vicinity Map
Legend
Malbis
Ponds
Wetland
Google Earth
© 2018 Google
3000 ft
N

**Project I.D.:** **D’Olive Creek DAE**

Project Names and Locations:

**D’Olive Creek Restoration DAE,** D’Olive Bay Watershed, Daphne, Alabama

Location: Latitude/Longitude (approx. center): 30°39’17.5” N; 87°52’40.1” W

Descriptive location: Daphne, Baldwin County, Alabama. The project is located south of US Hwy 90 approximately 0.55 miles west of CR 13, between Oakstone Drive and Oakstone Drive West.

General Project Information:

**Landowner(s):**

Jaqueline Burrell – 29471 Oakstone Dr W
Jeanie H Lindsey – 29473 Oakstone Dr

**Engineer:** **Integrated Science & Engineering, Inc. (ISE)**

**Contractors:**

**Southern Excavating LLC (Streamline Environmental)**

Date of start of construction: April 2017

Date of Substantial Completion of construction: September 2017

Date of completion of maintenance period: September 2019

Project Metrics:

For stream restoration / stabilization project:

Length of stream restored / stabilized (linear feet): 420

Riparian area modified, floodplain/wetlands (acres): 1.2

Wetlands restored (acres): 0 (not including wetlands incidental to stream restoration)

Wetlands protected (acres): 0.5 (downstream)

Downstream wetlands are considered protected due to reduced sediment loadings from the project area.

Project Description:

The unnamed tributary at the location of Project DAE was identified in the *Watershed Management Plan for the D'Olive Creek, Tiawasee Creek, and Joe's Branch Watersheds, Daphne, Spanish Fort, and Baldwin County, Alabama (Thompson Engineering, August 2010)* (WMP) as a stream segment of critical concern. The WMP identified the project area as a stream reach with excessive sediment accumulations and transport within the stream channel that was experiencing active head-cutting and channel erosion with the potential for future degradation from head-cutting and channel erosion.

The objective of this project was to address the identified active erosion and head-cutting in the unnamed tributary and to restore and stabilize the stream banks and stream bed located within the work area. The head cut had formed in an ephemeral stream segment upgradient of a perennial stream reach in the unnamed tributary. Prior to implementation of the project the head cut had migrated approximately 1,200 feet upstream through steep terrain and highly erodible soils to within 50' of US Highway 90. The project was designed to stabilize the severely degraded and incised stream channel, reduce the transport of non-point source pollutants (primarily sediment) to D'Olive Creek, help restore some of the hydrologic function of the stream, and prevent further damage. The ultimate goal of the project is to help improve water quality that flows into D'Olive Creek and then into D'Olive Bay and Mobile Bay.

The project repaired the upper portion (approximately 420 linear feet) of the ephemeral stream segment. Problems addressed during this project included: 1) channel incision; 2) interrupted hydrologic connectivity with the floodplain; 3) tributary head cutting, and 4) reduction of volume and velocity of peak flows caused by urbanization to more closely mimic natural hydrology.

Channel incision, interrupted hydrologic connectivity with the floodplain, and tributary head cutting were addressed by replacing the incised channel with a new stable channel at a higher elevation. This was accomplished by using on-site materials (borrowed from an excavated upstream stormwater detention basin and a downstream stilling basin), and importing off-site materials to fill the previously eroded channel. Due to steep valley slopes and highly erodible soils dominant at the site, the new channel was lined with rock for stability. Reduction of stormwater volume and velocity during peak flows was addressed by constructing the stormwater detention basin and the stilling basin. These basins were designed to receive stormwater (at high, short lived velocities) and slowly allow the stormwater to filter out through infiltration and draw-down orifices.

A robust native vegetation plan was also included in the project. Vegetation in the riparian corridor benefits water quality and habitat by regulating temperature, adding organic matter (leaves and twigs), assisting in pollution reduction, stabilizing streambanks, and providing wildlife habitat. The riparian buffer area was designed to include a combination of native trees, shrubs, and grasses to form functional plant communities. This plant community will knit site components together, producing native habitat, and serving as a carbon sink for the system. The project is expected to reclaim many of the ecological features and services within the project stream reach that had been lost to urbanization.

Project Maps:


SITE
Oakstone Dr W
Oakstone Dr
Oakstone Dr E
Woodside Dr
Rita Circle
Dorette Loop
90
16

**Project I.D.:** **D'Olive Creek DAF, DAF1**

Project Names and Locations:

**D'Olive Creek Restoration, Segments DAF and DAF1,** D'Olive Bay Watershed, Daphne, Alabama

Location: Latitude/Longitude (approx. center): DAF - 30$^{o}$38'54.6" N; 87$^{o}$52'19.7" W

DAF1 - 30$^{o}$38'53.8" N; 87$^{o}$52'22.7" W

Descriptive location: Daphne, Baldwin County, Alabama. The project is located in the Lake Forest Subdivision north of Worchester Drive.

General Project Information:

**Landowner(s):**

- Victoria Phelps, 111 Worchester Dr.
- City of Daphne
- Lake Forest Property Owners Association

**Engineer:** **Mott MacDonald**

**Contractors:**

**North State Environmental LLC**

Date of start of construction: January 2019 (anticipated)

Date of Substantial Completion of construction: March 2019 (anticipated)

Date of completion of maintenance period: March 2021 (anticipated)

Project Metrics:

For stream restoration / stabilization project:

Length of stream restored / stabilized (linear feet): 535 (DAF – 292 lf; DAF1 – 243 lf)

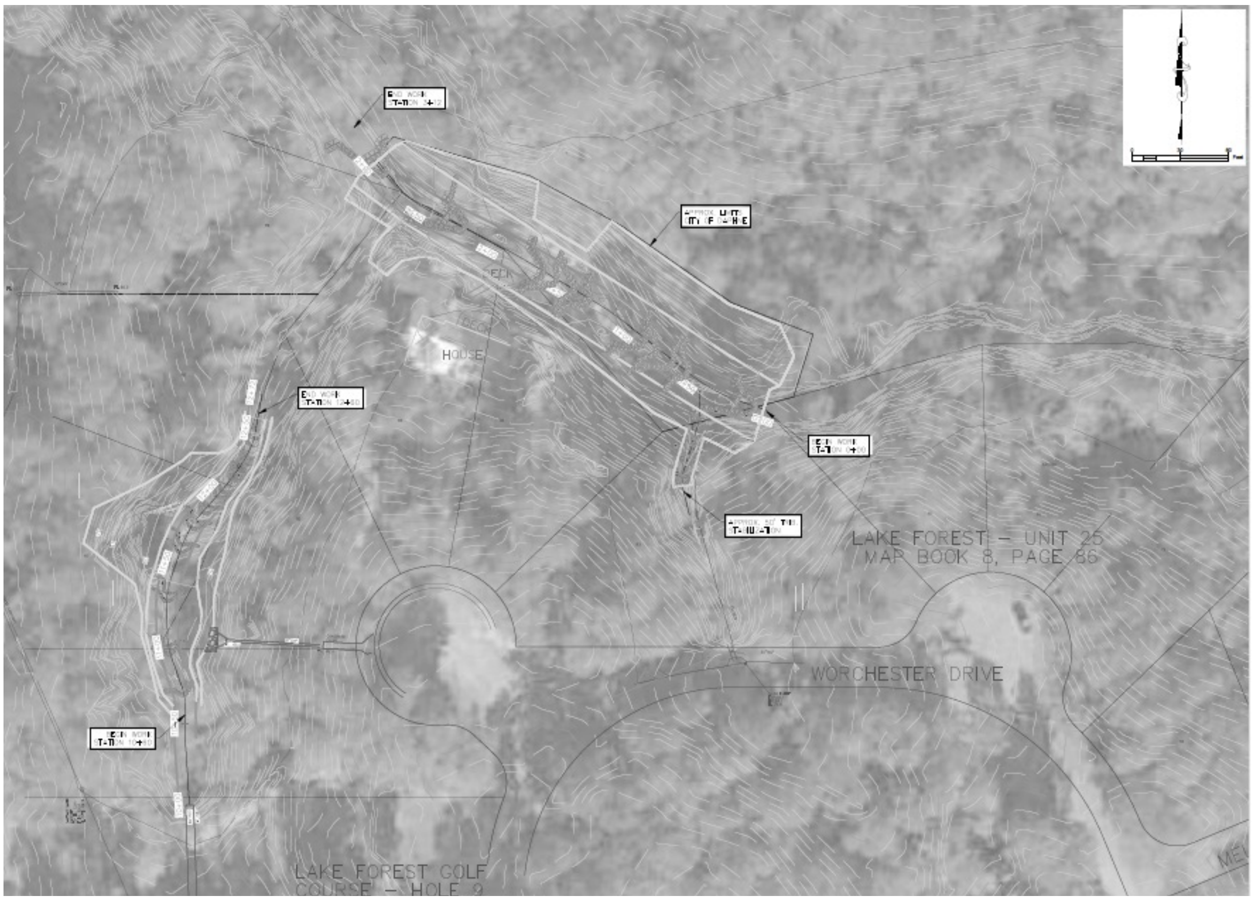
Riparian area modified, floodplain/wetlands (acres): 0.5

Wetlands restored (acres): 0 (not including wetlands incidental to stream restoration)

Project Description:

The project consists of the stabilization and restoration of two reaches totaling approximately 535 linear feet along an unnamed tributary to D'Olive Creek (designated as DAF) and an unnamed tributary to DAF (designated DAF-1). The main stem portion of the project is approximately 292 linear feet and the tributary portion of the project is approximately 243 linear feet. Both reaches are being proposed to stabilize head-cut migration into the watershed. Project activities include clearing and grubbing, site grading, instream rock structures, erosion control measures and permanent vegetation installation. lnstream structures include boulder vanes, threshold riffles and rock drop structures. Erosion control measures includes water control, straw mulch, temporary seed, and coconut coir matting. Landscaping includes installation of permanent erosion control matting, plugs, live stakes, shrubs, and trees.

<u>Project Maps</u>:



**Project I.D.:** **D'Olive Creek DAF-1A (Melanie Loop)**

Project Names and Locations:

**D'Olive Creek Restoration Project, Segment DAF-1A,** Melanie Loop Stream Restoration, D'Olive Bay Watershed, Daphne, Alabama

Location: Latitude/Longitude (approx. center): 30°38'48.7" N; 87°52'12.2" W

Descriptive location: Daphne, Baldwin County, Alabama. The project is located in the Lake Forest Subdivision and is bounded by Melanie Loop to the north, east, and south and Worcester Drive to the west. The project terminates downstream at the northern portion of Melanie Loop.

General Project Information:

**Landowner(s):**

- City of Daphne and private landowners

**Engineer:** **Goodwyn, Mills & Cawood Inc. (GMC)**

**Contractors:**

**North State Environmental LLC**

Date of start of construction: April 2018

Date of Substantial Completion of construction: May 2018

Date of completion of maintenance period: May 2020

Project Metrics:

For stream restoration / stabilization project:

Length of stream restored / stabilized (linear feet): 490

Riparian area modified, floodplain/wetlands (acres): 1.6

Wetlands restored (acres): 0 (not including wetlands incidental to stream restoration)

Wetlands protected (acres): 0.5 (downstream)

Downstream wetlands are considered protected due to reduced sediment loadings from the project area.

