Technical Memorandum

Analysis of Harvested Wetlands Potential in Virginia Beach

December 2012

City of Virginia Beach, VA
Corps No. W91236-09-D-0034 0031
URS No. 11658362

US Army Corps of Engineers
Norfolk District

URS

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Executive Summary

Engineers and planners from the City of Virginia Beach, Corps of Engineers, and URS Corporation (the Project Delivery Team) have completed a study to assist the City of Virginia Beach in evaluating the potential of harvesting wetland plant stalks to help meet stormwater pollutant removal requirements stemming from the Chesapeake Bay Total Maximum Daily Load (Chesbay TMDL) regulations.

'Harvesting' in this context means the careful cutting of plant stalks according to a harvesting protocol (described herein), and their removal from the watershed. The stalks contain nutrients that have been effectively filtered by the plant. Uptake of nutrients by these plants and removal of their stalks reduces nutrient discharges from the watershed into the Chesapeake Bay. These nutrients would otherwise contribute to algal blooms, leading to dissolved oxygen and other water quality problems. If the pants are allowed to experience their normal growth and die-back cycles, the nutrients decay with the plant stalks in place, and are re-introduced into the waters that flow into the Bay. Removing the stalks creates a harvest of pollutants (nutrients). Cutting the stalks according to a harvesting protocol minimizes the disturbance of sensitive lands, such as marsh surfaces, and leaves at least a foot to 18 inches of stalk in place for regenerative growth—it does not kill the plants. The process is similar to pruning garden plants to keep them healthy.

Specifically, the team obtained informal guidance and feedback from regulatory agencies as to which wetland species, such as Phragmites, might be suitable for these purposes, and developed a harvesting protocol and specifications for future contracting. The team reviewed wetlands inventory data within the City, and developed an initial plan for harvesting that identifies specific plant colonies that could be harvested. Computations were made to estimate how much Total Nitrogen (TN) and Total Phosphorous (TP) removal credit could be claimed based upon 480 plant tissue samples that were collected as part of the study.

The study was initially conceived to address multiple plant species, to include Cattails. However when the field screening was conducted, there was an abundance of Phragmites, but generally only fringe

colonies of Cattails. Based upon the sampling results from 480 Phragmites stalks at 80 locations described herein, readily discernible populations of Phragmites (in 2012), and the assumptions used to arrive at a dry-weight yield, the project delivery team estimates that it may be possible to harvest a maximum of **13,500 Pounds of TN**, and **1,000 Pounds of TP** annually for Chesapeake Bay TMDL pollutant reduction credit. While maximum costs for these harvesting operations could be on the order of **$ 500,000** per year, when compared to the cost of nutrient removal through other BMPs over time, the idea of harvesting Phragmites becomes attractive enough to implement. If the program goes well, the City may have found a cost-effective method to include in its Watershed Implementation Plan to meet the pollutant discharge requirements of the Chesapeake Bay TMDL. This study shows that such potential exists. On a unit-cost basis, the removal of one pound of TN by Phragmites harvesting would be $37 annually, and the cost to remove one pound of TP would be $500 annually.

The total annual effort would require the harvesting of suitable stalks from approximately 33 acres of land, with cutting limited to between September 1st and November 19th. Initially, the City would like to perform a 5-year study, in which some sites would be harvested each year, while others would be harvested every other year in order to compare the effects of harvesting on the regrowth of phragmites and the health of the plant stalks.

Because this type of harvesting operation has not been previously performed in the region, there is not much data upon which to build estimates of stalk yield. Identifying the areas to be harvested should be a straightforward process, but the pounds of stalks to be collected from those areas are based on plant density and height estimates that are speculative. As the program progresses and harvesting data is collected, the City should be able to develop good baseline information that can be used to more accurately assess the yields.

Findings or recommendations contained herein do not constitute Corps of Engineers approval of any project(s) or eliminate the need to follow normal regulatory permitting processes.

Background

The City must develop plans to comply with pollutant removal targets stemming from the Chesbay TMDL regulation and Executive Order 13508. These pollutant removal targets will be difficult to satisfy, and the City is considering using innovative techniques to achieve compliance in a cost-effective manner. This study provides support to the City to investigate the feasibility of harvesting the stalks of certain existing wetlands species, such as Phragmites, to help meet the mandated pollutant reduction targets.

Under the Chesbay TMDL, municipalities must reduce discharges of nitrogen, phosphorous, and sediment in their stormwater. Localities must select a number of Best Management Practices (BMPs) to meet the reduction targets. Some BMPs, such as the construction of new stormwater retention basins, are extremely expensive and require long lead times to implement. Other BMPs, such as street sweeping and erosion & sediment control programs are already in place and can help meet the reduction targets. However, the Chesbay TMDL set the bar sufficiently high that new BMPs will be required. One potential BMP is the harvesting of existing wetlands plant stalks. Wetlands plants typically remove nutrient pollutants from the water column by uptake processes, and the pollutants remain in the plants until they decay. If they are harvested before the decay occurs, these pollutants are physically removed from the stormwater system.

There are three key pollutants addressed by the Bay TMDL: nitrogen, phosphorous, and sediment. Wetlands systems are generally effective in reducing all three pollutants, but by different processes. Nitrogen (mostly) and phosphorous are taken up into the plant stalks, but sediment is filtered by settling and sorption processes such that the sediment is not present in the plant stalks. In other words, the

sediment benefits of wetlands occur because the plants slow the flow and gravity and sorption processes remove the sediment from the water column. While wetlands systems are reported to have relatively high sediment removal efficiencies, the sediment ends up in the bottom of the basin or lake, and is not present in the plant stalks. There is no significant sediment present in the plant stalks, and therefore the harvesting of wetlands stalks will not be effective at reducing sediment. For this reason, this study was limited to nitrogen and phosphorus only.

For localities such as Virginia Beach, nutrient reductions mandated under the Chesapeake Bay TMDL will be stipulated in a forthcoming MS4 permit. In the meantime DCR has created the Virginia Assessment Scenario Tool (VAST) to allow localities to study different modeling scenarios, and to evaluate alternative measures to meet the required reduction goals. Unfortunately, problems with the Chesapeake Bay Watershed Model and its associated data have led to confusion about exactly what a locality must do to meet the requirements of the Chesapeake Bay TMDL. In a discussion with James Davis-Martin of DCR on 11 December 2012, he stated that target reduction loads will be based upon the difference between the "2009 Progress Scenario" and Virginia's "WIP I Scenario." Using VAST on 14 December 2012 to evaluate the differences between the 2009 Progress Scenario and Virginia's WIP I Scenario, the City must reduce its annual nutrient discharges from stormwater to the Bay by approximately 37,000 pounds of TN, 7,200 pounds of TP, and 2,557,000 pounds of TSS. These values exclude all federal lands.

DCR and the U.S. Environmental Protection Agency (EPA) have given provisional approval to use harvested wetlands as a BMP for Chesbay TMDL purposes. Although provisional approval has been granted by the regulators, important details remain to be resolved. Questions include: the efficiency of the plant stalks in up-taking nitrogen and phosphorous; the extent of suitable plant colonies within the City; the appropriate and allowable protocols for harvesting; the pounds of pollutants that could be removed through annual harvesting; the appropriate disposal methods for the harvested stalks; and the ability to perform harvesting operations within regulatory and permitting agency constraints.

Funding for this project was provided under Section 22 of the Water Resources Development Act of 1974, as amended, which provides authority for the Corps of Engineers to provide planning assistance to states and tribes, with cost-sharing participation by the City. Planning Assistance States (PAS) Program funds were used for this project.

Similar Studies

The importance of wetland vegetation in the reduction of pollutants in aquatic systems is well known. Stands of aquatic plants act as a natural filter to help remove suspended solids in sediment laden runoff, as well as suspended forms of nutrients and trace metals. Biologic processes allow for the uptake of dissolved nutrients that make their way into waterways through stormwater runoff and groundwater transport. The ability of wetland vegetation to remove excess nutrients from an aquatic ecosystem is highly variable. The type of vegetation, local climate, hydrology, and pollutant loads in runoff are just a few of the factors that affect the ability of aquatic vegetation to take up excess nutrients. Nutrient removal efficiencies often vary within a given system due to seasonal changes, or climatic events such as droughts or flooding. While nutrient removal rates and efficiencies may be highly variable from one wetland system to the next, studies have shown that the contributions of aquatic vegetation in reducing pollutants can be significant.

A United States Geologic Survey study published in 2000, Effects of a Cattail Wetland on Water Quality of Irondequoit Creek near Rochester, New York (Water-resources Investigations Report 00-4032) by William F. Coon, John M. Bernard, and Frank K. Seischab, measured the reduction of pollutants in Irondequoit creek by marsh vegetation over a six-year period. The study area was a 423-acre marsh,

predominantly vegetated by cattails (*Typha glauca*). Irondequoit creek has a drainage area of 151 square miles comprised mainly of urban and suburban land uses. The study showed the marsh vegetation had an average removal efficiency of 47 percent for total suspended solids (TSS) and 28 percent for total phosphorus (TP) over the six-year study. Nitrogen levels were reduced slightly in the system, with an average total nitrogen (TN) removal efficiency of only 4.3 percent over the same six-year period. Although the removal efficiency for TN was much lower than that for TSS or TP, it accounted for an average annual reduction of nitrogen for Irondequoit creek in the study area of 24,000 pounds. The average annual reduction for TSS and TP was 26.6 million pounds and 14,400 pounds respectively.

The practice of harvesting wetland species near the end of the growing season, when nitrogen and phosphorus concentrations are highest in the above-ground biomass, aims to prevent nutrients from being reintroduced into the aquatic system through decomposition of plant material, or translocation of nutrients from above ground biomass to the roots. An ongoing project in Manitoba, Canada; the Netley-Libau Nutrient-Bioenergy Project by Richard E. Grosshans, The International Institute for Sustainable Development, the University of Manitoba, and Ducks Unlimited Canada has studied the harvesting of cattails (*Typha spp.*) in the Netley-Libau Marsh as a way to reduce nutrient loads in Lake Winnipeg, as well as provide a source of biomass to be used for energy production. The study has shown that when standing biomass is harvested, stored nutrients are removed and prevented from being re-released into the marsh. Harvested cattails yield approximately 20-60 kg of phosphorus per hectare; or 18-54 pounds per acre. http://www.redriverbasincommission.org/Conference/Proceedings/29th_Proceedings/Grosshans_-RRBC_2012.pdf.

A study published in 2009 by M. Ruiz and J. Velasco, Nutrient Bioaccumulation in Phragmites australis: Management Tool for Reduction of Pollution in the Mar Menor studied the nutrient levels in Phragmites in the Albujón rambla drainage basin leading into Mar Menor, a Mediterranean lagoon in southeast Spain. The drainage area is approximately 441 km^2 and drains agricultural and urban land. Also within the basin is a water treatment plant that inadequately treats sewage for an urban area with approximately 100,000 people. Phragmites grows in dense stands along the banks of Albujón rambla. In late summer, the phragmites has been typically harvested along the banks to increase conveyance during a flood and reduce damage to urban infrastructure. The study showed the peak nutrient levels in the above ground biomass of the phragmites typically occur in late July. Maximum nitrogen yields were 0.54 metric tons per hectare (approx. 480 lbs/acre), while maximum phosphorus yields were 0.025 metric tons per hectare (approx. 22 lbs/acre) with a maximum above-ground biomass dry weight of 3.72 kg/m^2 (0.76 lbs/ft^2).

Phragmites Inventory

Wetlands plant inventories have been available in GIS formats for many years—developed by the City of Virginia Beach, the Virginia Institute of Marine Science, the Virginia Department of Conservation and Recreation, other agencies, and private parties. It would be helpful if these separate inventories could be combined into a comprehensive mapping set, but currently there is no such inventory of Phragmites.

Lacking detailed GIS mapping data, engineers and planners must resort to estimating likely locations based upon local knowledge and/or aerial or Internet mapping, then make field visits to confirm the presence of the plants. Although Phragmites is a remarkably persistent plant, seasonal Growth rates, human activity (cutting, spraying to eradicate, land development), and other factors can cause wide fluctuations in plant population at any given site. There is no guarantee that populations will remain constant on a year-over-year basis at any particular location.

Phragmites does not show up well on aerial imagery. Internet mapping sites such Google Maps or Bing Maps have a great deal of high-resolution aerial imagery for Virginia Beach, but it is not possible to spot Phragmites colonies with any degree of certainty using those images. Street-view or street-side imagery,

where also available on Google and Bing, can provide a better look at plant colonies growing close to roads, but field verification is needed to confirm the existence of colonies at any particular location.

For this study Internet imagery was used to screen potential sites for sampling. However, of the 80 locations that were originally screened for sampling, approximately one dozen did not actually have enough plants to sample when field personnel arrived. The sampling teams just moved on and found additional locations to make sure that 80 locations were sampled in all. The mapping in this technical memorandum shows the 80 locations that were successfully sampled.

Plant Sampling and Laboratory Analysis

Aerial photographs were used to identify areas where Phragmites was visible and appeared to grow in dense, monotypic stands. Other areas, such as disturbed areas, or areas along drainage ditches and canals were also noted. Before sampling began, a field visit was made to several potential sampling locations to verify the location and densities of phragmites seen in the aerial photographs. Sampling sites were chosen based on location and accessibility. As many sampling locations as possible were chosen on City owned property, or property within a right-of-way or permanent easement. Sites where harvesting is most feasible, primarily areas where Phragmites can be reached from upland areas without disturbing or entering wetlands, were also prioritized.

In all, 80 locations were chosen for sampling. Large areas of extensive phragmites growth were often assigned more than one sampling location as checks and to account for possible spatial variations in the phragmites growth. Approximately 12 sites did not contain Phragmites in numbers to warrant sampling. Twelve additional locations were found during the sampling effort to replace those that were not sampled. Several of these were located in areas where phragmites did not appear to be prevalent in the aerial photos. Figure 1 shows an overview of the sampling locations, and detailed sampling locations can be found in Appendix A.

The number of plant stalks within a one-foot square was counted at each sampling location, as well as an estimation of overall plant density in the general sampling area. Six representative phragmites stalks were cut one-foot above the ground at each sample location. Each stalk was then measured for total length, before being cut into pieces approximately 1 to 4 inches in length. Each stalk was placed in an individual paper envelope, sealed and assigned a sample number. All samples were shipped the day they were cut using overnight delivery to an agronomy lab. Spectrum Analytic of Washington Court House, Ohio was the agronomy laboratory selected for this analytical work. This lab was highly recommended by several Hampton Roads laboratories (who perform water sampling but not plant tissue sampling), and by staff at the Hampton Roads Agricultural Research and Extension in Virginia Beach. No local lab was found that could perform the plant tissue sampling. In addition, Spectrum Analytic performs this type of analysis on a routine basis, and demonstrated their analytic experience through the detailed plant tissue analysis protocols they provided to URS. Spectrum Analytic was also able to meet federal contracting procurement requirements for small businesses with prompt and complete responses to requests for information.

At the lab, the samples were dried for 24 hours in an air drying oven at 150° F. They were then ground to pass a 40 mesh screen and weighed. Total nitrogen concentrations were measured using a Carlo Erba Nitrogen Analyzer. National Bureau of Standards (NBS) citrus leaves and an in-house check sample were analyzed with the plant samples as checks. To measure total phosphorus concentrations, samples first underwent microwave digestion. Nitric acid (HNO_3) was combined with 0.5 grams of each sample and placed in a tightly closed vessel before being placed in a microwave digester. Once digestion was complete, samples underwent inductively coupled plasma (ICP) analysis to determine phosphorus concentrations. Lab results for each plant sample contained the sample number, the lab ID number,

received weight, dry weight, total nitrogen as a percent of the dry weight, and total phosphorus as a percent of the dry weight. Lab results were received by URS approximately one week after samples were received by the lab.

Sampling Results

Sampling at 80 locations resulted in dry weight ranges from 0.168 to 1.37 pounds per square foot (see Table 1).

The average percentage of TN by dry weight per stalk ranged from 0.59 to 3.96 percent, and the average percentage of TP by dry weight per stalk ranged from 0.01 to 0.40 percent (see Appendix C). The average percentage of TN by dry weight in all samples was 1.5 percent. The average percentage TP by dry weight in all samples was 0.11 percent.

Measurements of stalk height and density were taken by the sampling crews at each site in Figures 1.1 and 1.2. These sampling counts are listed in Table F-1, and were used in developing the yield calculations.

The dry weight results were broken into low, medium and high ranges by taking the mean of the dry weights reported by the laboratory, and computing bands within one standard deviation of the mean in both directions, as indicated in Figures 3 and 4.

Average yield rates were computed with each of the three ranges. GIS work was performed to map areas that appeared to be low, medium or high yielding Phragmites colonies, and these average yield rates were used to compute the pollutant yields in Table 4.

The results of this study are comparable with the similar studies cited above; both in terms of dry weight yield within the stalks analyzed at the laboratory and the yield calculations in Table F-1.

Potential Yield for Chesapeake Bay TMDL Purposes

There are four essential steps required to quantify the potential TN and TP yield for Chesapeake Bay TMDL purposes:

1. Conduct sampling to determine the average dry weight concentrations of TN and TP in local Phragmites plants;
2. Estimate how much Phragmites exists in the Chesapeake Bay watershed within the City of Virginia Beach;
3. Estimate the dry weight yield of TN and TP for the Phragmites colonies that comprise the harvestable inventory; and
4. Estimate how much of that Phragmites inventory could actually be harvested on an annual basis.

The first step is straightforward, and the sampling results for this study indicate that laboratory values are in line with published values.

As noted above, currently there is no reliable Phragmites inventory for the City of Virginia Beach. The project delivery team used available aerial mapping and Internet imagery to locate active colonies of Phragmites, and conducted field visits to confirm the presence of the plants. GIS processing was performed to create polygons of Phragmites, estimating how much of the area could be reached for harvesting, and how much dry weight could be harvested from these locations. Figure 2 and Appendix F contain the details of this estimation process on a site-by-site basis. Consideration was given to which

areas could be accessed with side-boom mowers, and which would require cutting by hand. Hand cutting and the use of stand-off equipment will be the only harvesting methods allowed.

The field sampling conducted for this study involved counting the number of stalks per square foot and the stalk density at 80 sampling locations. To account for the fact that not all stalks are healthy and suitable for harvesting an adjustment factor was used based upon observations by the sampling team. This adjustment factor is listed as the "Fraction of Viable Stalks" in Table F-1, and simply recognizes that some stalks are too small, decayed, broken, or otherwise do not have significant amounts of nutrients in their stalks. Further and more detailed analyses could be conducted, but would have required more time and budget than was available for this project.

Using the procedures and methods described in this technical memorandum, the Chesapeake Bay TMDL maximum pollutant reductions that could be achieved by harvesting Phragmites stalks are tabulated in Table 4 to be approximately **13,500 pounds of TN and 1,000 pounds of TP annually**. Approximately 33 acres of Phragmites would have to be harvested within the allowable harvest window (September 1st to November 19th) to achieve these yields. Although 33 acres may seem like a small area, access issues and the need to keep off the marsh surface and away from sensitive habitat will make harvesting operations a challenge. Annual yields will be lower if some sites are harvested on a bi-annual basis.

Phragmites Disposal

After harvesting, the collected biomass needs to be transported for disposal. Once the Phragmites stalks have been cut and collected, chipping or shredding the stalks would be the most efficient way to reduce the volume of harvested biomass for transport, reducing the number of trucks needed to haul the material away. The main concern with the disposal of the biomass is the reintroduction of the nutrients back into the environment through burning, or disposal in a landfill. For this reason, disposal outside of the Chesapeake Bay watershed is recommended.

It may be possible to turn the harvested Phragmites over to a facility where biofuel pellets are manufactured. In Europe, Phragmites has been used as a fuel source for years. Phragmites along with cattails can be turned into biofuel by compressing the material into pellets. Biofuel can be converted into energy through gasification. Gasification furnaces convert organic material into carbon monoxide, hydrogen and carbon dioxide by heating the material to a high temperature without combustion. Oxygen and/or steam are added to the material producing a gas that can be used as a fuel itself. The advantage to gasification is that organic waste material can be converted to energy, and unlike incineration, the emissions contain very little nitrogen or phosphorus to be put back into the atmosphere, and unlike fossil fuels, the materials used in biofuel are renewable.

In Virginia, biofuel use is increasing and Virginia's Renewable Portfolio Standard calls for the State's energy producers to use renewable resources for 15% of their power generation by 2025. Dominion Virginia Power will convert three of its coal burning plants to use biofuel by 2014. In October of 2011 Dominion Virginia power made a deal with Enviva LP to supply two of those plants: one in Hopewell, Virginia and one in Southampton County, Virginia, with wood chips. Enviva LP produces wood pellets and wood chips for use as biofuel, and recently purchased a port facility in Chesapeake, Virginia to ship wood pellets to Europe for fuel. Enviva LP will soon have two pellet producing plants near the City of Virginia Beach. There is a plant in Ahoskie, NC, and the company just broke ground for a new plant in Southampton in July of 2012. According to the Enviva LP website, the Ahoskie plant will produce approximately 385,000 tons of wood pellets annually, and the Southampton facility is expected to produce an estimated 550,000 tons of pellets each year. Given the growth in the biofuel industry, and the need for raw materials for the production of wood pellets, a biofuel producer may gladly accept the harvested Phragmites biomass from the City.

It may also be possible for the City to generate some revenue to offset the costs of harvesting operations, but the project delivery team was not authorized to pursue or initiate any negotiations, and therefore purposely avoided making any contact with potential buyers for the harvested material.

Questions about how to dispose of harvested plant stalks in pits or landfill applications, or by burning, should be treated 'evenly' with respect to fate and transport. The current (Phase 5) Chesapeake Bay Watershed Model does not account for groundwater transport of infiltrated runoff into the Bay. If infiltration-type BMPs are used, there is a "free pass" of sorts that exists in accounting for the disposition of the infiltrated nutrients in the modeling world. Similarly, the fate of settled and re-suspended nutrients in ponds is not completely accounted for in the Phase 5 Watershed Model—likewise, the recovery of plants or bed material from bioretention facilities. To demand that harvested plant stalks be held to a higher disposal standard than other BMPs for Bay TMDL credit is inappropriate given the current limits of modeling technology. Fortunately, the biomass industry appears to have an excellent alternative for disposal of the stalks, but if those options close, the disposal of Phragmites stalks should be evaluated on a level playing field with other BMPs.

Regulatory Considerations

Any activity in or near wetlands areas will be of concern to regulatory authorities, and may require wetlands permits to be issued before work can begin. The concept of harvesting wetlands plants for Chesapeake Bay TMDL credit has not been previously explored with any regulatory personnel in a formal sense. Although it could require many months or even years to settle permitting requirements for this type of work, the project delivery team attempted to solicit informal preferences from regulatory personnel. By soliciting informal guidance and opinions, the project delivery team was able to keep this study on schedule while attempting to avoid problems later on that could come from blindsiding the regulatory community. The regulators were very helpful and their insights and preferences have been incorporated into the recommendations offered herein.

Three meetings were held with regulatory personnel to discuss these issues. Meeting notes are provided in Appendix E. The first meeting with regulatory personnel was held at the Norfolk District Corps of Engineers on 26 April 2012, and Tom Walker, Chief of the Norfolk District's Regulatory Branch, provided input on several types of wetlands harvesting, including harvesting of planted and floating wetlands. As the current study evolved, the focus became harvesting of Phragmites. Mr. Walker subsequently provided a Corps Permitting Matrix as presented in Table 5.

Regulatory personnel were invited to two other meetings, one on 18 September 2012 at the Norfolk District Corps of Engineers, and another on 22 October at the Virginia Institute of Marine Science (VIMS) in Gloucester Point. The project delivery team was fortunate to have these opportunities to dialog with experts in Phragmites and wetlands plant growth, as documented in Appendix E.

Based upon the input received from the subject matter experts and regulators, several key concerns and constraints were highlighted, including:

- Plants should be cut no shorter than one foot above the ground. Cutting shorter than one foot could kill the plants.
- Seasonal variations in plant growth result in nutrients moving from the rhizomes into the stalks, and then back into the rhizomes. We cannot assume that TN and TP are constantly present in the stalks of these plants. It is fortunate that the field sampling for this study took place in late October, so the agronomy lab results should match the time of year when harvesting will occur.

- Disturbance of marsh surfaces and wildlife habitat must be minimized.
- Harvesting must occur above the mean high water line.
- VIMS estimated a typical dry weight yield of 4 to 6 tons per acre of wetlands, and that approximately 30-percent of the wetlands in the Lynnhaven River are Phragmites. They further estimated that could mean there are 170 acres of Phragmites present in the Lynnhaven. Unfortunately, much of this plant population is located along private shorelines that are difficult to access.
- Public education about future Phragmites harvesting operations will be important. Many citizens seek to eradicate Phragmites, and have been prohibited from doing so by Article 14 of the City Zoning Ordinance. The City will need to communicate that it is not intending to kill plants—quite the opposite—and that controlled harvesting by the City is a cost-effective measure by which the City can meet its requirements to reduce pollution into the Bay.

Impacts to wildlife from the harvesting of Phragmites should be minimal if carefully managed. While some species of birds, such as marsh wrens, will nest in stands of Phragmites, nesting occurs in the spring, while harvesting efforts will take place in the fall. Much of the Phragmites in the City is located in areas that are inaccessible to mechanical equipment of any kind, let alone heavy trucks or tractors. Since impacts to marsh soils are to be avoided during harvesting efforts, the amount of phragmites that can be removed from an area will be a fraction of what is growing there and will generally be limited to narrow strips along ditch and marsh edges that can be reached by boom mounted mowing equipment or harvested by hand.

Article14 of the City Zoning Ordinance is provided in Appendix D. The Phragmites harvesting envisioned in this study should not be in violation of Article 14. City staff discussed this issue with the City Attorney's Office, which concurs that this harvesting would not be in violation of the ordinance. It is important to remember that the goal of the proposed harvesting is not to eradicate plants, but similar to pruning, to promote the healthy, continued growth of these plants.

Phragmites Harvesting Specification

For potential harvesting purposes, the Phragmites plants must be located in areas that are practical to harvest, and the plants have to exist in reliable, large quantities. Small, isolated patches of plants, located along private shorelines are not worth considering for now—for practical reasons, including gaining permission to enter private property.

The following harvesting protocols and requirements should be followed to maximize harvested nutrient yields, and minimize impacts to harvested locations (in addition to standard Virginia Beach contracting terms and conditions):

1. Phragmites shall be harvested in a manner that minimizes the disturbance of marsh soils. Anything that disturbs the roots will be subject to jurisdiction by the U.S. Army Corps of Engineers. Heavy equipment use on marsh soils and surfaces is prohibited.
2. Phragmites harvesting shall be performed above the mean high water line, to prevent tidal inundation of the cut stalks, which could kill the new shoots.
3. Nutrients are relocated from the stalks to the rhizomes after the growing season to supplement the next year’s growth. Cutting stalks too close to the ground may have a detrimental effect on the following year’s new growth, or kill the plants entirely. To prevent this, stalks must be cut a minimum of 18 inches above the ground.
4. Only one pass shall be permitted per season in any given area. The Contractor may not work any area twice within one harvesting season.

5. To maximize nutrient yield in harvested stalks, harvesting is only allowed between September 1st and November 19th, when nutrient levels are highest in the above ground biomass, but before translocation of nutrients to the rhizomes occurs.
6. Mower attachments such as flail mowers that allow the cut stalks to be shredded or ground up shall not be used, since it will be difficult or impossible to collect the fragments.
7. Stalks must be cut without grinding them in order to maximize the biomass that could be collected after cutting.
8. The use of sickle-bar mowers or handheld cutters with disk blades is required.
9. Contractors may suggest areas for harvesting to the City, but in no case shall harvesting operations be performed without prior approval of the City to ensure that adequate notifications have been made to citizens.
10. All areas to be harvested must be approved by the City for location and harvesting schedule. The City reserves the right to suspend or deny harvesting operations at any location.
11. Harvesting operations shall only take place during daylight hours.
12. The Contractor shall avoid the disturbance of wildlife habitat areas.
13. The Contractor shall secure all necessary permits for this work.
14. All harvested material shall be weighed prior to disposal at the approved disposal site.
15. The City is particularly interested in the quantities of plant stalks that are harvested, the specific locations of the plants that are cut, and the harvesting production rates. The Contractor must maintain daily logs of harvesting activities, and record the total weight of Phragmites delivered to the disposal site each day, and the location from which the material was harvested (including the latitude and longitude and text description of the harvesting operations. For example, "36.906683, -76.063253 at the Lynnhaven Drive dredge disposal site," or "36.801931, -76.068156 along the canal between New Land Drive and Crusader Circle."
16. Working in areas where Phragmites is growing presents specific safety concerns. All workers shall wear protective eyewear, long-sleeved shirts or jackets, and gloves to avoid puncture and cut wounds. All standard safety precautions such as reflective vest and footwear requirements must be incorporated into the project safety plan.

Due to the relatively short window for harvesting the City may opt to use work crews from the Sherriff's department, or Public Works/Operations crews to perform some or all of this work. City workers should follow these requirements as well.

The City should consider the method of payment carefully. Paying by the ton for collected material should lead to aggressive and efficient harvesting, but could create issues with careless disturbance of the environment. Likewise, the City should provide full, independent inspection of the harvesting operations.

Harvesting Costs

Due to a lack of data, and with no local contractors having experience with harvesting Phragmites, it is difficult to reliably estimate the cost to harvest Phragmites in Virginia Beach.

Estimated costs for harvesting operations are presented in Table 3. There is a great deal of uncertainty in these costs, particularly with respect to the daily yield that a harvesting crew can achieve, and the locations of the transfer site and ultimate disposal location.

The crews can only work between September 1st and November 19th, and need to harvest up to approximately 33 acres (again a number that requires significant assumptions). Detailed cost assumptions are listed in Table 3, but the cost to harvest 33 acres would be **approximately $ 500,000**. At this level, the unit cost to remove TP by harvesting Phragmites annually is comparable to some other BMPs the City is considering in Table 6, such as stream restoration, stream bank stabilization, and bioretention basins,

and is much cheaper than other options such as wet ponds. Unit costs for TN removal are close to Oyster Reefs, and much cheaper than other options. In order to adequately compare costs among alternative BMPs, it is necessary to normalize the unit costs, specifically adjusting for real estate acquisition, long term maintenance, and project depreciation.

Costs are based on an assumption of an 8-person work crew, with two pieces of equipment (one to cut and the other to 'rake' and load the material onto trucks,) using an intermediate transfer station, from which the material would be hauled to the final disposal site. Figure 5 shows pictures of some of the types of cutting equipment that might be used. A total of 66 crew-days would be required, which could be spread over two or three crews (allowing for bad weather) within the harvesting window (September 1st to November 19th).

Findings and Conclusions

When considering how to meet the requirements of a program as large and expensive as the Chesapeake Bay TMDL, costs become relative. While it is difficult to estimate the total pounds of TN and TP that could be harvested in Phragmites from Virginia Beach, the real value of this type of study is in its screening potential—particularly compared to other alternatives.

If the sampling results and estimations of potential harvest yields clearly pointed to higher unit costs (in terms of pounds of pollutants removed), then the City could abandon the idea of harvesting Phragmites, and focus efforts on using other BMPs—such as constructed Oyster Reefs, wet ponds, nutrient management, street sweeping, etc.—to reach the prescribed annual pollutant reduction goals of the Bay TMDL. In that case, the City could pragmatically conclude that the "squeeze is not worth the juice."

There are certain undeniable benefits to the concept of harvesting Phragmites to help satisfy Bay TMDL requirements. First, the removal of plant stalks containing TN and TP is a direct removal from the treatment train. Whereas other BMPs may 'treat' pollutants by methods such as infiltration, there is considerable debate about how much is actually being accomplished. Infiltrated pollutants enter our groundwater, which transports them ultimately back into the Bay. Conversely, if harvested plant stalks can be removed from the Bay watershed and processed overseas for biomass fuel consumption, arguably they are as far out of the watershed as we can accomplish with any BMP.

The City can use the results of this study to begin a harvesting program. If the program costs are tracked carefully, and trucks hauling harvested stalks are weighed consistently, the cost and benefits of harvesting Phragmites should be well understood within the first two years. It is also likely that as local contractors and City crews gain harvesting experience, dry weight yields and pollutant removals should increase while unit costs decrease.

Given the substantial and profound costs facing the City to achieve compliance with the Bay TMDL, it appears that Phragmites harvesting has great potential.

The harvesting envisioned does not necessarily have to be an 'annual' event. As long as the City tracks how much plant material is removed at specific locations, appropriate TN and TP reduction should be claimed based on actual (not prescribed) removals. Annual or biannual harvesting is recommended to allow the plants sufficient time to recover from the harvesting and reach full maturity within a growing season. The City would like to perform a 5-year study in which some areas are harvested annually, and others biannually to compare the effects of harvesting on the phragmites growth. If the harvested plant colonies prove to be particularly hearty, the City could explore more frequent harvesting. However the maximum harvest yields estimated through this study assume annual harvesting only.

Based upon the sampling results from 480 Phragmites stalks at 80 locations described herein, readily discernible populations of Phragmites (in 2012), and the assumptions used to arrive at a dry-weight yield, the project delivery team estimates that a maximum annual harvest of **13,500 Pounds of TN**, and **1,000 Pounds of TP** may be possible for Chesapeake Bay TMDL pollutant reduction credit.

Although they are difficult to estimate, costs for harvesting operations could be on the order of **$ 500,000** per year, as summarized in Table 3. On a unit-cost basis, removal of one pound of TN by Phragmites harvesting would range from 25 to 150 dollars and the cost to remove one pound of TP would range from 500 to 1,500 dollars.

These results and estimates are promising, in that the comparative costs to remove these pollutant discharges are much higher for most other types of BMPs, such as constructing new wet ponds or water quality retrofit facilities. For example, as presented in Table 6, City staff estimates that the annual cost to treat one pound of TN ranges from 15 to 9,500 dollars, and the cost to treat one pound of TP ranges from 200 to 85,000 dollars. There are many factors and conditions that produce the wide variability of these costs—obviously the City would not choose to spend large amounts of money on BMPs that provide only small gains towards meeting Bay TMDL requirements, but these facilities are often planned for other reasons, and the City should take credit where possible. It is also important to consider that the City cannot simply spend its entire budget on a single BMP. There are many constraints and complexities, such as limited land availability, regulatory constraints, private property restrictions, drainage patterns in the watershed (detention ponds built at the top of a hill don't collect much runoff), the need to remove multiple pollutants (TN, TP and TSS) and so forth.

The City should consider mapping the inventory of available, harvestable Phragmites colonies, and use the mapping to plan and execute annual harvesting operations. One way to obtain better data than is currently on hand would be to allow the contactors selected to perform this work to make recommendations for harvesting at alternative sites. If payment under the harvesting contracts that are awarded is based upon tonnage delivered to the disposal site, they would obviously have an incentive to find efficient locations with minimal haul routes.

Communication with the public will be very important. Citizens should be made aware that the City is conducting the harvesting of Phragmites as a planned BMP to meet the requirements of the Chesapeake Bay TMDL. Due to its invasive characteristics and proliferation, citizens in the past tried to eradicate plants that blocked their views, or that they otherwise found objectionable. Sometimes their efforts to kill Phragmites plants resulted in the application of toxic or non-approved herbicides (such as Roundup®) directly into waterways. Sometimes the destruction of the Phragmites plants destabilized their shoreline. The problems created by homeowners were addressed in Article 14 of the City Zoning Ordinance (see Appendix D). The intent of this ordinance should not be compromised by the proposed harvesting of Phragmites. The City should be careful to distinguish between its efforts to reduce pollution by harvesting Phragmites from careless attempts by citizens to kill the plants. Likewise the City should conduct an awareness campaign to notify citizens about the need for harvesting, the need to keep the plants alive after the harvesting, and the need to comply with the current ordinance and other regulations.

Study Caveats

Although portions of this study can be quantified with a reasonable degree of confidence, significant unknowns remain. The plant tissue sampling results are consistent with well-established values for TN and TP—which is not surprising given 480 samples that were collected for this study.

The potential harvest yield remains as the major unknown. Estimates can be developed by making good assumptions, and these assumptions are indeed necessary given the lack of available data (no one has tried this in Virginia before and there is no data on the inventory of Phragmites colonies in the City).

The dry weight yields from harvesting could be increased if equipment could operate on the growing surface. There are areas such as dredge disposal sites that have sandy bottoms that can support harvesting equipment. However there are also marsh and mucky areas where no equipment can be supported, and areas where the marsh surface is too soft to support even foot traffic. In the absence of survey data or accurate inventory information, the harvesting rates and areas that can be suitably and economically harvested have been assumed, as indicated in Table 4. The project delivery team has attempted to be conservative in estimating how much Phragmites can be harvested, while honoring the wishes of regulatory personnel to minimize disturbance of the plants, habitat, and growing surfaces.

If the City decides to pursue the harvesting of Phragmites for Chesapeake Bay TMDL purposes, accurate recording keeping and experience gained during the first two to five years of operations should close the gap between these early estimates and what can actually be harvested—and the costs to conduct these operations.

Given what appears to be a strong and growing regional market for biofuel material, the City might be able to generate some revenue to offset the harvesting costs. The project delivery team was not authorized to make any inquiries in this regard, and did not attempt to contact any potential biofuel producers or biomass consumers.

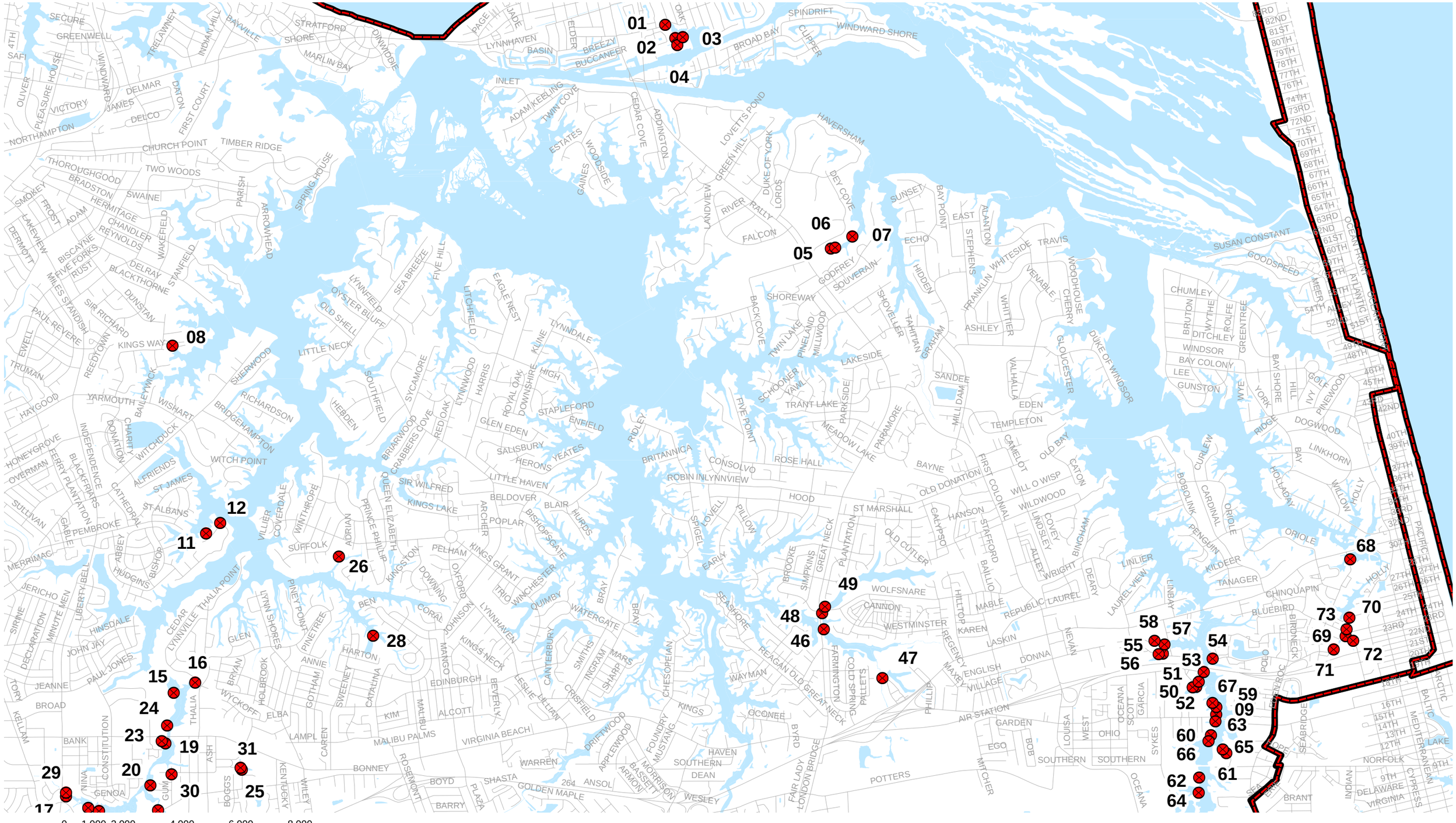
Findings or recommendations contained herein do not constitute Corps of Engineers approval of any project(s) or eliminate the need to follow normal regulatory permitting processes.

Contact Information

Steve McLaughlin (757.385.4783) served as the project manager for the City of Virginia Beach.

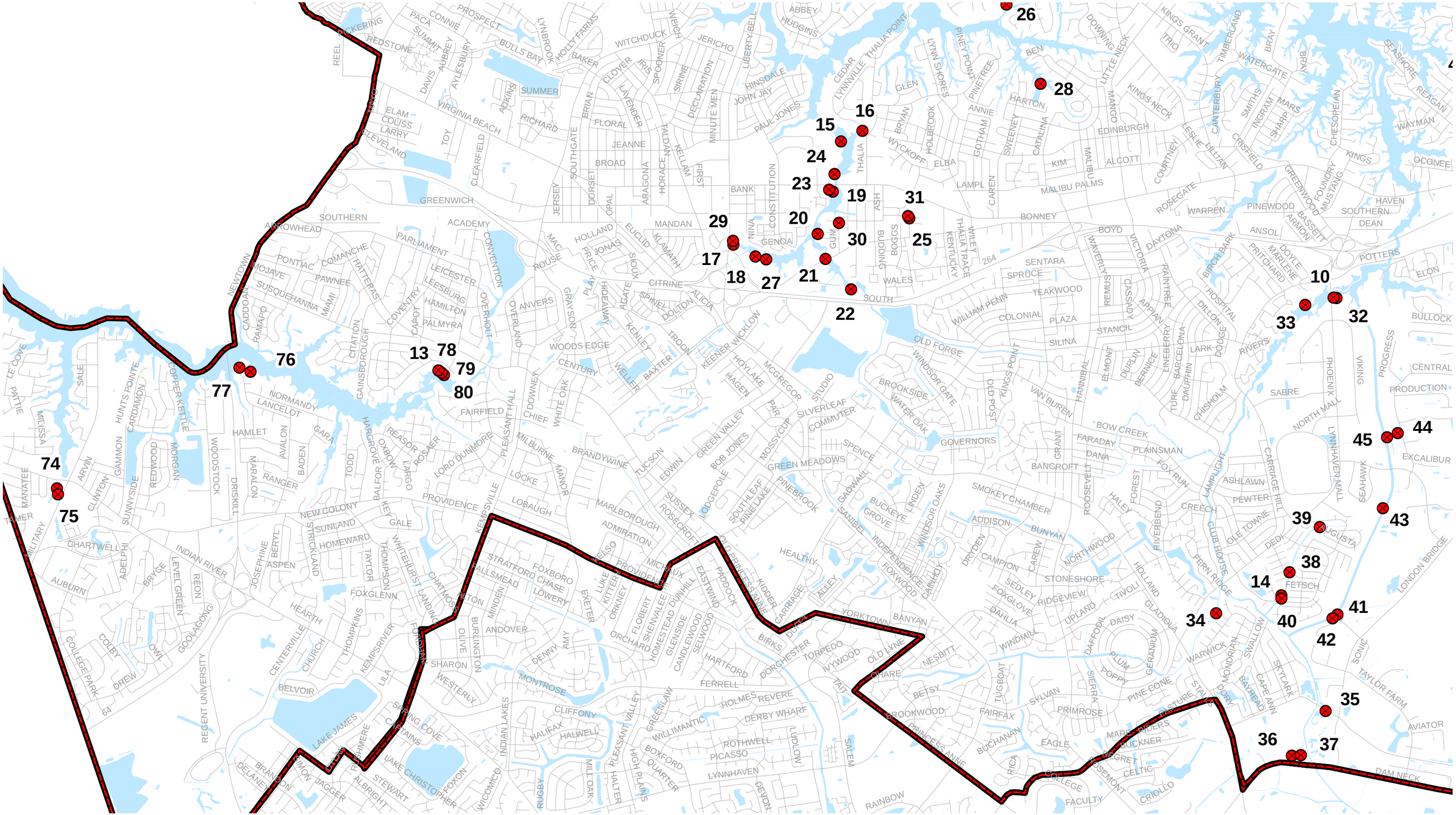
Mark Mansfield coordinated the project, and Susan Conner served as the Contracting Officer's Representative for the Corps of Engineers, Norfolk District (757.201.7390).

Sean Bradberry and Stephanie Hood served as the project engineers, and John Paine as the project manager for URS (757.873.0559).



See GIS for Complete Details

Figure 1.1. Sampling Location Map



See GIS for Complete Details

Figure 1.2. Sampling Location Map

See GIS for Complete Details

Figure 2.1. Dry Weight Inventory Map

See GIS for Complete Details

Figure 2.2. Dry Weight Inventory Map

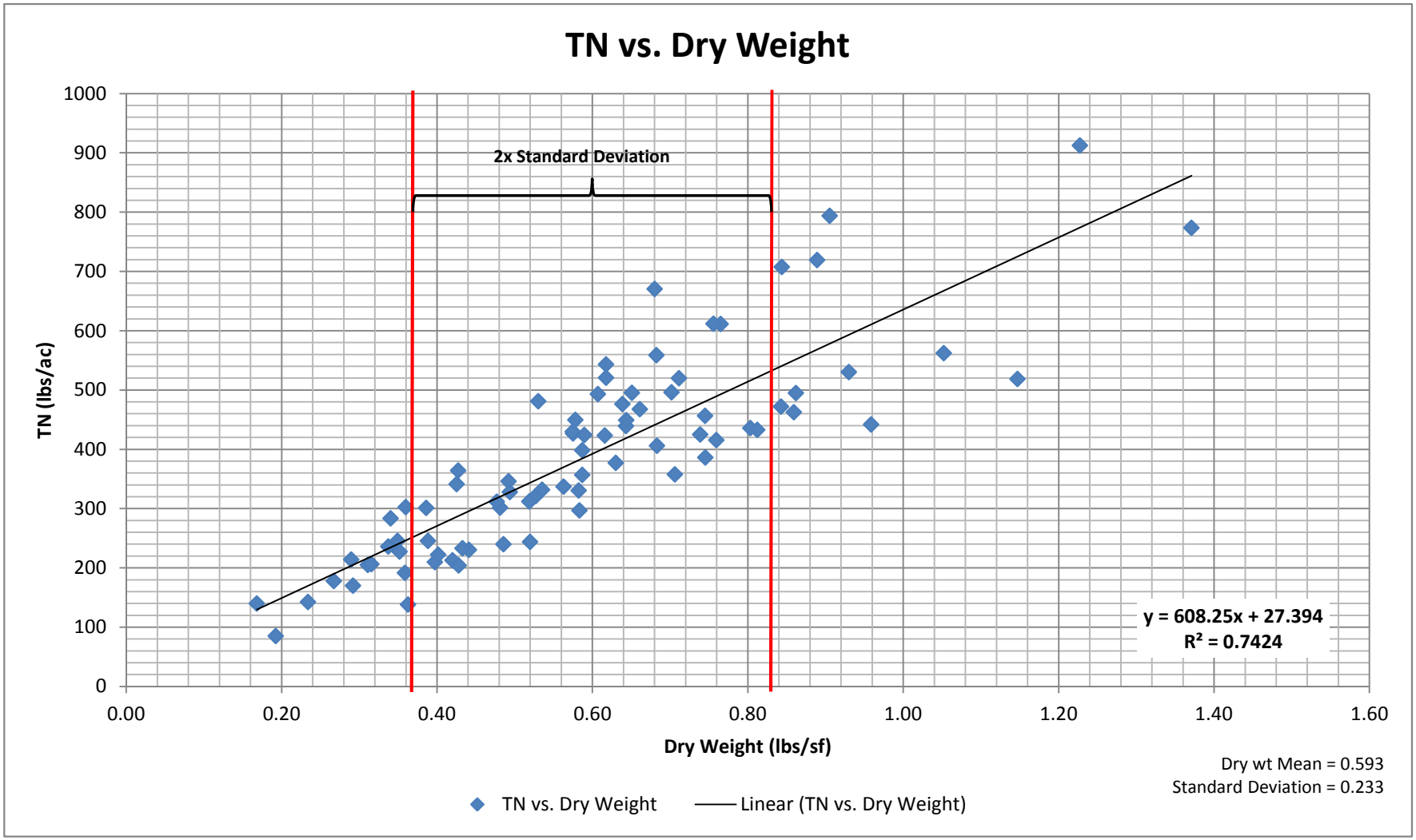


Figure 3. TN vs. Dry Weight

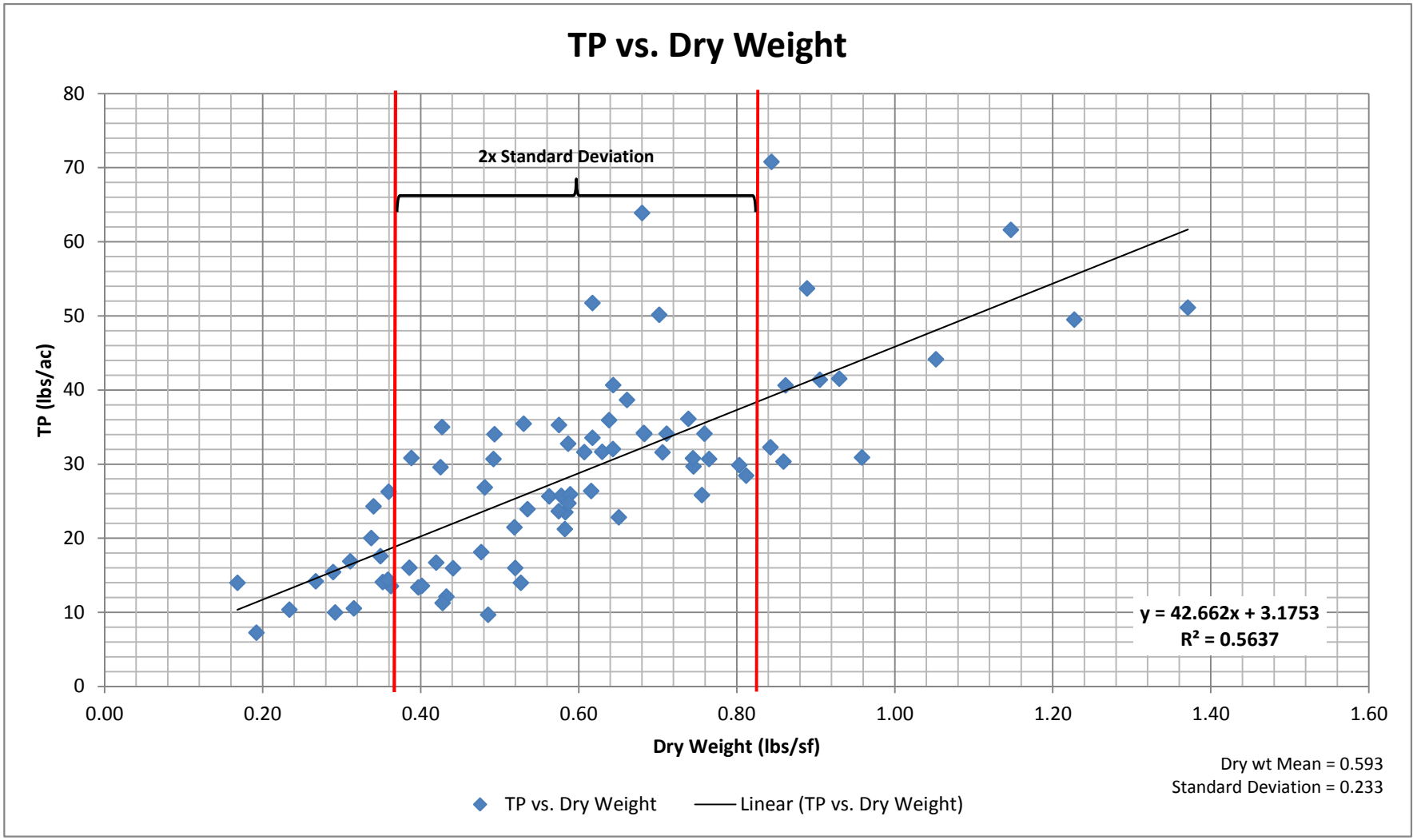


Figure 4. TP vs. Dry Weight

Figure 5. Examples of Cutting Equipment

Table 1. Dry Weight Ranges			
Yield Category	**Range (lbs./s.f.)**		
Low	0.168	-	0.360
Medium	0.360	-	0.826
High	0.826	-	1.371

Table 2. Average Yield Rates			
Yield Category	**Dry Wt. (lbs./s.f.)**	**Removal (lbs./ac.)**	
		TN	**TP**
Low	0.298	202	15
Medium	0.582	386	28
High	0.991	616	46

Table 3. Harvesting Cost Opinion

Item	Description	Quantity	Unit	Unit Cost	Total
1	Articulated Boom Arm Mowing Equipment Per Day	8	Hr	$90	$720
2	Truck/Tractor Mounted Grapple	8	Hr	$75	$600
3	Manual Labor (8 Man Crew)	64	Hr	$12	$768
4	Debris Haul to Central Collection Point (0-15 miles, Tandem Dump Truck)	270	CY	$7	$1,890
5	Debris Haul From Collection Point To Final Disposition (30-60 miles, Semi Tractor Trailer)	270	CY	$8	$2,160
6	Traffic Control	1	Day	$150	$150
	Crew Cost Per Day for 1/2 Acre Harvested				$6,288
7	Harvesting of 33 Acres of Phragmites	66	Day	6288	$415,008
8	Contingency	20	%	$83,001.60	$83,002
				Total Cost	**$498,010**

Assumptions:

1. Cubic yards of material/day to haul based on estimate of 1/2 acre harvested and stalk density of 10 stalks/ft^2 or ground of approximately .027 ft^2 (approx. 4"x4"x3").
2. Due to equipment transport from one harvest site to the next, it was assumed that approximately 1/2 acre could be harvested per day.
3. A contingency of 20% was added considering this type of harvesting is new, and equipment requirements or field conditions may alter harvesting methods, protocols, or yields.

Table 4. Potential Chesapeake Bay TMDL Pollutant Reduction

Sample Location	Included Sample Locations	Dry-weight Category	Ave. Yield Rates (lbs/ac)		Approx. Area of Phragmites (ac)	Percentage of Harvestable Area	Potential Reductions (lbs)		Description of Surrounding Property	Potential Harvest Process
			TN	TP			TN	TP		
1	1	Low	202	15	0.96	15	29	2	City-owned Property	Use boom mower
2	2	Medium	386	28	0.98	65	246	18	City-owned Property	Sandy bottom - use tractor during dry conditions
3	3	Low	202	15	1.13	65	148	11	City-owned Property	Sandy bottom - use tractor during dry conditions
4	4	High	616	46	0.77	65	308	23	City-owned Property	Sandy bottom - use tractor during dry conditions
5	5	Medium	386	28	0.90	65	226	16	Golf Course with property easements	Use boom mower/tractor
6	6	Medium	386	28	0.37	65	94	7	Golf Course with property easements	Use boom mower/tractor
7	7	High	616	46	1.14	50	352	26	Golf Course with property easements	Use boom mower/tractor
8	8	Medium	386	28	0.21	0	0	0	Private Property w/easement	No passing on driveway
9	09	Medium	386	28	9.67	15	560	41	City-owned/Private w/easement Property	Use boom mower/tractor
10	10	High	616	46	0.11	25	16	1	Private Property w/easement	Use boom mower
11	11	Low	202	15	0.12	0	0	0	Private Property w/easement	No easy equipment access from street - hand cut
12	12	Low	202	15	0.19	0	0	0	Private Property w/easement	No easy equipment access from street - hand cut
13	13, 78	Low	202	15	0.30	0	0	0	Private Property - no easement	
14	14	Medium	386	28	0.22	70	60	4	City-owned Property	Use boom mower
15	15	Medium	386	28	3.50	25	338	25	City-owned Property	Use tractor during dry conditions
16	16	Medium	386	28	0.67	10	26	2	City-owned Property	Use boom mower
17	17	High	616	46	0.29	70	124	9	City-owned Property	No easy equipment access - hand cut
18	18	Medium	386	28	0.85	25	82	6	City-owned/Private w/easement Property	No easy equipment access - hand cut
19	19	Medium	386	28	0.63	0	0	0	Private Property - no easement	
20	20	Low	202	15	0.32	0	0	0	Private Property - no easement	
21	21	Medium	386	28	0.08	0	0	0	Private Property - no easement	
22	22	Medium	386	28	2.47	70	668	48	City-owned Property	Use tractor during dry conditions
23	23	Medium	386	28	0.29	0	0	0	Private Property - no easement	
24	24	Medium	386	28	0.30	10	11	1	Private Property w/easement	Use boom mower
25	25	Medium	386	28	0.37	70	101	7	Private Property w/easement	Use tractor during dry conditions
26	26	Low	202	15	0.35	50	36	3	City-owned Property	No easy equipment access from street - hand cut
27	27	Medium	386	28	0.46	25	44	3	City-owned/Private w/easement Property	No easy equipment access - hand cut
28	28	Low	202	15	0.19	50	19	1	City-owned Property	No easy equipment access from street - hand cut
29	29	Medium	386	28	0.30	70	81	6	Private Property w/easement	No easy equipment access - hand cut
30	30	Medium	386	28	0.53	10	20	1	Rail Road Right-of-way	Use boom mower/tractor at the end of Gum Ave.
31	31	Low	202	15	0.31	70	44	3	Private Property w/easement	Use tractor during dry conditions
32	32	Medium	386	28	1.06	30	122	9	City-owned/Private w/easement Property	Use tractor during dry conditions
33	33	Low	202	15	6.78	25	343	25	Private Property w/easement	Use tractor during dry conditions
34	34	Low	202	15	0.31	70	44	3	Private Property w/easement	Use boom mower
35	35	Medium	386	28	0.19	70	52	4	City-owned/Private w/easement Property	Use boom mower
36	36	Medium	386	28	0.59	70	160	12	City-owned Property	Use tractor during dry conditions
37	37	Medium	386	28	0.43	70	116	8	City-owned Property	Use tractor during dry conditions
38	38	Medium	386	28	0.20	60	47	3	City-owned Property	Use boom mower
39	39	Medium	386	28	0.45	60	105	8	City-owned/Private w/easement Property	Use boom mower
40	40	Medium	386	28	0.35	60	81	6	City-owned Property	Use boom mower
41	41	Low	202	15	1.64	50	165	12	City-owned Property	Use boom mower
42	42	Medium	386	28	1.16	60	269	20	City-owned Property	Use boom mower

Table 4. Potential Chesapeake Bay TMDL Pollutant Reduction

Sample Location	Included Sample Locations	Dry-weight Category	Ave. Yield Rates (lbs/ac)		Approx. Area of Phragmites (ac)	Percentage of Harvestable Area	Potential Reductions (lbs)		Description of Surrounding Property	Potential Harvest Process
			TN	TP			TN	TP		
43	43	Medium	386	28	1.67	30	194	14	City-owned/Private w/easement Property	Use boom mower
45	44, 45	Medium	386	28	5.66	35	764	55	City-owned/Private w/easement Property	Use boom mower/tractor
46	46	Medium	386	28	5.42	15	314	23	City-owned/Private w/easement Property	Use tractor during dry conditions
47	47	Medium	386	28	4.64	0	0	0	Private Property - no easement	
48	48	High	616	46	0.29	40	70	5	Private Property w/easement	Use boom mower
49	49	High	616	46	8.02	25	1235	92	Private Property w/easement	Use tractor during dry conditions
50	50	High	616	46	0.76	55	256	19	Private Property w/easement	Use tractor during dry conditions
51	51	High	616	46	2.06	50	635	47	Private Property w/easement	Use tractor during dry conditions
54	54	Medium	386	28	1.69	0	0	0	Private Property - no easement	
55	55	Medium	386	28	0.92	0	0	0	Private Property - no easement	
56	56	Medium	386	28	0.60	0	0	0	Private Property - no easement	
57	57	High	616	46	0.18	50	56	4	Private Property w/easement	Use tractor during dry conditions
58	58	Medium	386	28	0.75	50	146	11	City-owned Property	Use tractor during dry conditions
59	59	Low	202	15	0.99	10	20	1	Private Property w/easement	Use boom mower/tractor
60	60	High	616	46	1.31	25	202	15	Private Property w/easement	Use boom mower/tractor
61	61	Medium	386	28	0.23	10	9	1	Private Property w/easement	Use boom mower/tractor
62	62, 64	High	616	46	10.91	20	1345	100	City-owned/Private w/easement Property	Use boom mower/tractor
63	63	Medium	386	28	1.76	25	170	12	Private Property w/easement	Use boom mower/tractor
65	65-66	Medium	386	28	15.24	10	588	43	Private Property w/easement	Use boom mower/tractor
67	52, 53, 67	Medium	386	28	3.70	20	286	21	Private Property w/easement	Use boom mower/tractor
68	68	Medium	386	28	0.59	0	0	0	Private Property - no easement	
69	69	Medium	386	28	0.98	50	190	14	City-owned Property	No easy equipment access from street - hand cut
70	70	Medium	386	28	1.00	10	39	3	City-owned/Private w/easement Property	No easy equipment access from street - hand cut
71	71	Medium	386	28	0.94	50	182	13	City-owned Property	No easy equipment access from street - hand cut
72	72	Medium	386	28	0.11	50	22	2	City-owned Property	No easy equipment access from street - hand cut
73	73	Medium	386	28	0.60	50	115	8	City-owned Property	No easy equipment access from street - hand cut
74	74, 75	Medium	386	28	1.13	55	240	17	Private Property w/easement	No easy equipment access - hand cut
76	76, 77	Medium	386	28	8.79	40	1357	98	Private Property w/easement	Use tractor during dry conditions-Great harvest location access at end of Lancelot Dr & Healey Dr.
79	79, 80	Medium	386	28	0.12	50	23	2	City-owned/Private w/easement Property	No easy equipment access - hand cut
						Total Reduction (lbs) =	**13,597**	**998**		

Table 5. Corps Permitting Matrix

Chesapeake Bay TMDL Activity	Corps Jurisdictions and Associated Permitting Action		
	Waters Regulated under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean water Act (All Tidal waters and/or waters the Corps or a federal Court has determined are presently used, or have been used in the past or may be susceptible to use to transport interstate or foreign commerce.	**Waters Regulated under Section 404 of the Clean Water Act only (All waters that meet the definition of "Waters of the US" but are not Regulated under RHA Section 10)**	**Isolated Waters where the Corps has determined no CWA or RHA jurisdiction exists**
Planted Wetlands	Corps authorization required. Approvals/permits from local wetlands board and/or DEQ likely required.	Corps authorization required. Approvals/permits from local wetlands board and/or DEQ likely required.	Corps authorization not required. Approvals/permits from local wetlands board and/or DEQ may be required.
Pruning of Phragmites (cutting above substrate surface with hand tools)	Corps authorization not required. Approvals/permits from local wetlands board and/or DEQ may be required.	Corps authorization not required. Approvals/permits from local wetlands board and/or DEQ may be required.	Corps authorization not required. Approvals/permits from local wetlands board and/or DEQ may be required.
Seeding	Corps authorization probably not required. Approvals/permits from local wetlands board and/or DEQ may be required.	Corps authorization probably not required. Approvals/permits from local wetlands board and/or DEQ may be required.	Corps authorization not required. Approvals/permits from local wetlands board and/or DEQ may be required.

Notes:

1. This table was prepared informally for broad planning purposes. The Corps of Engineers recommends contacting the appropriate agencies for site and case specific determinations before beginning any work in Waters of the U.S. including Navigable Waters.
2. The Corps contact for the City of Virginia Beach is Lynette Rhodes (757) 201-7727.

Table 6. Comparative Treatment Costs

Source: City of Virginia Beach, Public Works

BMP [1]	Annual Estimated Cost Per Pound of Pollutant Removed (2012 Dollars)		
	Cost for Removal of Total Nitrogen (TN)	Cost for Removal of Total Phosphorous (TP)	Cost for Removal of Total Suspended Solids (TSS)
Sanctuary Oyster Reef [2] (Reconstruction/Renovation Every **5** Years)	50 to 100	N/A	0.50 to 1.50
Sanctuary Oyster Reef [2] (Reconstruction/Renovation Every **10** Years)	25 to 50	N/A	0.25 to 1.00
Boat Pumpouts in No Discharge Zone [3]	15 to 75	200 to 1,000	20 to 250
Phragmites Harvesting [4]	25 to 150	500 to 1,500	N/A
Stream Restoration [5]	400 to 750	2,500 to 5,000	5 to 8
Stream Bank Stabilization [5]	400 to 750	2,500 to 5,000	5 to 8
Bioretention Basin [6]	300 to 600	3,000 to 4,000	10 to 15
Pond [7]	500 to 2,000	4,000 to 8,000	15 to 75
Cistern [8]	5,500 to 9,500	45,000 to 85,000	700 to 1,000

Notes:

1. The estimated pollutant removal costs do not include land acquisition or easement fees required for construction and/or maintenance of the BMPs.

2. Sanctuary Oyster Reef removal estimates based upon Nitrogen removal rates of 200 pounds Total Nitrogen / Acre / Year and Total Suspended Solids removal rates of 20,000 pounds Total Suspended Solids / Acre / Year with no Phosphorus change, at a construction/renovation cost of $50,000 to $100,000 per Acre with oyster spat on shell planted annually or bi-annually.

3. Boat Pumpout in No Discharge Zone costs are based on estimates of removal rates of 0.014 lbs./gal. for TN, 0.001 lbs./gal. for TP and 0.01 to 0.001 lbs./gal. for TSS. The annual pumpout volume was calculated assuming 3 twenty-five gallon pumpouts per hour at pumpout facility, 12 hours per day for 260 days per year. A capital outlay of $50,000 every 10 years was assumed, as well as a $5 fee per pumpout per the Clean Vessel Act.

Table 6. Comparative Treatment Costs

Source: City of Virginia Beach, Public Works

4. Nitrogen and phosphorus removal costs for harvesting phragmites were estimated assuming the harvest of 33 acres with a maximum total yield of approximately 13,500 lbs. of nitrogen and approximately 1,000 lbs. of phosphorous. Harvest rates were assumed to be 1/2 acre per day. Harvest costs include cutting and transport of the biomass out of the Chesapeake Bay watershed.

5. Stream Restoration and Stream Bank Stabilization estimates based upon Center for Watershed Protection work with reconstruction/renovation at full original construction cost every 5 to 10 years.

6. Biorention Basin estimates based upon Center for Watershed Protection work with reconstruction/renovation at full original construction cost every 2.5 to 3 years.

7. Average annual pollutant removal costs for ponds for a 10 year period assuming reconstruction/retrofitting equal to the original construction cost after 10 years. Maintenance costs for the 10 year period were assumed to be 10% of the original construction cost.