Project Description:

The project consists of the stabilization and restoration of approximately 489 linear feet of an unnamed tributary to an unnamed tributary of D'Olive Creek. The D'Olive Creek watershed drains part of the eastern shore of Mobile Bay, including the City of Daphne. Due to continued development, the watershed is transitioning from a mix of forested, agricultural, and residential land uses to primarily residential and commercial land use. With this development comes changes in land cover, most notably an increase in impervious surfaces. The resulting runoff conditions caused increased erosion and stream channel degradation leading to extensive sediment loading and destroyed habitat. These water quality and habitat impacts affect both the D'Olive Creek watershed and Mobile Bay downstream.

The section of stream comprising the project site is bounded upstream and downstream by the Melanie Loop and Worchester Drive road crossings with concrete pipe culverts. Increased flow (in both amount and rate) as a result of the upstream watershed development increased the energy within the channel comprising the project site such that the existing stream was not able to effectively convey its flow. Instead, the channel eroded to increase its flow capacity, which in turn led to an increase in sediment loading and transport in the system.

A severe head cut formed just west of County Road 13, between Melanie Loop and Worchester Drive in the Lake Forest subdivision in Daphne, Alabama, resulting in excessive vegetation and soil loss. The head cut extends from a culvert located on the northern portion of Melanie Loop (downstream end of the project) to within approximately 300 feet of the southern intersection of Worchester Drive and Melanie Loop. Additionally, the functionality of the floodplain and banks along the project reach were being threatened due to similar impacts as bank incision continued to promote erosion and sediment loss along the length of the project. The head cut is migrating rapidly upstream and would soon threaten existing infrastructure and potentially several residential lots adjacent to the stream. Based on field observations, it was estimated that the banks within the project area have eroded approximately 2,073 tons of sediment of the years due to headcutting, incision, and widening.

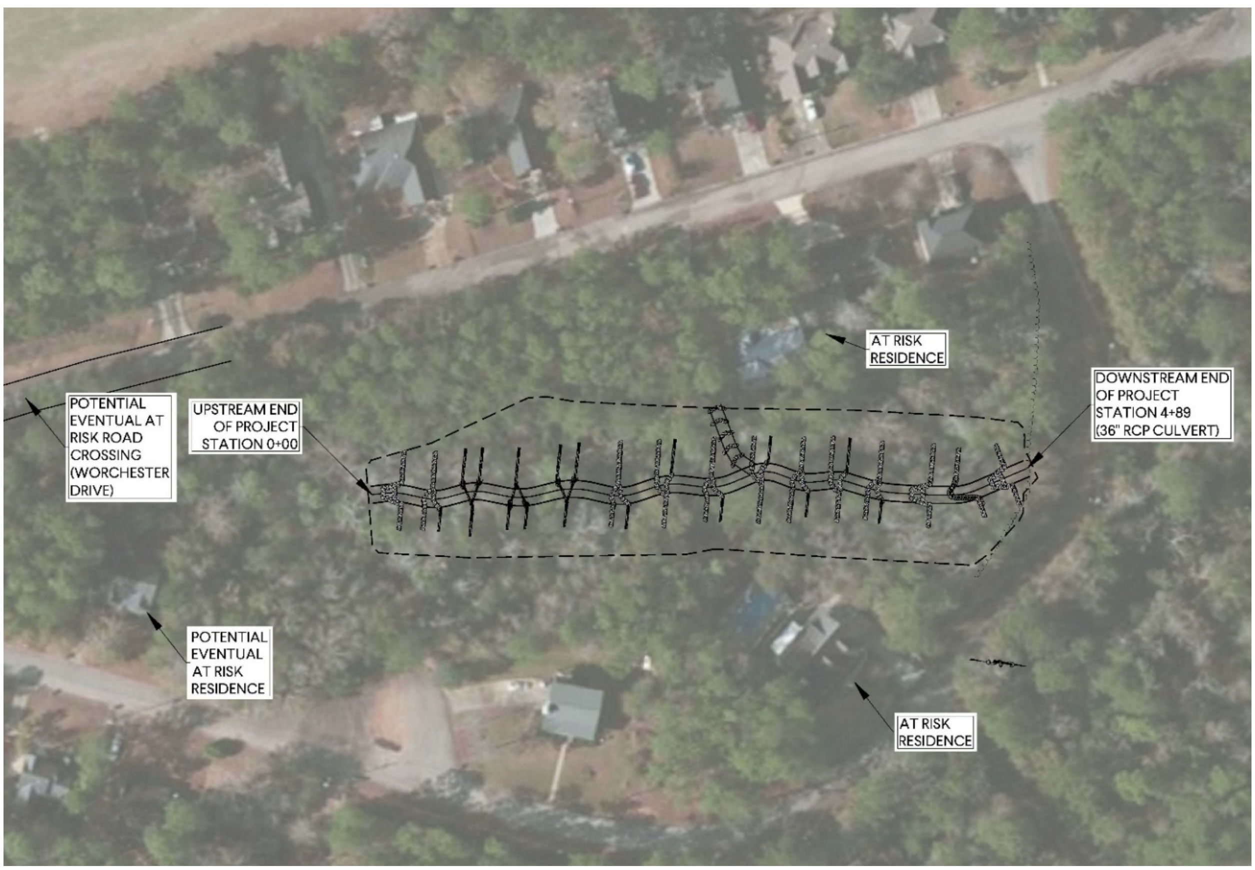
This project was supported wholly or in part by Mobile Bay National Estuary Program as part of a grant from National Fish and Wildlife Foundation (NFWF) Gulf Environmental Benefit Fund. Additional funds from the United States Environmental Protection Agency (USEPA) and Alabama Department of Environmental Management (ADEM) were also used to address the outlined issues.

The purpose of this project was to address the instability of the project reach by repairing the head cut between Melanie Loop and Worchester Drive. This was done using a natural channel restoration approach and best engineering practices. The natural channel restoration for this project included the design and construction of proper channel dimension, layout, and profile based on reference reach data, as well as the utilization of in-stream stabilization structures. The project is currently being installed (constructed), but is designed to achieve the following:

- Stop in-stream head cutting
- Create a self-sustaining, natural, and stable stream

- Reduce sediment deposition and supply through the project reach
- Create a stream and floodplain that can handle the design applied shear stresses without eroding
- Minimize impacts to stable channel, floodplain, and vegetation upstream
- Improve water quality and aquatic habitat of the stream
- Improve the riparian buffer functions of stability, habitat, and aesthetics
- Optimize design to best meet objectives while minimizing costs and resources

Project Maps:



**Project I.D.:** **Tiawasee Creek TC1-TC2 and TC2-Trib.**

Project Names and Locations:

**Tiawasee Creek Stream Restoration Project, Segment TC1-TC2 and TC2-Trib.,** D'Olive Bay Watershed, Daphne, Alabama

Location: Latitude/Longitude (approx. center): TC1-TC2 30°37'54.8" N; 87°53'01.8" W

TC2-Trib. 30°37'55.3" N; 87°53'04.1" W

Descriptive location: Daphne, Baldwin County, Alabama. The TC1-TC2 project starts east of the intersection of Park Drive and Pollard Road and terminates downstream at Greenwood Drive in the Lake Forest Subdivision. TC2-Trib. is located northeast of the intersection of Park Drive and Pollard Road on a small unnamed tributary entering the TC1-TC2 project area from the west.

General Project Information:

**Landowner(s):**

- City of Daphne and private landowners

**Engineer:** **Goodwyn, Mills & Cawood Inc. (GMC)**

**Contractors:**

**North State Environmental LLC**

**TC1-TC2**

Date of start of construction: January 2016

Date of Substantial Completion of construction: May 2016

Date of completion of maintenance period: May 2018

**TC2-Trib.**

Date of start of construction: September 2017

Date of Substantial Completion of construction: September 2017

Date of completion of maintenance period: May 2018

Project Metrics:

For stream restoration / stabilization project:

Length of stream restored / stabilized (linear feet): 1,724 (TC1-TC2 – 1,146 lf; TC2-Trib. – 578 lf)

Riparian area modified, floodplain/wetlands (acres): 3.9

Wetlands restored (acres): 1.0

Wetlands protected (acres): 18.4 (upstream)

Upstream wetlands are considered protected by halting the advance of head-cuts.

For stormwater management facilities (SWMF):

**Restoration/stabilization of old dirt pit (Park Drive and Pollard Road)**

Area (acres): 0.3

Detention/retention storage volume (cubic feet): 35,500

Project Description:

The Tiawasee Creek watershed drains part of the eastern shore of Mobile Bay, including the City of Daphne. Due to continued development, the watershed is transitioning from a mix of forested, agricultural, and residential land uses to primarily residential and commercial land use. With this development comes changes in land cover, most notably an increase in impervious surfaces. The resulting runoff conditions caused increased erosion and stream channel degradation leading to extensive sediment loading and destroyed habitat. These water quality and habitat impacts affected both the Tiawasee watershed and the Mobile Bay downstream.

At the project site, the increased flow (in both amount and rate) as a result of the upstream watershed development increased the energy within the channel such that the existing stream was not able to effectively convey its flow. Instead, the channel eroded to increase its flow capacity, which in turn led to an increase in sediment loading and transport in the system. Directly upstream of the project area, the braided channel wetland complex was being jeopardized by extensive headcutting that had resulted in excessive vegetation and soil loss. Additionally, the functionality of the floodplain and banks along the project reach was being threatened due to similar impacts. At the downstream end of the project, culverts served as grade control, preventing headcutting and establishing a lower gradient system on the downstream portion of the project. However, bank incision continued to promote erosion and sediment loss along the length of the project. In September of 2015, it was estimated that the banks within the project area were eroding at an average rate of 1,440 tons per year due to headcutting, incision, and widening.

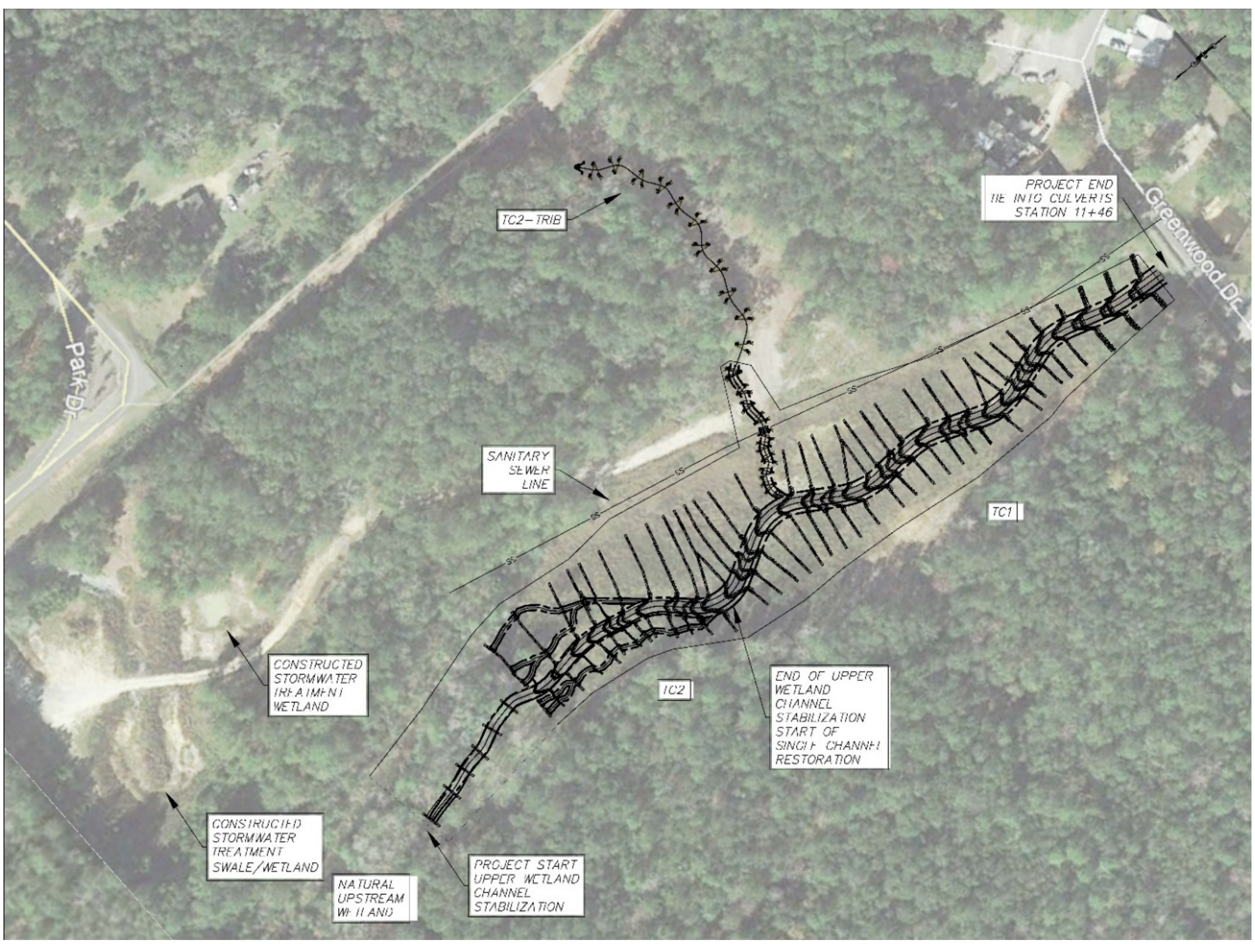
This project was managed by the City of Daphne, using funding from Coastal Impact Assistance Program (CIAP) and Alabama Department of Environmental Management (ADEM) to address the outlined issues.

The purpose of this project was to address the instability of the project reach and the upstream wetlands of Tiawasee Creek. This was done using a natural channel restoration approach and best engineering practices. The natural channel restoration included the design and construction of proper channel dimension, layout, and profile based on reference reach data, as well as the utilization of instream stabilization structures. A stormwater treatment swale and wetland was also constructed in the former staging area of the project, which treats stormwater runoff from the adjacent road before discharging into the Tiawasee Creek watershed.

Since installation the project has:

- Created a self-sustaining, natural, and stable stream
- Created a stream and floodplain that can handle the design applied shear stresses without eroding
- Stopped in-stream headcutting, preserving upstream wetlands.
- Reduced sediment deposition and supply through the project reach
- Improved water quality and aquatic habitat of the stream
- Improved floodplain functions of water storage and habitat
- Improved the riparian buffer functions of stability, habitat, and aesthetics
- Reduced stormwater impacts to stream

Project Maps:



**Project I.D.: Lake Forest Lake SWMF (Preliminary Planning and Investigations)**

Project Names and Locations:

**Lake Forest Lake,** D'Olive Bay Watershed, Daphne, Alabama

Location: Latitude/Longitude (approx. center): 30°39'4.73"N; 87°54'7.99"W

Descriptive location: Daphne, Baldwin County, Alabama. Lake Forest Lake is located south of Jubilee Square Shopping Center at 6850 US-90, Daphne, AL. It is roughly bound to its north and east by Bayview Drive and to the south by Lake Forest Blvd and Lake Front Drive. The dam is most easily accessed via construction drive at the extreme south corner of Jubilee Square Shopping Center at 30°39'6.62"N; 87°54'23.41"W.

General Project Information:

**Landowner(s):**

Lake Forest Property Owners Association

**Engineer: Integrated Science & Engineering, Inc. (ISE)**

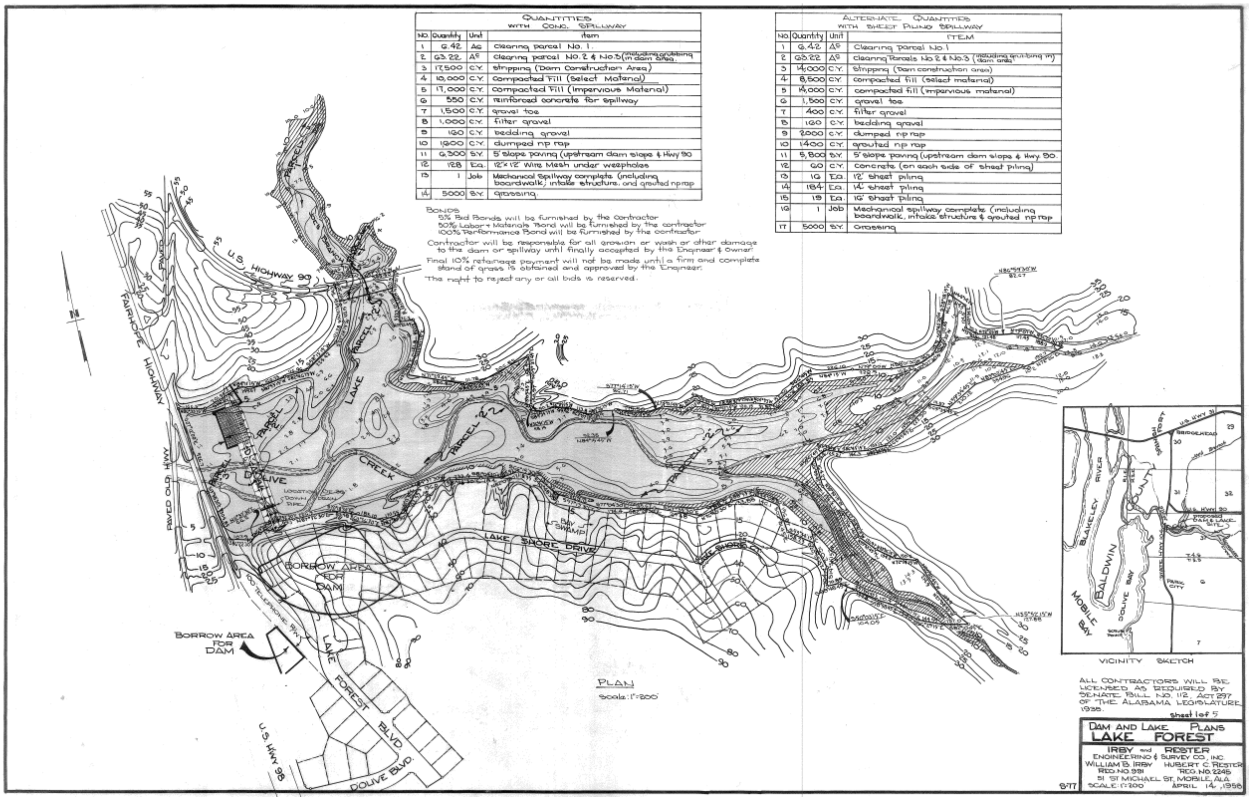
**Contractors: NA**

Project Metrics: NA

Project Description:

Lake Forest Lake has suffered from excessive sedimentation since its construction in 1973. The functional life of the lake, beneficial to both plant and animal life of the bay, decreases year-by-year as lake volume is lost to sediment. In order to consider restoration of volume to the lake, a Sediment Removal Feasibility Study was prepared and issued on April 20, 2017. This study examined several different options with the goal being the most efficient manner to restore the lake considering a finite sum of available funds. Dr. Brett Webb also issued a report on June 30, 2016 entitled Lake Forest Mapping – Analysis of Shoaling and Pool Volumes providing topographic and bathymetric data to support the feasibility study. Additionally, an exhaustive literature review of information related to Lake Forest Lake was conducted and compiled. During the course of this study the lake's 50 year old dam revealed several deficiencies and demonstrated signs of aging. Consequently a visual dam inspection and a breach analysis was performed. The Lake Forest Dam Inspection Report and Breach Analysis was issued on September 15, 2017. That report revealed items in need of repair and demonstrated that there is a high risk of loss of life should the Dam Breach during a 100-year flood event.

Project Map:




QUANTITIES WITH CONC. SPILLWAY

| No. | Quantity | Unit | Item |
|---|---|---|---|
| 1 | 6.42 | Ac | Clearing parcel No. 1. |
| 2 | 63.22 | Ac | Clearing parcel No. 2 & No. 3 (including grubbing in dam area) |
| 3 | 17,500 | C.Y. | Stripping (Dam Construction Area) |
| 4 | 10,000 | C.Y. | Compacted Fill (Select Material) |
| 5 | 17,000 | C.Y. | Compacted Fill (Impervious Material) |
| 6 | 550 | C.Y. | reinforced concrete for spillway |
| 7 | 1,500 | C.Y. | gravel toe |
| 8 | 1,000 | C.Y. | filter gravel |
| 9 | 160 | C.Y. | bedding gravel |
| 10 | 1,900 | C.Y. | dumped rip rap |
| 11 | 6,300 | S.Y. | 5' slope paving (upstream dam slope & Hwy 90 |
| 12 | 128 | Ea. | 12"x12" Wire Mesh under weepholes |
| 13 | 1 | Job | Mechanical Spillway complete (including boardwalk; intake structure, and grouted riprap |
| 14 | 5000 | S.Y. | Grassing. |

ALTERNATE QUANTITIES WITH SHEET PILING SPILLWAY

| No. | Quantity | Unit | Item |
|---|---|---|---|
| 1 | 6.42 | Ac | Clearing parcel No. 1 |
| 2 | 63.22 | Ac | Clearing Parcels No. 2 & No. 3 (including grubbing in dam area) |
| 3 | 14,000 | C.Y. | Stripping (Dam construction area) |
| 4 | 8,500 | C.Y. | compacted fill (select material) |
| 5 | 14,000 | C.Y. | compacted fill (impervious material) |
| 6 | 1,500 | C.Y. | gravel toe |
| 7 | 400 | C.Y. | filter gravel |
| 8 | 160 | C.Y. | bedding gravel |
| 9 | 2000 | C.Y. | dumped rip rap |
| 10 | 1400 | C.Y. | grouted rip rap |
| 11 | 5,800 | S.Y. | 5' slope paving (upstream dam slope & Hwy. 90. |
| 12 | 60 | C.Y. | Concrete (on each side of sheet piling) |
| 13 | 16 | Ea. | 12' sheet piling |
| 14 | 184 | Ea. | 14' sheet piling |
| 15 | 19 | Ea. | 16' sheet piling |
| 16 | 1 | Job | Mechanical spillway complete (including boardwalk, intake structure & grouted rip rap |
| 17 | 5000 | S.Y. | Grassing |