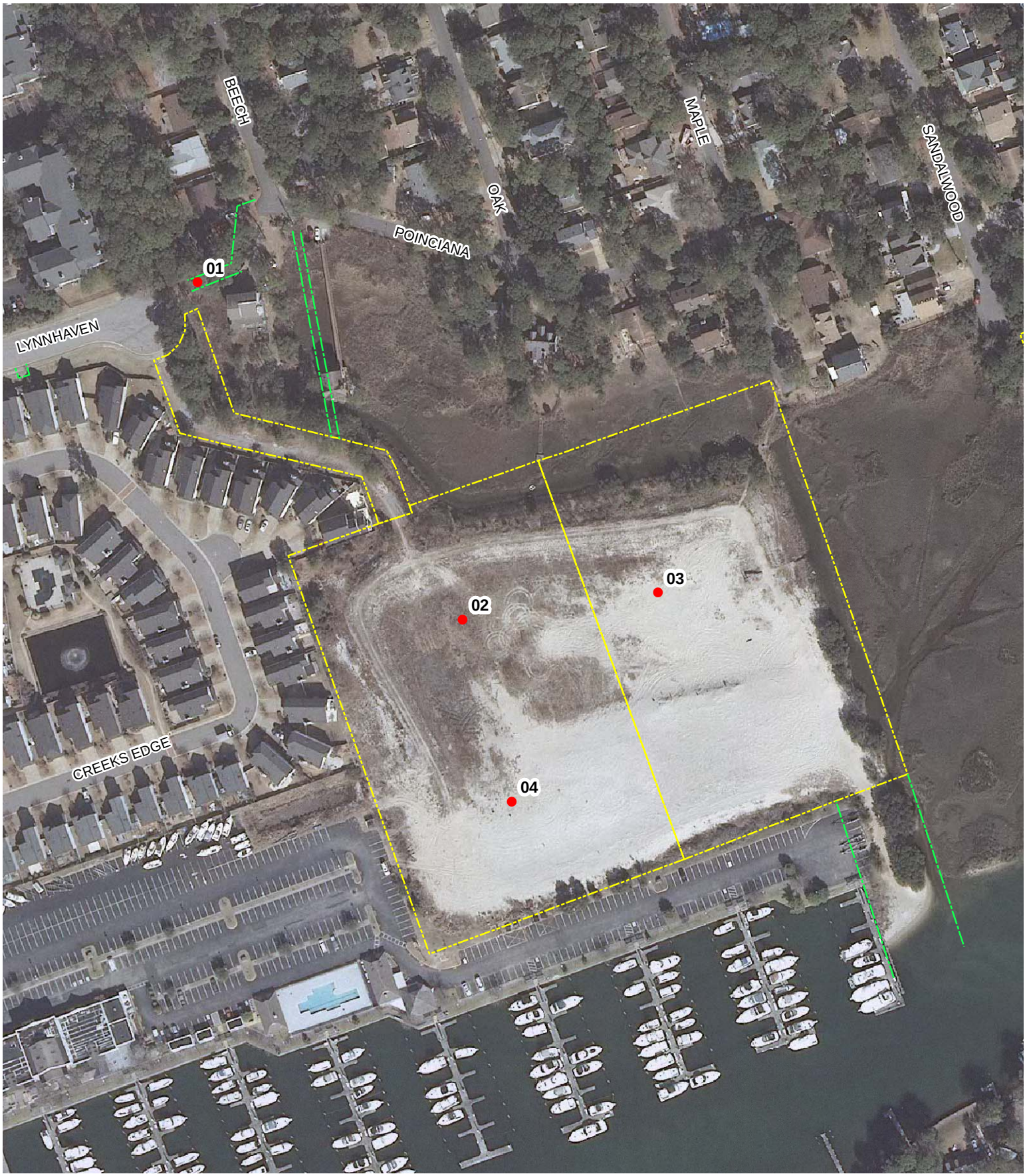
8. Cistern estimates based upon Center for Watershed Protection work, does not include pumps, piping, controls needed for use of the water.

Appendix A

Detailed Sampling Locations

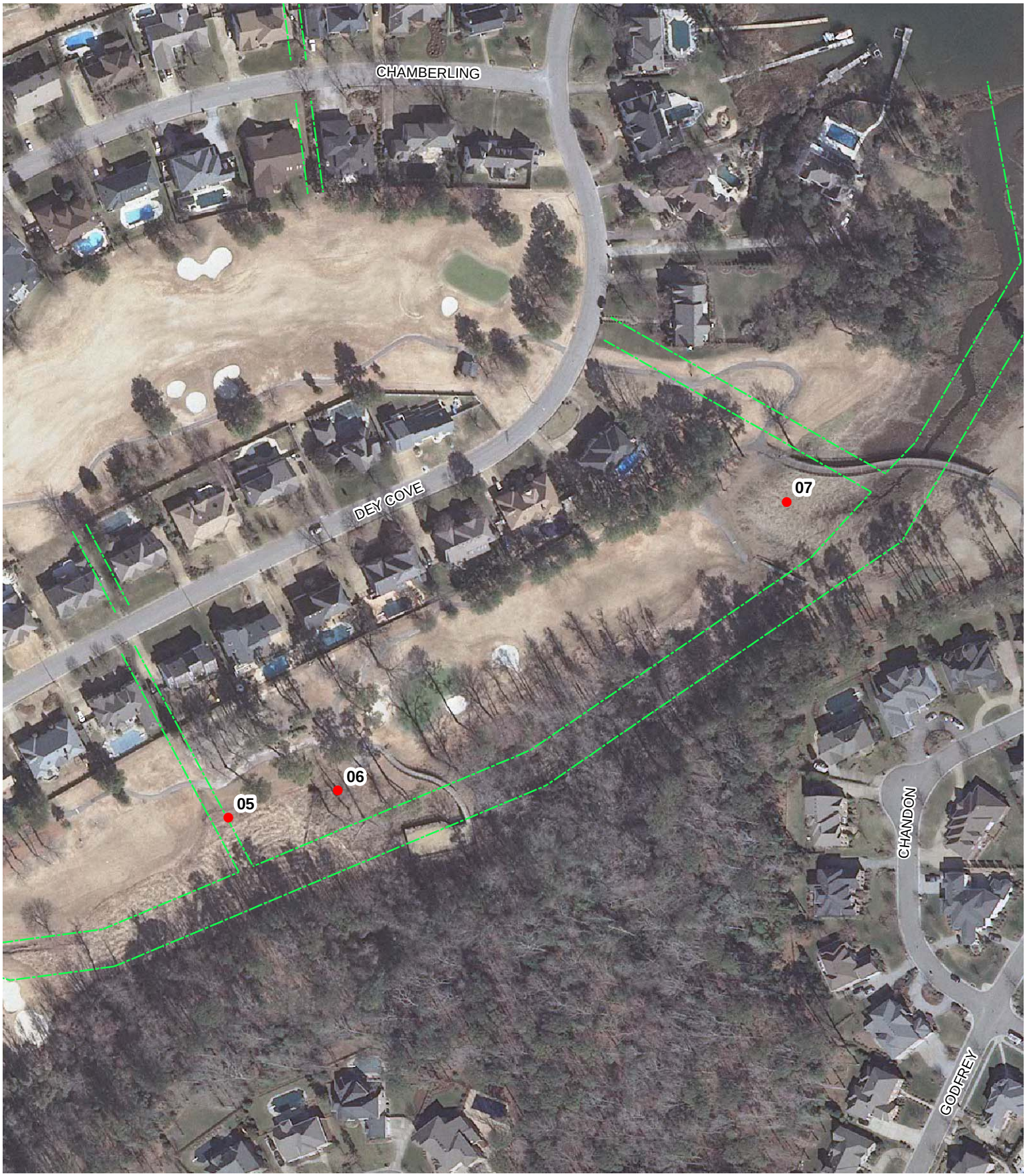
US Army Corps
of Engineers
Norfolk District

URS



See GIS for Complete Details

Figure A.1. Detailed Sampling Locations



0 40 80 160 240 320
Feet

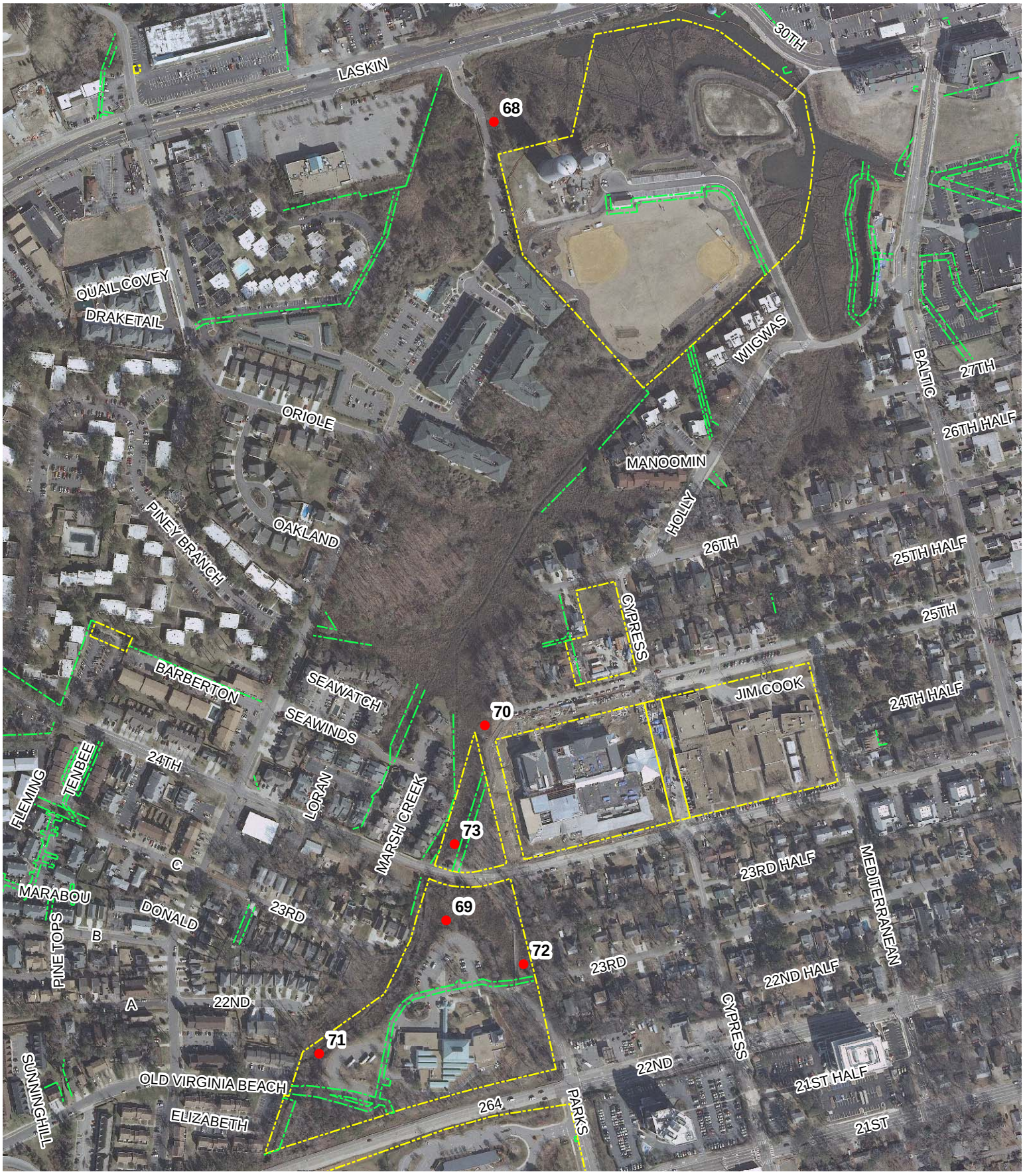
N

Legend

- Sample Locations
- Property Easements
- City Owned Property

See GIS for Complete Details

Figure A.2. Detailed Sampling Locations



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Feet

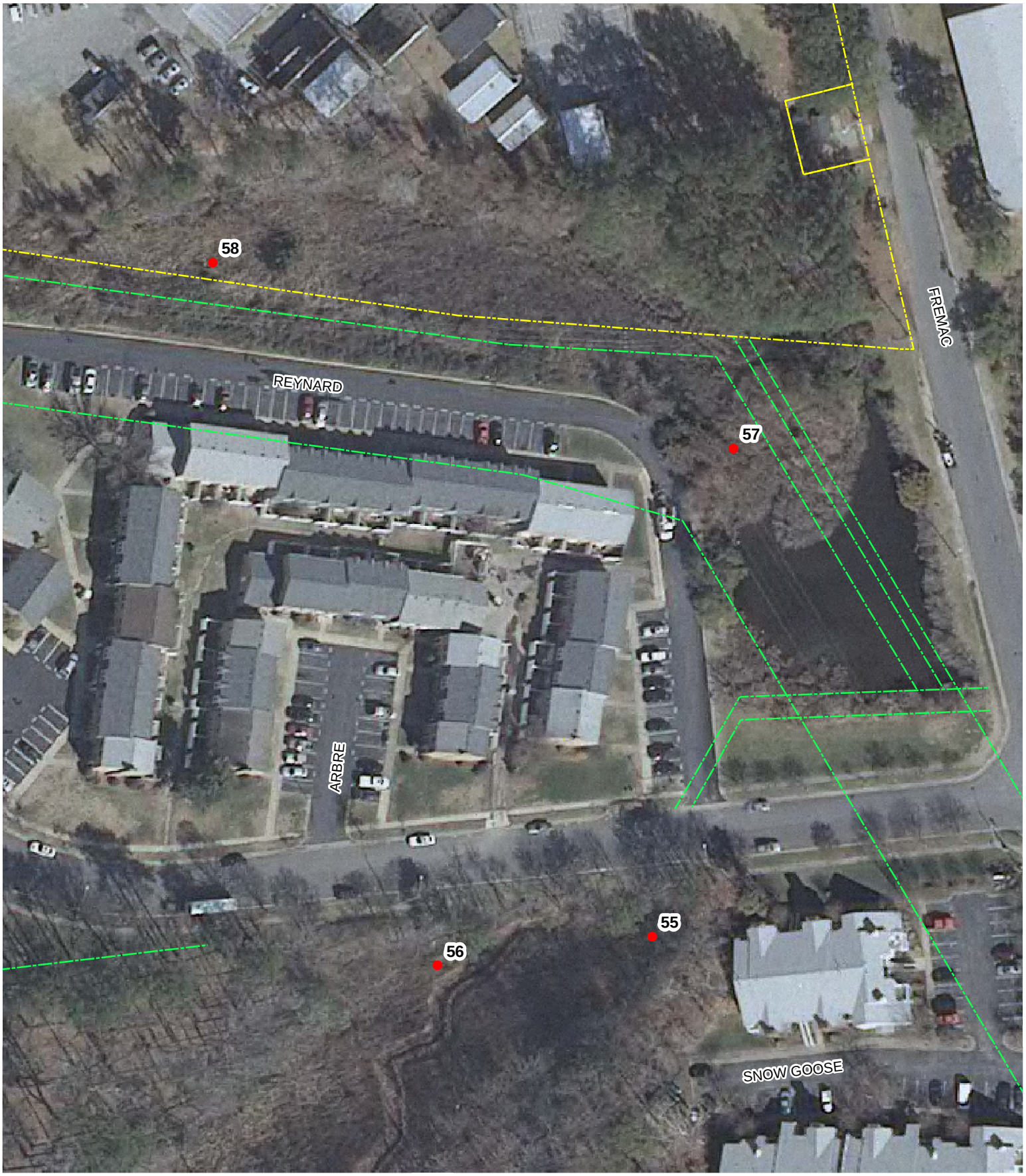
N

Legend

- Sample Locations
- Property Easements
- City Owned Property

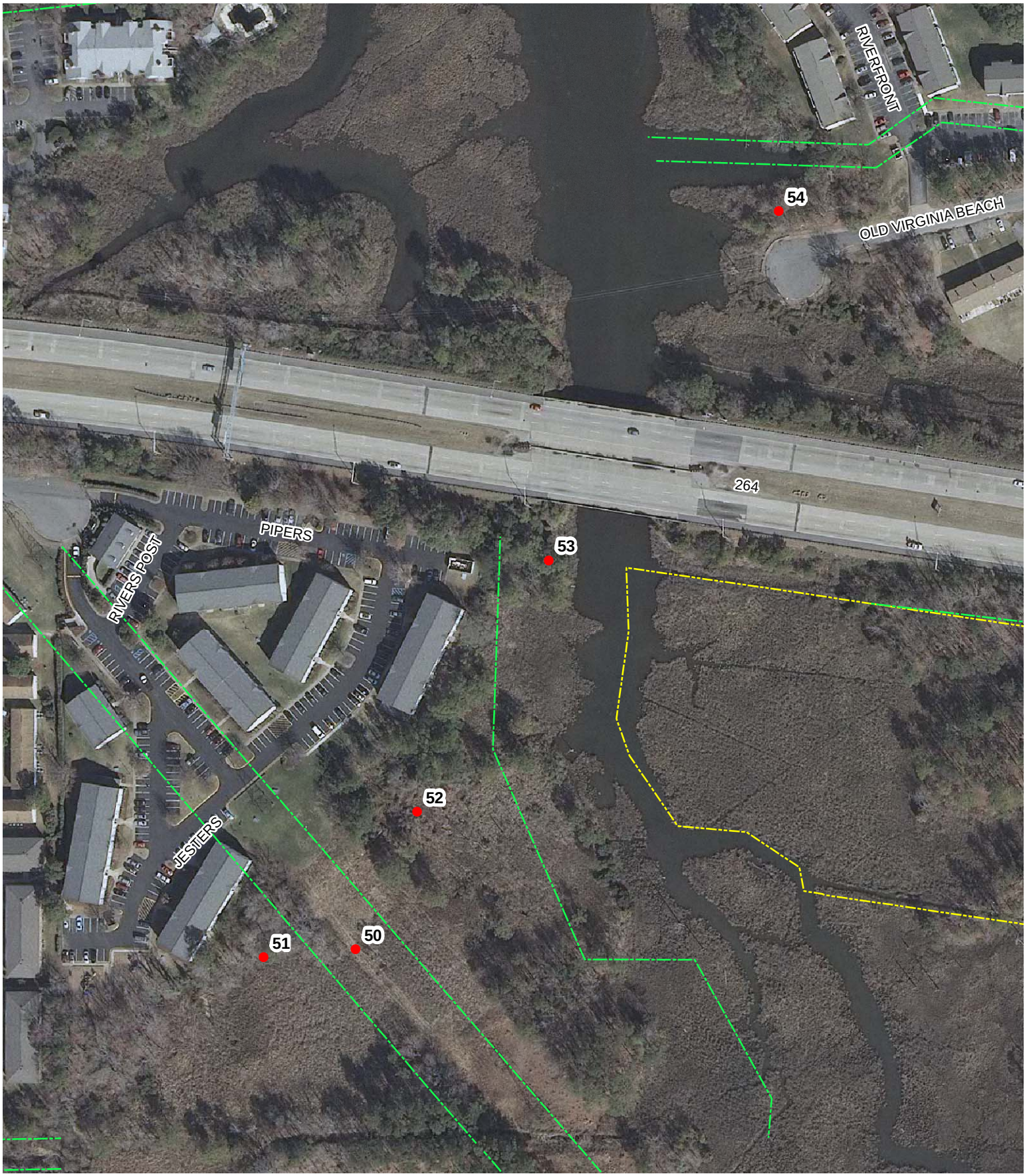
See GIS for Complete Details

Figure A.3. Detailed Sampling Locations



See GIS for Complete Details

Figure A.4. Detailed Sampling Locations



See GIS for Complete Details

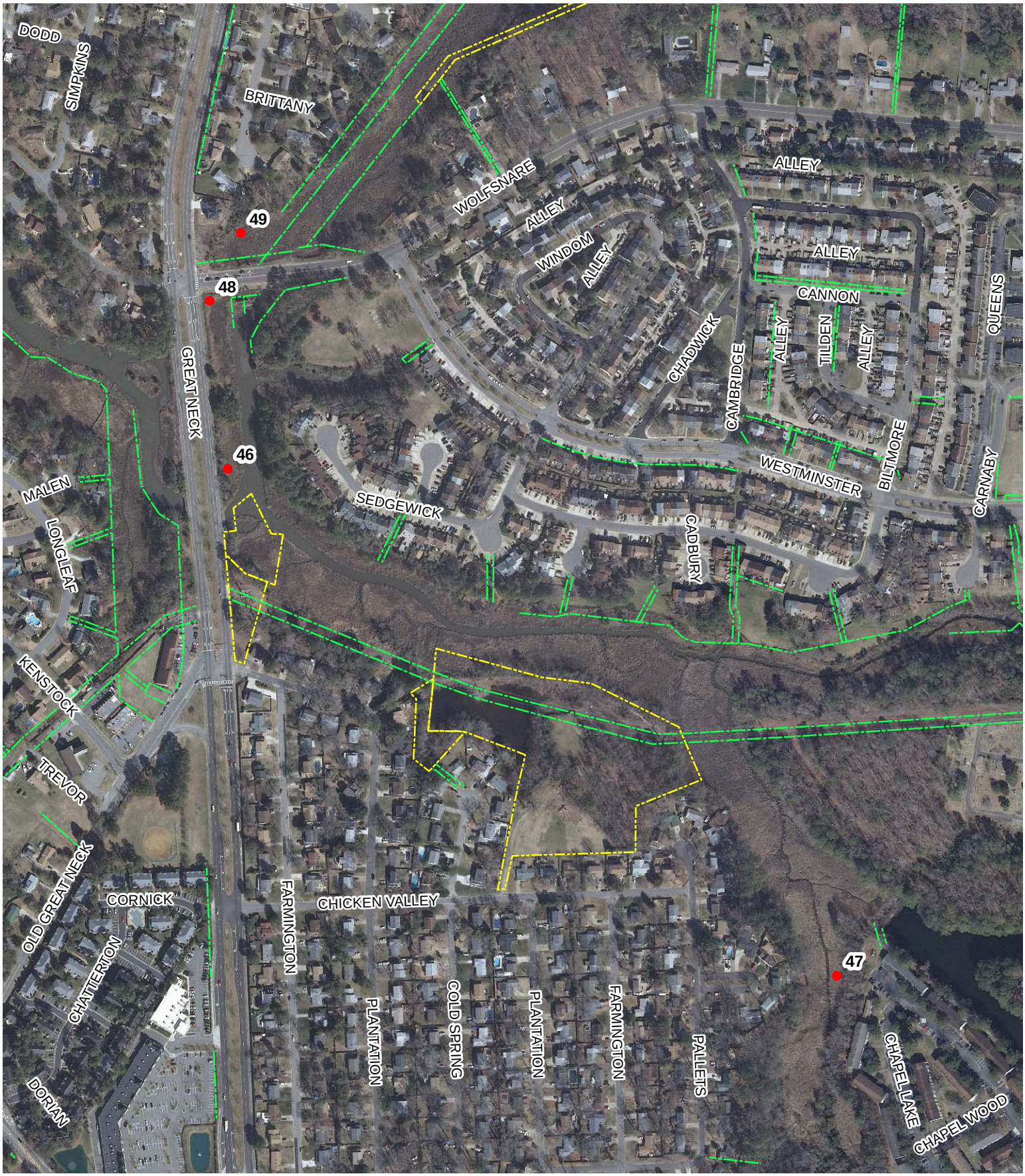
Figure A.5. Detailed Sampling Locations

See GIS for Complete Details

Figure A.6. Detailed Sampling Locations

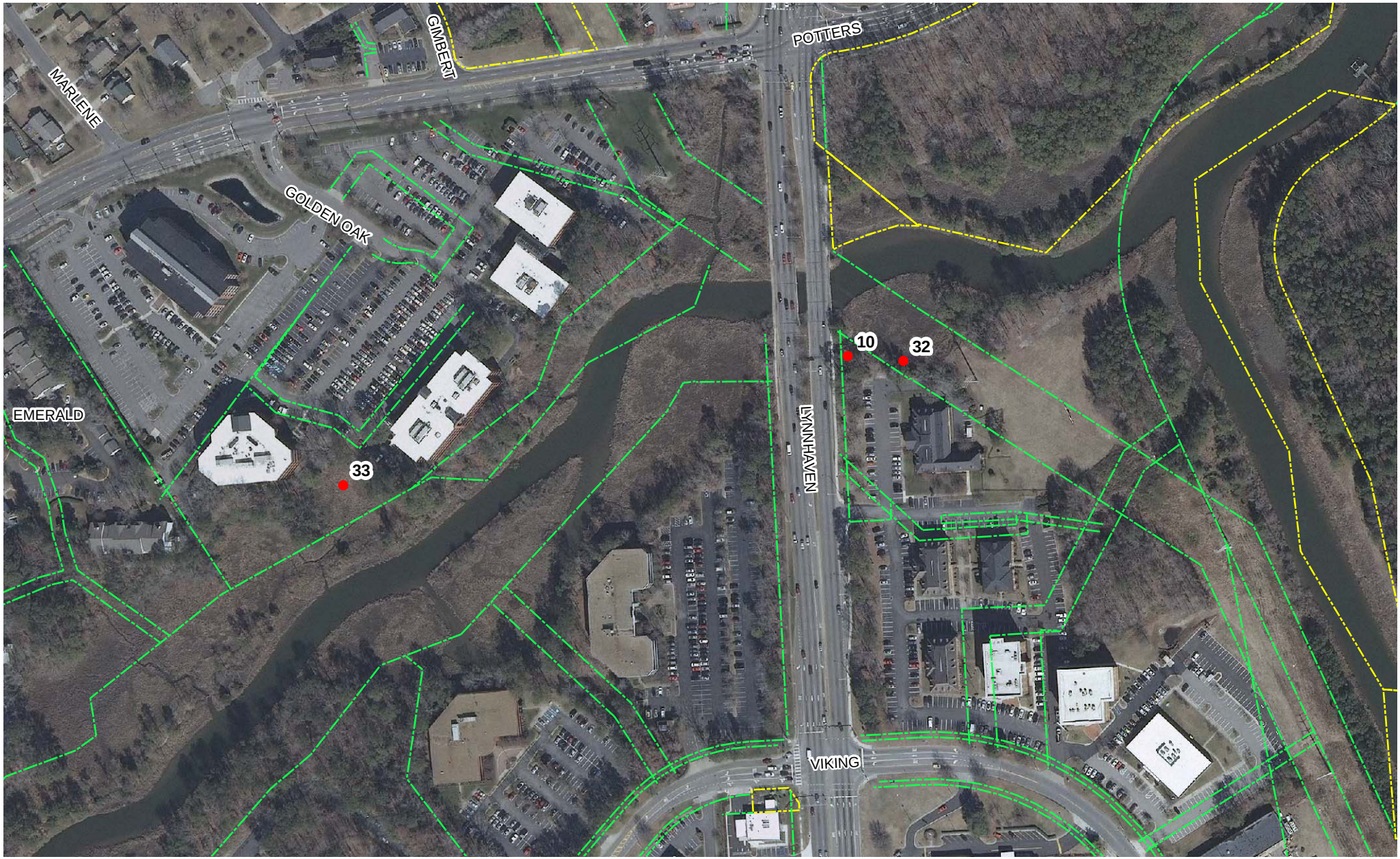
See GIS for Complete Details

Figure A.7. Detailed Sampling Locations



See GIS for Complete Details

Figure A.8. Detailed Sampling Locations



See GIS for Complete Details

Figure A.9. Detailed Sampling Locations

0 80 160 320 480 640

Feet

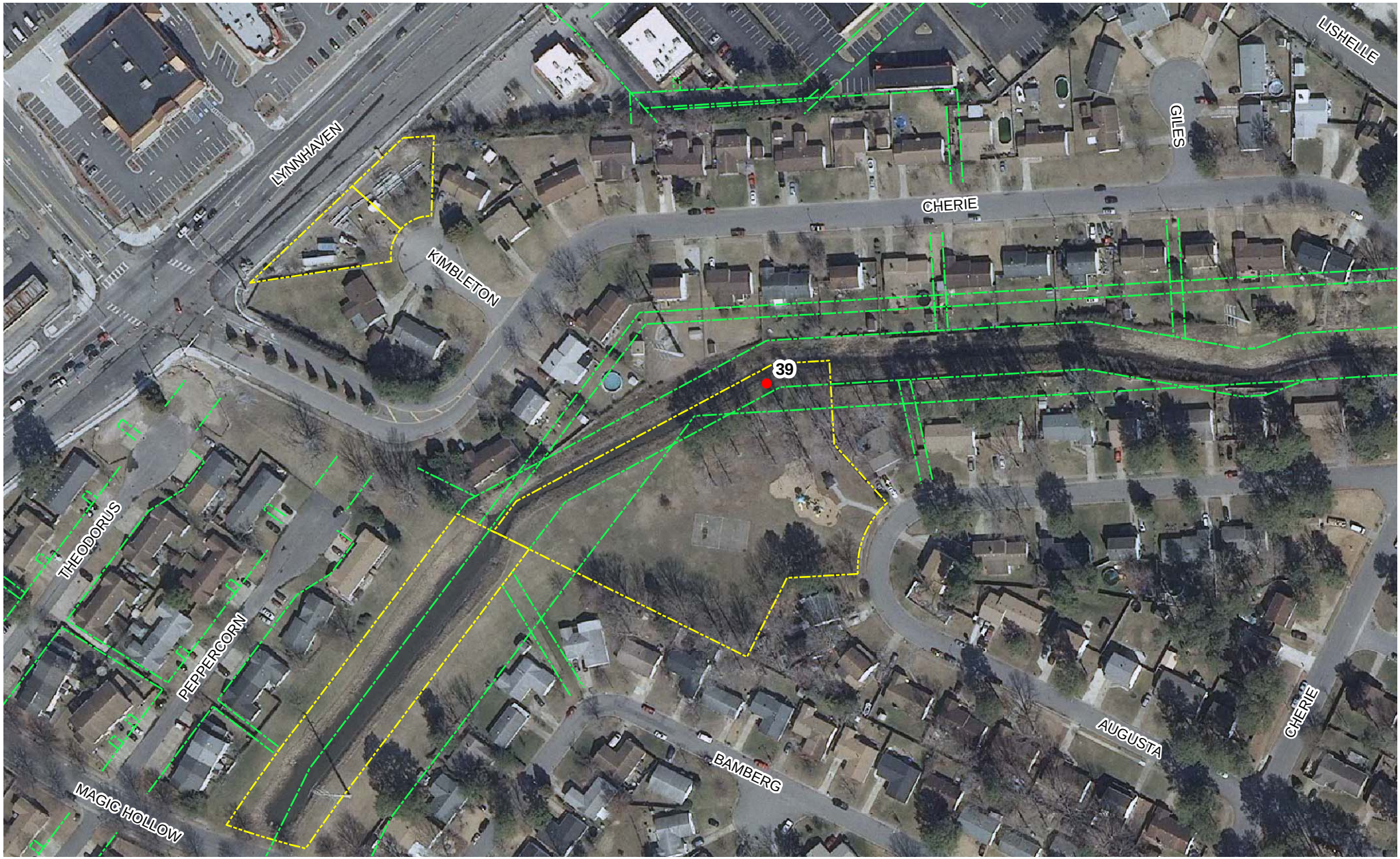
N

See GIS for Complete Details

Legend

- Sample Locations
- Property Easements
- City Owned Property

Figure A.10. Detailed Sampling Locations



See GIS for Complete Details

Figure A.11. Detailed Sampling Locations

See GIS for Complete Details

Figure A.12. Detailed Sampling Locations

See GIS for Complete Details

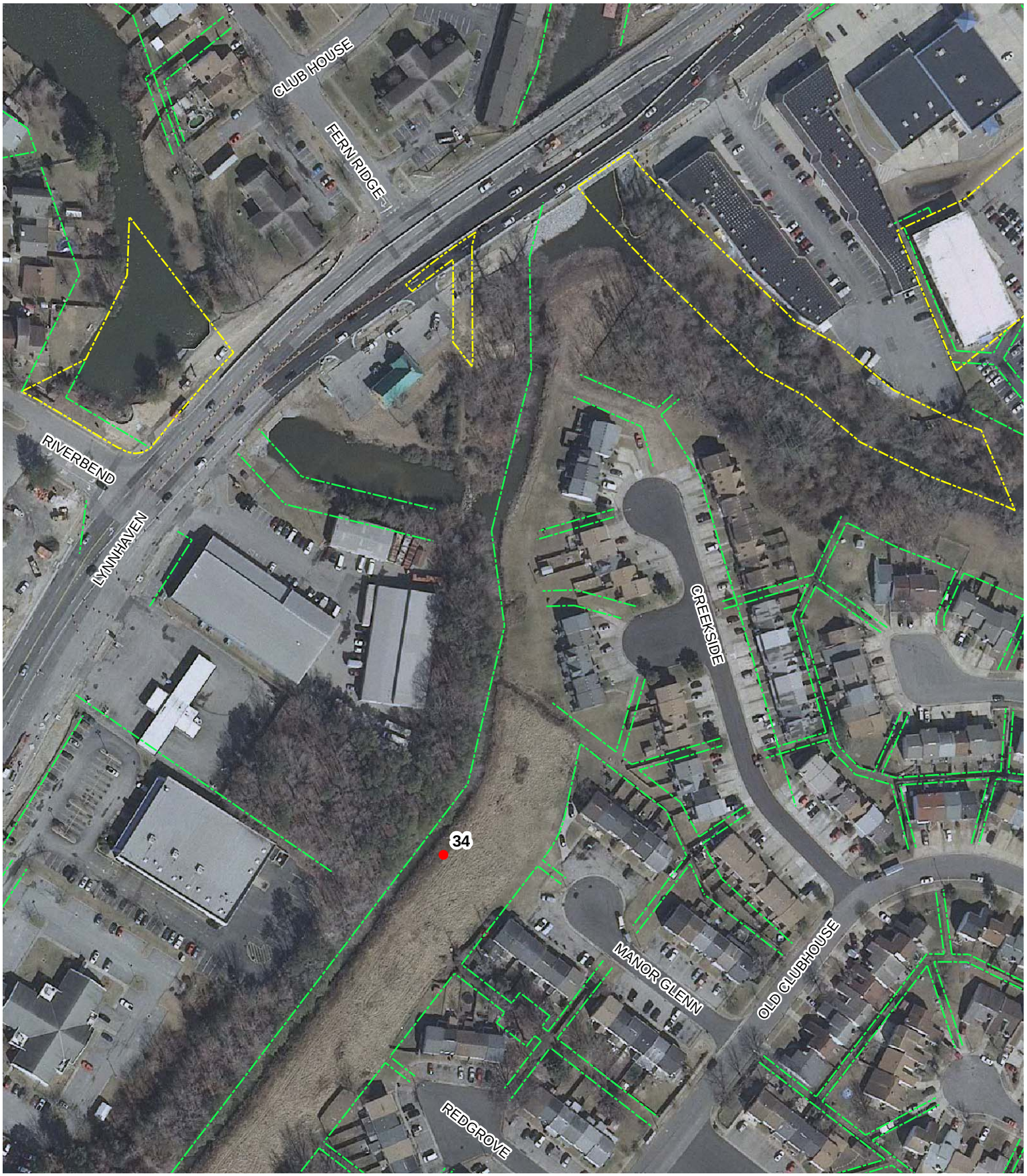
Figure A.13. Detailed Sampling Locations

See GIS for Complete Details

Figure A.14. Detailed Sampling Locations

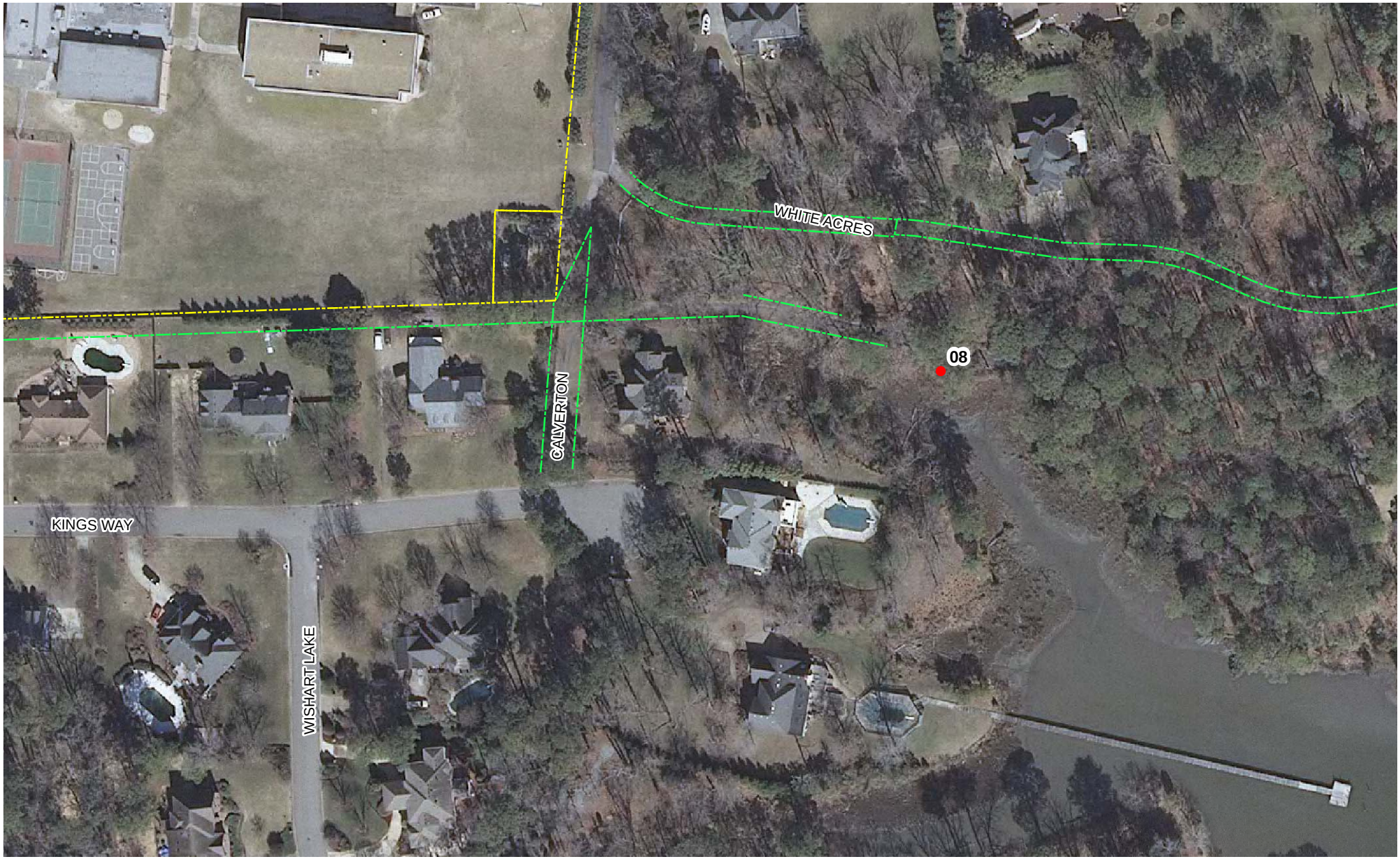
See GIS for Complete Details

Figure A.15. Detailed Sampling Locations



See GIS for Complete Details

Figure A.16. Detailed Sampling Locations

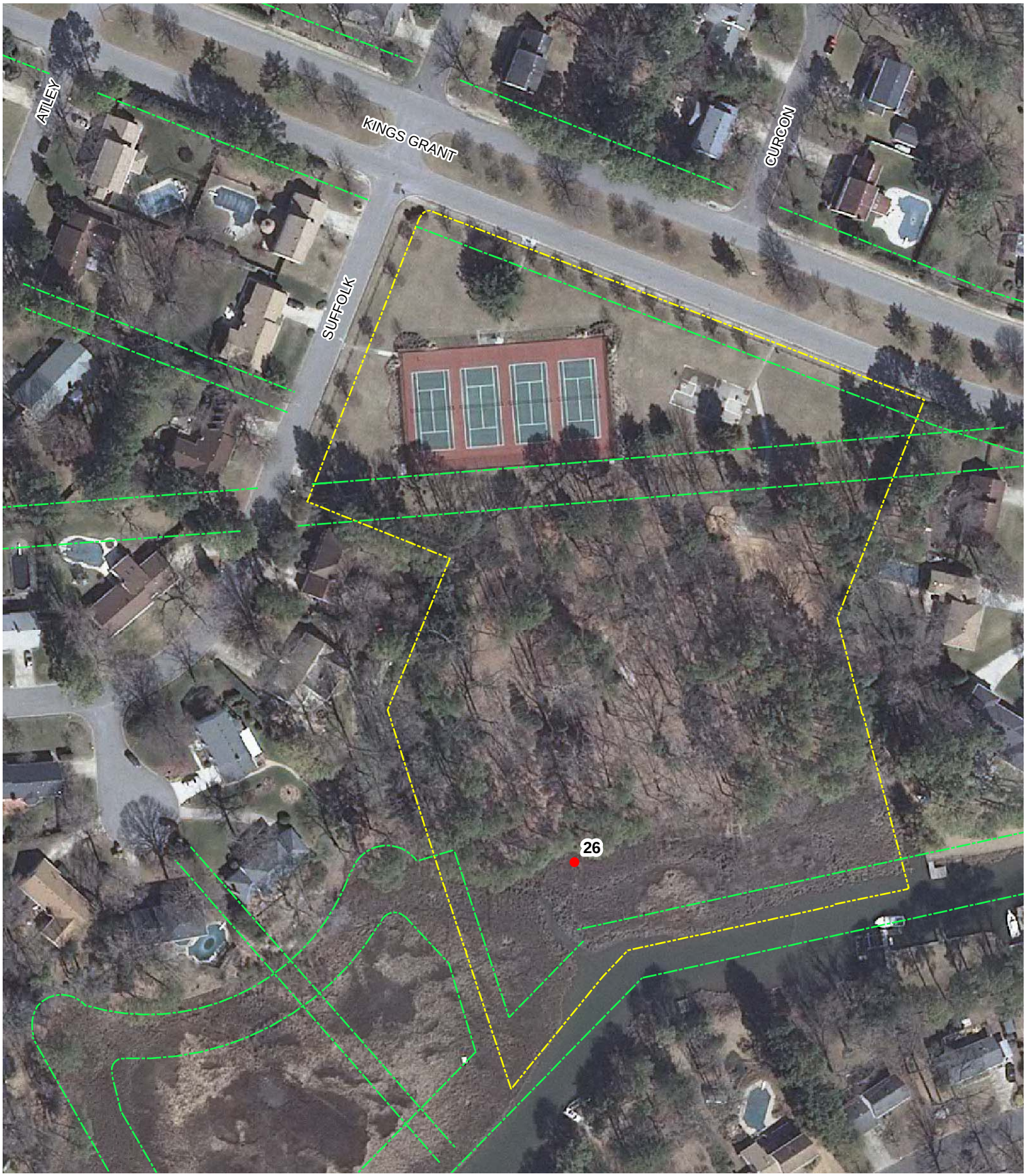


See GIS for Complete Details

Figure A.17. Detailed Sampling Locations

See GIS for Complete Details

Figure A.18. Detailed Sampling Locations



See GIS for Complete Details

Figure A.19. Detailed Sampling Locations

0 40 80 160 240 320
Feet

N

Legend

- Sample Locations
- Property Easements
- City Owned Property

See GIS for Complete Details

Figure A.20. Detailed Sampling Locations

0 60 120 240 360 480
Feet

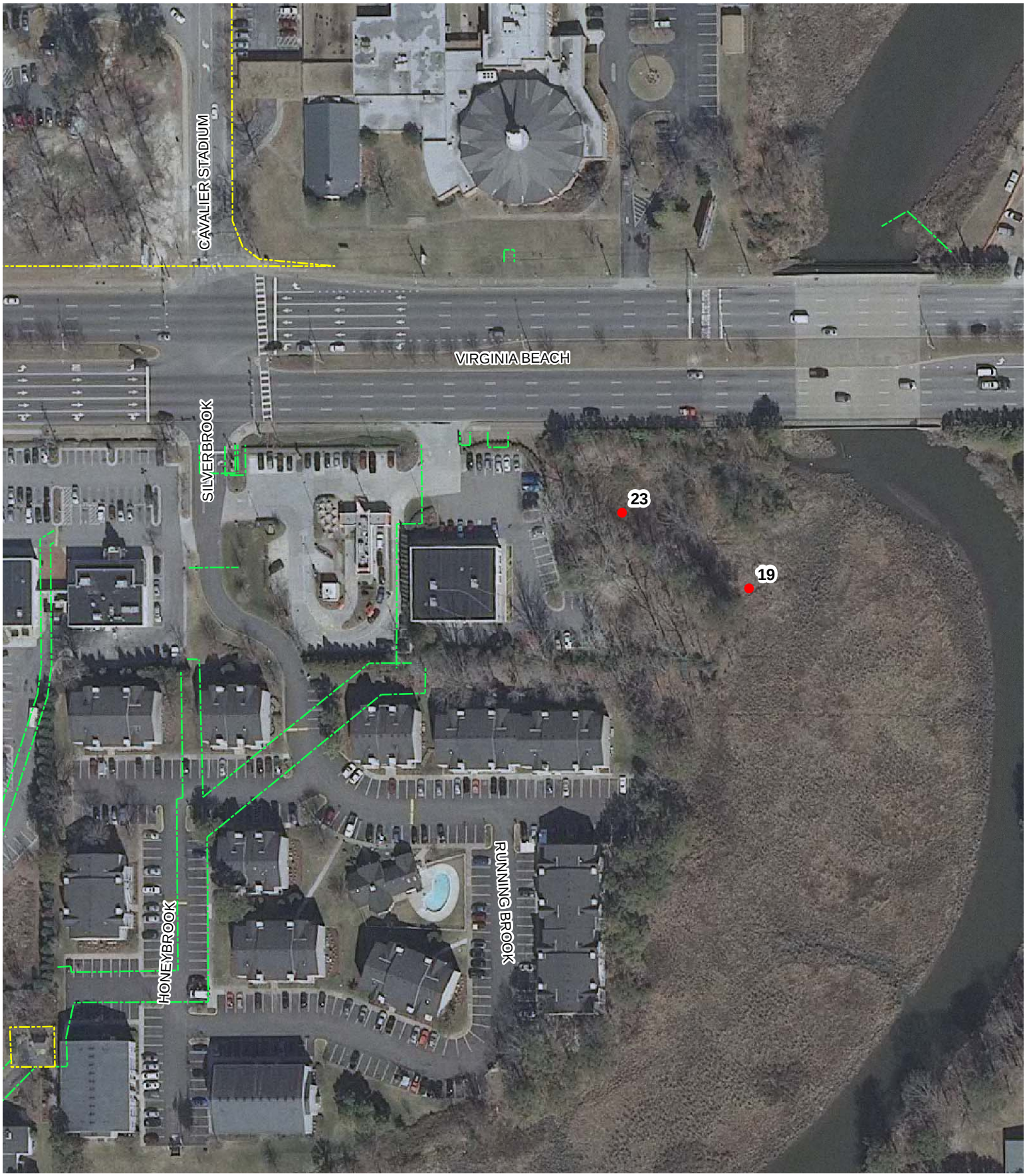
N

Legend

- Sample Locations
- Property Easements
- City Owned Property

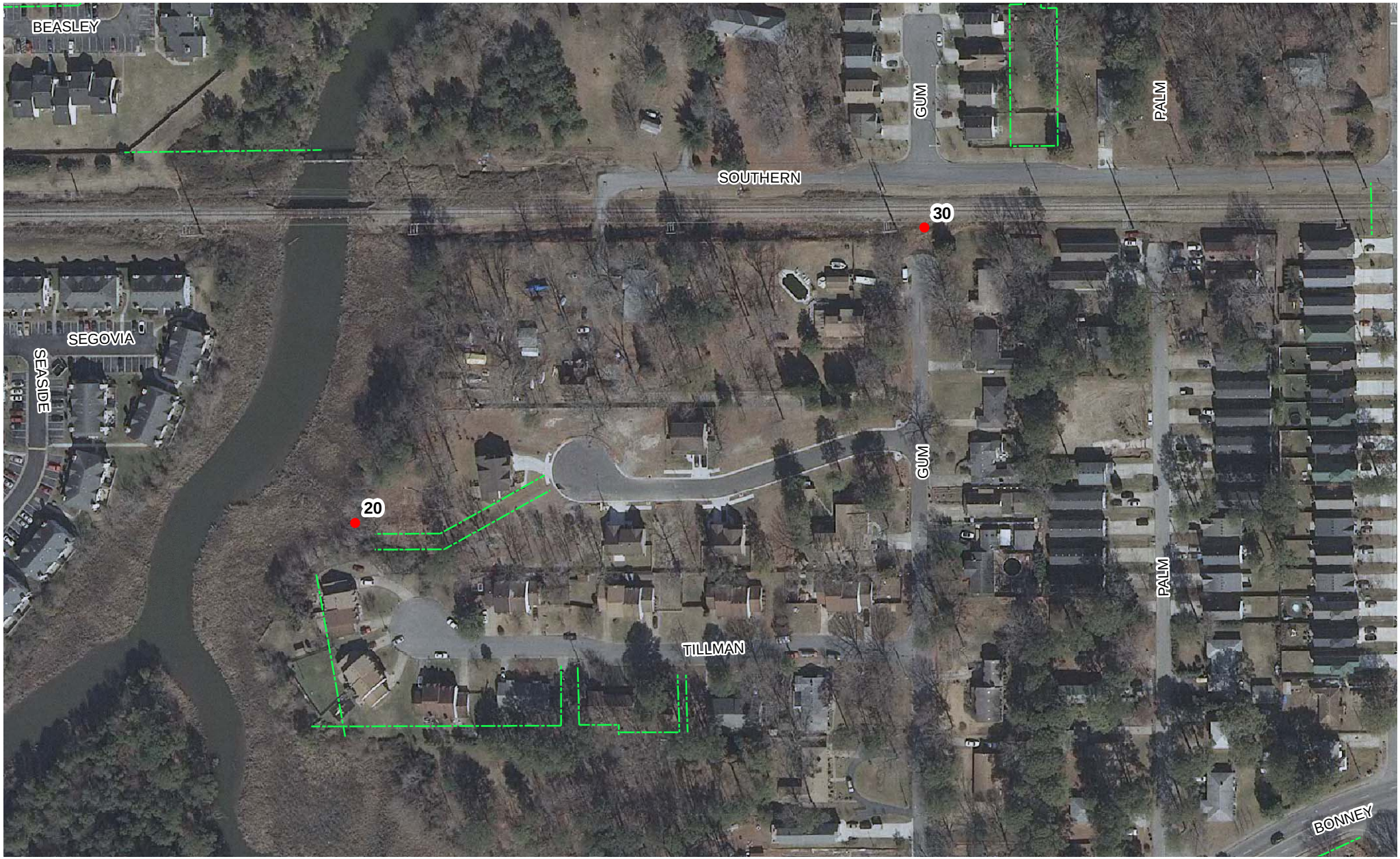
See GIS for Complete Details

Figure A.21. Detailed Sampling Locations



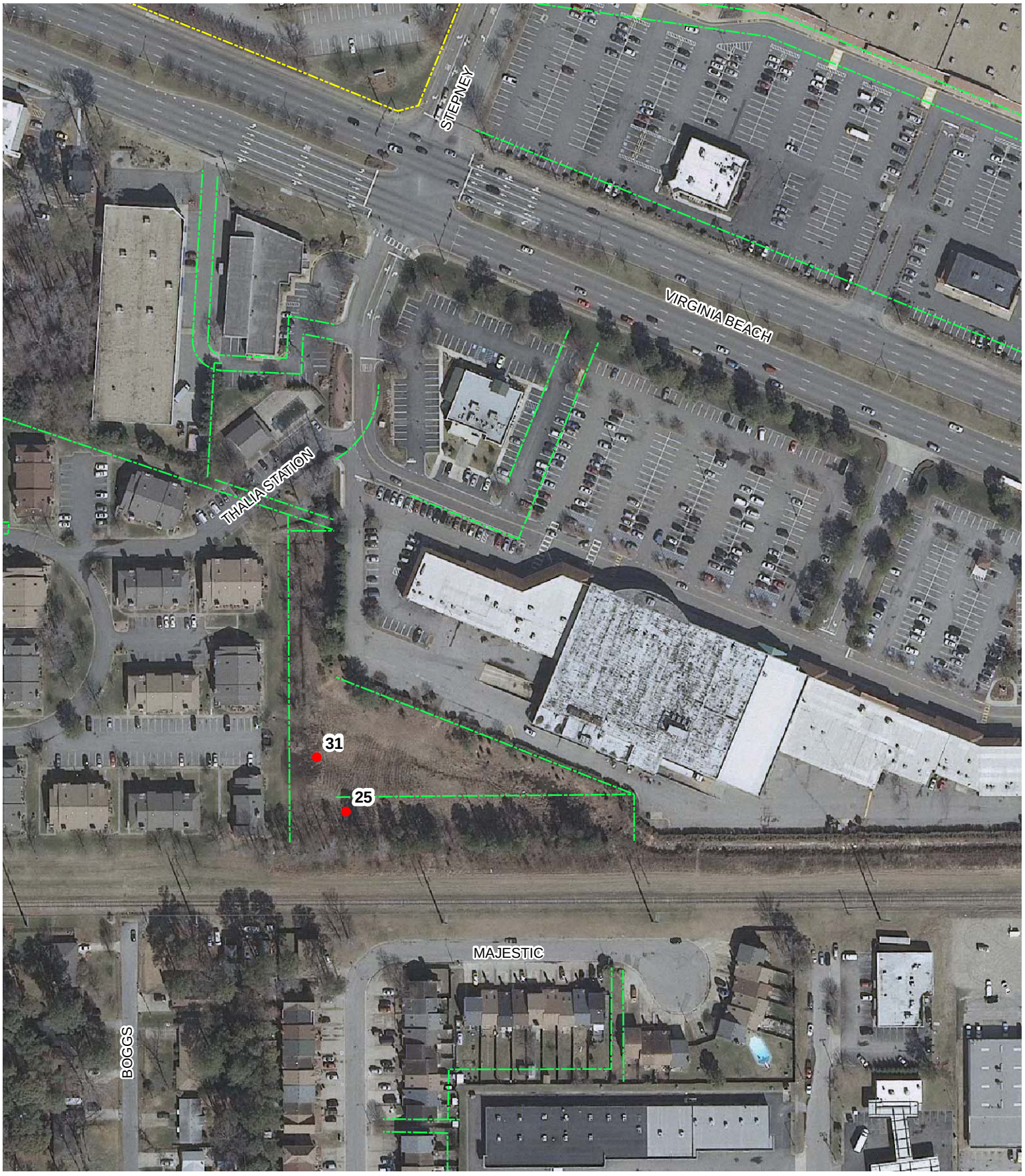
See GIS for Complete Details

Figure A.22. Detailed Sampling Locations



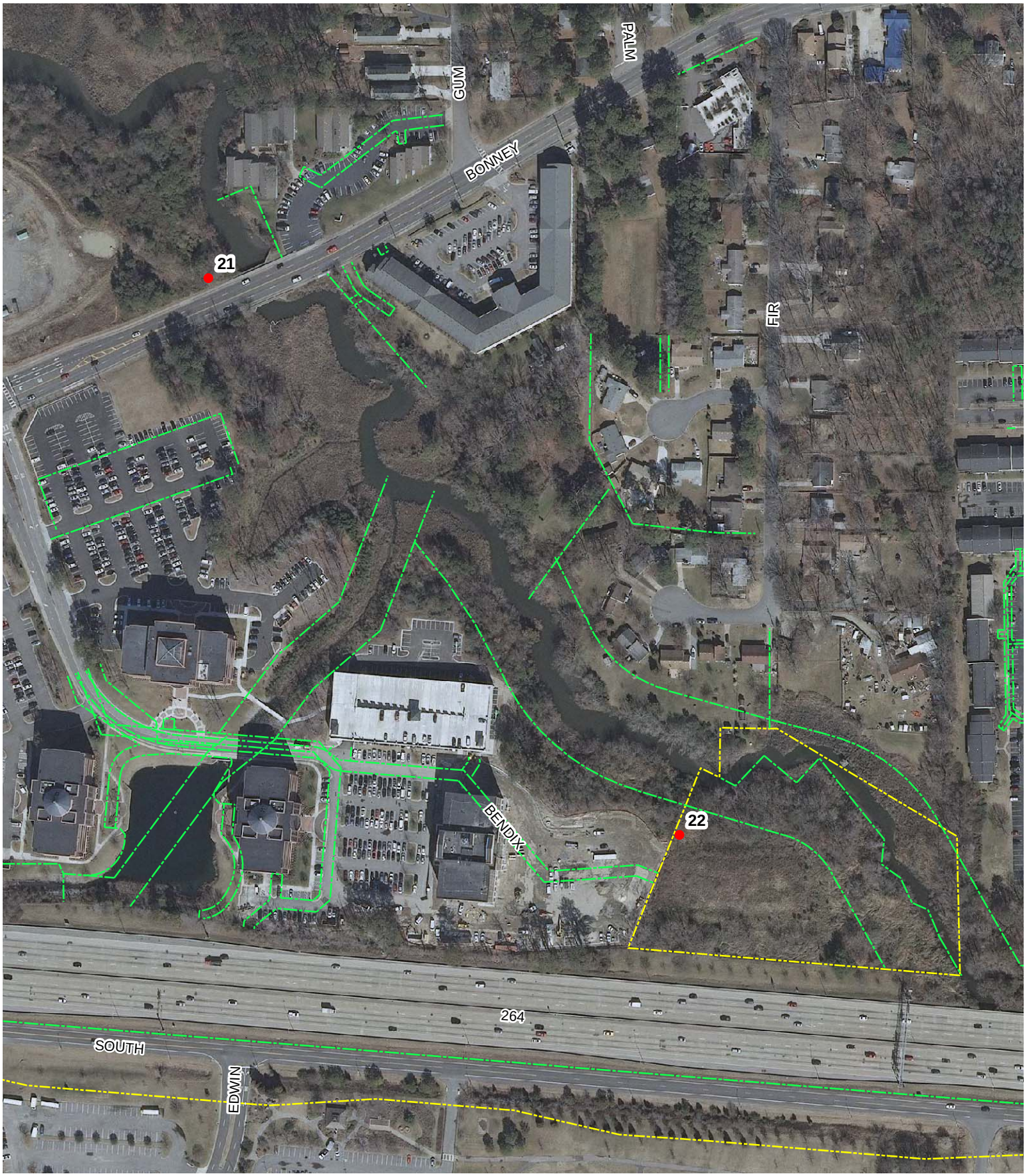
See GIS for Complete Details

Figure A.23. Detailed Sampling Locations



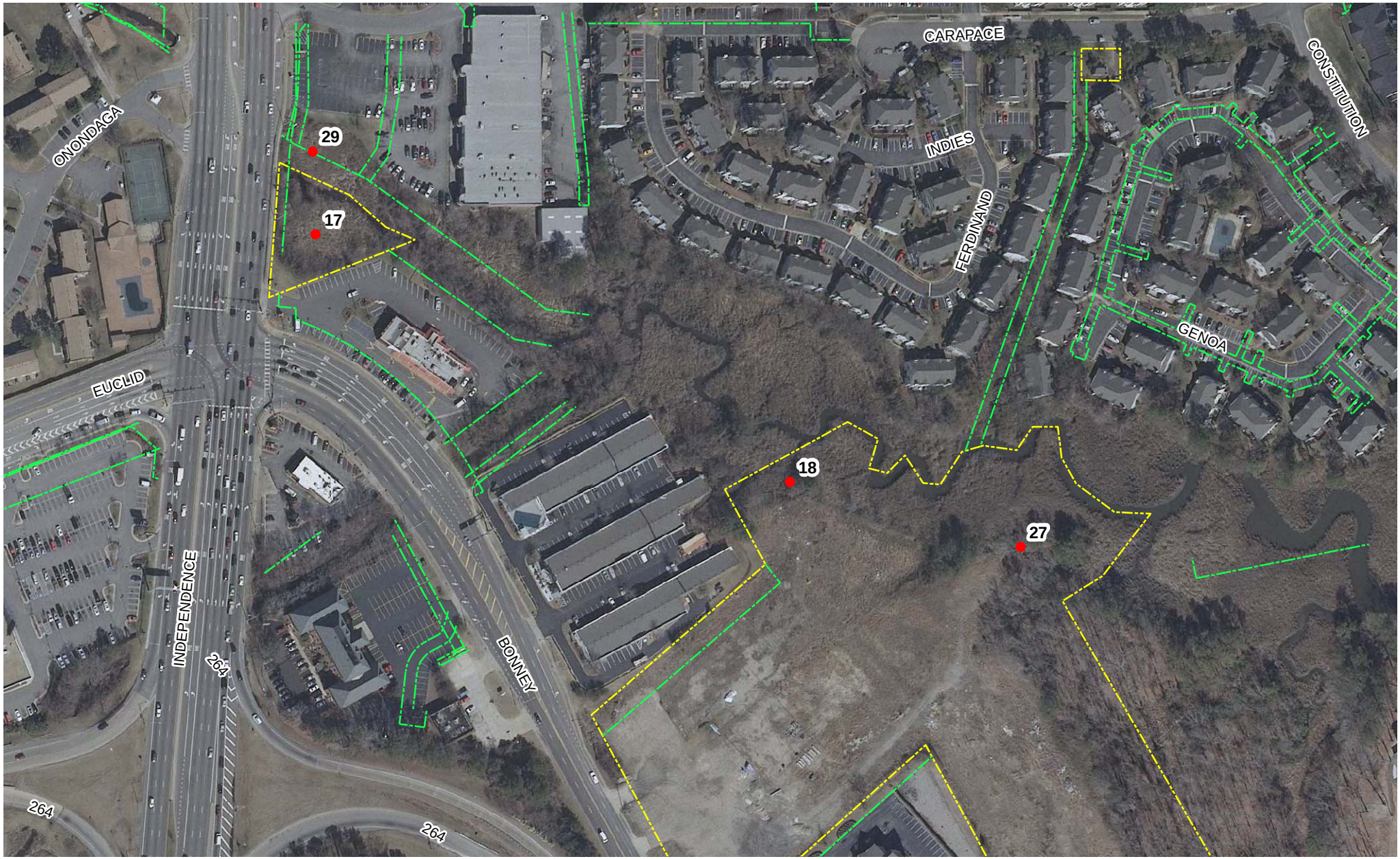
See GIS for Complete Details

Figure A.24. Detailed Sampling Locations



See GIS for Complete Details

Figure A.25. Detailed Sampling Locations

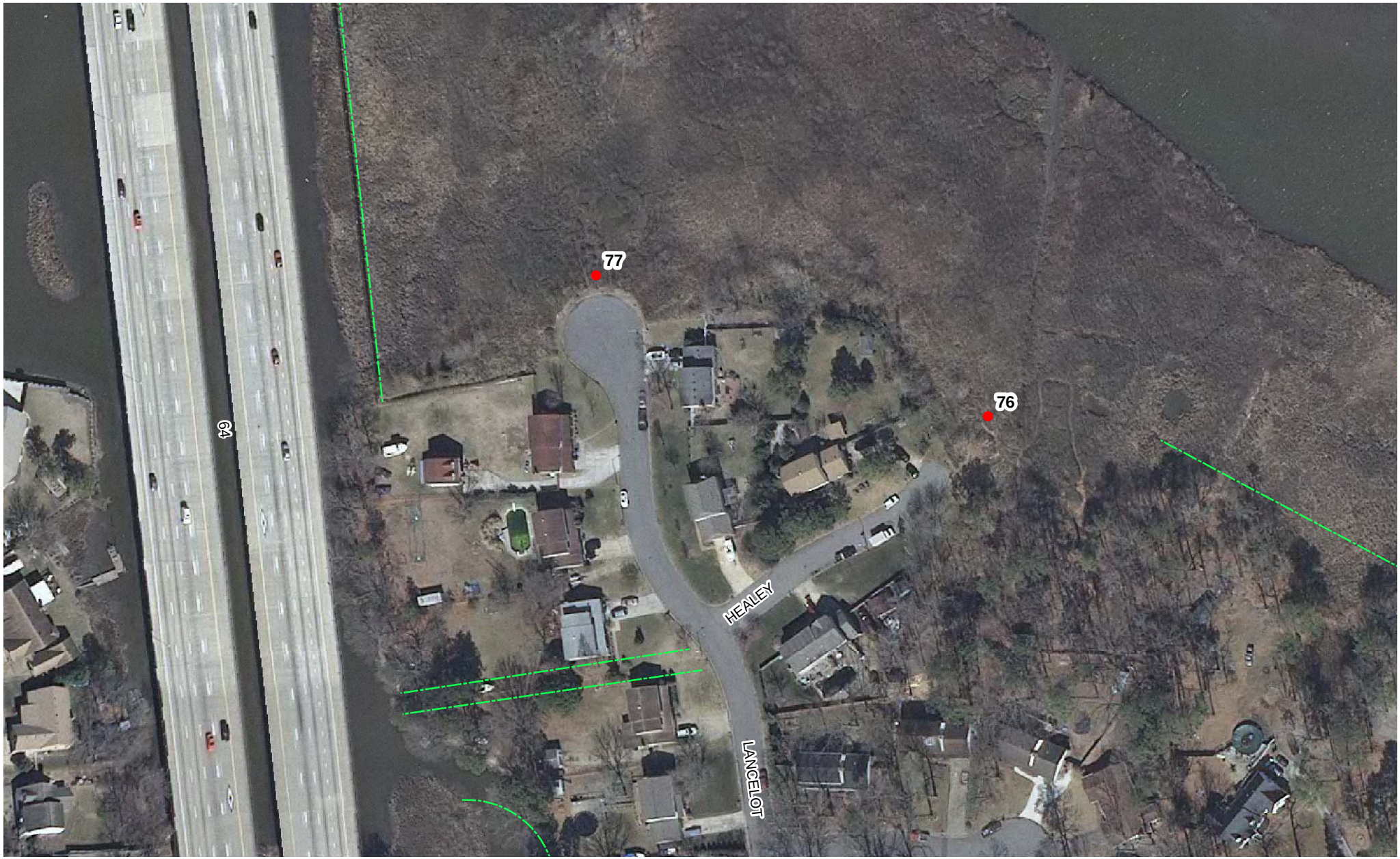


See GIS for Complete Details

Figure A.26. Detailed Sampling Locations

See GIS for Complete Details

Figure A.27. Detailed Sampling Locations



0 30 60 120 180 240
Feet

N

Legend

- Sample Locations
- Property Easements
- City Owned Property

See GIS for Complete Details

Figure A.28. Detailed Sampling Locations

See GIS for Complete Details

Figure A.29. Detailed Sampling Locations

Appendix B

Photographs

US Army Corps
of Engineers
Norfolk District

Photo 1. Sample Location 4

Photo 2. Sample Location 4

Photo 3. Sample Location 4

Photo 4. Sample Location 5

Photo 5. Sample Location 9

Photo 6. Sample Location 10

Photo 7. Sample Location 14

Photo 8. Sample Location 17

Photo 9. Sample Location 18

Photo 10. Sample Location 19

Photo 11. Sample Location 20

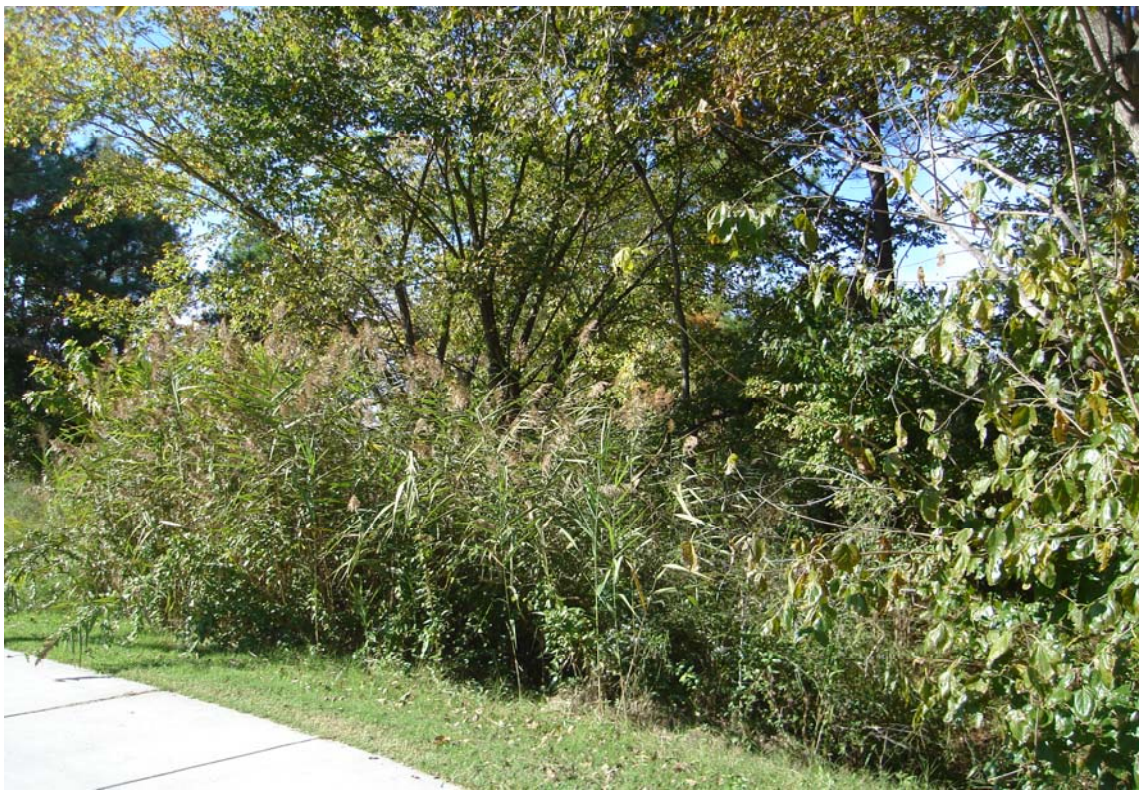


Photo 12. Sample Location 21

Photo 13. Sample Location 22

Photo 14. Sample Location 23

Photo 15. Sample Location 26

Photo 16. Sample Location 28

Photo 17. Sample Location 29

Photo 18. Sample Location 30

Photo 19. Sample Location 31

Photo 20. Sample Location 35

Photo 21. Sample Location 35

Photo 22. Sample Location 38

Photo 23. Sample Location 39

Photo 24. Sample Location 39

Photo 25. Sample Location 40

Photo 26. Sample Location 40

Photo 27. Sample Location 41

Photo 28. Sample Location 46

Photo 29. Sample Location 46

Photo 30. Sample Location 49

Photo 31. Sample Location 50

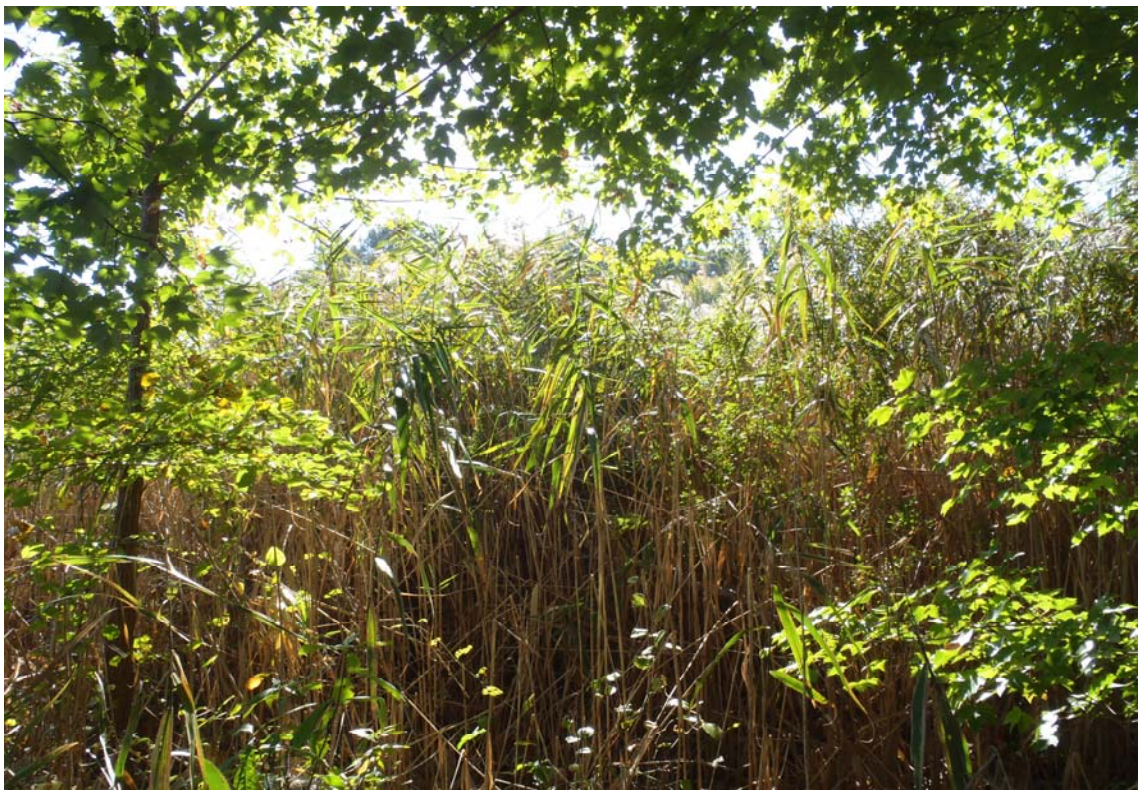


Photo 32. Sample Location 51

Photo 33. Sample Location 53

Photo 34. Sample Location 54

Photo 35. Sample Location 54

Photo 36. Sample Location 54

Photo 37. Sample Location 54

Photo 38. Sample Location 59

Photo 39. Sample Location 59

Photo 40. Sample Location 62

Photo 41. Sample Location 63

Photo 42. Sample Location 63

Photo 43. Sample Location 63

Photo 44. Sample Location 69

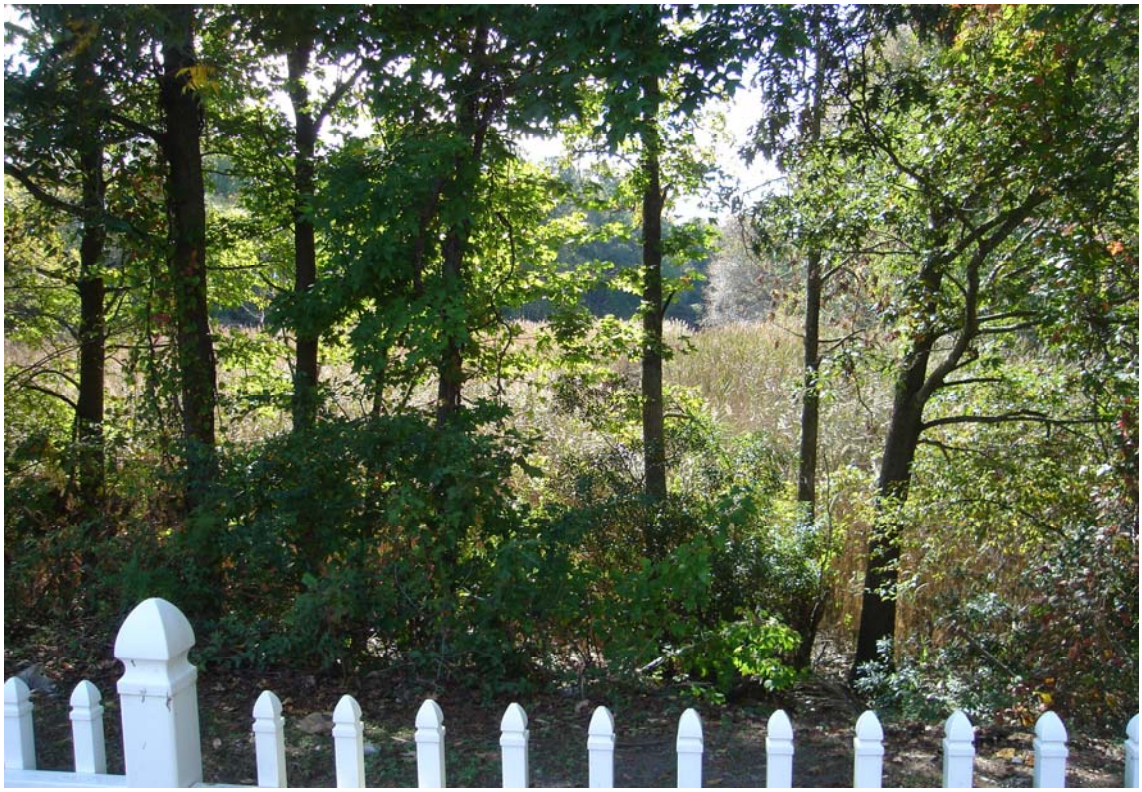


Photo 45. Sample Location 74

Photo 46. Sample Location 76

Photo 47. Sample Location 76

Photo 48. Sample Location 77

Appendix C

Laboratory Results

US Army Corps
of Engineers
Norfolk District

Tabled Plant Analysis Report

Spectrum Analytic
1087 Jamison Road NW
Washingon Court House, OH 43160-8748
www.spectrumanalytic.com

Report To	Prepared For	
URS CORPORATION 11832 ROCK LANDING DR STE 306 NEWPORT NEWS, VA 23606	Account - 5604 URS 11832 ROCK LANDING DR STE 306 NEWPORT NEWS, VA 23606	Sampled 10-17-2012 Tested 10-25-2012

Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
001	PL92001	1.71	0.11											
002	PL92002	1.22	0.09											
003	PL92003	1.70	0.14											
004	PL92004	1.40	0.16											
005	PL92005	1.75	0.13											
006	PL92006	1.37	0.13											
007	PL92007	0.94	0.09											
008	PL92008	0.64	0.08											
009	PL92009	0.92	0.09											
010	PL92010	0.84	0.10											
011	PL92011	0.99	0.07											

Sample Number	Lab Number	Dry W g	Rec W g	
001	PL92001	20.39	27.97	
002	PL92002	16.73	21.12	
003	PL92003	8.2	10.47	
004	PL92004	11.32	16.5	
005	PL92005	14.66	21.31	
006	PL92006	11.34	16.75	
007	PL92007	22.86	34.44	
008	PL92008	16.24	24.23	
009	PL92009	17.11	23.68	
010	PL92010	24.3	35.21	
011	PL92011	22.64	34.8	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
012	PL92012	0.85	0.08											
013	PL92013	0.86	0.08											
014	PL92014	1.12	0.12											
015	PL92015	1.17	0.08											
016	PL92016	0.99	0.09											
017	PL92017	1.07	0.11											
018	PL92018	0.88	0.06											
019	PL92019	0.91	0.08											
020	PL92020	0.87	0.13											

Sample Number	Lab Number	Dry W g	Rec W g	
012	PL92012	12.25	15.79	
013	PL92013	20.17	26.54	
014	PL92014	17.7	23.04	
015	PL92015	26.97	38.49	
016	PL92016	14.23	18.43	
017	PL92017	12.75	18.27	
018	PL92018	23.17	32.31	
019	PL92019	39.93	60.41	
020	PL92020	40.33	83.81	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
021	PL92021	1.50	0.13											
022	PL92022	1.24	0.17											
023	PL92023	0.77	0.12											
024	PL92024	0.89	0.10											
025	PL92025	1.03	0.07											
026	PL92026	1.33	0.09											
027	PL92027	1.05	0.08											
028	PL92028	1.12	0.10											
029	PL92029	0.78	0.04											
030	PL92030	1.03	0.05											
031	PL92031	1.24	0.11											

Sample Number	Lab Number	Dry W g	Rec W g
021	PL92021	46.24	87.5
022	PL92022	53.6	85.09
023	PL92023	47.8	72.88
024	PL92024	50.78	76.95
025	PL92025	56.64	87.79
026	PL92026	42.46	72.18
027	PL92027	51.85	78.72
028	PL92028	70.32	116.34
029	PL92029	44.58	62.98
030	PL92030	44.69	69.87
031	PL92031	35.31	57.9

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
032	PL92032	1.17	0.08											
033	PL92033	1.61	0.11											
034	PL92034	1.43	0.09											
035	PL92035	1.51	0.12											
036	PL92036	1.15	0.12											
037	PL92037	1.14	0.10											
038	PL92038	1.00	0.07											
039	PL92039	1.97	0.17											
040	PL92040	1.03	0.09											

Sample Number	Lab Number	Dry W g	Rec W g	
032	PL92032	29.04	48	
033	PL92033	42.05	67.4	
034	PL92034	35.89	62.88	
035	PL92035	30.85	49.41	
036	PL92036	23.21	37	
037	PL92037	47.8	84.51	
038	PL92038	55.16	96.16	
039	PL92039	61.39	102.84	
040	PL92040	53.89	87.72	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
041	PL92041	1.15	0.10											
042	PL92042	1.12	0.08											
043	PL92043	2.26	0.18											
044	PL92044	2.59	0.25											
045	PL92045	1.91	0.19											
046	PL92046	2.29	0.21											
047	PL92047	2.41	0.29											
048	PL92048	2.29	0.21											
049	PL92049	1.46	0.12											
050	PL92050	1.92	0.10											
051	PL92051	1.94	0.12											

Sample Number	Lab Number	Dry W g	Rec W g
041	PL92041	39.11	73.58
042	PL92042	55.76	89.32
043	PL92043	40.34	89.36
044	PL92044	25.33	72.63
045	PL92045	41.55	97.57
046	PL92046	39.49	87.89
047	PL92047	28.31	83.64
048	PL92048	45.34	93.06
049	PL92049	26.4	38.37
050	PL92050	19.85	29.03
051	PL92051	21.72	30.85

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
052	PL92052	1.86	0.11											
053	PL92053	1.90	0.12											
054	PL92054	2.08	0.14											
055	PL92055	1.15	0.11											
056	PL92056	1.49	0.12											
057	PL92057	1.01	0.09											
058	PL92058	1.63	0.11											
059	PL92059	0.68	0.05											
060	PL92060	1.45	0.10											

Sample Number	Lab Number	Dry W g	Rec W g	
052	PL92052	27.74	42.1	
053	PL92053	40.29	63.37	
054	PL92054	30.87	45.7	
055	PL92055	56.48	92.58	
056	PL92056	51.02	83.39	
057	PL92057	63.86	107.33	
058	PL92058	57	90.12	
059	PL92059	55.01	85.04	
060	PL92060	53.46	85.43	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
061	PL92061	1.76	0.11											
062	PL92062	1.38	0.11											
063	PL92063	0.93	0.05											
064	PL92064	1.57	0.10											
065	PL92065	0.79	0.06											
066	PL92066	1.43	0.10											
067	PL92067	1.43	0.10											
068	PL92068	1.02	0.09											
069	PL92069	1.14	0.06											
070	PL92070	0.89	0.07											
071	PL92071	1.40	0.08											

Sample Number	Lab Number	Dry W g	Rec W g
061	PL92061	33.65	50.37
062	PL92062	55.38	88.99
063	PL92063	45.9	69.11
064	PL92064	43.22	82.71
065	PL92065	51.09	75.37
066	PL92066	57.41	91.64
067	PL92067	38.41	61.94
068	PL92068	25.3	37.63
069	PL92069	44.16	72.88
070	PL92070	23.4	36.27
071	PL92071	43.6	66.01

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
072	PL92072	1.63	0.10											
073	PL92073	1.31	0.09											
074	PL92074	1.61	0.14											
075	PL92075	0.88	0.06											
076	PL92076	0.97	0.06											
077	PL92077	0.96	0.09											
078	PL92078	1.25	0.18											
079	PL92079	1.56	0.12											
080	PL92080	1.33	0.12											

Sample Number	Lab Number	Dry W g	Rec W g	
072	PL92072	45.26	72.57	
073	PL92073	51.54	83.37	
074	PL92074	40.59	66.72	
075	PL92075	40.01	58.94	
076	PL92076	45.2	66.28	
077	PL92077	45.94	73.75	
078	PL92078	43.62	75.03	
079	PL92079	35.54	59.92	
080	PL92080	43.54	74.98	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
081	PL92081	1.07	0.09											
082	PL92082	1.95	0.16											
083	PL92083	1.49	0.12											
084	PL92084	1.11	0.10											
085	PL92085	1.59	0.22											
086	PL92086	2.10	0.22											
087	PL92087	1.58	0.14											
088	PL92088	1.98	0.17											
089	PL92089	1.90	0.18											
090	PL92090	2.58	0.26											
091	PL92091	2.47	0.27											

Sample Number	Lab Number	Dry W g	Rec W g	
081	PL92081	38.45	60.26	
082	PL92082	23.86	37.98	
083	PL92083	33.49	57.54	
084	PL92084	39.4	65.35	
085	PL92085	24.19	38.73	
086	PL92086	31.57	65.36	
087	PL92087	41.01	72.21	
088	PL92088	34.72	61.63	
089	PL92089	38.6	70.08	
090	PL92090	27.57	62.5	
091	PL92091	18.42	35.1	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
092	PL92092	1.81	0.18											
093	PL92093	1.57	0.12											
094	PL92094	1.03	0.08											
095	PL92095	2.00	0.14											
096	PL92096	1.75	0.13											
097	PL92097	2.20	0.23											
098	PL92098	2.05	0.19											
099	PL92099	2.51	0.25											
100	PL92100	1.53	0.15											

Sample Number	Lab Number	Dry W g	Rec W g
092	PL92092	19.51	30.57
093	PL92093	35.33	53.9
094	PL92094	53.41	86.48
095	PL92095	26.97	38.94
096	PL92096	35.72	51.8
097	PL92097	43.44	96.88
098	PL92098	41.77	81.52
099	PL92099	45.89	100.96
100	PL92100	31.47	50.21

Tabled Plant Analysis Report

Spectrum Analytic
1087 Jamison Road NW
Washingon Court House, OH 43160-8748
www.spectrumanalytic.com

Report To	Prepared For	
URS CORPORATION 11832 ROCK LANDING DR STE 306 NEWPORT NEWS, VA 23606	Account - 5604 URS 11832 ROCK LANDING DR STE 306 NEWPORT NEWS, VA 23606	Sampled 10-17-2012 Tested 10-25-2012

Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
101	PL92101	1.67	0.14											
102	PL92102	1.40	0.12											
103	PL92103	1.19	0.12											
104	PL92104	1.47	0.12											
105	PL92105	1.76	0.12											
106	PL92106	1.26	0.11											
107	PL92107	1.38	0.11											
108	PL92108	1.28	0.11											
109	PL92109	1.87	0.16											
110	PL92110	0.93	0.09											
111	PL92111	1.28	0.12											

Sample Number	Lab Number	Dry W g	Rec W g
101	PL92101	23.83	35.52
102	PL92102	35.06	53.68
103	PL92103	42.68	67.19
104	PL92104	26.54	40.46
105	PL92105	30.08	51
106	PL92106	42.13	66.34
107	PL92107	36.1	57.38
108	PL92108	41.19	68.98
109	PL92109	41.49	63.06
110	PL92110	35.44	56.63
111	PL92111	40.27	60.73

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
112	PL92112	1.14	0.08											
113	PL92113	1.19	0.09											
114	PL92114	1.38	0.09											
115	PL92115	2.11	0.24											
116	PL92116	1.13	0.15											
117	PL92117	1.35	0.17											
118	PL92118	1.08	0.14											
119	PL92119	1.38	0.20											
120	PL92120	1.54	0.19											

Sample Number	Lab Number	Dry W g	Rec W g	
112	PL92112	30.04	43.51	
113	PL92113	32.1	46.28	
114	PL92114	30.05	43.26	
115	PL92115	40.44	76.36	
116	PL92116	36.66	71.4	
117	PL92117	33.32	57.64	
118	PL92118	35.96	65.07	
119	PL92119	25.3	51.04	
120	PL92120	43.96	84.86	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
121	PL92121	1.12	0.07											
122	PL92122	1.06	0.07											
123	PL92123	1.10	0.08											
124	PL92124	0.92	0.05											
125	PL92125	0.96	0.06											
126	PL92126	1.38	0.10											

Sample Number	Lab Number	Dry W g	Rec W g	
121	PL92121	20.12	27.89	
122	PL92122	23.36	27.65	
123	PL92123	17.38	21.28	
124	PL92124	15.18	20.58	
125	PL92125	31.09	38.36	
126	PL92126	16.97	24.17	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