# APPENDIX B

# Cost Estimates of Avoided Damages to Infrastructure

# for the

# D'Olive Watershed Restoration Program

# Cost Estimates of Avoided Damages to Infrastructure for the D'Olive Watershed Restoration Restoration Program

*Prepared for:*

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October 2, 2018

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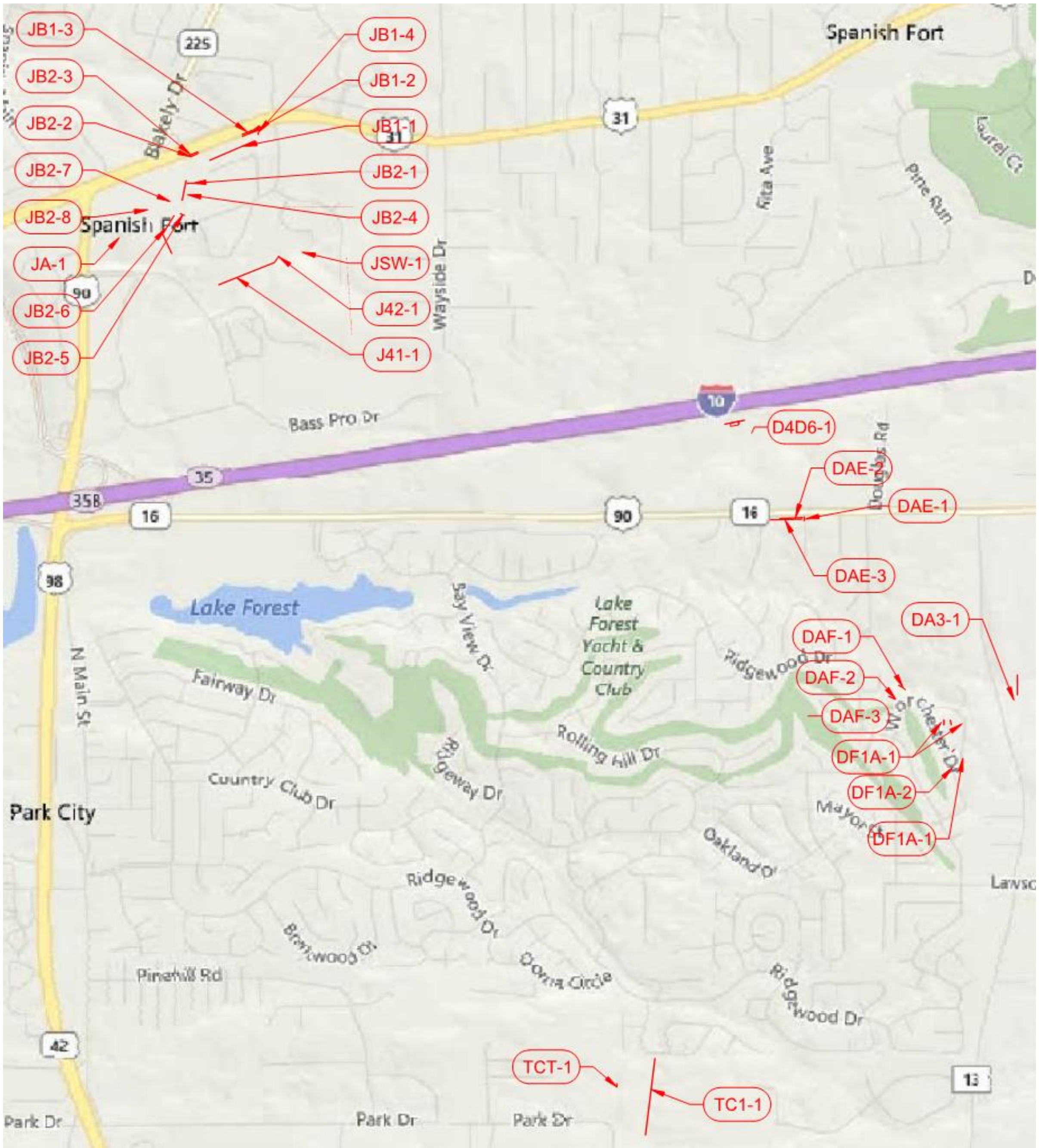
Wade Burcham, P.E.

Cost Estimates of Avoided Damages to Infrastructure for
the D'Olive Watershed Restoration Restoration Program

## 1.0 General Overview

Mobile Bay National Estuary Program (MBNEP) has served as the lead agency for implementation of multiple stream restoration and stormwater management projects in the D'Olive Watershed. These projects were funded primarily with a grant from the National Fish and Wildlife Foundation - Gulf Environmental Benefit Fund (NFWF-GEBF). MBNEP also leveraged the resources of other entities through their many partnerships and associations, who have also significantly contributed to the effort. The projects have stabilized degraded streams and implemented management measures to reduce riparian and downstream impacts, including stream bank erosion, and wetlands loss. They also provide infrastructure protection resulting in millions of dollars of avoided, decreased, or delayed costs. This report seeks to quantify and describe the process employed by the Vittor & Associates team (Team) to provide an Engineer's Opinion of Probable Cost (OPC) of avoided infrastructure damages associated with the MBNEP restoration projects.

The projects were worked on by various contractors and engineers including Goodwyn Mills & Cawood (GMC), Volkert, Mott MacDonald, Thompson Engineering, Integrated Science & Engineering, Streamline Environmental (formerly Southern Excavating), and North State Environmental. Wade Burcham and Emery Baya met with or consulted with each of these entities as well as the City of Daphne, Daphne Utilities, and the Alabama Department of Transportation (ALDOT) to detail locations of avoided cost and inform the OPC. Each documented avoided cost was assigned an identifier and plotted on a map (see Figure 1). The team visited each site and utilized topographic maps, design drawings, as-builts, utility GIS records, and other data to serve as the basis of the OPC. The OPC developed represents the engineer's best judgment based only on the information obtained through the course of this scope of work. The team provides this opinion without the benefit of conceptual plans, competitive bidding, or detailed investigations. The OPC developed is similar to the Association for the Advancement of Cost Engineering's (AACE) Recommended Practice No. 56R-08 Class 4 Cost Estimate Classification . The primary characteristics of this class of estimate includes a Project Definition being 1% - 15% complete; a schematic design or concept study; and an expected accurancy range in the -20% to +30%.



JB1-3
JB2-3
JB2-2
JB2-7
JB2-8
JA-1
JB2-6
JB2-5
JB1-4
JB1-2
JB1-1
JB2-1
JB2-4
JSW-1
J42-1
J41-1
Spanish Fort
Spanish Fort
Blakely Dr
Wayside Dr
Rita Ave
Pine Run
Laurel Ct
Bass Pro Dr
D4D6-1
DAE-2
DAE-1
DAE-3
Douglas Rd
Lake Forest
Lake Forest Yacht & Country Club
Bay View Dr
Fairway Dr
N Main St
Ridgewood Dr
Rolling Hill Dr
Ridgeway Dr
Country Club Dr
Park City
DA3-1
DAF-1
DAF-2
DAF-3
DF1A-1
DF1A-2
DF1A-1
Mayor Ct
Oakland Dr
Ridgewood Dr
Brentwood Ct
Pinehill Rd
Ridgewood Dr
TCT-1
TC1-1
Park Dr
Park Dr
Park Dr


Figure 1

## 2.0 Cost Descriptions and Specific Assumptions

JSW-1: Dam rehabilitation

Cost Avoidance Description: A stormwater detention basin was installed in line with Joe's Branch during the construction of Westminister Gates Subdivision. The detention basin quickly filled with sediment during the development of the subdivision. This sediment removed significant volume from the basin, causing it to overtop the dam frequently. Project J SWMF removed much of the sediment, reestablishing the detention pond close to its original dimensions. Based on visual observations the dam does not appear to overtop as often as before the project. This reduced stress on the dam extends the life of the dam and prevents the need for immediate repairs.

The Opinion of Probable Cost (OPC) assumes a breach of the dam in three years approximately three time the height; removal of sediment (equivalent to the amount included in the grant); topsoil replacement; temporary erosion control blanket; borrow replacement in breach; outfall replacement; and seeding.

J41-1: Sewer Main Repair

Cost Avoidance Description: Joe's Branch previously meandered through its floodplain. However, at some point, the stream short-circuited its natural channel and conveyed along an existing sewer main. The short-circuit caused down-cutting within the trench to (and sometimes below) the existing sewer main. Project J41 arrested the head cut and stabilized the stream avoiding the cost of a lift station and force main to replace a damaged gravity main.

OPC assumes repair occurs in eight years before a break occurs*; and includes abandonment of main/concrete plugs; installation of a lift station/force main system. OPC does not include easements or filling of headcut.

* Note: If a break occurred and resulted in the release of sewage, required response and cleanup costs could be significant. Such potential response costs are not included.

J42-1: Sewer Main Repair

Cost Avoidance Description: Joe's Branch Head Cut had progressed upstream across a sewer main in several locations. Project J42 arrested the head cut and stabilized the stream avoiding the cost of a lift station and force main to replace a damaged gravity main.

OPC assumes repair occurs in eight years before a break occurs*; and is addressed in J4-1 cost. OPC does not include easements or filling of headcut.

* Note: If a break occurred and resulted in the release of sewage, required response and cleanup costs could be significant. Such potential response costs are not included.

JA-1: Repair of shopping center outfall – New headwall

Cost Avoidance Description: A head cut had progressed up to an outfall at the rear of a shopping center. The outfall had been repaired one time and was in danger of failing again due to undercutting. Project JA stabilized the outfall preventing the need for repair of the existing outfall.

OPC assumes repair occurs in ten years; requires a headwall, short length of pipe and headwall.

JB1-1: A wall varying in height from 3’ to 18’ along the back of six residential structures (Westminister Village).

Cost Avoidance Description: A head cut had progressed up Tributary JB to Highway 31. The head cut had provided substantial threats to six residential structures along its south side. Joe’s Branch Project 1 stabilized the area and prevented the need for a wall to protect the homes or properties.

OPC assumes repair occurs in ten years; requires a wall an average of five feet tall to provide protection of existing structures.

JB1-2: Relocation of utilities including gas main and fiber optic line.

Cost Avoidance Description: A head cut had progressed up Tributary JB to Highway 31 being within a few feet of a gas main and fiber optic line. Joe’s Branch Project 1 stabilized the head cut preventing the need for removal and relocation of the utility lines.

OPC assumes repair occurs within one year; requires gas main installation by directional drilling; requires relocation of fiber optic bank or removal/replacement at a cost 30% higher than gas line.

JB1-3: Repair of roadway (US. Highway 31).

Cost Avoidance Description: A head cut had progressed up Tributary JB to within approximately ten feet of Highway 31. Joe’s Branch Project 1 stabilized the head cut, preventing the need for roadway repair and stabilization.

OPC assumes repair occurs within one year after roadway experiences damage; requires the repair of one lane; the speed of one half of average annual traffic is reduced 10 mph over 30 days (see appendix); repair of tie slope; addition of rip-rap; addition of new outfall and line.

JB1-4: Relocation of a water lateral to Westminster Village.

Cost Avoidance Description: A head cut had progressed up Tributary JB to Highway 31 and was progressing further upstream each rainfall. If the project had not stabilized the head cut, it would have eventually crossed Westminster Village’s primary utility access containing water and gas laterals. Joe’s Branch Project 1 stabilized the head cut, preventing the need for the removal and relocation of the large laterals.

OPC assumes repair occurs in fifteen years; requires the removal and replacement of water and gas main.

JB2-1: Repair / reinforce sewer lateral.

Cost Avoidance Description: Tributary JB's head cut crossed one of Westminster Village's sewer laterals. The head cut exposed the lateral and would have eventually destroyed it. Joe's Branch Project 2 stabilized the head cut, avoiding the need for the repair and reinforcement of the lateral crossing.

OPC assumes repair occurs in three years before a break occurred*; requires the removal and replacement of lateral; and addition of a small grinder pump at $35,000. OPC does not include filling of headcut.

* Note: If a break occurred and resulted in the release of sewage, required response and cleanup costs could be significant. Such potential response costs are not included.

JB2-2: Relocation of utilities including a gas main and fiber optic line.