127	PL92196	1.21	0.12											
128	PL92197	1.78	0.19											
129	PL92198	1.60	0.07											
130	PL92199	1.85	0.19											
131	PL92200	1.61	0.11											
132	PL92201	1.57	0.14											
133	PL92202	1.23	0.10											
134	PL92203	1.47	0.08											
135	PL92204	1.14	0.08											
136	PL92205	1.81	0.16											
137	PL92206	2.08	0.21											

Sample Number	Lab Number	Dry W g	Rec W g
127	PL92196	34.52	60.49
128	PL92197	56.97	116.62
129	PL92198	16.95	19.4
130	PL92199	24.86	42.24
131	PL92200	52.07	86.23
132	PL92201	20.66	34.1
133	PL92202	20.71	30.03
134	PL92203	27.14	37.38
135	PL92204	20.07	30.12
136	PL92205	16.31	29.3
137	PL92206	10.43	21.75

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
138	PL92207	1.86	0.23											
139	PL92208	1.63	0.18											
140	PL92209	1.72	0.15											
141	PL92210	2.49	0.23											
142	PL92211	1.81	0.17											
143	PL92212	1.94	0.22											
144	PL92213	1.86	0.19											
145	PL92214	1.32	0.15											
146	PL92215	1.19	0.15											

Sample Number	Lab Number	Dry W g	Rec W g
138	PL92207	11.08	19.1
139	PL92208	14.02	19.02
140	PL92209	10.7	16.11
141	PL92210	14.18	27.62
142	PL92211	19.3	33.99
143	PL92212	15.57	25.75
144	PL92213	19.63	31.07
145	PL92214	33.84	55.9
146	PL92215	23.35	37.91

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
147	PL92216	0.59	0.02											
148	PL92217	2.56	0.28											
149	PL92218	3.01	0.33											
150	PL92219	1.57	0.15											
151	PL92220	1.55	0.12											
152	PL92221	1.30	0.10											
153	PL92222	1.51	0.13											
154	PL92223	1.46	0.14											
155	PL92224	1.55	0.23											
156	PL92225	1.25	0.06											
157	PL92226	1.28	0.09											

Sample Number	Lab Number	Dry W g	Rec W g
147	PL92216	23.42	26.98
148	PL92217	15.82	40.44
149	PL92218	12.38	32.62
150	PL92219	40.46	71.92
151	PL92220	20.66	31.66
152	PL92221	36.86	63.66
153	PL92222	33.67	55.36
154	PL92223	24.92	37.05
155	PL92224	14.6	19.72
156	PL92225	9.39	10.06
157	PL92226	61.05	96.65

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
158	PL92227	1.32	0.11											
159	PL92228	0.89	0.06											
160	PL92229	0.98	0.08											
161	PL92230	1.26	0.18											
162	PL92231	1.18	0.08											

Sample Number	Lab Number	Dry W g	Rec W g	
158	PL92227	16.33	22.82	
159	PL92228	10.91	12.72	
160	PL92229	41.84	65.27	
161	PL92230	14.59	22.97	
162	PL92231	40.94	62.49	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
163	PL92236	1.41	0.22											
164	PL92237	1.35	0.12											
165	PL92238	1.99	0.13											
166	PL92239	1.72	0.15											
167	PL92240	1.71	0.12											
168	PL92241	1.52	0.13											
169	PL92242	1.22	0.04											
170	PL92243	1.65	0.13											
171	PL92244	1.76	0.10											
172	PL92245	2.39	0.17											
173	PL92246	1.80	0.15											

Sample Number	Lab Number	Dry W g	Rec W g
163	PL92236	9.26	11.12
164	PL92237	24.24	41.98
165	PL92238	15.54	27.55
166	PL92239	13.25	23.06
167	PL92240	21.22	40.12
168	PL92241	18.5	32.6
169	PL92242	17.08	19.51
170	PL92243	26.52	50.18
171	PL92244	31.62	53.15
172	PL92245	12.91	20.42
173	PL92246	20.03	34.11

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
174	PL92247	1.43	0.18											
175	PL92248	1.90	0.14											
176	PL92249	1.78	0.27											
177	PL92250	2.53	0.30											
178	PL92251	1.37	0.12											
179	PL92252	3.96	0.40											
180	PL92253	1.41	0.16											
181	PL92254	1.36	0.09											
182	PL92255	1.31	0.10											

Sample Number	Lab Number	Dry W g	Rec W g
174	PL92247	13	21.61
175	PL92248	76.06	147
176	PL92249	29.9	78.45
177	PL92250	16.69	43.16
178	PL92251	40.86	75.85
179	PL92252	21.16	69.72
180	PL92253	47.31	94.03
181	PL92254	40.3	60.2
182	PL92255	24.78	42.93

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
183	PL92256	1.34	0.10											
184	PL92257	1.03	0.08											
185	PL92258	0.93	0.02											
186	PL92259	1.50	0.10											
187	PL92260	1.10	0.06											
188	PL92261	0.91	0.03											
189	PL92262	1.03	0.04											
190	PL92263	1.27	0.09											
191	PL92264	1.43	0.08											
192	PL92265	1.34	0.12											
193	PL92266	2.03	0.17											

Sample Number	Lab Number	Dry W g	Rec W g
183	PL92256	67.92	106.75
184	PL92257	51.09	77.67
185	PL92258	24.87	28.22
186	PL92259	24.84	38.44
187	PL92260	19.56	25.65
188	PL92261	14.98	19.09
189	PL92262	16.3	22.07
190	PL92263	27.53	46.29
191	PL92264	21.01	29.07
192	PL92265	29.26	45.8
193	PL92266	32.56	67.33

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
194	PL92267	0.96	0.02											
195	PL92268	1.29	0.04											
196	PL92269	1.73	0.15											
197	PL92270	1.79	0.17											
198	PL92271	1.54	0.11											
199	PL92272	1.92	0.14											
200	PL92273	0.96	0.04											
201	PL92274	1.08	0.07											
202	PL92275	0.94	0.07											

Sample Number	Lab Number	Dry W g	Rec W g	
194	PL92267	34.25	38.74	
195	PL92268	19.99	22.45	
196	PL92269	19.97	25.62	
197	PL92270	43.52	84.88	
198	PL92271	55.67	84.45	
199	PL92272	18.3	30.23	
200	PL92273	13.76	15.83	
201	PL92274	16.92	21.9	
202	PL92275	15.46	20.39	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
203	PL92276	1.86	0.15											
204	PL92277	1.64	0.15											
205	PL92278	1.91	0.16											
206	PL92279	1.22	0.10											
207	PL92280	1.07	0.09											
208	PL92281	1.67	0.13											
209	PL92282	0.98	0.08											
210	PL92283	0.78	0.01											
211	PL92284	1.48	0.10											
212	PL92285	1.29	0.04											
213	PL92286	1.25	0.08											

Sample Number	Lab Number	Dry W g	Rec W g	
203	PL92276	13.77	22.09	
204	PL92277	10.82	16.64	
205	PL92278	14.2	21.93	
206	PL92279	32.3	47	
207	PL92280	29.93	44.36	
208	PL92281	22.2	31.6	
209	PL92282	52.44	76.97	
210	PL92283	17.96	20.08	
211	PL92284	48.31	80.82	
212	PL92285	14.03	15.65	
213	PL92286	31.56	50.9	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
214	PL92287	1.65	0.11											
215	PL92288	1.36	0.09											
216	PL92289	1.17	0.11											
217	PL92290	1.60	0.11											
218	PL92291	1.50	0.11											
219	PL92292	1.52	0.11											
220	PL92293	1.85	0.12											
221	PL92294	1.37	0.11											
222	PL92295	1.65	0.22											

Sample Number	Lab Number	Dry W g	Rec W g	
214	PL92287	51.9	81.31	
215	PL92288	49.43	65.55	
216	PL92289	29.99	35.22	
217	PL92290	17.68	22.27	
218	PL92291	41.75	62.32	
219	PL92292	25.95	37	
220	PL92293	29.7	44.59	
221	PL92294	46.3	69.78	
222	PL92295	28.75	48.26	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
223	PL92296	1.69	0.21											
224	PL92297	1.41	0.05											
225	PL92298	1.59	0.13											
226	PL92299	1.70	0.17											
227	PL92300	1.44	0.11											
228	PL92301	1.95	0.22											
229	PL92302	1.24	0.14											
230	PL92303	1.06	0.03											
231	PL92304	1.40	0.13											
232	PL92305	1.37	0.12											
233	PL92306	1.28	0.12											

Sample Number	Lab Number	Dry W g	Rec W g	
223	PL92296	25.63	41.37	
224	PL92297	16.95	19.15	
225	PL92298	35.73	58.51	
226	PL92299	54.73	97.69	
227	PL92300	49.92	91.09	
228	PL92301	11.67	18.12	
229	PL92302	28.66	47.05	
230	PL92303	20.89	23.41	
231	PL92304	46.53	77.52	
232	PL92305	32.1	55.82	
233	PL92306	36.41	58.84	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
234	PL92307	1.43	0.10											

Sample Number	Lab Number	Dry W g	Rec W g	
234	PL92307	36.46	55.42	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
235	PL92320	1.47	0.07											
236	PL92321	1.36	0.06											
237	PL92322	1.31	0.04											
238	PL92323	1.24	0.01											
239	PL92324	1.41	0.08											
240	PL92325	1.48	0.08											
241	PL92326	1.53	0.08											
242	PL92327	1.54	0.09											
243	PL92328	1.50	0.08											
244	PL92329	1.43	0.06											
245	PL92330	1.49	0.08											

Sample Number	Lab Number	Dry W g	Rec W g
235	PL92320	38.46	56.46
236	PL92321	18.56	23.33
237	PL92322	24.8	41.53
238	PL92323	12.51	17.69
239	PL92324	19.74	24.16
240	PL92325	23.17	35.45
241	PL92326	19.99	29.15
242	PL92327	17.36	21.8
243	PL92328	18.91	24.28
244	PL92329	30.33	44.77
245	PL92330	25.88	43.54

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1087 Jamison Road NW
Washingon Court House, OH 43160-8748
www.spectrumanalytic.com

Report To	Prepared For	
URS CORPORATION 11832 ROCK LANDING DR STE 306 NEWPORT NEWS, VA 23606	Account - 5604 URS 11832 ROCK LANDING DR STE 306 NEWPORT NEWS, VA 23606	Sampled 10-23-2012 Tested 10-29-2012

Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
246	PL92331	1.58	0.08											
247	PL92332	1.68	0.08											
248	PL92333	1.81	0.12											
249	PL92334	1.62	0.07											
250	PL92335	1.89	0.12											
251	PL92336	1.99	0.13											
252	PL92337	1.75	0.10											
253	PL92338	1.65	0.13											
254	PL92339	1.59	0.20											

Sample Number	Lab Number	Dry W g	Rec W g	
246	PL92331	17.61	27.82	
247	PL92332	31.84	46.7	
248	PL92333	26.11	37.13	
249	PL92334	28.19	44.13	
250	PL92335	25.96	38.97	
251	PL92336	26.77	37.23	
252	PL92337	22.42	31.72	
253	PL92338	24.99	37.15	
254	PL92339	17.53	26.84	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
255	PL92340	1.77	0.11											
256	PL92341	1.75	0.12											
257	PL92342	1.78	0.13											
258	PL92343	1.66	0.12											
259	PL92344	1.95	0.12											
260	PL92345	1.85	0.11											
261	PL92346	1.93	0.12											
262	PL92347	2.01	0.13											
263	PL92348	1.74	0.11											
264	PL92349	1.78	0.10											
265	PL92350	1.71	0.10											

Sample Number	Lab Number	Dry W g	Rec W g
255	PL92340	28.69	41.4
256	PL92341	41.11	62.03
257	PL92342	40.36	61.79
258	PL92343	38.27	57.9
259	PL92344	44.68	66.42
260	PL92345	37.32	64.52
261	PL92346	38.02	56.43
262	PL92347	52.77	89.1
263	PL92348	37.64	61.43
264	PL92349	54.92	91.29
265	PL92350	66.39	105.9

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
266	PL92351	1.76	0.10											
267	PL92352	1.64	0.09											
268	PL92353	1.79	0.10											
269	PL92354	1.66	0.07											
270	PL92355	1.67	0.09											
271	PL92356	1.99	0.22											
272	PL92357	1.87	0.13											
273	PL92358	1.90	0.13											
274	PL92359	1.81	0.12											

Sample Number	Lab Number	Dry W g	Rec W g	
266	PL92351	59.45	97.19	
267	PL92352	51.57	77.99	
268	PL92353	58.08	92.11	
269	PL92354	46.96	71.93	
270	PL92355	65.45	104.14	
271	PL92356	38.62	87.83	
272	PL92357	43.51	92	
273	PL92358	49.25	94.58	
274	PL92359	79.27	152.62	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
275	PL92360	1.82	0.13											
276	PL92361	1.81	0.13											
277	PL92362	1.43	0.06											
278	PL92363	1.61	0.08											
279	PL92364	1.34	0.07											
280	PL92365	2.13	0.18											
281	PL92366	2.04	0.15											
282	PL92367	1.50	0.08											
283	PL92368	1.76	0.11											
284	PL92369	1.37	0.08											
285	PL92370	1.39	0.08											

Sample Number	Lab Number	Dry W g	Rec W g	
275	PL92360	49.11	88.88	
276	PL92361	50.45	87.6	
277	PL92362	24.3	36.5	
278	PL92363	21.94	31.87	
279	PL92364	31.84	47.23	
280	PL92365	24.4	44.8	
281	PL92366	24.04	42.42	
282	PL92367	31.53	46.39	
283	PL92368	12.37	17.55	
284	PL92369	17.74	21.12	
285	PL92370	15.36	18.56	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
286	PL92371	1.46	0.09											
287	PL92372	1.45	0.09											
288	PL92373	1.56	0.11											
289	PL92374	1.95	0.12											
290	PL92375	2.14	0.13											
291	PL92376	1.90	0.11											
292	PL92377	2.17	0.15											
293	PL92378	2.05	0.12											
294	PL92379	1.87	0.12											

Sample Number	Lab Number	Dry W g	Rec W g	
286	PL92371	14.6	21.76	
287	PL92372	16.26	22.44	
288	PL92373	12.35	17.26	
289	PL92374	28.96	52.84	
290	PL92375	30.57	56.75	
291	PL92376	26.99	43.19	
292	PL92377	22.57	39	
293	PL92378	25.2	38.03	
294	PL92379	17.82	27.96	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
295	PL92380	1.69	0.12											
296	PL92381	1.48	0.09											
297	PL92382	1.58	0.10											
298	PL92383	1.81	0.14											
299	PL92384	1.73	0.11											
300	PL92385	1.74	0.10											
301	PL92386	1.41	0.05											
302	PL92387	1.96	0.12											
303	PL92388	2.46	0.15											
304	PL92389	1.77	0.09											
305	PL92390	1.49	0.04											

Sample Number	Lab Number	Dry W g	Rec W g
295	PL92380	43.82	62.97
296	PL92381	44.15	68.16
297	PL92382	37.44	55.43
298	PL92383	46.01	69.14
299	PL92384	42.42	61.01
300	PL92385	55.09	81.34
301	PL92386	36.35	48.61
302	PL92387	25.03	32.73
303	PL92388	23.81	39.48
304	PL92389	46.25	68.65
305	PL92390	31.3	42.79

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
306	PL92391	1.66	0.06											
307	PL92392	1.99	0.11											
308	PL92393	1.99	0.12											
309	PL92394	1.99	0.14											
310	PL92395	1.99	0.09											
311	PL92396	2.12	0.08											
312	PL92397	1.98	0.09											
313	PL92398	2.17	0.13											
314	PL92399	2.04	0.15											

Sample Number	Lab Number	Dry W g	Rec W g
306	PL92391	34.07	46.24
307	PL92392	39.33	52.38
308	PL92393	38.96	54.09
309	PL92394	53.27	70.84
310	PL92395	41.45	54.08
311	PL92396	52.33	72.18
312	PL92397	48.42	64.58
313	PL92398	35.85	54.03
314	PL92399	30.32	48.98

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
315	PL92400	2.03	0.13											
316	PL92401	2.27	0.18											
317	PL92402	1.91	0.15											
318	PL92403	2.05	0.18											
319	PL92404	2.02	0.17											
320	PL92405	1.98	0.19											
321	PL92406	1.80	0.14											
322	PL92407	1.83	0.15											
323	PL92408	1.79	0.14											
324	PL92409	1.65	0.18											
325	PL92410	1.04	0.03											

Sample Number	Lab Number	Dry W g	Rec W g	
315	PL92400	37.32	57.19	
316	PL92401	45.28	76.58	
317	PL92402	43.8	70.23	
318	PL92403	29.5	39.84	
319	PL92404	33.99	53.85	
320	PL92405	26.11	37.72	
321	PL92406	33.35	46.76	
322	PL92407	31.67	44.98	
323	PL92408	38.84	59.49	
324	PL92409	28.96	45.93	
325	PL92410	49.02	61.09	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
326	PL92411	1.03	0.10											
327	PL92412	1.02	0.04											
328	PL92413	1.93	0.20											
329	PL92414	1.92	0.22											
330	PL92415	1.51	0.12											
331	PL92416	1.32	0.05											
332	PL92417	1.47	0.15											
333	PL92418	1.25	0.07											
334	PL92419	1.30	0.15											

Sample Number	Lab Number	Dry W g	Rec W g
326	PL92411	56.53	82.75
327	PL92412	40.43	50.54
328	PL92413	31.46	62.62
329	PL92414	20.43	42.56
330	PL92415	43.16	76.8
331	PL92416	58.9	79.04
332	PL92417	26.16	51.97
333	PL92418	54.93	78.2
334	PL92419	31.34	55.1

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
335	PL92420	1.13	0.07											
336	PL92421	1.32	0.08											
337	PL92422	1.55	0.10											
338	PL92423	1.35	0.11											
339	PL92424	2.01	0.10											
340	PL92425	1.72	0.15											
341	PL92426	1.47	0.10											
342	PL92427	1.52	0.09											
343	PL92428	1.16	0.06											
344	PL92429	0.95	0.09											
345	PL92430	1.17	0.09											

Sample Number	Lab Number	Dry W g	Rec W g
335	PL92420	29.95	42.69
336	PL92421	49.97	68.2
337	PL92422	21.26	29.17
338	PL92423	31.46	45.69
339	PL92424	28.85	40.32
340	PL92425	70.6	97.69
341	PL92426	39.05	56.49
342	PL92427	35.09	51.5
343	PL92428	21.05	27.07
344	PL92429	33.87	45.76
345	PL92430	24.66	37.87

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
346	PL92431	1.36	0.08											
347	PL92432	1.32	0.08											
348	PL92433	1.27	0.10											
349	PL92434	1.35	0.08											
350	PL92435	1.20	0.09											
351	PL92436	1.22	0.09											
352	PL92437	1.29	0.08											
353	PL92438	1.17	0.08											
354	PL92439	1.11	0.07											

Sample Number	Lab Number	Dry W g	Rec W g	
346	PL92431	33.26	47.7	
347	PL92432	29.46	44.78	
348	PL92433	15.64	20.14	
349	PL92434	55.84	81.08	
350	PL92435	37.01	52.7	
351	PL92436	21.41	29.94	
352	PL92437	37.51	47.86	
353	PL92438	37.62	48.58	
354	PL92439	33.28	48.16	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
355	PL92442	2.57	0.23											
356	PL92443	1.41	0.10											
357	PL92444	1.34	0.08											
358	PL92445	1.28	0.09											
359	PL92446	1.00	0.06											
360	PL92447	1.31	0.08											
361	PL92448	1.23	0.07											
362	PL92449	1.21	0.07											
363	PL92450	1.50	0.11											
364	PL92451	1.13	0.07											
365	PL92452	1.17	0.07											

Sample Number	Lab Number	Dry W g	Rec W g	
355	PL92442	12.3	22.68	
356	PL92443	30.86	38.76	
357	PL92444	26.39	33.48	
358	PL92445	24.68	33.81	
359	PL92446	26.43	33.32	
360	PL92447	24.1	34.54	
361	PL92448	15.41	19.33	
362	PL92449	20.16	27.19	
363	PL92450	16.59	21.73	
364	PL92451	26.68	35.74	
365	PL92452	17.53	23.77	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
366	PL92453	1.41	0.08											
367	PL92454	1.51	0.14											
368	PL92455	1.38	0.10											
369	PL92456	1.17	0.09											
370	PL92457	1.10	0.11											
371	PL92458	1.29	0.07											
372	PL92459	1.00	0.07											
373	PL92460	1.01	0.05											
374	PL92461	1.26	0.07											

Sample Number	Lab Number	Dry W g	Rec W g	
366	PL92453	25.04	36.53	
367	PL92454	12.88	16.85	
368	PL92455	16.77	21.74	
369	PL92456	24.74	34.27	
370	PL92457	21.59	30.25	
371	PL92458	30.71	43.83	
372	PL92459	18.46	27.09	
373	PL92460	24.26	31.93	
374	PL92461	18.39	24.77	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
375	PL92462	1.13	0.04											
376	PL92463	1.36	0.08											
377	PL92464	1.40	0.08											
378	PL92465	1.28	0.08											
379	PL92466	1.21	0.07											
380	PL92467	1.22	0.07											
381	PL92468	1.20	0.07											
382	PL92469	1.20	0.09											
383	PL92470	1.33	0.08											
384	PL92471	1.16	0.11											
385	PL92472	1.09	0.09											

Sample Number	Lab Number	Dry W g	Rec W g	
375	PL92462	41.54	57.31	
376	PL92463	32.38	46.03	
377	PL92464	29.53	39.63	
378	PL92465	17.46	22.38	
379	PL92466	41.81	63.07	
380	PL92467	32.04	45.13	
381	PL92468	32.1	48.7	
382	PL92469	35.3	52.66	
383	PL92470	37.12	54.81	
384	PL92471	26.24	39.39	
385	PL92472	32.19	45.33	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
386	PL92473	1.10	0.11											
387	PL92474	1.10	0.09											
388	PL92475	1.25	0.09											
389	PL92476	1.16	0.09											
390	PL92477	1.26	0.08											
391	PL92478	1.07	0.04											
392	PL92479	1.16	0.04											
393	PL92480	1.08	0.07											
394	PL92481	1.13	0.05											

Sample Number	Lab Number	Dry W g	Rec W g	
386	PL92473	39.84	58.22	
387	PL92474	37.22	53.2	
388	PL92475	29.8	44.25	
389	PL92476	28.6	40.58	
390	PL92477	49.96	73.39	
391	PL92478	29.96	40.73	
392	PL92479	23.82	32.11	
393	PL92480	19.15	24.53	
394	PL92481	27.55	39.07	

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URS CORPORATION 11832 ROCK LANDING DR STE 306 NEWPORT NEWS, VA 23606	Account - 5604 URS 11832 ROCK LANDING DR STE 306 NEWPORT NEWS, VA 23606	Sampled 10-23-2012 Tested 10-31-2012

Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
395	PL92482	1.16	0.04											
396	PL92483	1.22	0.04											
397	PL92484	1.22	0.06											
398	PL92485	1.23	0.08											
399	PL92486	1.49	0.11											
400	PL92487	1.55	0.11											
401	PL92488	1.43	0.12											
402	PL92489	1.42	0.10											
403	PL92490	1.46	0.08											
404	PL92491	1.46	0.10											
405	PL92492	1.20	0.15											

Sample Number	Lab Number	Dry W g	Rec W g	
395	PL92482	24.95	32.98	
396	PL92483	21.36	30.15	
397	PL92484	26.53	36.47	
398	PL92485	27.4	37.53	
399	PL92486	41.73	60.31	
400	PL92487	26.9	35.98	
401	PL92488	19.1	24.36	
402	PL92489	21.35	28.95	
403	PL92490	46.86	68.73	
404	PL92491	30.73	44.39	
405	PL92492	25.06	42.95	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
406	PL92493	1.53	0.09											
407	PL92494	1.49	0.11											
408	PL92495	1.34	0.11											
409	PL92496	1.22	0.07											
410	PL92497	1.33	0.10											
411	PL92498	1.25	0.07											
412	PL92499	1.46	0.10											
413	PL92500	1.27	0.05											
414	PL92501	1.56	0.10											

Sample Number	Lab Number	Dry W g	Rec W g
406	PL92493	27.9	43.39
407	PL92494	23.03	35.65
408	PL92495	18.78	27.5
409	PL92496	16.21	21.01
410	PL92497	19.82	25.7
411	PL92498	18.68	23.03
412	PL92499	19.52	26.08
413	PL92500	30.59	40.23
414	PL92501	15.57	22.92

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
415	PL92517	1.05	0.06											
416	PL92518	1.19	0.06											
417	PL92519	1.17	0.07											
418	PL92520	1.07	0.06											
419	PL92521	1.06	0.06											
420	PL92522	1.03	0.05											
421	PL92523	1.32	0.09											
422	PL92524	1.37	0.11											
423	PL92525	1.93	0.11											
424	PL92526	2.17	0.08											
425	PL92527	2.04	0.08											

Sample Number	Lab Number	Dry W g	Rec W g
415	PL92517	12.84	13.83
416	PL92518	12.96	14.04
417	PL92519	40.53	47.91
418	PL92520	29.45	33.65
419	PL92521	20.29	22.97
420	PL92522	33.15	39.71
421	PL92523	15.92	18.69
422	PL92524	25.25	29.87
423	PL92525	21.64	25.77
424	PL92526	13.92	16.01
425	PL92527	20.28	24.68

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
426	PL92528	2.13	0.09											
427	PL92529	1.96	0.08											
428	PL92530	1.80	0.09											
429	PL92531	1.93	0.11											
430	PL92532	1.68	0.07											
431	PL92533	1.79	0.10											
432	PL92534	1.81	0.11											
433	PL92535	1.74	0.10											
434	PL92536	1.87	0.09											

Sample Number	Lab Number	Dry W g	Rec W g	
426	PL92528	14.12	16.67	
427	PL92529	36.02	47.58	
428	PL92530	34.57	39.78	
429	PL92531	27.86	31.67	
430	PL92532	26.77	39.27	
431	PL92533	28.56	42.21	
432	PL92534	21.2	28	
433	PL92535	23.06	28.1	
434	PL92536	15.59	18.27	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
435	PL92537	1.88	0.07											
436	PL92538	2.00	0.07											
437	PL92539	1.58	0.08											
438	PL92540	1.68	0.08											
439	PL92541	1.45	0.10											
440	PL92542	1.57	0.09											
441	PL92543	1.77	0.14											
442	PL92544	1.86	0.13											
443	PL92545	1.53	0.09											
444	PL92546	1.41	0.07											
445	PL92547	1.44	0.07											

Sample Number	Lab Number	Dry W g	Rec W g
435	PL92537	19.88	23.48
436	PL92538	66.22	97.82
437	PL92539	12.03	14.5
438	PL92540	22.06	28.39
439	PL92541	23.99	32.24
440	PL92542	55.26	80.02
441	PL92543	17.8	21.54
442	PL92544	19.74	25.68
443	PL92545	51.57	71.47
444	PL92546	17.82	20.58
445	PL92547	27.99	36.96

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
446	PL92548	1.72	0.12											
447	PL92549	1.36	0.08											
448	PL92550	1.57	0.09											
449	PL92551	1.43	0.08											
450	PL92552	1.63	0.10											
451	PL92553	1.93	0.16											
452	PL92554	1.90	0.17											
453	PL92555	1.83	0.15											
454	PL92556	2.02	0.13											

Sample Number	Lab Number	Dry W g	Rec W g
446	PL92548	17.04	21.2
447	PL92549	34.74	44.99
448	PL92550	17.48	22.82
449	PL92551	29.35	38.36
450	PL92552	27.86	37.49
451	PL92553	33.2	46.84
452	PL92554	44.49	61.92
453	PL92555	40.03	55.99
454	PL92556	30.57	42.04

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
455	PL92557	2.02	0.21											
456	PL92558	1.89	0.21											
457	PL92559	2.09	0.14											
458	PL92560	2.08	0.16											
459	PL92561	1.61	0.20											
460	PL92562	1.86	0.16											
461	PL92563	1.48	0.12											
462	PL92564	2.40	0.29											
463	PL92565	1.78	0.18											
464	PL92566	1.52	0.17											
465	PL92567	1.57	0.17											

Sample Number	Lab Number	Dry W g	Rec W g	
455	PL92557	35.56	50.87	
456	PL92558	11.92	13.78	
457	PL92559	30.53	41.86	
458	PL92560	49.74	71.75	
459	PL92561	16.62	22.1	
460	PL92562	40.27	57.87	
461	PL92563	32.75	44.71	
462	PL92564	15.3	25.4	
463	PL92565	42.03	69.8	
464	PL92566	66.89	135.58	
465	PL92567	30.88	49.35	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
466	PL92568	1.61	0.15											
467	PL92569	1.73	0.17											
468	PL92570	1.56	0.14											
469	PL92571	1.68	0.14											
470	PL92572	1.60	0.16											
471	PL92573	1.71	0.13											
472	PL92574	1.75	0.15											
473	PL92575	1.96	0.18											
474	PL92576	1.58	0.10											

Sample Number	Lab Number	Dry W g	Rec W g	
466	PL92568	32.72	53.65	
467	PL92569	47.56	90.78	
468	PL92570	45.22	80.48	
469	PL92571	22.05	29.14	
470	PL92572	25.28	33.8	
471	PL92573	23.55	28.15	
472	PL92574	48.58	74.81	
473	PL92575	19.53	28.27	
474	PL92576	34.91	51.58	

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Sample Number	Lab Number	Percent (%)						Parts Per Million (ppm)						
		Nitrogen N	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Sulfur S	Boron B	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Sodium Na	Aluminum Al
475	PL92577	1.63	0.07											
476	PL92578	1.71	0.12											
477	PL92579	1.92	0.11											
478	PL92580	1.71	0.13											
479	PL92581	1.48	0.05											
480	PL92582	1.86	0.07											

Sample Number	Lab Number	Dry W g	Rec W g	
475	PL92577	39.06	48.48	
476	PL92578	35.18	44.25	
477	PL92579	20.85	25.52	
478	PL92580	25.55	31.75	
479	PL92581	14.49	16.28	
480	PL92582	21.3	25.42	

Appendix D

Article 14 of the Virginia Beach City Zoning Ordinance

US Army Corps
of Engineers
Norfolk District

URS

ARTICLE 14. - WETLANDS ZONING ORDINANCE [131]

Sec. 1400. - Intent.

The city council of the City of Virginia Beach, acting pursuant to Chapter 13 (§ 28.2-1300 et seq.) of the Code of Virginia, reordains this article regulating the use and development of wetlands.

(Ord. No. 1804, 8-22-88; Ord. No. 2198, 12-8-92)

Sec. 1401. - Definitions.

For the purposes of this article:

(a) *Commission* means the Virginia Marine Resources Commission.

(b) *Commissioner* means the commissioner of marine resources.

(c) *Person* means any corporation, association, partnership, individual, company, business, trust, joint venture or other legal entity or any unit of government or agency thereof.

(d) *Governmental activity* means any or all of the services provided by the City of Virginia Beach to its citizens for the purpose of maintaining this city, and shall include, but not be limited to,

such services as constructing, repairing and maintaining roads, providing sewage facilities, supplying and treating water, providing street lights, and constructing public buildings.

(e) *Vegetated wetlands* means lands lying between and contiguous to mean low water and an elevation above mean low water equal to the factor one and one-half (1½) times the mean tide range at the site of the proposed project in the City of Virginia Beach; and upon which is growing any one (1) or more of the following species: saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow hay (*Spartina patens*), saltgrass (*Distichlis spicata*), black needlerush (*Juncus roemerianus*), saltwort (*Salicornia* spp.), sea lavender (*Limonium* spp.), marsh elder (*Iva frutescens*), groundsel bush (*Baccharis halimifolia*), wax myrtle (*Myrica* sp.), sea oxeye (*Borrichia frutescens*), arrow arum (*Peltandra virginica*), pickerelweed (*Pontederia cordata*), big cordgrass (*Spartina cynosuroides*), rice cutgrass (*Leersia oryzoides*), wildrice (*Zizania aquatica*), bulrush (*Scirpus validus*), spikerush (*Eleocharis* sp.), sea rocket (*Cakile edentula*), southern wildrice (*Zizaniopsis miliacea*), cattails (*Typha* spp.), three-squares (*Scirpus* spp.), buttonbush (*Cephalanthus occidentalis*), bald cypress (*Taxodium distichum*), black gum (*Nyssa sylvatica*), tupelo (*Nyssa aquatica*), dock (*Rumex* spp.), yellow pond lily (*Nuphar* sp.), marsh fleabane (*Pluchea purpurascens*), royal fern (*Osmunda regalis*), marsh hibiscus (*Hibiscus moscheutos*), beggar's tick (*Bidens* sp.), smartweeds (*Polygonum* sp.), arrowhead (*Sagittaria* spp.), sweet flag (*Acorus calamus*), water hemp (*Amaranthus cannabinus*), reed grass (*Phragmites communis*), and switch grass (*Panicum virgatum*).

(f) *Vegetated wetlands of Back Bay and its tributaries* or *vegetated wetlands of the North Landing River and its tributaries* shall mean all marshes subject to flooding by normal and wind tides, but not hurricane or tropical storm tides, and upon which is growing any of the following species: saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow hay (*Spartina patens*), black needlerush (*Juncus roemerianus*), marsh elder (*Iva frutescens*), groundsel bush (*Baccharis halimifolia*), wax myrtle (*Myrica* sp.), arrow arum (*Peltandra virginica*), pickerelweed (*Pontederia cordata*), big cordgrass (*Spartina cynosuroides*), rice cutgrass (*Leersia oryzoides*), wildrice (*Zizania acquatica*), bulrush (*Scirpus validus*), spikerush (*Eleocharis* sp.), cattails (*Typha* spp.), three-squares (*Scirpus* spp.), dock (*Rumex* sp.), smartweed (*Polygonum* sp.), yellow pond lily (*Nuphar* sp.), royal fern (*Osmunda regalis*), marsh hibiscus (*Hibiscus moscheutos*), beggar's tick (*Bidens* sp.), arrowhead (*Sagittaria* sp.), water hemp (*Amaranthus cannabinus*), reed grass (*Phragmites communis*), and switch grass (*Panicum virgatum*).

(g) *Wetlands board* or *board* means the Wetlands Board of the City of Virginia Beach.

(h) *Back Bay and its tributaries* means the following, as shown on the U.S. Geological Survey Quadrangle Sheets for Virginia Beach, North Bay, and Knotts Island: Back Bay north of the Virginia-North Carolina state line; Capsies Creek north of the Virginia-North Carolina state line; Deal Creek; Devil Creek; Nawney Creek; Redhead Bay, Sand Bay, Shipps Bay, North Bay, and the waters connecting them; Beggars Bridge Creek; Muddy Creek; Ashville Bridge Creek; Hells Point Creek; Black Gut; and all coves, ponds and natural waterways adjacent to or connecting with the above-named bodies of water.

(i) *North Landing River and its tributaries* means the following, as shown on United States Geological Survey Quadrangle Sheets for Pleasant Ridge, Creeds, and Fentress: the North Landing River from the Virginia-North Carolina line to Virginia Highway 165 at North Landing Bridge; the Chesapeake and Albemarle Canal from Virginia Highway 165 at North Landing Bridge to the locks at Great Bridge; all named and unnamed streams, creeks and rivers flowing into the North Landing River and the Chesapeake and Albermarle Canal except the following: West Neck Creek north of Indian River Road; Pocaty River west of Blackwater Road; Blackwater Creek west of its forks located at a point approximately six thousand four

hundred (6,400) feet due west of the point where the Blackwater Road crosses the Blackwater Creek at the village of Blackwater; and Mill Dam Creek west of Blackwater Road.

(j) *Nonvegetated wetlands* means unvegetated lands lying contiguous to mean low water and between mean low water and mean high water, including those unvegetated areas of Back Bay and its tributaries and the North Landing River and its tributaries subject to flooding by normal and wind tides but not hurricane or tropical storm tides.

(k) *Wetlands* means both vegetated and nonvegetated wetlands.

(l) *Ordinance* means the Wetlands Zoning Ordinance [this article].

(Ord. No. 1804, 8-22-88; Ord. No. 2198, 12-8-92; Ord. No. 2268, 6-14-94)

Sec. 1402. - Uses.

The following uses of and activities in wetlands are authorized, if otherwise permitted by law:

(a) The construction and maintenance of noncommercial catwalks, piers, boathouses, boat shelters, fences, duckblinds, wildlife management shelters, footbridges, observation decks and shelters and other similar structures; provided that such structures are so constructed on pilings as to permit the reasonably unobstructed flow of the tide and preserve the natural contour of the wetlands;

(b) The cultivation and harvesting of shellfish, and worms for bait;

(c) Noncommercial outdoor recreational activities, including hiking, boating, trapping, hunting, fishing, shellfishing, horseback riding, swimming, skeet and trap shooting, and shooting on shooting preserves; provided that no structure shall be constructed except as permitted in subsection (a) of this section;

(d) Grazing, haying, and the cultivation and harvesting of agricultural, forestry or horticultural products;

(e) Conservation, repletion and research activities of the commission, the Virginia Institute of Marine Science, the Department of Game and Inland Fisheries and other conservation-related agencies;

(f) The construction or maintenance of aids to navigation which are authorized by governmental authority;

(g) Emergency measures decreed by any duly appointed health officer of a governmental subdivision acting to protect the public health;

(h) The normal maintenance and repair of, or addition to, presently existing roads, highways, railroad beds, or facilities abutting on or crossing wetlands, provided that no waterway is altered and no additional wetlands are covered;

(i) Governmental activity on wetlands owned or leased by the commonwealth or a political subdivision thereof;

(j) The normal maintenance of manmade drainage ditches, provided that no additional wetlands are covered; and provided further, that this subsection shall not be deemed to authorize construction of any drainage ditch; and

(k) Outdoor recreational activities other than those set forth in subsection (c), provided that such activities do not impair the natural functions of the wetlands or alter the natural contour of the wetlands.

(Ord. No. 1804, 8-22-84; Ord. No. 1903, 8-14-89; Ord. No. 2198, 12-8-92)

Sec. 1403. - Applications for permits.

(a) Any person who desires to use or develop any wetland within this city, other than for those activities specified in section 1402, shall first file an application for a permit with the Wetlands Board.

(b) An application shall be accompanied by plans and other data in reference to the proposed use or development. Plans shall be prepared, stamped and endorsed by such qualified professional licensed to practice in the Commonwealth of Virginia as the planning director may require; provided, however, that this requirement may be waived if, in the judgment of the planning director, the nature of the work to be performed renders it unnecessary. An application shall include the following: The name and address of the applicant; a detailed description of the proposed activity or activities; map, drawn to an appropriate and uniform scale, showing the area of wetland directly affected, with the location of the proposed work thereon, indicating the area of existing and proposed fill and excavation, the location, width, depth and length of any proposed channel the disposal area, and the location of all existing and proposed structures, sewage collection and treatment facilities, utility installations, roadways, and other related appurtenances or facilities, including those on adjacent uplands; a description of the type of equipment to be used and the means of equipment access to the activity site; the names and addresses of owners of record of adjacent land and known claimants of water rights in or adjacent to the wetland of whom the applicant has notice; and estimate of cost; the primary purpose of the project; and secondary purposes of the project, including further projects; the public benefit to be derived from the proposed project; a complete description of measures to be taken during and after the alteration to reduce detrimental off-site effects; the completion date of the proposed work, project, or structure and such additional materials and documentation as the Wetlands Board or planning director may require.

(c) A nonrefundable processing fee to cover the cost of processing the application accompany each permit application. Such fee shall be in an amount of two hundred dollars ($200.00) plus the cost of advertisement shall be required. Such fees shall apply to original applications, including after-the-fact applications, and to reapplications. A fee in an amount of one hundred dollars ($100.00) shall be required for deferral of an application unless waived by the Board for good cause shown.

(Ord. No. 1804, 8-22-88; Ord. No. 1874, 5-15-89; Ord. No. 1883, 6-19-89; Ord. No. 2030, 2-12-91; Ord. No. 2152, 6-23-92; Ord. No. 2198, 12-8-92; Ord. No. 2811, 5-11-04)

Sec. 1404. - Public inspection of permit applications, maps, etc.

All applications, maps, and documents relating thereto shall be open for public inspection at the planning department.

(Ord. No. 1804, 8-22-88; Ord. No. 2152, 6-23-62; Ord. No. 2198, 12-8-92)

Sec. 1405. - Public hearing procedure on permit applications [wetlands permit applications].

Not later than sixty (60) days after receipt of a complete application, the Wetlands Board shall hold a public hearing on such application. The applicant, the city council, the commissioner, the owner of record of any land adjacent to the wetlands in question, known claimants of water rights in or adjacent to the wetlands in question, the Virginia Institute of Marine Science, the Department of Game and Inland Fisheries, the Virginia Water Control Board, the Department of Transportation and any governmental agencies expressing an interest therein shall be notified of the hearing. The Board shall mail such notices not less than twenty (20) days prior to the date set for the hearing. The Board shall also cause notice of the hearing to be published at least once a week for two (2) weeks prior to such hearing in a newspaper of general circulation in the City of Virginia Beach. The published notice shall state that copies of the application may be examined in the planning department. The costs of such publication shall be paid by the applicant. The applicant shall also erect, on the property which is the subject of the hearing, a sign of a

size, type and lettering approved by the board. One such sign shall be posted within ten (10) feet of every public street adjoining the property, and within ten (10) feet of any body of water or waterway less than five hundred (500) feet wide adjoining the property or in such alternate location or locations as may be prescribed by the planning director. Such sign shall be erected not less than thirty (30) days before the Wetlands Board hearing and shall state the nature of the application and date and time of the hearing. Such signs shall be removed no later than five (5) days thereafter. In any case in which the Wetlands Board determines that the requirements of this section have not been met, the application shall be deferred or denied.

(Ord. No. 1804, 8-22-88; Ord. No. 2152, 6-23-92; Ord. No. 2198, 12-8-92; Ord. No. 2683, 1-22-02; Ord. No. 2741, 4-22-03)

Sec. 1406. - Action of Board on permit application.

(a) In acting on any application for a permit, the Board shall grant the application upon the affirmative vote of note less than four (4) members. If the application receives less than four (4) affirmative votes, the permit shall be denied.

(b) The chairperson of the Board, or in his or her absence the acting chairperson, may administer oaths and compel the attendance of witnesses. Any person may appear and testify at the public hearing. Each witness at the hearing may submit a concise written statement of his testimony. The Board shall make a record of the proceeding, which shall include the application, any written statements of witnesses, a summary of statements of all witnesses, the findings and decision of the Board, and the rationale for the decision.

(c) The Board shall make its determination within thirty (30) days of the hearing. If the Board fails to take a vote within such time, the application shall be deemed approved. Within forty-eight (48) hours of its determination, the Board shall notify the applicant and the commissioner of such determination. If the Board has not made a determination within such thirty-day period, it shall promptly notify the applicant and the commission that the application is deemed approved.

(d) If the Board's decision is reviewed or appealed, the Board shall transmit the record of its hearing to the commissioner. Upon a final determination by the commission, the record shall be returned to the Board. The record shall be open for public inspection at the planning department.

(Ord. No. 1804, 8-22-88; Ord. No. 2152, 6-23-92; Ord. No. 2198, 12-8-92)

Sec. 1407. - Bonding requirements; suspension or revocation of permit.

The Board may require a reasonable bond or letter of credit in an amount and with surety and conditions satisfactory to it, securing to the Commonwealth compliance with the conditions and limitations set forth in the permit. The Board may, after hearing as provided herein, suspend or revoke a permit if the Board finds that the applicant has failed to comply with any of the conditions or limitations set forth in the permit or has exceeded the scope of work described in the application. The Board, after hearing, may suspend a permit if the applicant fails to comply with the terms and conditions set forth in the application.

(Ord. No. 1804, 8-22-88; Ord. No. 2198, 12-8-92)

Sec. 1407.1. - Duties of Board.

In fulfilling its responsibilities under this article, the Board shall preserve, and prevent the despoliation and destruction of, wetlands within its jurisdiction while accommodating necessary economic development in a manner consistent with wetlands preservation.

(Ord. No. 2198, 12-8-92)

Sec. 1408. - Standards for grant or denial of permit.

(a) In making its decision whether to grant, to grant in modified form, or to deny an application for a permit, the Board shall consider the following:

(1) The testimony of any person in support of or in opposition to the permit application.

(2) Impact of the development on the public health and welfare; and

(3) The proposed development's conformance with the standards prescribed in section 1408.1 of this ordinance and Code of Virginia, section 28.2-1308 and the guidelines promulgated by the commission pursuant to Code of Virginia, section 28.2-1301.

(b) The Board shall grant the permit if all of the following criteria have been met:

(1) The anticipated public and private benefit of the proposed activity exceeds its anticipated public and private detriment;

(2) The proposed development conforms with the standards prescribed in section 1408.1 of this ordinance and Code of Virginia, section 28.2-1308 and the guidelines promulgated by the commission pursuant to Code of Virginia, section 28.2-1301; and

(3) The proposed activity does not violate the purposes and intent of this article or Code of Virginia, chapter 13 (§ 28.2-1300 et seq.) of Title 28

If the Board finds that any of the criteria set forth in subdivisions (1), (2) and (3) of this subsection are not met, the Board shall deny the permit application with leave to the applicant to resubmit the application in modified form.

(Ord. No. 1804, 8-22-88; Ord. No. 2198, 12-8-92)

Sec. 1408.1. - Standards for use and development of wetlands.

(a) The following standards shall apply to the use and development of wetlands and shall be considered by the Board in the determination of whether any permit required by this article should be granted or denied:

(1) Wetlands of primary ecological significance shall not be altered so that the ecological systems in the wetlands are unreasonably disturbed; and

(2) To the maximum extent practical, development shall be concentrated in wetlands of lesser ecological significance, in vegetated wetlands which have been irreversibly disturbed before July 1, 1972, in nonvegetated wetlands which have been irreversibly disturbed prior to January 1, 1983, and in areas outside of wetlands.

(b) The provisions of guidelines promulgated by the commission pursuant to Code of Virginia, section 28.2-1301 shall be considered in applying the standards set forth in subsection (a).

(c) When any activity authorized by a permit issued pursuant to this article is conditioned upon compensatory mitigation for adverse impacts to wetlands, the applicant may be permitted to satisfy all or part of such mitigation requirements by the purchase of credits from any wetlands mitigation bank that has been approved and is operating in accordance with applicable federal guidance for the establishment, use and operation of mitigation banks as long as: (1) the bank is in the same U.S.G.S. cataloging unit, as defined by the Hydrologic Unit Map of the United States (U.S.G.S. 1980), or an adjacent cataloging unit within the same river watershed, as the impacted site; (2) the bank is ecologically preferable to practicable on-site and off-site individual mitigation options, as defined by federal wetlands regulations; and (3) the banking instrument, if approved after July 1, 1996, has been approved by a process that included public review and comment.

(Ord. No. 2198, 12-8-92; Ord. No. 2428, 10-29-96)

Sec. 1409. - Permits to be in writing, signed, and notarized.

The permit shall be in writing, signed by the chairperson of the Board or an authorized representative and notarized. The Board shall transmit a copy of the permit to the commissioner.

(Ord. No. 1804, 8-22-88; Ord. No. 2198, 12-8-92; Ord. No. 2305, 12-13-94)

Sec. 1409.1. - Private rights, zoning and land use ordinances not affected.

No permit granted by the Board shall in any way affect the applicable zoning and land use ordinances of the City of Virginia Beach or the right of any person to seek compensation for any injury in fact incurred by him or her because of the proposed activity.

(Ord. No. 2198, 12-8-92)

Sec. 1410. - Expiration date and extensions of permit.

No permit shall be granted without an expiration date established by the Board; provided, however, that the Board may, upon proper application, extend the permit expiration date.

(Ord. No. 1804, 8-22-88; Ord. No. 2198, 12-8-92)

Sec. 1411. - Emergency sand grading activities on nonvegetated wetlands located on the Atlantic shoreline of Virginia Beach.

Notwithstanding the provisions of sections 1401 through 1410, sand grading activities are permitted on nonvegetated wetlands located on the Atlantic shoreline of the City of Virginia Beach if otherwise permitted by law, and if the city manager has declared an emergency and has issued a permit for this purpose. Such activities may be conducted without advance notice and hearing; however, the city manager, upon request and after reasonable notice as to time and place, shall hold a hearing to affirm, modify, amend, or cancel such emergency permit.

"Emergency," as used in this section, means a sudden and unforeseeable occurrence or condition, either as to its onset or as to its extent, of such disastrous severity or magnitude that governmental action beyond that authorized or contemplated by existing law is required because governmental inaction for the period required to amend the law to meet the exigency would work immediate and irrevocable harm upon the citizens of the commonwealth or some clearly defined portion or portions thereof.

(Ord. No. 2198, 12-8-92)

Sec. 1412. - Conducting activity without permit.

It shall be unlawful for any person to conduct any activity requiring a permit under this article without first having obtained a permit authorizing such activity.

(Ord. No. 2198, 12-8-92)

Sec. 1413. - Investigations and prosecutions.

The Board shall have the authority to investigate all projects, whether proposed or ongoing, which alter wetlands within the City of Virginia Beach. The Board shall have the authority to prosecute violations of its orders, or any violation of any of the provisions of this article.

(Ord. No. 1804, 8-22-88; Ord. No. 2198, 12-8-92)

Sec. 1414. - Reporting, monitoring, site inspections and notice to comply; stop-work orders.

(a) The Board chairperson may require a permittee to implement monitoring and reporting procedures the chairperson believes are reasonably necessary to ensure compliance with the provisions of the permit and this article.

(b) The chairperson may require such on-site inspections as he or she believes are reasonably necessary to determine whether the measures required by the permit are being properly performed, or whether the provisions of this article are being violated. Prior to conducting any such inspections, notice shall be provided by the chairperson to the resident owner, occupier or operator, who shall be given an opportunity to accompany the site inspector. If it is determined that there is a failure to comply with the permit, the chairperson shall serve notice upon the permittee at the address specified in his or her application or by delivery at the site of the permitted activities to the person supervising such activities and designated in the permit to receive the notice. Such notice shall describe the measures needed for compliance and the time within which such measures shall be completed. Failure of such person to comply within the specified period, shall constitute a violation of this section.