Cost Avoidance Description: A head cut had progressed up Tributary JB to within approximately ten feet of Highway 31 to the north. Also, a side head cut was progressing towards Highway 31 further to the south near the outfall of the shopping center across the street. Joe's Branch Project 2 stabilized the head cut, preventing the need for removal and relocation of the utility lines.

OPC assumes repair occurs in ten years; requires gas main installation by directional drilling; requires relocation of fiber optic bank or removal/replacement at a cost 30% higher than gas line.

JB2-3: Repair of roadway.

Cost Avoidance Description: A head cut had progressed up Tributary JB to within approximately ten feet of Highway 31 to the north. Also, a side head cut was progressing towards Highway 31 further to the south near the outfall of the shopping center across the street. Joe's Branch Project 2 stabilized the head cut, preventing the need for roadway repair and stabilization.

OPC assumes repair occurs in fifteen years when the roadway experiences damage; requires the repair of one lane; the speed of one half of average annual traffic is reduced ten mph over 30 days; repair of tie slope; addition of rip-rap; repair of guardrail; repair of outfall and line.

JB2-4: Repair of sewer main.

Cost Avoidance Description: Tributary JB's head cut crossed a large sewer main. The main was exposed as well as several manholes. The head cut had progressed down to near the bottom of the roughly ten-foot manhole. Joe's Branch Project 2 stabilized the head cut, preventing the need for removal and relocation of the sewer main.

OPC assumes repair occurs in five years before a break occurs*. OPC does not include easements or filling of headcut.

* Note: If a break occurred and resulted in the release of sewage, required response and cleanup costs could be significant. Such potential response costs are not included.

JB2-5: Repair / reinforce sewer lateral.

Cost Avoidance Description: Tributary JB's head cut crossed one of Westminster Village's sewer laterals. The head cut exposed the lateral and would have eventually destroyed it. Joe's Branch Project 2 stabilized the head cut, preventing the need for the repair and reinforcement of the lateral crossing.

OPC assumes repair occurs in three years before a break occurs*; requires the removal and replacement of lateral; and addition of a small grinder pump at $35,000. OPC does not include filling of headcut.

* Note: If a break occurred and resulted in the release of sewage, required response and cleanup costs could be significant. Such potential response costs are not included.

JB2-6: Repair of sewer main.

Cost Avoidance Description: Tributary JB's head cut crossed a large sewer main. The main was exposed. Joe's Branch Project 2 stabilized the head cut, preventing the need for removal and relocation of the sewer main.

OPC assumes repair occurs in five years before a break occurs*; and installation of a lift station/force main system. OPC does not include easements or filling of headcut.

* Note: If a break occurred and resulted in the release of sewage, required response and cleanup costs could be significant. Such potential response costs are not included.

JB2-7: Repair of Church Parking Lot Roadway

Cost Avoidance Description: A side head cut from Tributary JB had progressed up a hill towards an outfall from the Church Parking Lot. The slope was beginning to show signs of imminent failure and the outfall had undercut severely. Joe's Branch Project 2 stabilized the head cut, preventing the need to repair the slope, parking lot roadway, and outfall.

OPC assumes repair occurs in five years;and includes a MSE wall; repaving; replacement of storm system to floodplain; and borrow excavation.

JB2-8: Repair of Church Parking Roadway

Cost Avoidance Description: A side head cut from Tributary JB had progressed up a hill towards an outfall from the Church Parking Roadway. The slope was beginning to show signs of imminent failure and the outfall was severely undercut. Joe's Branch Project 2 stabilized the head cut, preventing the need to repair the slope, parking lot roadway, and outfall.

OPC assumes repair occurs in fifteen years; and includes a MSE wall; repaving; replacement of storm system to floodplain; and borrow excavation.

D4D6-1 Repairs at I-10 Outfall

Cost Avoidance Description: Degradation of D'Olive Creek was threatening I-10. ALDOT made certain repairs. However, project D4-D6 stabilized the stream avoiding the cost of relaying a fiber optic line, and outfall protection.

OPC assumes repair occurs within one year; boring/lowering of a significant AT&T fiber-optic trunk line; boulder outlet control; the speed of one-fourth of average annual traffic on I-10 is reduced ten mph over 30 days (see appendix).

DA3-1 Rebore of Water / Gas Main

Cost Avoidance Description: DA3 Head Cut had progressed upstream and threatened a water and gas main at the power line crossing. Arresting of the head cut and stabilization of the stream bed avoided the cost of having to lower the mains.

OPC assumes repair occurs within one year; grout filling of existing mains; boring of 300'; no filling of headcut.

DAE-1 Oakstone Drive Repair

Cost Avoidance Description: A head cut had progressed up Tributary DAE to within approximately fifty feet of Highway 98. The OPC assumes that the head cut would continue to Highway 98, turn east, and eventually damage Oakstone Drive. Project DAE stabilized the head cut, preventing the need for roadway repair and stabilization.

OPC assumes repair occurs within ten years; requires the repair of one lane; repair of tie slope; addition of rip-rap; addition of new outfall and line.

DAE-2 Highway 90 Shoulder Repair

Cost Avoidance Description: A head cut had progressed up Tributary DAE to within approximately fifty feet of Highway 98. The OPC assumes that the head cut would continue to Highway 98 and then turn east. Project DAE stabilized the head cut, preventing the need for roadway repair and stabilization.

OPC assumes repair occurs within seven years; repair of tie slope; addition of rip-rap; the speed of one half of average annual traffic is reduced ten mph over 30 days (see appendix).

DAE-3 Highway 90 Utility Remove and Replace

Cost Avoidance Description: A head cut had progressed up Tributary DAE to within approximately fifty feet of Highway 98. The OPC assumes that the head cut would continue to Highway 98 and then turn east. Project DAE stabilized the head cut, preventing the need for relocation of sanitary sewer main, water main, telephone conduit, and fiber optic.

OPC assumes repair occurs within five years; removal and relocation of sewer, water, telephone, and fiber optic lines.

DAF-1 Stabilization of Residence

Cost Avoidance Description: Instream erosion is threatening a residence adjacent to project DAF. Stabilization of the stream will avoid the cost of retaining wall construction and foundation stabilization.

OPC assumes repair occurs in five years; and requires a wall an average of five feet tall to provideprotection of existing structures.

DAF-2 Roadway Side Drain Removal and Replacement

Cost Avoidance Description: Instream erosion is threatening a roadway side drain system. Project DAF removes and replaces the outfall, pipe, and inlet.

OPC assumes repair occurs in ten years; requires outfall, pipe, and inlet.

DAF-3 Repair Lift Station

Cost Avoidance Description: A head cut is progressing up Tributary DAF. The head cut is expected to continue and will impact a lift station. Project DAF will arrest the head cut before impact of the lift station avoiding cost of repair.

OPC assumes repair occurs within ten years; addition of fill; addition of rip-rap.

DAF1A-1 Stabilization through installation of walls along three residences and pool.

Cost Avoidance Description: A head cut had progressed up Tributary DAF to Melanie Loop. The headcut had provided substantial threats to three residential structures. Project DAF1A stabilized the area, avoiding the cost of walls to protect the homes or properties.

OPC assumes average repair occurs in seven years; requires a wall an average of ten feet tall to provide protection of existing structures.

DAF1A-2 Repair of roadway (Worchester Drive)

Cost Avoidance Description: A head cut had progressed up Tributary DAF to Melanie Loop and would have continued to Worchester Drive. Project DAF1A stabilized the area, avoiding the cost of a repair to the roadway.

OPC assumes repair occurs in 25 years; requires the repair of one lane; repair of tie slope; addition of rip-rap; addition of new outfall and line.

TC1-1 Sewer Main Repair

Cost Avoidance Description: The Tiawasee Head Cut had progressed alongside an existing sewer main. Project TC1 stabilized the head cut, preventing the need for removal and relocation of the sewer main.

OPC assumes repair occurs in fifteen years before a break occurs*; installation of a lift station / force main system. OPC does not include easements or filling of headcut.

* Note: If a break occurred and resulted in the release of sewage, required response and cleanup costs could be significant. Such potential response costs are not included.

TC2T-1 Water Main Remove and Replace (lower) 12” water main

Cost Avoidance Description: A tributary head cut to TC2 had progressed to a point that it was threatening a water main. The OPC assumes that this water main would eventually need removal and replacement (lowering).

OPC assumes repair occurs in five years before a break occurs; removal and replacement of water main; and abandoning of existing main/concrete plugs.  OPC does not include easements or filling of headcut.

LF Lake Forest

Lake Forest Lake's dam was in a state of disrepair prior to MBNEP efforts.  The dam's primary spillway was not functional.  This OPC assumes that 4 million dollars worth of dam repairs were deferred from 15 years to 25 years and uses the difference in present value based on stated discount rates based on efforts and education by MBNEP and Lake Forest, completed/scheduled maintenance, and limited inspections to extend the dams functional life.

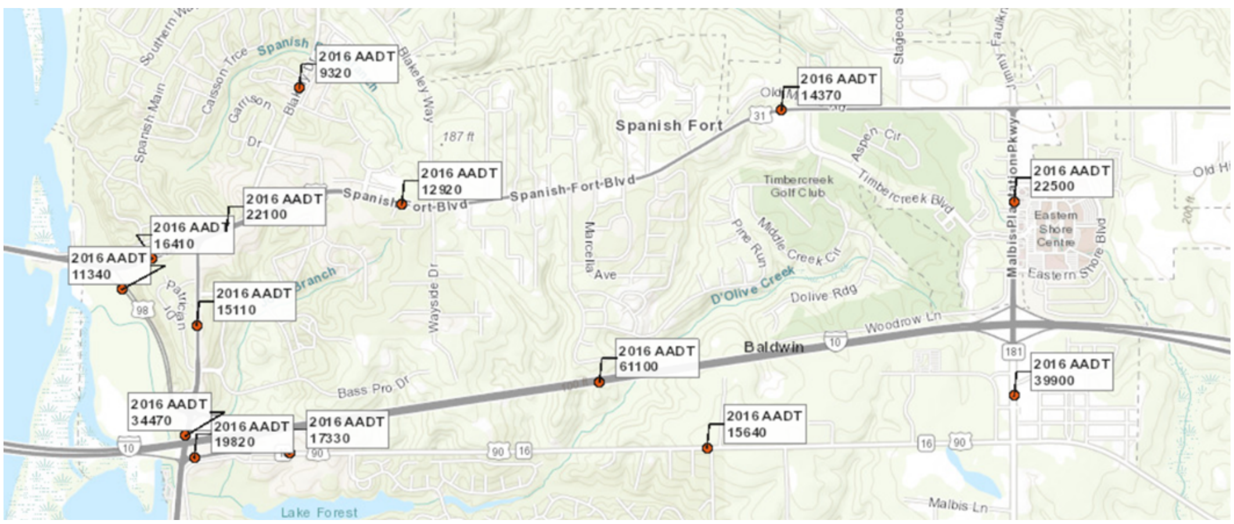
OPC excludes the value of sediment removal cost avoided due to reduced sediment loadings since definitive data on reductions to sediment entering the lake is currently not available.

The OPC does not include Tiawasee Montclair as the project is currently stalled.

## 3.0 General Assumptions

The team utilized several assumptions that generally apply to all the sites. Those were as follows:

- 18% Engineering and Construction Observation (not including work zone user cost)
- 6% General Erosion Control (not including work zone user cost)
- 10% Mobilization and miscellaneous
- Lump Sum Lift Station OPC includes engineering, erosion control, and mobilization.
- 0 % for construction layout
- 0% for as-builts
- 2.75% discount rate
- Present value = Future Value * (1 + discount rate)^(-Years)
- Traffic calculations assume 10% truck traffic; cost per hour car is $23.09, cost per hour truck is $62.33; current traffic counts assuming no growth; traffic reduction is over one mile.
- Where installation of a lift station/force main system is indicated, OPC assumes gravity system is abandoned; force main installation occurs in same easement; 6” force mains replaces 12” gravity mains; and 4” force main replaces 8” gravity mains;
- Average Annual Daily Traffic (AADT) as follows (with no growth factor for future work)



## 4.0 Engineers Opinion of Probable Cost

The Team compiled an Engineer's Opinion of Probable Cost (OPC) for avoided damages to infrastructure using the general and specific assumptions above, additional broad-based assumptions, costs from comparable projects and data, cost books, cost engineering judgment, and parametric cost. Unit cost was estimated as if the project were to occur today. Inflation and the time value of money were adjusted to present value with the discount rate noted above. Appended is the Engineer's Opinion of Probable Cost (OPC) for the items detailed above.

The Engineer's OPC totals approximately $4.0 million. This should be considered in line with a Class Four Estimate that AACE recongnizes with an uncertainty range of -20% to +30% (i.e., a range of $3.2 million to $5.2 million).

## 5.0 Noteworthy Items Excluded from the Engineer's OPC

This analysis leans towards a conservative approach to the costs avoided. Therefore some items were not included in the total but do provide value to the community and are noted here. While approaches for monetizing these benefits have been considered, they have not been included in the Engineer's OPC for the reasons given.

Benefits of Reduced Sediment Loadings Entering Lake Forest Lake

This evaluation has considered that Lake Forest benefits from stabilized conveyances upstream. Reduced sediment inputs to the lake will lessen the quantity of sediments that will require removal when and if the lake is dredged to maintain its capacity as a sediment trap and/or for other purposes. However, the overall economic benefit valuation listed in prior sections does not include the value of prevented sediment from entering the lake due in part to the lack of completed monitoring results documenting the actual reduced sediment loadings, and also because future plans for maintenance (dredging) of the lake are uncertain.

Dr. Greg Jennings of Jennings Environmental, who serves as MBNEP's stream restoration consultant for the D'Olive Watershed Restoration Program, has provided estimates of the erosion reduction (tons/year) for each project. Using the erosion reduction estimates and making additional assumptions gives one a feel for the potential value. For example, should one make the assumptions listed below then the present value of the benefit of sediment prevention to Lake Forest would be $1.1 million dollars.

- 3,650 tons/year erosion reduction upstream of Lake Forest
- Sediment input to the lake is approximately 50% of the erosion reduction at the project sites (sedimentation occurs in stream segments upstream of the lake, and some sediment passes through the lake)
- 1,825 tons/year prevented from entering the lake
- 1.6 CY / ton
- $38 / CY dredging cost
- 25 Year Period (lake occurs 25 years in the future)
- 2.75% Discount Rate

Benefits of Stormwater Detention and/or Retention

The D'Olive Watershed Restoration Program has included Stormwater Management Facilities (SWMFs) that provide stormwater detention and/or retention. Additionally, several of the stream restoration projects have increased detention/retention by reconnecting the stream channel with their floodplains (that is, during a storm event, storage is accomplished within the floodplain). Estimates of the detention/retention volume at facilities were made based on design plans and topographic features (existing grades vs. proposed grades). The volume of stormwater attenuation at stream restoration sites was estimated by considering the difference between the post-restoration volume compared to pre-restoration volume during a 1-percent Annual Exceedance Probability Storm, calculated from pre/post models.

Estimated stormwater detention and/or retention volumes at various projects were calculated as shown below:

- JB SWMF 53,400 CF
- J SWMF 35,000 CF
- TC2 SWMF 35,500 CF
- JB Phase 1 9,200 CF
- JB2 65,700 CF
- JA 6,700 CF
- D4-D6 77,600 CF
- DAE 20,300 CF

TOTAL 303,400 CF

One approach towards estimating the economic value of stormwater attenuation provided by these projects would be to estimate the cost of a conventual dry detention basin. A preliminary analysis indicates a cost for a typical detention basin would be about $2.88 per CF, which leads to a preliminary value of the increased stormwater attenuation of approximately $870,000. However, because there are no regulations requiring such detention facilities, and it is considered doubtful that they would be constructed, the potential economic benefits of stormwater detention and/or retention have not been included in the Engineer's OPC presented in the preceeding section.

## 6.0 Conclusion

The MBNEP D'Olive Watershed Restoration Program has stabilized degraded streams that has reduced stream bank erosion and wetlands loss, and mitigated riparian and downstream impacts. The value of these projects extends beyond the environmental water quality and habitat benefits. The restoration projects additionally have provided substantial protection to infrastructure (roads, structures, and utilities). Using a conservative approach, the Vittor & Associates team has evaluated the economic value of these avoided infrastructure damages and developed an Engineer's Opinion of Probable Cost (OPC) in the order of 4.0 million dollars in present value. This Class Four Estimate recongnizes an uncertainty range of -20% to +30% (i.e., a range of $3.2 million to $5.2 million).

| ITEM NO. | AREA NO. | ITEM DESCRIPTION | ESTIMATED QUANTITY | UNIT | UNIT PRICE | TOTAL |
|---|---|---|---|---|---|---|
| 1 | JB1-1 | Clearing And Grubbing | 0.3 | Acre | $ 7,000.00 | $2,000.69 |
| 2 | JB1-3 | Clearing And Grubbing | 0.2 | Acre | $ 7,000.00 | $1,400.00 |
| 3 | JB2-1 | Clearing And Grubbing | 0.2 | Acre | $ 7,000.00 | $1,400.00 |
| 4 | JB2-3 | Clearing And Grubbing | 0.2 | Acre | $ 7,000.00 | $1,400.00 |
| 5 | JB2-5 | Clearing And Grubbing | 0.2 | Acre | $ 7,000.00 | $1,400.00 |
| 6 | JB2-7 | Clearing And Grubbing | 0.1 | Acre | $ 7,000.00 | $482.09 |
| 7 | JB2-8 | Clearing And Grubbing | 0.1 | Acre | $ 7,000.00 | $361.57 |
| 8 | DAE-1 | Clearing And Grubbing | 0.1 | Acre | $ 7,000.00 | $361.57 |
| 9 | DAF-3 | Clearing And Grubbing | 0.1 | Acre | $ 7,000.00 | $361.57 |
| 10 | JB1-1 | Protection or Repair of Existing Conditions (Misc.) | 1 | Lump Sum | $ 7,600.00 | $7,600.00 |
| 11 | DAF-1 | Protection or Repair of Existing Conditions (Misc.) | 1 | Lump Sum | $ 7,600.00 | $7,600.00 |
| 12 | DF1A-1 | Protection or Repair of Existing Conditions (Misc.) | 1 | Lump Sum | $ 7,600.00 | $7,600.00 |
| 13 | JB1-1 | MSE Wall | 3650 | Face SF | $ 75.00 | $273,750.00 |
| 14 | JB2-7 | MSE Wall | 1500 | Face SF | $ 75.00 | $112,500.00 |
| 15 | JB2-8 | MSE Wall | 900 | Face SF | $ 75.00 | $67,500.00 |
| 16 | DAF-1 | MSE Wall | 600 | Face SF | $ 75.00 | $45,000.00 |
| 17 | DF1A-1 | MSE Wall | 2000 | Face SF | $ 75.00 | $150,000.00 |
| 18 | JSW-1 | Borrow Excavation | 978 | Cubic Yard | $ 27.50 | $26,881.25 |
| 19 | JB1-3 | Borrow Excavation | 889 | Cubic Yard | $ 27.50 | $24,444.44 |
| 20 | JB2-3 | Borrow Excavation | 889 | Cubic Yard | $ 27.50 | $24,444.44 |
| 21 | JB2-7 | Borrow Excavation | 806 | Cubic Yard | $ 27.50 | $22,152.78 |
| 22 | JB2-8 | Borrow Excavation | 1208 | Cubic Yard | $ 27.50 | $33,229.17 |
| 23 | DAE-1 | Borrow Excavation | 25 | Cubic Yard | $ 27.50 | $687.50 |
| 24 | DAE-2 | Borrow Excavation | 681 | Cubic Yard | $ 27.50 | $18,715.28 |
| 25 | DAF-3 | Borrow Excavation | 24 | Cubic Yard | $ 27.50 | $662.04 |
| 26 | JSW-1 | Cut to Waste | 1122 | Cubic Yard | $ 21.00 | $23,562.00 |
| 27 | JB2-1 | Loose Riprap, Class 2 | 20 | Ton | $ 110.00 | $2,200.00 |
| 28 | JB2-5 | Loose Riprap, Class 2 | 20 | Ton | $ 110.00 | $2,200.00 |
| 29 | JB1-3 | Loose Riprap, Class 2 | 90 | Ton | $ 110.00 | $9,900.00 |
| 30 | JB2-3 | Loose Riprap, Class 2 | 90 | Ton | $ 110.00 | $9,900.00 |
| 31 | JB2-7 | Loose Riprap, Class 2 | 60 | Ton | $ 110.00 | $6,600.00 |
| 32 | JB2-8 | Loose Riprap, Class 2 | 60 | Ton | $ 110.00 | $6,600.00 |
| 33 | DAE-1 | Loose Riprap, Class 2 | 10 | Ton | $ 110.00 | $1,100.00 |
| 34 | DAE-2 | Loose Riprap, Class 2 | 280 | Ton | $ 110.00 | $30,800.00 |
| 35 | DAF-2 | Loose Riprap, Class 2 | 20 | Ton | $ 110.00 | $2,200.00 |
| 36 | DAF-3 | Loose Riprap, Class 2 | 200 | Ton | $ 110.00 | $22,000.00 |
| 37 | DF1A-2 | Loose Riprap, Class 2 | 20 | Ton | $ 110.00 | $2,200.00 |
| 38 | JB1-3 | Asphalt | 64 | Ton | $ 117.00 | $7,507.50 |
| 39 | JB2-3 | Asphalt | 64 | Ton | $ 117.00 | $7,507.50 |