(c) Upon receipt of a sworn complaint of a substantial violation of this article from the designated enforcement officer of the Board, the Board chairperson may, in conjunction with or subsequent to a notice to comply as specified in subsection (b) of this section, issue an order requiring all or part of the activities on the site to be stopped until the specified corrective measures have been taken. In the case of an activity not authorized by this article, or where the alleged permit noncompliance is causing, or is in imminent danger of causing, significant harm to the wetlands protected by this article, such an order may be issued without regard to whether the person has been issued a notice to comply as specified in subsection (b) of this section. Otherwise, such an order may be issued only after the permittee has failed to comply with a notice to comply. The order shall be served in the same manner as a notice to comply, and shall remain in effect for a period of seven (7) days from the date of service pending application by the enforcing authority, permittee, resident owner, occupier or operator for appropriate relief to the circuit court. Upon completion of corrective action, the order shall immediately be lifted. Nothing in this section shall prevent the Board chairperson from taking any other action specified in section 1413 of this ordinance.

(d) Upon receipt of a sworn complaint of a substantial violation of this article from a designated enforcement officer, the Board may order that the affected site be restored to predevelopment conditions if the Board finds that restoration is necessary to recover lost resources or to prevent further damage to resources. The order shall specify the restoration necessary and establish a reasonable time for its completion. The order shall be issued only after a hearing with at least thirty (30) days' notice to the affected person of the hearing's time, place and purpose, and shall become effective immediately upon issuance by the Board. The Board shall require any scientific monitoring plan it believes necessary to ensure the successful reestablishment of wetlands protected by this article and may require that a prepaid contract acceptable to the Board be in effect for the purpose of carrying out the scientific monitoring plan. The Board may also require a reasonable bond or letter of credit in an amount and with surety and conditions satisfactory to it securing to the commonwealth compliance with the conditions set forth in the restoration order. The appropriate court, upon petition by the Board, may enforce such restoration order by injunction, mandamus, or other appropriate remedy. Failure to complete the required restoration is a violation of this article.

(e) The duties of the Board chairperson prescribed in this section may be delegated to his or her designees; however, such designees shall not be designated enforcement officers.

(Ord. No. 1804, 8-22-88; Ord. No. 2198, 12-8-92)

Sec. 1415. - Violations; penalty.

Any person who knowingly, intentionally, or negligently violates any order, rule or regulation of the commission or any provision of this article, or any provision of a permit granted pursuant to Chapter 13 of Title 28.2 of the Code of Virginia or this article shall be guilty of a Class 1 misdemeanor. Following a conviction, every day the violation continues shall constitute a separate offense.

(Ord. No. 1804, 8-22-88; Ord. No. 2198, 12-8-92)

Sec. 1416. - Injunctions.

In addition to and not in lieu of the provisions of sections 1413, 1414, and 1415 of this ordinance, upon petition of the Wetlands Board to the circuit court, the court may enjoin an act which is unlawful under the provisions of this article and may order the defendant to take such steps as are necessary to restore, protect and preserve the wetlands involved.

(Ord. No. 1804, 8-22-88; Ord. No. 2198, 12-8-92)

Sec. 1417. - Reserved.

Editor's note—

Section 1417 was repealed by Ord. No. 2198, adopted Dec. 8, 1992. The section was formerly derived from Ord. No. 1804, adopted Aug. 22, 1988, and dealt with exemptions to the provisions of this article.

Sec. 1418. - Civil penalties; civil charges.

(a) Without limiting the remedies which may be obtained under this article, any person who violates any provision of this article or who violates or fails, neglects or refuse to obey any commission or Board notice, order, rule, regulation or permit condition authorized by this article or Chapter 13 of Title 28.2 of the Code of Virginia shall, upon such finding by the circuit court, be assessed a civil penalty not to exceed twenty-five thousand dollars ($25,000.00) for each day of violation. Such civil penalties may, at the discretion of the court, be directed to be paid into the treasury of the city for the purpose of abating environmental damage to or restoring wetlands in the city, in such manner as the court may, by order, direct; except that in the event the city or its agent is the violator, the court shall direct the penalty to be paid into the state treasury.

(b) Without limiting the remedies which may be obtained under this article, and with the consent of any person who has violated any provision of this article or Chapter 13 of Title 28.2 of the Code of Virginia, or who has violated or failed, neglected or refused to obey any commission or Board order, rule, regulation or permit condition authorized by this article or Chapter 13 of Title 28.2 of the Code of Virginia, the Board may provide, in an order issued by the Board against such person, for the one-time payment of civil charges for each violation in specific sums, not to exceed ten thousand dollars ($10,000.00) for each violation. Civil charges shall be in lieu of any appropriate civil penalty which could be imposed under subsection (a) of this section. Civil charges may be in addition to the cost of any restoration ordered by the commission or Board.

(Ord. No. 2198, 12-8-92)

FOOTNOTE(S):

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(131) ***Cross reference—*** *Southern Watersheds Management ordinance, App. G.* *(Back)*

Appendix E

Meeting Notes

US Army Corps
of Engineers
Norfolk District

Meeting Notes

Harvested Wetlands Meeting at Norfolk District Corps of Engineers	URS Unassigned No.
26 April 2012 **Meeting to Discuss Potential Permitting for Harvested Wetlands**	▪ Mark Mansfield, Norfolk District COE ▪ Tom Walker, Norfolk District COE ▪ Steve McLaughlin, City of Virginia Beach ▪ Rachel Friend, City of Chesapeake ▪ John Paine, URS

This meeting was held to initiate a dialog between the Cities of Virginia Beach and Chesapeake and the Corps of Engineers regarding potential future permitting issues for harvested wetlands. Floating and planted wetlands (generally referred to as 'harvested' wetlands) have significant potential value as a BMP to help meet Chesapeake Bay TMDL requirements. The State of Virginia and EPA have both recently agreed to accept the use of harvested wetlands as a provisional BMP to meet TMDL requirements. Studies are being contemplated to quantify the pollutant removal value of harvested wetlands and particulars regarding the appropriate species to use, degree of coverage, and limits on contributing watershed area. It is important to discuss the use of harvested wetlands with regulators to gain their input and insight with respect to permitting issues. This meeting was a first attempt in that regard.

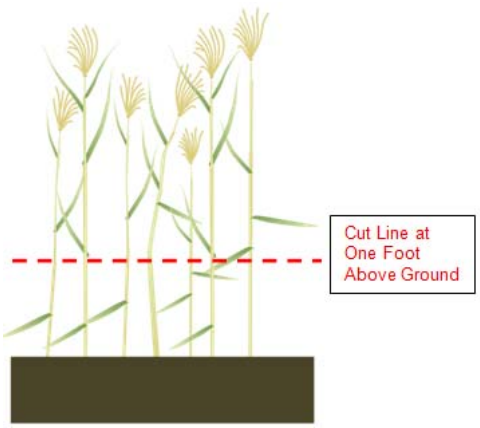
Tom Walker said that in principle, the Corps supports efforts to clean up runoff, similar to how LID is promoted.

The pertinent questions would be where and how the wetlands would be placed, and how long they would be in position.

Cut and fill activities in open water are regulated under the Clean Water Act, so *floating* wetlands may not require a permit. If navigable waters are involved, a permit will be required.

There are no design standards yet for harvested wetlands, and details such as how they would be anchored and how much surface coverage would be required have yet to be worked out. Studies are focusing along the lines of five- to ten-percent coverage, but have not been addressed yet in Virginia.

Nationwide permits may be useful for some wetland retrofit projects. The Corps is open to considering nationwide permits for certain types of retrofit projects.



If an activity, such as cutting the stalks of Phragmites plants one foot above the soil, does not involve cut or fill in the water then a permit is not required. Steve McLaughlin noted that plant stalks typically hold the nitrogen removed from the system, whereas phosphorous is held in the roots.

Mark Mansfield suggested that a matrix be developed indicating which regulatory authorities have jurisdiction for these types of activities (e.g. planted wetlands, floating wetlands, pruning of Phragmites, seeding wetlands). The Corps may not take jurisdiction over stormwater management facilities (such as wet ponds), but it depends on particulars. The matrix should indicate Section 10 of the Rivers and Harbors Act, Section 404 of the Clean Water Act, Local Wetlands Boards, DEQ, DCR, and other jurisdictional agencies and requirements. Mark offered to start the draft of the matrix and circulate it.

According to Tom Walker, for planted wetlands, DEQ, Local Wetlands Boards, and the Corps will all have jurisdiction under Section 404 because digging in the water is required.

"Seeding" of wetland plants will typically not require a permit.

With respect to Corps Jurisdiction

	Section 10	**Section 404**
Planted Wetlands	Yes	Probably
Floating Wetlands	Yes	Probably Not (depending on anchoring and harvesting techniques)

The two key questions are 1) Is it in a Section 10 waterway—within reach of the tide, and 2) how will the harvesting be done? Specifications for these projects should indicate that the soil will remain undisturbed.

Anything that disturbs the roots would be subject to jurisdiction. We don't want heavy equipment on the soils. Hip waders may be OK. The Corps can provide feedback on project specifications.

Sinking anchors and mats that may be left behind in Section 10 waters must be avoided.

Mark Mansfield offered to help facilitate additional conversations with regulators as appropriate. Steve McLaughlin indicated that a discussion with DEQ might be very helpful.

"Isolated Wetlands" were discussed, but jurisdictional decisions could be made on project-by-project basis.

Assessment of Harvested Wetlands as a Chesapeake Bay Total Maximum Daily Load Best Management Practice

IN-PROGRESS REVIEW (IPR #1)

Date: 22 AUGUST 2012

Project: Assessment of Harvested Wetlands as a Chesapeake Bay Total Maximum Daily Load Best Management Practice

Sponsor: City of Virginia Beach, VA

Participants (Conference Call):

Steve McLaughlin, City of Virginia Beach
John Paine, URS
Sean Bradberry, URS
Stephanie Hood, URS
Mark Mansfield, Corps of Engineers
Susan Conner, Corps of Engineers
Cristy Gomez, Corps of Engineers

Review Items

1. Does the Contractor have all items needed from the local Sponsor? (Y/N) Yes.

2. Are we on schedule for delivery of final work product on (date)? Yes, 31 DEC 2012.

3. Project report by work task: Project summary by work task provided by John Paine.

General Notes

After a brief introduction of City of Virginia Beach, URS, and Corps of Engineers participants, Steve provided an overview of the City of Virginia Beach needs in support of the Chesapeake Bay Executive Order 13508. Mark provided a study background indicating that this effort has been authorized and funded via Section 22 of the Water Resources Development Act (WRDA) of 1974 (Public Law 93-251), and Section 2013 of WRDA 2007 (Public Law 110-114), as amended, and previously provided the fully executed copy of the cost sharing agreement and signed project management plan to Steve. Mark read excerpts from the Executive Summary of a similar TMDL initiative (nutrient and sediment reduction efforts via oyster sanctuary reef restoration) completed in DEC 2011 for the Lynnhaven River.

The following items were indicated as being important to consider as part of the study effort:

(1) Nutrient reductions (nitrogen and phosphorus) will be considered in this effort.

(2) Total suspended solids will not be considered in this effort.

(3) The growing season and first frost are key determinants in this effort as is the scheduling of laboratory time to perform the spectral analytic evaluations.

(4) John introduced Sean Bradberry who is responsible for the technical part of the report and Stephanie Hood who is responsible for the GIS data. John mentioned that regulatory requirements are being drafted and is expected to be completed in one week.

(5) To make the study recommendation more flexible, it will include not only the harvesting of phragmites but also of cattails. John described the time of harvest in the study to be within two weeks of the first frost or around 2 NOV. Sampling or cutting will start on 18 OCT and lab results will be back by 6 NOV.

Meeting Due-outs (Next Steps/Actionable Outcomes):

(1) The Corps will host a meeting of regulatory agencies (City of Virginia Beach to provide) on/about 18 SEP 2012 (see item (2) below).

(2) IPR #2 recommended for SEP 2012 and IPR #3 recommended for OCT 2012.

(3) Steve will brief Sam Sawan periodically on the progress of the efforts.

(4) John will determine what work task production will be completed by the end of SEP and provide to Mark (note: this item has been completed)

(Attachment)
Assessment of Harvested Wetlands as a Chesapeake Bay Total Maximum Daily Load Best Management Practice
IPR #1
Meeting Agenda
22 August 2012

1. Welcome & Introductions -- Mark Mansfield
2. Study Background – Steve McLaughlin/Mark Mansfield
3. Study Status -- ALL
4. Identification of Issues -- ALL
5. Summary and Next Steps/Actionable Outcomes -- ALL

Assessment of Harvested Wetlands as a Chesapeake Bay Total Maximum Daily Load Best Management Practice

IN-PROGRESS REVIEW (IPR #2)

Date: 18 SEPTEMBER 2012

Project: Assessment of Harvested Wetlands as a Chesapeake Bay Total Maximum Daily Load Best Management Practice

Sponsor: City of Virginia Beach, VA

Participants (See attached):

Review Items

1. Does the Contractor have all items needed from the local Sponsor? (Y/N) Yes.

2. Are we on schedule for delivery of final work product on (date)? Yes, 31 DEC 2012.

3. Project report by work task: Project summary by work task provided by John Paine.

General Notes

A copy of the meeting agenda is attached. After a brief introduction of meeting participants, Steve provided an overview of the City of Virginia Beach needs in support of the Chesapeake Bay Executive Order 13508. Mark provided a study background indicating that this effort has been authorized and funded via Section 22 of the Water Resources Development Act (WRDA) of 1974 (Public Law 93-251), and Section 2013 of WRDA 2007 (Public Law 110-114), as amended, and previously provided the fully executed copy of the cost sharing agreement and signed project management plan to Steve. Mark read excerpts from the Executive Summary of a similar TMDL initiative (nutrient and sediment reduction efforts via oyster sanctuary reef restoration) completed in DEC 2011 for the Lynnhaven River.

By way of background, the annual Chesapeake Bay TMDL requirements for the city of Virginia Beach are as follows:

Nitrogen – 126,000 pounds
Phosphorous – 2,200 pounds
Total Suspended Solids – 5,250,000 pounds

The meeting served to receive agencies inputs, guidance, and concerns on the study effort. The following general areas of interest were discussed:

(1) Plant types to be considered (generally *Phragmites* and cattails)

(2) Definition of “harvesting”

(3) Impacts on vegetated and non-vegetated wetlands

(4) Impacts of the disposition of harvested material

(5) Access issues with private property

(6) Communication strategy. Lynnette Rhodes said there needs to be clear communication with the public—on one hand they are told not to touch wetlands, and on the other the City may be harvesting the plants. Mark Mansfield said a communication strategy should be included in this Study Report.

URS has collected GIS information from VIMS and the City pertaining to *Phragmites*, cattails, and other wetlands plants, particularly along the Lynnhaven shoreline. Aerial imagery (shown to the group during this meeting) indicates that the Phragmites is spread thinly along private shorelines, and that harvesting these areas will likely prove to be infeasible (too spread out, too patchy, too inaccessible). URS asked the regulators in this meeting if there would be any possibility of using the islands in the mouth of the Lynnhaven estuary for plant harvesting for Chesapeake Bay TMDL purposes. Currently these islands are considered high marsh, largely populated with cordgrass. After a lengthy discussion, the clear consensus of those present was that such harvesting of the high marsh on these islands would not be feasible from a regulatory standpoint. URS was not proposing such harvesting, but needed to ask the question for due diligence reasons.

URS will look for suitable wetland plant inventory elsewhere within the Chesapeake Bay watershed in Virginia Beach. Several meeting participants suggested possible sites, including the City-owned borrow pit that receives dredge material from the Lynnhaven. Other potential sites could include areas near Princess Anne High School, Broad Bay, Linkhorn Bay, the Milldam Creek area, and Wolfsnare Creek.

Meeting Due-outs (Next Steps/Actionable Outcomes)

(1) Seek input from agencies not represented in today’s meeting (Virginia Beach Wetlands Board, VIMS (CCRM), Environmental Protection Agency, Fish & Wildlife Service, National Oceanic and Atmospheric Administration) (Steve McLaughlin/Susan Conner).

(2) Definition of the term “harvesting” (John Paine/URS).

(3) IPR #3 recommended for OCT 2012 (Susan Conner).

(4) Steve McLaughlin will continue to brief Sam Sawan periodically on the progress of the efforts.

(5) The project is on schedule as follows:

a. 2012 10 16 – Begin Sample Collection
b. 2012 11 15 – Progress Meeting to Review Initial Results (IPR #3 unless there is another IPR in October per Item 3 above)
c. 2012 12 20 – Progress Meeting (IP #4) to Review Final Delivery
d. 2012 12 31 – Project Completion

(Attachment)

Assessment of Harvested Wetlands as a Chesapeake Bay Total Maximum Daily Load Best Management Practice
IPR #2
Meeting Agenda
18 September 2012

1. Welcome & Introductions -- Mark Mansfield

2. Study Status -- Steve McLaughlin/John Paine

3. Identification of Issues – ALL

4. Summary and Next Steps/Actionable Outcomes -- ALL

Meeting Notes

Harvested Wetlands Meeting at Virginia Institute of Marine Science	11658362
22 October 2012 **Meeting to Discuss the Potential for Harvested Wetlands**	▪ Emily Egginton, VIMS ▪ Carl Hershner, VIMS ▪ Kirk Havens, VIMS ▪ Mac Sisson, VIMS ▪ Justin Worrell, VMRC ▪ Dave Schulte, Norfolk District COE ▪ Steve McLaughlin, City of Virginia Beach ▪ Charles McKennah, City of Virginia Beach ▪ Sean Bradberry, URS ▪ John Paine, URS

This meeting was held to discuss the potential for harvested wetlands (particularly the harvesting of *Phragmites* and Cattails) as a BMP to meet Chesapeake Bay TMDL pollutant reduction targets.

John Paine gave a PowerPoint presentation on the status of a project being completed for the City of Virginia Beach and the Corps of Engineers (attached). The presentation reviewed the requirements of Executive Order 13508, and the Watershed Implementation Plans (WIPs) that Virginia localities had to submit by 1 February 2012. The TMDL compliance costs are a substantial, and localities are looking for cost-effective BMPs to meet their pollution reduction targets. Steve McLaughlin conceived the possibility of harvesting Phragmites and Cattails, and commissioned the current study through the Corps of Engineers Section 22 program. The study will be completed by 31 December 2012.

After this brief presentation on the project status, those present asked questions of the project delivery team, and provided feedback that will be useful in developing harvesting protocols if such harvesting indeed proves to be feasible. These notes summarize what was said during this discussion.

<u>Kirk Havens (VIMS)</u>

1. Stay above the Mean High Water line with harvesting operations.
2. Timing is important. Phragmites (Phrag) transfers TN back into the rhizomes on a seasonal basis.
3. The Virginia Intertidal Wetlands Act allows intertidal harvesting.
4. Cutting Phrag too low will kill the plant. Leaving one foot of plant above the ground should be OK, but should be monitored carefully.
5. Habitat is an issue (minimize the disruption).
6. Phrag spreads “many, many feet per year” and is very hearty.
7. One way to control Phrag is to dig perimeter ditches deep enough to prevent Phrag growth.

8. VIMS is interested in the plant tissue sampling results.
9. 4-6 tons per acre of dry weight is a typical Phrag yield.

Carl Hershner

10. 30% of wetlands in the Lynnhaven River estuary are estimated to be Phrag.
11. There are approximately 170 acres of Phrag in the Lynnhaven.
12. Disturbance of the marsh surface soils will be a key regulatory issue.
13. Watch out for Marsh Wren nesting sites.
14. Look at oil spill recovery operations for ideas on working in marsh conditions.
15. Phrag is currently imported into Virginia (Jamestown Park for thatched roofs).
16. Virginia Natural Heritage (http://www.naturalarea.org/12conference/) just completed a Phrag symposium.
17. VIMS is interested in the project data to see what the plant sampling results show for variation between locations (e.g. next to golf courses).
18. Harvesting may be a good solution—after years of failing to eradicate the plant as a nuisance, maybe harvesting can offer some benefits.

Steve McLaughlin (City of Virginia Beach)

19. The City may contemplate jail labor for this type of project.

Justin Worrell (VMRC)

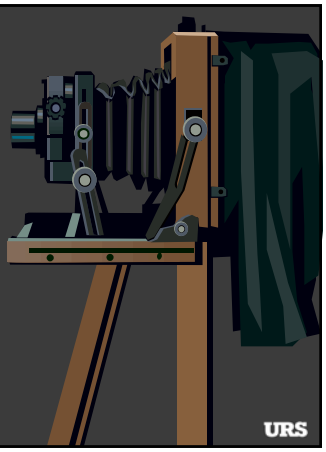
20. It is important to stay consistent between public and private property use. If the residents are told to stay away from the Phrag and wetlands, but see the City harvesting in these areas, there will be communications and education issues.

HARVESTED WETLANDS PROJECT SNAPSHOT

22 OCTOBER 2012

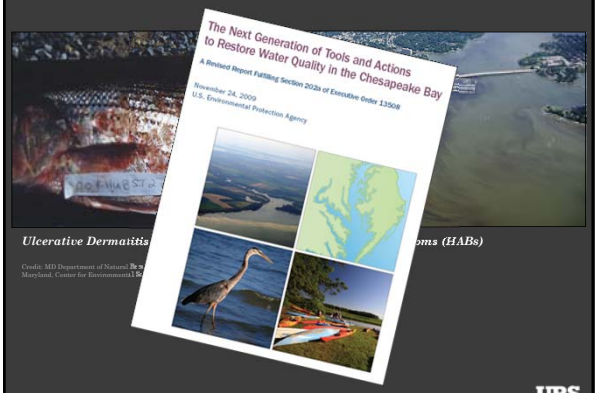
JOHN PAINE,
SEAN BRADBERRY

URS CORPORATION



URS

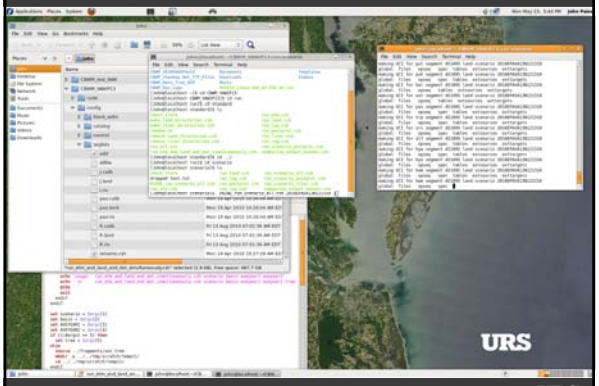
Chesapeake Bay TMDL



Ulcerative Dermatitis *...oms (HABs)*

URS

Phase 5.3 Watershed Model (Running)



URS

URS

Under the Chesapeake Bay TMDL…

localities develop and implement Watershed Implementation Plans (WIPs)

…to reduce their annual discharges of
Total Nitrogen (TN),
Total Phosphorus (TP), and
Total Suspended Solids (TSS or 'sediment')
to prescribed limits.

These pollutants contribute to water quality problems (like algal blooms, dissolved oxygen depletion, fish lesions and mahogany tides) in the Bay.

Putting a WIP Together

URS

The WIP identifies Best Management Practices (BMPs) that will be used to reach the goals.

Typical BMPs include:

- Erosion & Sediment Control Practices
- Street Sweeping
- Detention ('Dry') Ponds
- Retention ('Wet') Ponds
- Nutrient Management Plans
- Restrictions on the Use of Fertilizer
- Creation of Wetlands
- Bioretention
- Infiltration Practices
- Urban Filtering Practices

Putting a WIP Together

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The challenge is to select BMPs that can meet the regulated pollutant reduction levels set by the Chesapeake Bay TMDL at a reasonable cost.

So…How can that be done?

Putting a WIP Together

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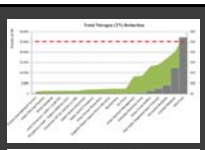
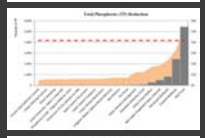
Most BMPs serve to reduce some amount of *all three* pollutants. For example, a wet pond removes TN, TP *and* TSS from stormwater discharges.

Localities need to select a toolbox of cost-effective BMPs that when implemented collectively can meet the prescribed pollutant reduction levels.

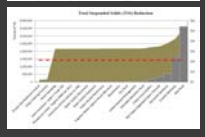
TN



TP



TSS



Putting a WIP Together

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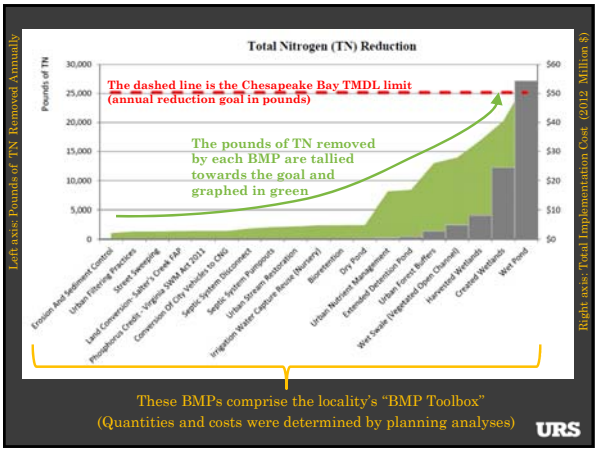

These BMPs comprise the locality's "BMP Toolbox"
(Quantities and costs were determined by planning analyses)

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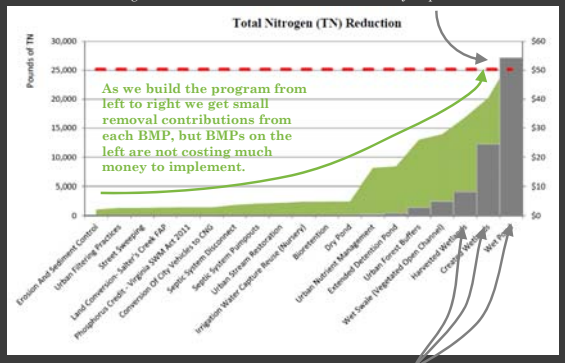
Plan to exceed the goal because not all BMPs can be successfully implemented.



These BMPs begin to cost significantly. They represent the largest capital outlays, but are needed to reach the pollutant reduction goal.

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For this locality TN was the most difficult target to meet.

The other pollutant removals for this WIP program are shown on the following charts.

Putting a WIP Together

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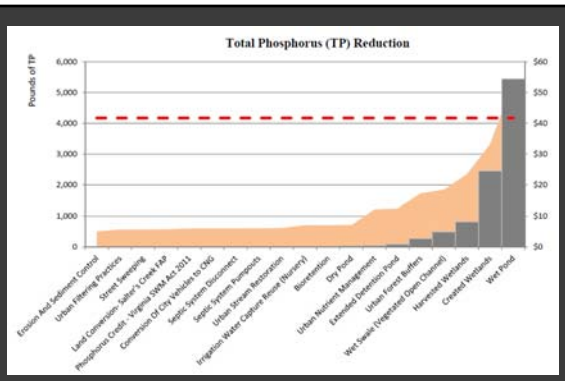

Putting a WIP Together

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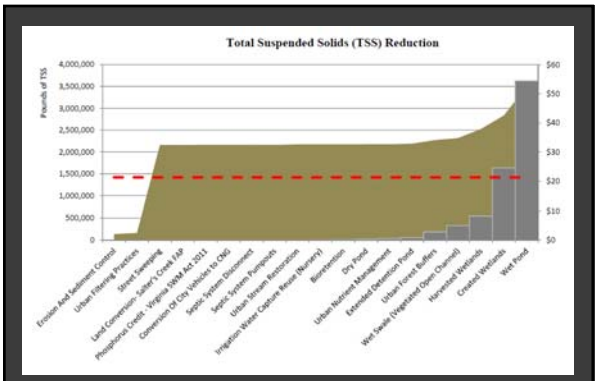

Putting a WIP Together

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Why Do We Need Harvested Wetlands?

- Need Efficient BMP Retrofits in the toolbox
  - High Pollutant Removal Efficiencies
- Real Estate and Easement Acquisition takes YEARS
  - Already have Right-of-Way
  - Little/no construction required for footprints
- Can be implemented quickly
- They Work (why else are we protecting wetlands?)
  - Cannot say that for many Chesbay BMPs

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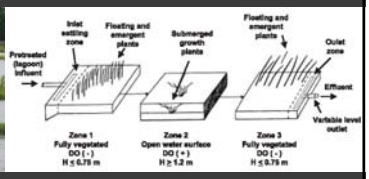
Examples of "Harvested Wetlands"

Source: Beemats.com



Source: EPA

"Harvested Wetlands" includes Floating Wetlands and Free Water Surface (FWS) Wetlands

Not just floating wetlands!

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TABLE 14.9
Removal Performance of Constructed, Gravity-Fed, Urban Stormwater Wetlands

System	Location	Wetland Area (ha)	Drainage Area (ha)	Area Ratio (%)	NH_4 (%)	NO_xN (%)	TN (%)	Reference
Clear Lake	Minnesota	21.4	433	4.94	55	—	—	Carleton *et al.* (2001)
Crestwood	Virginia	0.070	2.90	2.41	55	39	22	Carleton *et al.* (2001)
DUST	California	22	1,200	1.83	10	15	—	Carleton *et al.* (2001)
Franklin County	Ohio	6.1	260	2.35	—	—	—	Carleton *et al.* (2001)
Franklin Farms	Virginia	0.125	16.2	0.78	–1	60	—	Carleton *et al.* (2001)
Greenwood	Florida	5.24	213	2.46	10	–13	–11	Carleton *et al.* (2001)
Lake McCarrons	Minnesota	2.50	38.0	6.58		35	35	Carleton *et al.* (2001)
Lake Tahoe	California	0.066	1.0	1.84	–53	85	—	Carleton *et al.* (2001)
Mays Chapel	Maryland	0.240	39.3	0.61	22	28	—	Carleton *et al.* (2001)
Queen Anne	Maryland	0.240	0.64	3.75	56	55	23	Carleton *et al.* (2001)
Shop Creek	Colorado	1.42	223	0.64	—	21	41	Carleton *et al.* (2001)
Spring Lake	Minnesota	26	2,260	1.15	–86	—	–14	Carleton *et al.* (2001)
Tampa Office	Florida	0.129	2.55	5.08	39	65	—	Carleton *et al.* (2001)
Motorway	Slovenia	0.009	0.75	1.13	89	76	80	Bulc and Sajn Slak (2003)
Kaohsiung	Taiwan	0.120	—	—	91	—	—	Kao *et al.* (2001a)
Blacktown, NSW	Australia	0.450	75	0.60	–6	16	58	Knoll and Bavor (2004)
Calamvale, QLD	Australia	0.187	160	0.12	50	50	30	Greenway and Jenkins (2004)
Coorparoo, QLD	Australia	0.800	197	0.41	—	78	—	Greenway and Jenkins (2004)
Median					**1.83**	**31**	**45**	**30**

Note: All are FWS except for Slovenia and Taiwan.

TN Reduction = 30%

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TABLE 14.7
Phosphorus Entering and Leaving Constructed Urban Runoff Treatment Wetlands

Name	Location	Reference	Area Ratio	HLR (cm/d)	% Reduction TP
Armstrong Slough	Florida	Carleton *et al.* (2001)	0.3	34.65	39.7
Mays Chapel	Maryland	Carleton *et al.* (2001)	0.6	5.55	–7
Shop Creek	Colorado	Carleton *et al.* (2001)	0.6	—	36
Franklin Farms	Virginia	Carleton *et al.* (2001)	0.8	17.16	14.9
Lake Munson	Florida	Maristany and Bartel (1989)	1.1	5.19	62.7
Highway	Slovenia	Bulc and Sajn Slak (2003)	1.1	—	75
Spring Lake	Minnesota	Carleton *et al.* (2001)	1.2	—	–7
DUST Marsh	California	Meiorin (1989)	1.8	—	48
Franklin County	Ohio	Carleton *et al.* (2001)	2.4	10.60	16
Crestwood	Virginia	Carleton *et al.* (2001)	2.4	3.69	45.9
Greenwood	Florida	Carleton *et al.* (2001)	2.5	2.57	61.5
Queen Anne	Maryland	Carleton *et al.* (2001)	3.8	—	39.4
Clear Lake	Minnesota	Carleton *et al.* (2001)	4.9	1.71	54
Tampa Pond	Florida	Carleton *et al.* (2001)	5.1	8.16	65
Lake McCarrons	Minnesota	Carleton *et al.* (2001)	6.6	7.38	41
Hidden River	Florida	Carr and Rushton (1995)	19.5	1.04	70
Spring Creek	North Dakota	Carleton *et al.* (2001)	—	0.22	39.6
Elbow Valley	Calgary	Ansell (2004)	—	—	36
Kaohsiung	China	Kao *et al.* (2001a)	—	7.10	70
Median				**5.6**	**41**

Note: All are FWS except for Slovenia, which is SSF.

TP Reduction = 41%

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TABLE 14.5
Suspended Solids Reduction in Constructed Urban Runoff Treatment Wetlands

Name	Location	Reference	WWAR Area Ratio (%)	HLR (cm/d)	Reduction (%)
Crookes	Australia	Raisin *et al.* (1997)	0.1	21.83	12
Mays Chapel	Maryland	Carleton *et al.* (2001)	0.6	5.55	11
Shop Creek	Colorado	Carleton *et al.* (2001)	0.6	—	25
Franklin Farms	Virginia	Carleton *et al.* (2001)	0.8	17.16	62
Lake Munson	Florida	Maristany and Bartel (1989)	1.1	5.19	93
Slovenia Highway	Slovenia	Bulc and Sajn Slak (2003)	1.1	—	74
DUST Marsh	California	Meiorin (1989)	1.8	—	64
Crestwood	Virginia	Carleton *et al.* (2000)	2.4	3.69	58
Greenwood	Florida	McCann and Olson (1994)	2.5	2.57	68
Queen Anne	Maryland	Carleton *et al.* (2001)	3.8	—	65
Clear Lake	Minnesota	Carleton *et al.* (2001)	4.9	1.71	76
Tampa Office Pond	Florida	Carleton *et al.* (2001)	5.1	8.16	55
West Lafayette	Indiana	Harbor *et al.* (2000)	6.3	—	75
Lake McCarrons	Minnesota	Carleton *et al.* (2001)	6.6	7.38	83
Hidden River	Florida	Carr and Rushton (1995)	19.5	1.04	86
Elbow Valley	Calgary	Ansell (2004)	—	—	72
Hallam Valley Low	Australia	Wong *et al.* (2006)	—	400	94
Hallam Valley High	Australia	Wong *et al.* (2006)	—	220	94
Kaohsiung	China	Kao *et al.* (2001a)	—	7.10	37
Villanova	Pennsylvania	Rea (2004)	—	8.16	70
Median				**7.10**	**68**

Note: All are FWS except for Slovenia, which is HSSF.