| ITEM NO. | AREA NO. | ITEM DESCRIPTION | ESTIMATED QUANTITY | UNIT | UNIT PRICE | TOTAL |
|---|---|---|---|---|---|---|
| 40 | JB2-7 | Asphalt | 55 | Ton | $ 117.00 | $6,435.00 |
| 41 | JB2-8 | Asphalt | 33 | Ton | $ 117.00 | $3,861.00 |
| 42 | DAE-1 | Asphalt | 3 | Ton | $ 117.00 | $386.10 |
| 43 | DF1A-2 | Asphalt | 3 | Ton | $ 117.00 | $386.10 |
| 44 | JB1-3 | Crushed Aggregate Base | 156 | Square Yard | $ 20.00 | $3,111.11 |
| 45 | JB2-3 | Crushed Aggregate Base | 156 | Square Yard | $ 20.00 | $3,111.11 |
| 46 | JB2-7 | Crushed Aggregate Base | 133 | Square Yard | $ 20.00 | $2,666.67 |
| 47 | JB2-8 | Crushed Aggregate Base | 133 | Square Yard | $ 20.00 | $2,666.67 |
| 48 | DAE-1 | Crushed Aggregate Base | 13 | Square Yard | $ 20.00 | $266.67 |
| 49 | DF1A-2 | Crushed Aggregate Base | 13 | Square Yard | $ 20.00 | $266.67 |
| 50 | D4D6-1 | Loose Riprap, Class 3 | 100 | Ton | $ 270.00 | $27,000.00 |
| 51 | D4D6-1 | Boulders | 946 | Ton | $ 276.00 | $260,958.00 |
| 52 | JSW-1 | Topsoil | 247 | Cubic Yard | $ 35.50 | $8,756.67 |
| 53 | JA-1 | Headwall | 1 | Each | $ 1,250.00 | $1,250.00 |
| 54 | JB1-3 | Headwall | 2 | Each | $ 1,250.00 | $2,500.00 |
| 55 | JB2-3 | Headwall | 2 | Each | $ 1,250.00 | $2,500.00 |
| 56 | JB2-7 | Headwall | 1 | Each | $ 1,250.00 | $1,250.00 |
| 57 | JB2-8 | Headwall | 1 | Each | $ 1,250.00 | $1,250.00 |
| 58 | DAE-1 | Headwall | 1 | Each | $ 1,250.00 | $1,250.00 |
| 59 | DF1A-2 | Headwall | 1 | Each | $ 1,250.00 | $1,250.00 |
| 60 | DAF-2 | Headwall (Remove and Replace) | 1 | Each | $ 1,562.50 | $1,562.50 |
| 61 | JSW-1 | Headwall (Remove and Replace) | 1 | Each | $ 1,562.50 | $1,562.50 |
| 62 | JA-1 | Storm Inlet / Manhole | 1 | Each | $ 6,775.00 | $6,775.00 |
| 63 | JB1-3 | Storm Inlet / Manhole | 2 | Each | $ 6,775.00 | $13,550.00 |
| 64 | JB2-3 | Storm Inlet / Manhole | 1 | Each | $ 6,775.00 | $6,775.00 |
| 65 | JB2-7 | Storm Inlet / Manhole | 5 | Each | $ 6,775.00 | $33,875.00 |
| 66 | JB2-8 | Storm Inlet / Manhole | 5 | Each | $ 6,775.00 | $33,875.00 |
| 67 | DAE-1 | Storm Inlet / Manhole | 1 | Each | $ 6,775.00 | $6,775.00 |
| 68 | DF1A-2 | Storm Inlet / Manhole | 1 | Each | $ 6,775.00 | $6,775.00 |
| 69 | DAF-2 | Storm Inlet / Manhole (remove and replace) | 1 | Each | $ 8,468.75 | $8,468.75 |
| 70 | JSW-1 | Storm Inlet / Manhole (remove and replace) | 1 | Each | $ 8,468.75 | $8,468.75 |
| 71 | JB1-3 | 24" RCP, Class III | 30 | Linear Foot | $ 103.50 | $3,105.00 |
| 72 | JB2-7 | 18" RCP, Class III | 150 | Linear Foot | $ 77.63 | $11,643.75 |
| 73 | JB2-8 | 18" RCP, Class III | 150 | Linear Foot | $ 77.63 | $11,643.75 |
| 74 | JSW-1 | 18" RCP, Class III | 60 | Linear Foot | $ 77.63 | $4,657.50 |
| 75 | DAE-1 | 18" RCP, Class III | 20 | Linear Foot | $ 77.63 | $1,552.50 |
| 76 | DF1A-2 | 18" RCP, Class III | 20 | Linear Foot | $ 77.63 | $1,552.50 |
| 77 | DAF-2 | 18" RCP, Class III (remove CMP) | 60 | Linear Foot | $ 77.63 | $4,657.50 |
| 78 | JA-1 | 48" RCP, Class III | 15 | Linear Foot | $ 175.00 | $2,625.00 |

| ITEM NO. | AREA NO. | ITEM DESCRIPTION | ESTIMATED QUANTITY | UNIT | UNIT PRICE | TOTAL |
|---|---|---|---|---|---|---|
| 79 | JB1-3 | 48" RCP, Class III | 30 | Linear Foot | $ 175.00 | $5,250.00 |
| 80 | JB2-3 | 48" RCP, Class III | 30 | Linear Foot | $ 175.00 | $5,250.00 |
| 81 | JSW-1 | Temporary Rolled Erosion Control Product - Coir Mat | 185 | SquareYard | $ 6.05 | $1,119.25 |
| 82 | JB1-3 | Temporary Rolled Erosion Control Product - Coir Mat | 428 | SquareYard | $ 6.05 | $2,589.40 |
| 83 | JB2-3 | Temporary Rolled Erosion Control Product - Coir Mat | 428 | SquareYard | $ 6.05 | $2,589.40 |
| 84 | JB2-7 | Temporary Rolled Erosion Control Product - Coir Mat | 258 | SquareYard | $ 6.05 | $1,560.90 |
| 85 | JB2-8 | Temporary Rolled Erosion Control Product - Coir Mat | 258 | SquareYard | $ 6.05 | $1,560.90 |
| 86 | JSW-1 | Detention Pond Ground Cover | 0.5 | Acre | $ 2,000.00 | $1,000.00 |
| 87 | JB1-3 | Ground Cover/Hydro Mulching (Permanent and Temporary) | 4,050 | Square Feet | $ 0.25 | $1,012.50 |
| 88 | JB2-3 | Ground Cover/Hydro Mulching (Permanent and Temporary) | 4,050 | Square Feet | $ 0.25 | $1,012.50 |
| 89 | JB2-7 | Ground Cover/Hydro Mulching (Permanent and Temporary) | 2,250 | Square Feet | $ 0.25 | $562.50 |
| 90 | JB2-8 | Ground Cover/Hydro Mulching (Permanent and Temporary) | 2,250 | Square Feet | $ 0.25 | $562.50 |
| 91 | DAE-1 | Ground Cover/Hydro Mulching (Permanent and Temporary) | 300 | Square Feet | $ 0.25 | $75.00 |
| 92 | DF1A-2 | Ground Cover/Hydro Mulching (Permanent and Temporary) | 300 | Square Feet | $ 0.25 | $75.00 |
| 93 | JSW-1 | Permanent Seeding | 0.1 | Acre | $ 4,300.00 | $430.00 |
| 94 | JB2-6 | Abandon Existing 12" Sewer Main | 2000 | Linear Foot | $ 35.98 | $71,960.00 |
| 95 | JB2-6 | Abandon Existing Manholes | 6 | Each | $ 1,637.22 | $9,823.32 |
| 96 | JB2-6 | 8" Ductile Iron Force Main and Fittings | 2000 | Linear Foot | $ 100.00 | $200,000.00 |
| 97 | J41-1 | Abandon Existing 8" Sewer Main | 1750 | Linear Foot | $ 21.68 | $37,940.00 |
| 98 | J41-1 | Abandon Existing Manholes | 4 | Each | $ 1,637.22 | $6,548.88 |
| 99 | J41-1 | 4" Ductile Iron Force Main and Fittings | 1750 | Linear Foot | $ 65.96 | $115,430.00 |
| 100 | TC1-1 | Abandon Existing 8" Sewer Main | 1430 | Linear Foot | $ 21.68 | $31,002.40 |
| 101 | TC1-1 | Abandon Existing Manholes | 3 | Each | $ 1,637.22 | $4,911.66 |
| 102 | TC1-1 | 4" Ductile Iron Force Main and Fittings | 1430 | Linear Foot | $ 65.96 | $94,322.80 |
| 102 | DA3-1 | Abandon Existing Main with Flowable Fill | 200 | Linear Foot | $ 21.68 | $4,336.00 |
| 103 | TC2T-1 | Abandon Existing Main and Add Concrete Plugs | 2 | Lump Sum | $ 2,000.00 | $4,000.00 |
| 104 | JB2-4 | Demolish Existing Sanitary Sewer Manhole | 1 | Each | $ 2,000.00 | $2,000.00 |
| 105 | DAE-3 | 6" Force Sewer Pipe and Fittings | 350 | Linear Foot | $ 71.20 | $24,920.00 |
| 106 | JB1-4 | 8" Ductile Iron Water Main and Fittings | 50 | Linear Foot | $ 78.21 | $3,910.50 |
| 107 | DAE-3 | 8" Ductile Iron Water Main and Fittings | 350 | Linear Foot | $ 78.21 | $27,373.50 |
| 108 | JB1-4 | 4" Steel Gas Main Laid | 50 | Linear Foot | $ 67.60 | $3,380.00 |
| 109 | JB1-2 | 4" Steel Gas Main Laid, by directional drilling | 100 | Linear Foot | $ 101.40 | $10,140.00 |
| 110 | JB1-2 | Fiber Optic Line relaid, or laid by directional drilling | 1 | LS | $ 22,230.00 | $22,230.00 |
| 111 | JB2-2 | 4" Steel Gas Main Laid, by directional drilling | 100 | Linear Foot | $ 101.40 | $10,140.00 |
| 112 | DA3-1 | Steel Gas Main Laid, by directional drilling | 1 | LS | $ 100,000.00 | $100,000.00 |
| 113 | DA3-1 | Water Main HDPE, by boring | 300 | Linear Foot | $ 70.47 | $21,141.00 |
| 114 | TC2T-1 | 12" Water Main | 50 | Linear Foot | $ 107.95 | $5,397.50 |
| 115 | JB2-2 | Fiber Optic Line relaid, or laid by directional drilling | 1 | LS | $ 22,230.00 | $22,230.00 |
| 116 | D4D6-1 | Fiber Optic Line relaid, or laid by directional drilling (Major) | 100 | LF | $ 342.00 | $34,200.00 |

| ITEM NO. | AREA NO. | ITEM DESCRIPTION | ESTIMATED QUANTITY | UNIT | UNIT PRICE | TOTAL |
|---|---|---|---|---|---|---|
| 117 | DAE-3 | Communications Line relaid | 350 | LF | $ 28.00 | $9,800.00 |
| 118 | DAE-3 | Fiber Optic Line relaid | 350 | LF | $ 32.77 | $11,467.80 |
| 119 | TC1-1 | Lift Station | 1 | Each | $ 300,000.00 | $300,000.00 |
| 120 | J41-1 | Lift Station | 1 | Each | $ 300,000.00 | $300,000.00 |
| 121 | JB2-6 | Lift Station | 1 | Each | $ 300,000.00 | $300,000.00 |
| 122 | D4D6-1 | Work Zone User Cost (Traffic) | 1 | LS | $ 37,591.00 | $37,591.00 |
| 123 | DAE-2 | Work Zone User Cost (Traffic) | 1 | LS | $ 40,243.00 | $40,243.00 |
| 124 | JB1-3 | Work Zone User Cost (Traffic) | 1 | LS | $ 33,244.00 | $33,244.00 |
| 125 | JB2-3 | Work Zone User Cost (Traffic) | 1 | LS | $ 33,244.00 | $33,244.00 |
| 126 | JB2-1 | Small Grinder Lift Station / Force Main System | 1 | Each | $ 35,000.00 | $35,000.00 |
| 127 | JB2-5 | Small Grinder Lift Station / Force Main System | 1 | Each | $ 35,000.00 | $35,000.00 |
| 128 | LF | Deferred cost of repairs to Lake Forest Lake Dam | 1 | LS | $ 632,678.09 | $632,678.09 |
| 129 | JSW-1 | JSW-1 Misc. | 1 | LS | $ 3,821.90 | $3,821.90 |
| 130 | JSW-1 | JSW-1 Erosion Control | 1 | LS | $ 4,586.28 | $4,586.28 |
| 131 | JSW-1 | JSW-1 Engineering | 1 | LS | $ 13,758.83 | $13,758.83 |
| 132 | JA-1 | JA Misc. | 1 | LS | $ 532.50 | $532.50 |
| 133 | JA-1 | JA Erosion Control | 1 | LS | $ 639.00 | $639.00 |
| 134 | JA-1 | JA Engineering | 1 | LS | $ 1,917.00 | $1,917.00 |
| 135 | JB1-1 | JB1-1 Misc. | 1 | LS | $ 14,167.53 | $14,167.53 |
| 136 | JB1-1 | JB1-1 Erosion Control | 1 | LS | $ 17,001.04 | $17,001.04 |
| 137 | JB1-1 | JB1-1 Engineering | 1 | LS | $ 51,003.12 | $51,003.12 |
| 138 | JB1-2 | JB1-2 Misc. | 1 | LS | $ 1,618.50 | $1,618.50 |
| 139 | JB1-2 | JB1-2 Erosion Control | 1 | LS | $ 1,942.20 | $1,942.20 |
| 140 | JB1-2 | JB1-2 Engineering | 1 | LS | $ 5,826.60 | $5,826.60 |
| 141 | JB1-3 | JB1-3 Misc. | 1 | LS | $ 3,718.50 | $3,718.50 |
| 142 | JB1-3 | JB1-3 Erosion Control | 1 | LS | $ 4,462.20 | $4,462.20 |
| 143 | JB1-3 | JB1-3 Engineering | 1 | LS | $ 13,386.59 | $13,386.59 |
| 144 | JB1-4 | JB1-4 Misc. | 1 | LS | $ 364.53 | $364.53 |
| 145 | JB1-4 | JB1-4 Erosion Control | 1 | LS | $ 437.43 | $437.43 |
| 146 | JB1-4 | JB1-4 Engineering | 1 | LS | $ 1,312.29 | $1,312.29 |
| 147 | JB2-2 | JB2-2 Misc. | 1 | LS | $ 1,618.50 | $1,618.50 |
| 148 | JB2-2 | JB2-2 Erosion Control | 1 | LS | $ 1,942.20 | $1,942.20 |
| 149 | JB2-2 | JB2-2 Engineering | 1 | LS | $ 5,826.60 | $5,826.60 |
| 150 | JB2-3 | JB2-3 Misc. | 1 | LS | $ 3,224.50 | $3,224.50 |
| 151 | JB2-3 | JB2-3 Erosion Control | 1 | LS | $ 3,869.40 | $3,869.40 |
| 152 | JB2-3 | JB2-3 Engineering | 1 | LS | $ 11,608.19 | $11,608.19 |
| 153 | JB2-7 | JB2-7 Misc. | 1 | LS | $ 9,986.43 | $9,986.43 |
| 154 | JB2-7 | JB2-7 Erosion Control | 1 | LS | $ 11,983.72 | $11,983.72 |
| 155 | JB2-7 | JB2-7 Engineering | 1 | LS | $ 35,951.16 | $35,951.16 |

| ITEM NO. | AREA NO. | ITEM DESCRIPTION | ESTIMATED QUANTITY | UNIT | UNIT PRICE | TOTAL |
|---|---|---|---|---|---|---|
| 156 | JB2-8 | JB2-8 Misc. | 1 | LS | $ 8,155.53 | $8,155.53 |
| 157 | JB2-8 | JB2-8 Erosion Control | 1 | LS | $ 9,786.63 | $9,786.63 |
| 158 | JB2-8 | JB2-8 Engineering | 1 | LS | $ 29,359.90 | $29,359.90 |
| 159 | D4D6-1 | D4D6-1 Misc. | 1 | LS | $ 17,987.45 | $17,987.45 |
| 160 | D4D6-1 | D4D6-1 Erosion Control | 1 | LS | $ 19,329.48 | $19,329.48 |
| 161 | D4D6-1 | D4D6-1 Engineering | 1 | LS | $ 57,988.44 | $57,988.44 |
| 162 | DA3-1 | DA3-1 Misc. | 1 | LS | $ 6,273.85 | $6,273.85 |
| 163 | DA3-1 | DA3-1 Erosion Control | 1 | LS | $ 7,528.62 | $7,528.62 |
| 164 | DA3-1 | DA3-1 Engineering | 1 | LS | $ 22,585.86 | $22,585.86 |
| 165 | DAE-1 | DAE-1 Misc. | 1 | LS | $ 622.72 | $622.72 |
| 166 | DAE-1 | DAE-1 Erosion Control | 1 | LS | $ 747.26 | $747.26 |
| 167 | DAE-1 | DAE-1 Engineering | 1 | LS | $ 2,241.78 | $2,241.78 |
| 168 | DAE-2 | DAE-2 Misc. | 1 | LS | $ 2,475.76 | $2,475.76 |
| 169 | DAE-2 | DAE-2 Erosion Control | 1 | LS | $ 2,970.92 | $2,970.92 |
| 170 | DAE-2 | DAE-2 Engineering | 1 | LS | $ 8,912.75 | $8,912.75 |
| 171 | DAE-3 | DAE-3 Misc. | 1 | LS | $ 3,678.07 | $3,678.07 |
| 172 | DAE-3 | DAE-3 Erosion Control | 1 | LS | $ 4,413.68 | $4,413.68 |
| 173 | DAE-3 | DAE-3 Engineering | 1 | LS | $ 13,241.03 | $13,241.03 |
| 174 | DAF-1 | DAF-1 Misc. | 1 | LS | $ 2,630.00 | $2,630.00 |
| 175 | DAF-1 | DAF-1 Erosion Control | 1 | LS | $ 3,156.00 | $3,156.00 |
| 176 | DAF-1 | DAF-1 Engineering | 1 | LS | $ 9,468.00 | $9,468.00 |
| 177 | DAF-2 | DAF-2 Misc. | 1 | LS | $ 844.44 | $844.44 |
| 178 | DAF-2 | DAF-2 Erosion Control | 1 | LS | $ 1,013.33 | $1,013.33 |
| 179 | DAF-2 | DAF-2 Engineering | 1 | LS | $ 3,039.98 | $3,039.98 |
| 180 | DAF-3 | DAF-3 Misc. | 1 | LS | $ 1,151.18 | $1,151.18 |
| 181 | DAF-3 | DAF-3 Erosion Control | 1 | LS | $ 1,381.42 | $1,381.42 |
| 182 | DAF-3 | DAF-3 Engineering | 1 | LS | $ 4,144.25 | $4,144.25 |
| 183 | DF1A-1 | DF1A-1 Misc. | 1 | LS | $ 7,880.00 | $7,880.00 |
| 184 | DF1A-1 | DF1A-1 Erosion Control | 1 | LS | $ 9,456.00 | $9,456.00 |
| 185 | DF1A-1 | DF1A-1 Engineering | 1 | LS | $ 28,368.00 | $28,368.00 |
| 186 | DF1A-2 | DF1A-2 Misc. | 1 | LS | $ 625.26 | $625.26 |
| 187 | DF1A-2 | DF1A-2 Erosion Control | 1 | LS | $ 750.32 | $750.32 |
| 188 | DF1A-2 | DF1A-2 Engineering | 1 | LS | $ 2,250.95 | $2,250.95 |
| 189 | TC2T-1 | TC2T-1 Misc. | 1 | LS | $ 469.88 | $469.88 |
| 190 | TC2T-1 | TC2T-1 Erosion Control | 1 | LS | $ 563.85 | $563.85 |
| 191 | TC2T-1 | TC2T-1 Engineering | 1 | LS | $ 1,691.55 | $1,691.55 |
| | | | | | | |
| | | | | | | $4,651,179.30 |

| ITEM NO. | AREA NO. | ITEM DESCRIPTION | ESTIMATED QUANTITY | UNIT | UNIT PRICE | TOTAL |
|---|---|---|---|---|---|---|
| | **Area** | **Assumed Time Frame (years)** | | | **Present Value** | **Total OPC** |
| | JSW-1 | 3 | **Total JSW-1** | | **$ 90,897.73** | $ 98,604.91 |
| | J41-1 | 8 | **Total J41** | | **$ 370,191.63** | $ 459,918.88 |
| | J42-1 | 8 | **Total J42 (included in J41-1)** | | **$ -** | $ - |
| | JA-1 | 10 | **Total JA-1** | | **$ 10,474.20** | $ 13,738.50 |
| | | Varies | **Total JB1** | | **$ 451,297.70** | $ 545,865.68 |
| | JB1-1 | 10 | | JB1-1 | $ 278,673.50 | $ 365,522.39 |
| | JB1-2 | 1 | | JB1-2 | $ 40,639.71 | $ 41,757.30 |
| | JB1-3 | 1 | | JB1-3 | $ 125,723.84 | $ 129,181.24 |
| | JB1-4 | 15 | | JB1-4 | $ 6,260.65 | $ 9,404.75 |
| | | Varies | **Total JB2** | | **$ 1,055,282.57** | $ 1,287,239.28 |
| | JB2-1 | 3 | | JB2-1 | $ 35,582.94 | $ 38,600.00 |
| | JB2-2 | 10 | | JB2-2 | $ 31,835.68 | $ 41,757.30 |
| | JB2-3 | 15 | | JB2-3 | $ 77,510.40 | $ 116,436.04 |
| | JB2-4 | 5 | | JB2-4 | $ 1,746.31 | $ 2,000.00 |
| | JB2-5 | 3 | | JB2-5 | $ 35,582.94 | $ 38,600.00 |
| | JB2-6 | 5 | | JB2-6 | $ 507,986.43 | $ 581,783.32 |
| | JB2-7 | 5 | | JB2-7 | $ 224,968.13 | $ 257,650.01 |
| | JB2-8 | 15 | | JB2-8 | $ 140,069.74 | $ 210,412.61 |
| | D4D6-1 | 1 | Total D4D6 | | **$ 442,875.30** | $ 455,054.37 |
| | DA3-1 | 1 | Total DA3 | | **$ 157,533.17** | $ 161,865.33 |
| | | Varies | Total DAE | | **$ 181,215.55** | $ 215,077.88 |
| | DAE-1 | 10 | | DAE-1 | $ 12,248.76 | $ 16,066.09 |
| | DAE-2 | 7 | | DAE-2 | $ 86,109.64 | $ 104,117.71 |
| | DAE-3 | 5 | | DAE-3 | $ 82,857.15 | $ 94,894.08 |
| | | Varies | Total DAF | | **$ 100,913.51** | $ 119,340.94 |
| | DAF-1 | 5 | | DAF-1 | $ 59,246.99 | $ 67,854.00 |
| | DAF-2 | 5 | | DAF-2 | $ 19,022.96 | $ 21,786.49 |
| | DAF-3 | 10 | | DAF-3 | $ 22,643.56 | $ 29,700.45 |
| | | Varies | Total DAF1A | | **$ 176,328.03** | $ 219,435.79 |
| | DAF1A-1 | 7 | | DAF1A-1 | $ 168,140.80 | $ 203,304.00 |
| | DAF1A-2 | 25 | | DAF1A-2 | $ 8,187.23 | $ 16,131.79 |
| | | Varies | Total TC | | **$ 296,989.76** | $ 442,359.64 |
| | TC1-1 | 15 | | TC1-1 | $ 286,404.71 | $ 430,236.86 |
| | TC2T-1 | 5 | | TC2T-1 | $ 10,585.05 | $ 12,122.78 |
| | LF | Deferred cost of repairs to Lake Forest Lake Dam | Total LF | | **$ 632,678.09** | $ 632,678.09 |
| | | | **Grand Total** | **$** | **3,966,677.24** | $ 4,651,179.30 |