TSS Reduction = 68%

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Drawbacks?

- Provisionally on approved list of BMPs for Chesbay TMDL
  - BMP Clearinghouse approval process takes years
- Not tested on large-scale implementation in Virginia
- Annual maintenance cost could be high to very high
- Floating wetlands could have seed stock shortages
- Harvest should occur in short time frame
- Invasive Species potential
- Leaching of nutrients from bed material (floating wetlands)

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One Idea

- Look at harvesting *Phragmites* and Cattails
- Benefits:
  - Potential high removal efficiencies
  - Potential (relatively) low cost
  - No need to plant
  - Directly measurable TN and TP removal
  - Hearty, self-replenishing stock is already abundant in watershed
  - Can be implemented on scalable basis
  - Markets exist for biomass (for disposal)

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Chesapeake Bay Water Quality Treatment Activities

Activity	Cost for removal of pollutant $ per # Total Nitrogen	Cost for removal of pollutant $ per # Total Phosphorus	Cost for removal of pollutant $ per # Total Suspended Solids
Oyster Reef [1]	25 to 150	No Change Probable	0.25 to 1.50
Stream Restoration [2]	400 to 750	2,500 to 5,000	5 to 8
Stream Bank Stabilization [2]	400 to 750	2,500 to 5,000	5 to 8
Bioretention Basin [3]	300 to 600	3,000 to 4,000	10 to 15
Pond [4]	5,000 to 14,000	30,000 to 75,000	75 to 250
Cistern [5]	5,500 to 9,500	45,000 to 85,000	700 to 1,000

[1] Oyster Reef removal estimates based upon Nitrogen removal rates of 100 to 300 # Total Nitrogen / Acre / Year and Total Suspended Solids removal rates of 10,000 to 30,000 # Total Suspended Solids / Acre / Year with no Phosphorus change, at a construction/renovation cost of $50,000 to $100,000 per Acre every 5 to 10 years

[2] Stream Restoration and Stream Bank Stabilization estimates based upon Center for Watershed Protection work with reconstruction/renovation at full original construction cost every 5 to 10 years

[3] Bioretention Basin estimates based upon Center for Watershed Protection work with reconstruction/renovation at full original construction cost every 2.5 to 3 years

[4] Costs and pollutant removals for Alanton Elem School Pond and Lynnhaven Middle School Pond, does not include land acquisition costs

[5] Cistern estimates based upon Center for Watershed Protection work, does not include pumps, piping, controls needed for use of the water

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Netley-Libau Marsh – Another Piece in the Lake Winnipeg Nutrient Puzzle:

utilizing a natural wetland for nutrient removal and bioenergy production

Richard E. Grosshans, PhD Candidate
University of Manitoba & IISD

R.E. Grosshans*[1], L.G. Goldsborough[3,4], N. Cicek[4], D.A. Wrubleski[2], H.D. Venema[1], and Eric Bibeau[1]
[1]International Institute for Sustainable Development, [2]Ducks Unlimited Canada, [3]Delta Marsh Field Station, and [4]University of Manitoba

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Biomass Harvesting for Gasification

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Nutrient Content from Collected Samples (winter)

Parameters	Netley-Libau Results				Reported in Literature*			
	Cattail	Bulrush	Sedges	Giant Reeds	Cattail	Bulrush	Sedges	Giant Reeds
Moisture (%)	13.2	12.7	12.8	11	-	-	-	-
TN (% dry matter)	1.72	1.32	0.9	0.64	1.37	1.22	1.24	2.57
TP (% dry matter)	0.32	0.11	0.1	0.08	0.21	0.18	0.27	0.18
Heating Value (KJ/kg)	18,229	17,417	17,285	NA	15,400-19,600	17,700-18,400	16,700-20,700	15,400

*Kadlec, 1996; Mitch, 1994; Reddy, 1987

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Inventory of *Phragmites* and Cattails

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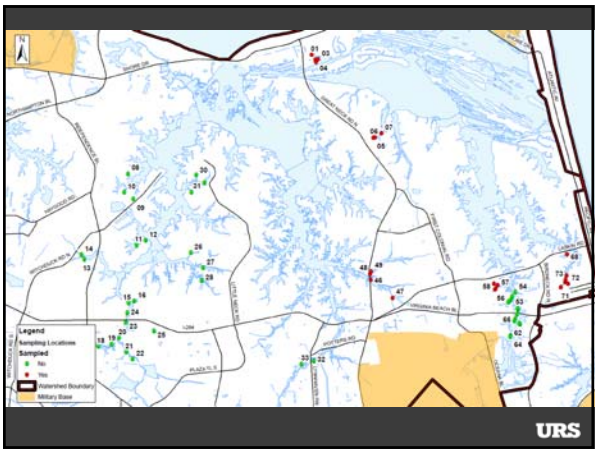
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Sampled
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Yes
Watershed Boundary
Military Base
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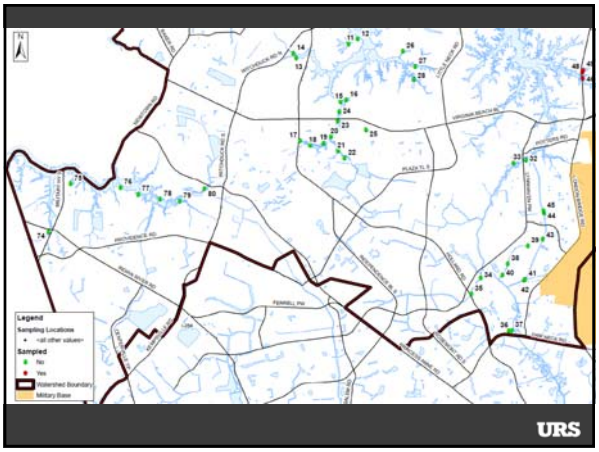
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Sampling Locations
Sampled
No
Yes
Watershed Boundary
Military Base
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Legend
Sampling Locations
City Owned Property
Property Easement Lines
Watershed Boundary
Military Base
URS


MAPLE STREET BORROW PIT
URS


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Sampling Locations
City Owned Property
Property Easement Lines
Watershed Boundary
Military Base
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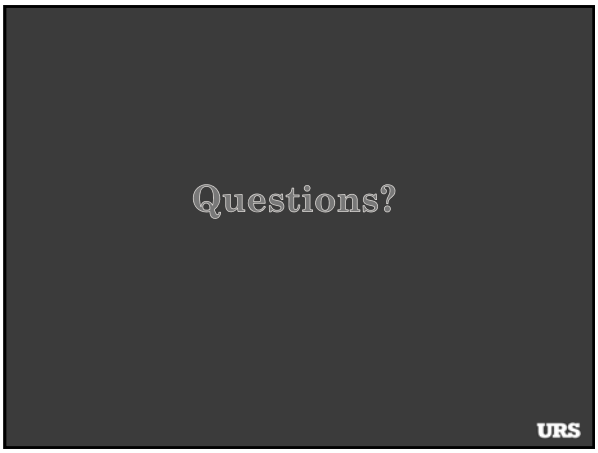
Questions?
URS

Appendix F

Yield Calculations

US Army Corps
of Engineers
Norfolk District

Table F-1. Yield Calculations

				Laboratory Results						
Sample #	**Site Loc. #**	**Plant Species**	**Density (plants/sf)**	**Dry Wt. (g)**	**N (lbs)**	**P (lbs)**	**Fraction of Viable Stalks**	**Dry Wt. (lbs/sf)**	**N (lbs/ac)**	**P (lbs/ac)**
001	01	P	22	20.39	0.00077	0.00005				
002	01	P	22	16.73	0.00045	0.00003				
003	01	P	22	8.20	0.00031	0.00003				
004	01	P	22	11.32	0.00035	0.00004				
005	01	P	22	14.66	0.00057	0.00004				
006	01	P	22	11.34	0.00034	0.00003				
	01			82.64	0.00278	0.00022				
	01			**13.77**	**0.00046**	**0.00004**	**0.40**	**0.27**	**178**	**14**
007	02	P	19	22.86	0.00047	0.00005				
008	02	P	19	16.24	0.00023	0.00003				
009	02	P	19	17.11	0.00035	0.00003				
010	02	P	19	24.30	0.00045	0.00005				
011	02	P	19	22.64	0.00049	0.00003				
012	02	P	19	12.25	0.00023	0.00002				
	02			115.40	0.00222	0.00022				
	02			**19.23**	**0.00037**	**0.00004**	**0.45**	**0.36**	**138**	**14**
013	03	P	7	20.17	0.00038	0.00004				
014	03	P	7	17.70	0.00044	0.00005				
015	03	P	7	26.97	0.00070	0.00005				
016	03	P	7	14.23	0.00031	0.00003				
017	03	P	7	12.75	0.00030	0.00003				
018	03	P	7	23.17	0.00045	0.00003				
	03			114.99	0.00258	0.00022				
	03			**19.17**	**0.00043**	**0.00004**	**0.65**	**0.19**	**85**	**7**
019	04	P	28	39.93	0.00080	0.00007				
020	04	P	28	40.33	0.00077	0.00012				
021	04	P	28	46.24	0.00153	0.00013				
022	04	P	28	53.60	0.00147	0.00020				
023	04	P	28	47.80	0.00081	0.00013				
024	04	P	28	50.78	0.00100	0.00011				
	04			278.68	0.00638	0.00076				
	04			**46.45**	**0.00106**	**0.00013**	**0.40**	**1.15**	**519**	**62**
025	07	P	14	56.64	0.00129	0.00009				
026	07	P	14	42.46	0.00124	0.00008				
027	07	P	14	51.85	0.00120	0.00009				
028	07	P	14	70.32	0.00174	0.00016				
029	07	P	14	44.58	0.00077	0.00004				
030	07	P	14	44.69	0.00101	0.00005				
	07			310.54	0.00725	0.00051				
	07			**51.76**	**0.00121**	**0.00008**	**0.60**	**0.96**	**442**	**31**
031	06	P	12	35.31	0.00097	0.00009				
032	06	P	12	29.04	0.00075	0.00005				
033	06	P	12	42.05	0.00149	0.00010				
034	06	P	12	35.89	0.00113	0.00007				
035	06	P	12	30.85	0.00103	0.00008				
036	06	P	12	23.21	0.00059	0.00006				
	06			196.35	0.00595	0.00045				
	06			**32.73**	**0.00099**	**0.00008**	**0.65**	**0.56**	**337**	**26**
037	05	P	11	47.80	0.00120	0.00011				
038	05	P	11	55.16	0.00122	0.00009				
039	05	P	11	61.39	0.00267	0.00023				
040	05	P	11	53.89	0.00122	0.00011				
041	05	P	11	39.11	0.00099	0.00009				
042	05	P	11	55.76	0.00138	0.00010				
	05			313.11	0.00868	0.00071				
	05			**52.19**	**0.00145**	**0.00012**	**0.60**	**0.76**	**416**	**34**

Table F-1. Yield Calculations

				Laboratory Results						
Sample #	**Site Loc. #**	**Plant Species**	**Density (plants/sf)**	**Dry Wt. (g)**	**N (lbs)**	**P (lbs)**	**Fraction of Viable Stalks**	**Dry Wt. (lbs/sf)**	**N (lbs/ac)**	**P (lbs/ac)**
043	47	P	14	40.34	0.00201	0.00016				
044	47	P	14	25.33	0.00145	0.00014				
045	47	P	14	41.55	0.00175	0.00017				
046	47	P	14	39.49	0.00199	0.00018				
047	47	P	14	28.31	0.00150	0.00018				
048	47	P	14	45.34	0.00229	0.00021				
	47			220.36	0.01099	0.00105				
	47			**36.73**	**0.00183**	**0.00017**	**0.60**	**0.68**	**670**	**64**
049	46	P	22	26.40	0.00085	0.00007				
050	46	P	22	19.85	0.00084	0.00004				
051	46	P	22	21.72	0.00093	0.00006				
052	46	P	22	27.74	0.00114	0.00007				
053	46	P	22	40.29	0.00169	0.00011				
054	46	P	22	30.87	0.00142	0.00010				
	46			166.87	0.00686	0.00044				
	46			**27.81**	**0.00114**	**0.00007**	**0.45**	**0.61**	**493**	**32**
055	48	P	17	56.48	0.00143	0.00014				
056	48	P	17	51.02	0.00168	0.00013				
057	48	P	17	63.86	0.00142	0.00013				
058	48	P	17	57.00	0.00205	0.00014				
059	48	P	17	55.01	0.00082	0.00006				
060	48	P	17	53.46	0.00171	0.00012				
	48			336.83	0.00911	0.00072				
	48			**56.14**	**0.00152**	**0.00012**	**0.50**	**1.05**	**562**	**44**
061	49	P	16	33.65	0.00131	0.00008				
062	49	P	16	55.38	0.00168	0.00013				
063	49	P	16	45.90	0.00094	0.00005				
064	49	P	16	43.22	0.00150	0.00010				
065	49	P	16	51.09	0.00089	0.00007				
066	49	P	16	57.41	0.00181	0.00013				
	49			286.65	0.00813	0.00056				
	49			**47.78**	**0.00135**	**0.00009**	**0.50**	**0.84**	**472**	**32**
067	68	P	12	38.41	0.00121	0.00008				
068	68	P	12	25.30	0.00057	0.00005				
069	68	P	12	44.16	0.00111	0.00006				
070	68	P	12	23.40	0.00046	0.00004				
071	68	P	12	43.60	0.00135	0.00008				
072	68	P	12	45.26	0.00163	0.00010				
	68			220.13	0.00632	0.00041				
	68			**36.69**	**0.00105**	**0.00007**	**0.60**	**0.58**	**330**	**21**
073	70	P	12	51.54	0.00149	0.00010				
074	70	P	12	40.59	0.00144	0.00013				
075	70	P	12	40.01	0.00078	0.00005				
076	70	P	12	45.20	0.00097	0.00006				
077	70	P	12	45.94	0.00097	0.00009				
078	70	P	12	43.62	0.00120	0.00017				
	70			266.90	0.00685	0.00060				
	70			**44.48**	**0.00114**	**0.00010**	**0.60**	**0.71**	**358**	**32**
079	73	P	16	35.54	0.00122	0.00009				
080	73	P	16	43.54	0.00128	0.00012				
081	73	P	16	38.45	0.00091	0.00008				
082	73	P	16	23.86	0.00103	0.00008				
083	73	P	16	33.49	0.00110	0.00009				
084	73	P	16	39.40	0.00096	0.00009				
	73			214.28	0.00650	0.00055				
	73			**35.71**	**0.00108**	**0.00009**	**0.50**	**0.63**	**377**	**32**

Table F-1. Yield Calculations

Sample #	Site Loc. #	Plant Species	Density (plants/sf)	Laboratory Results: Dry Wt. (g)	Laboratory Results: N (lbs)	Laboratory Results: P (lbs)	Fraction of Viable Stalks	Dry Wt. (lbs/sf)	N (lbs/ac)	P (lbs/ac)
085	72	P	17	24.19	0.00085	0.00012				
086	72	P	17	31.57	0.00146	0.00015				
087	72	P	17	41.01	0.00143	0.00013				
088	72	P	17	34.72	0.00152	0.00013				
089	72	P	17	38.60	0.00162	0.00015				
090	72	P	17	27.57	0.00157	0.00016				
	72			197.66	0.00844	0.00084				
	72			**32.94**	**0.00141**	**0.00014**	**0.50**	**0.62**	**521**	**52**
091	69	P	19	18.42	0.00100	0.00011				
092	69	P	19	19.51	0.00078	0.00008				
093	69	P	19	35.33	0.00122	0.00009				
094	69	P	19	53.41	0.00121	0.00009				
095	69	P	19	26.97	0.00119	0.00008				
096	69	P	19	35.72	0.00138	0.00010				
	69			189.36	0.00678	0.00056				
	69			**31.56**	**0.00113**	**0.00009**	**0.50**	**0.66**	**468**	**39**
097	71	P	7	43.44	0.00211	0.00022				
098	71	P	7	41.77	0.00189	0.00017				
099	71	P	7	45.89	0.00254	0.00025				
100	71	P	7	31.47	0.00106	0.00010				
101	71	P	7	23.83	0.00088	0.00007				
102	71	P	7	35.06	0.00108	0.00009				
	71			221.46	0.00956	0.00092				
	71			**36.91**	**0.00159**	**0.00015**	**0.75**	**0.43**	**364**	**35**
103	58	P	17	42.68	0.00112	0.00011				
104	58	P	17	26.54	0.00086	0.00007				
105	58	P	17	30.08	0.00117	0.00008				
106	58	P	17	42.13	0.00117	0.00010				
107	58	P	17	36.10	0.00110	0.00009				
108	58	P	17	41.19	0.00116	0.00010				
	58			218.72	0.00658	0.00055				
	58			**36.45**	**0.00110**	**0.00009**	**0.50**	**0.68**	**406**	**34**
109	57	P	28	41.49	0.00171	0.00015				
110	57	P	28	35.44	0.00073	0.00007				
111	57	P	28	40.27	0.00114	0.00011				
112	57	P	28	30.04	0.00075	0.00005				
113	57	P	28	32.10	0.00084	0.00006				
114	57	P	28	30.05	0.00091	0.00006				
	57			209.39	0.00608	0.00050				
	57			**34.90**	**0.00101**	**0.00008**	**0.40**	**0.86**	**495**	**41**
115	56	P	7	40.44	0.00188	0.00021				
116	56	P	7	36.66	0.00091	0.00012				
117	56	P	7	33.32	0.00099	0.00012				
118	56	P	7	35.96	0.00086	0.00011				
119	56	P	7	25.30	0.00077	0.00011				
120	56	P	7	43.96	0.00149	0.00018				
	56			215.64	0.00690	0.00087				
	56			**35.94**	**0.00115**	**0.00014**	**0.70**	**0.39**	**246**	**31**
121	55	P	19	20.12	0.00050	0.00003				
122	55	P	19	23.36	0.00055	0.00004				
123	55	P	19	17.38	0.00042	0.00003				
124	55	P	19	15.18	0.00031	0.00002				
125	55	P	19	31.09	0.00066	0.00004				
126	55	P	19	16.97	0.00052	0.00004				
	55			124.10	0.00295	0.00019				
	55			**20.68**	**0.00049**	**0.00003**	**0.60**	**0.52**	**244**	**16**

Table F-1. Yield Calculations

				Laboratory Results						
Sample #	**Site Loc. #**	**Plant Species**	**Density (plants/sf)**	**Dry Wt. (g)**	**N (lbs)**	**P (lbs)**	**Fraction of Viable Stalks**	**Dry Wt. (lbs/sf)**	**N (lbs/ac)**	**P (lbs/ac)**
127	08	P	13	34.52	0.00092	0.00009				
128	08	P	13	56.97	0.00224	0.00024				
129	08	P	13	16.95	0.00060	0.00003				
130	08	P	13	24.86	0.00101	0.00010				
131	08	P	13	52.07	0.00185	0.00013				
132	08	P	13	20.66	0.00072	0.00006				
	08			206.03	0.00733	0.00065				
	08			**34.34**	**0.00122**	**0.00011**	**0.50**	**0.49**	**346**	**31**
133	12	P	20	20.71	0.00056	0.00005				
134	12	P	20	27.14	0.00088	0.00005				
135	12	P	20	20.07	0.00050	0.00004				
136	12	P	20	16.31	0.00065	0.00006				
137	12	P	20	10.43	0.00048	0.00005				
138	12	P	20	11.08	0.00045	0.00006				
	12			105.74	0.00353	0.00029				
	12			**17.62**	**0.00059**	**0.00005**	**0.40**	**0.31**	**205**	**17**
139	11	P	7	14.02	0.00050	0.00006				
140	11	P	7	10.70	0.00041	0.00004				
141	11	P	7	14.18	0.00078	0.00007				
142	11	P	7	19.30	0.00077	0.00007				
143	11	P	7	15.57	0.00067	0.00008				
144	11	P	7	19.63	0.00080	0.00008				
	11			93.40	0.00393	0.00039				
	11			**15.57**	**0.00065**	**0.00007**	**0.70**	**0.17**	**140**	**14**
145	16	P	18	33.84	0.00098	0.00011				
146	16	P	18	23.35	0.00061	0.00008				
147	16	P	18	23.42	0.00030	0.00001				
148	16	P	18	15.82	0.00089	0.00010				
149	16	P	18	12.38	0.00082	0.00009				
150	16	P	18	40.46	0.00140	0.00013				
	16			149.27	0.00502	0.00052				
	16			**24.88**	**0.00084**	**0.00009**	**0.50**	**0.49**	**328**	**34**
151	15	P	17	20.66	0.00071	0.00005				
152	15	P	17	36.86	0.00106	0.00008				
153	15	P	17	33.67	0.00112	0.00010				
154	15	P	17	24.92	0.00080	0.00008				
155	15	P	17	14.60	0.00050	0.00007				
156	15	P	17	9.39	0.00026	0.00001				
	15			140.10	0.00444	0.00040				
	15			**23.35**	**0.00074**	**0.00007**	**0.55**	**0.48**	**302**	**27**
157	24	P	19	61.05	0.00172	0.00012				
158	24	P	19	16.33	0.00048	0.00004				
159	24	P	19	10.91	0.00021	0.00001				
160	24	P	19	41.84	0.00090	0.00007				
161	24	P	19	14.59	0.00041	0.00006				
162	24	P	19	40.94	0.00107	0.00007				
	24			185.66	0.00479	0.00038				
	24			**30.94**	**0.00080**	**0.00006**	**0.45**	**0.58**	**297**	**24**
163	26	P	18	9.26	0.00029	0.00004				
164	26	P	18	24.24	0.00072	0.00006				
165	26	P	18	15.54	0.00068	0.00004				
166	26	P	18	13.25	0.00050	0.00004				
167	26	P	18	21.22	0.00080	0.00006				
168	26	P	18	18.50	0.00062	0.00005				
	26			102.01	0.00361	0.00031				
	26			**17.00**	**0.00060**	**0.00005**	**0.50**	**0.34**	**236**	**20**

Table F-1. Yield Calculations

				Laboratory Results						
Sample #	**Site Loc. #**	**Plant Species**	**Density (plants/sf)**	**Dry Wt. (g)**	**N (lbs)**	**P (lbs)**	**Fraction of Viable Stalks**	**Dry Wt. (lbs/sf)**	**N (lbs/ac)**	**P (lbs/ac)**
169	28	P	10	17.08	0.00046	0.00002				
170	28	P	10	26.52	0.00096	0.00008				
171	28	P	10	31.62	0.00123	0.00007				
172	28	P	10	12.91	0.00068	0.00005				
173	28	P	10	20.03	0.00079	0.00007				
174	28	P	10	13.00	0.00041	0.00005				
	28			121.16	0.00454	0.00033				
	28			**20.19**	**0.00076**	**0.00005**	**0.65**	**0.29**	**214**	**15**
175	17	P	18	76.06	0.00319	0.00023				
176	17	P	18	29.90	0.00117	0.00018				
177	17	P	18	16.69	0.00093	0.00011				
178	17	P	18	40.86	0.00123	0.00011				
179	17	P	18	21.16	0.00185	0.00019				
180	17	P	18	47.31	0.00147	0.00017				
	17			231.98	0.00984	0.00098				
	17			**38.66**	**0.00164**	**0.00016**	**0.55**	**0.84**	**707**	**71**
181	18	P	17	40.30	0.00121	0.00008				
182	18	P	17	24.78	0.00072	0.00005				
183	18	P	17	67.92	0.00201	0.00015				
184	18	P	17	51.09	0.00116	0.00009				
185	18	P	17	24.87	0.00051	0.00001				
186	18	P	17	24.84	0.00082	0.00005				
	18			233.80	0.00642	0.00044				
	18			**38.97**	**0.00107**	**0.00007**	**0.55**	**0.80**	**436**	**30**
187	27	P	14	19.56	0.00047	0.00003				
188	27	P	14	14.98	0.00030	0.00001				
189	27	P	14	16.30	0.00037	0.00001				
190	27	P	14	27.53	0.00077	0.00005				
191	27	P	14	21.01	0.00066	0.00004				
192	27	P	14	29.26	0.00086	0.00008				
	27			128.64	0.00344	0.00022				
	27			**21.44**	**0.00057**	**0.00004**	**0.60**	**0.40**	**210**	**13**
193	29	P	17	32.56	0.00146	0.00012				
194	29	P	17	34.25	0.00072	0.00002				
195	29	P	17	19.99	0.00057	0.00002				
196	29	P	17	19.97	0.00076	0.00007				
197	29	P	17	43.52	0.00172	0.00016				
198	29	P	17	55.67	0.00189	0.00014				
	29			205.96	0.00712	0.00052				
	29			**34.33**	**0.00119**	**0.00009**	**0.50**	**0.64**	**439**	**32**
199	20	P	11	18.30	0.00077	0.00006				
200	20	P	11	13.76	0.00029	0.00001				
201	20	P	11	16.92	0.00040	0.00003				
202	20	P	11	15.46	0.00032	0.00002				
203	20	P	11	13.77	0.00056	0.00005				
204	20	P	11	10.82	0.00039	0.00004				
	20			89.03	0.00274	0.00020				
	20			**14.84**	**0.00046**	**0.00003**	**0.65**	**0.23**	**142**	**10**
205	30	P	24	14.20	0.00060	0.00005				
206	30	P	24	32.30	0.00087	0.00007				
207	30	P	24	29.93	0.00071	0.00006				
208	30	P	24	22.20	0.00082	0.00006				
209	30	P	24	52.44	0.00113	0.00009				
210	30	P	24	17.96	0.00031	0.00000				
	30			169.03	0.00443	0.00034				
	30			**28.17**	**0.00074**	**0.00006**	**0.50**	**0.75**	**386**	**30**

Table F-1. Yield Calculations

				Laboratory Results						
Sample #	**Site Loc. #**	**Plant Species**	**Density (plants/sf)**	**Dry Wt. (g)**	**N (lbs)**	**P (lbs)**	**Fraction of Viable Stalks**	**Dry Wt. (lbs/sf)**	**N (lbs/ac)**	**P (lbs/ac)**
211	22	P	18	48.31	0.00158	0.00011				
212	22	P	18	14.03	0.00040	0.00001				
213	22	P	18	31.56	0.00087	0.00006				
214	22	P	18	51.90	0.00189	0.00013				
215	22	P	18	49.43	0.00148	0.00010				
216	22	P	18	29.99	0.00077	0.00007				
	22			225.22	0.00699	0.00047				
	22			**37.54**	**0.00116**	**0.00008**	**0.50**	**0.74**	**457**	**31**
217	21	P	14	17.68	0.00062	0.00004				
218	21	P	14	41.75	0.00138	0.00010				
219	21	P	14	25.95	0.00087	0.00006				
220	21	P	14	29.70	0.00121	0.00008				
221	21	P	14	46.30	0.00140	0.00011				
222	21	P	14	28.75	0.00105	0.00014				
	21			190.13	0.00653	0.00054				
	21			**31.69**	**0.00109**	**0.00009**	**0.60**	**0.59**	**398**	**33**
223	23	P	15	25.63	0.00095	0.00012				
224	23	P	15	16.95	0.00053	0.00002				
225	23	P	15	35.73	0.00125	0.00010				
226	23	P	15	54.73	0.00205	0.00021				
227	23	P	15	49.92	0.00158	0.00012				
228	23	P	15	11.67	0.00050	0.00006				
	23			194.63	0.00687	0.00062				
	23			**32.44**	**0.00115**	**0.00010**	**0.60**	**0.64**	**449**	**41**
229	19	P	20	28.66	0.00078	0.00009				
230	19	P	20	20.89	0.00049	0.00001				
231	19	P	20	46.53	0.00144	0.00013				
232	19	P	20	32.10	0.00097	0.00008				
233	19	P	20	36.41	0.00103	0.00010				
234	19	P	20	36.46	0.00115	0.00008				
	19			201.05	0.00585	0.00050				
	19			**33.51**	**0.00098**	**0.00008**	**0.50**	**0.74**	**425**	**36**
235	25	P	19	38.46	0.00125	0.00006				
236	25	P	19	18.56	0.00056	0.00002				
237	25	P	19	24.80	0.00072	0.00002				
238	25	P	19	12.51	0.00034	0.00000				
239	25	P	19	19.74	0.00061	0.00003				
240	25	P	19	23.17	0.00076	0.00004				
	25			137.24	0.00423	0.00018				
	25			**22.87**	**0.00071**	**0.00003**	**0.55**	**0.53**	**321**	**14**
241	31	P	11	19.99	0.00067	0.00004				
242	31	P	11	17.36	0.00059	0.00003				
243	31	P	11	18.91	0.00063	0.00003				
244	31	P	11	30.33	0.00096	0.00004				
245	31	P	11	25.88	0.00085	0.00005				
246	31	P	11	17.61	0.00061	0.00003				
	31			130.08	0.00431	0.00022				
	31			**21.68**	**0.00072**	**0.00004**	**0.60**	**0.32**	**206**	**11**
247	54	P	15	31.84	0.00118	0.00006				
248	54	P	15	26.11	0.00104	0.00007				
249	54	P	15	28.19	0.00101	0.00004				
250	54	P	15	25.96	0.00108	0.00007				
251	54	P	15	26.77	0.00117	0.00008				
252	54	P	15	22.42	0.00086	0.00005				
	54			161.29	0.00635	0.00036				
	54			**26.88**	**0.00106**	**0.00006**	**0.65**	**0.58**	**449**	**26**

Table F-1. Yield Calculations

				Laboratory Results						
Sample #	**Site Loc. #**	**Plant Species**	**Density (plants/sf)**	**Dry Wt. (g)**	**N (lbs)**	**P (lbs)**	**Fraction of Viable Stalks**	**Dry Wt. (lbs/sf)**	**N (lbs/ac)**	**P (lbs/ac)**
253	53	P	13	24.99	0.00091	0.00007				
254	53	P	13	17.53	0.00061	0.00008				
255	53	P	13	28.69	0.00112	0.00007				
256	53	P	13	41.11	0.00159	0.00011				
257	53	P	13	40.36	0.00158	0.00012				
258	53	P	13	38.27	0.00140	0.00010				
	53			190.95	0.00721	0.00054				
	53			**31.83**	**0.00120**	**0.00009**	**0.70**	**0.64**	**477**	**36**
259	52	P	10	44.68	0.00192	0.00012				
260	52	P	10	37.32	0.00152	0.00009				
261	52	P	10	38.02	0.00162	0.00010				
262	52	P	10	52.77	0.00234	0.00015				
263	52	P	10	37.64	0.00144	0.00009				
264	52	P	10	54.92	0.00216	0.00012				
	52			265.35	0.01100	0.00067				
	52			**44.23**	**0.00183**	**0.00011**	**0.70**	**0.68**	**559**	**34**
265	50	P	16	66.39	0.00250	0.00015				
266	50	P	16	59.45	0.00231	0.00013				
267	50	P	16	51.57	0.00186	0.00010				
268	50	P	16	58.08	0.00229	0.00013				
269	50	P	16	46.96	0.00172	0.00007				
270	50	P	16	65.45	0.00241	0.00013				
	50			347.90	0.01309	0.00071				
	50			**57.98**	**0.00218**	**0.00012**	**0.60**	**1.23**	**913**	**49**
271	51	P	12	38.62	0.00169	0.00019				
272	51	P	12	43.51	0.00179	0.00012				
273	51	P	12	49.25	0.00206	0.00014				
274	51	P	12	79.27	0.00316	0.00021				
275	51	P	12	49.11	0.00197	0.00014				
276	51	P	12	50.45	0.00201	0.00014				
	51			310.21	0.01270	0.00095				
	51			**51.70**	**0.00212**	**0.00016**	**0.65**	**0.89**	**719**	**54**
277	63	P	29	24.30	0.00077	0.00003				
278	63	P	29	21.94	0.00078	0.00004				
279	63	P	29	31.84	0.00094	0.00005				
280	63	P	29	24.40	0.00115	0.00010				
281	63	P	29	24.04	0.00108	0.00008				
282	63	P	29	31.53	0.00104	0.00006				
	63			158.05	0.00576	0.00035				
	63			**26.34**	**0.00096**	**0.00006**	**0.35**	**0.59**	**424**	**26**
283	59	P	24	12.37	0.00048	0.00003				
284	59	P	24	17.74	0.00054	0.00003				
285	59	P	24	15.36	0.00047	0.00003				
286	59	P	24	14.60	0.00047	0.00003				
287	59	P	24	16.26	0.00052	0.00003				
288	59	P	24	12.35	0.00042	0.00003				
	59			88.68	0.00290	0.00018				
	59			**14.78**	**0.00048**	**0.00003**	**0.45**	**0.35**	**227**	**14**
289	67	P	17	28.96	0.00124	0.00008				
290	67	P	17	30.57	0.00144	0.00009				
291	67	P	17	26.99	0.00113	0.00007				
292	67	P	17	22.57	0.00108	0.00007				
293	67	P	17	25.20	0.00114	0.00007				
294	67	P	17	17.82	0.00073	0.00005				
	67			152.11	0.00677	0.00042				
	67			**25.35**	**0.00113**	**0.00007**	**0.65**	**0.62**	**543**	**34**

Table F-1. Yield Calculations

Sample #	Site Loc. #	Plant Species	Density (plants/sf)	Laboratory Results			Fraction of Viable Stalks	Dry Wt. (lbs/sf)	N (lbs/ac)	P (lbs/ac)
				Dry Wt. (g)	N (lbs)	P (lbs)				
295	09	P	12	43.82	0.00163	0.00012				
296	09	P	12	44.15	0.00144	0.00009				
297	09	P	12	37.44	0.00130	0.00008				
298	09	P	12	46.01	0.00184	0.00014				
299	09	P	12	42.42	0.00162	0.00010				
300	09	P	12	55.09	0.00211	0.00012				
	09			268.93	0.00994	0.00065				
	09			**44.82**	**0.00166**	**0.00011**	**0.60**	**0.71**	**520**	**34**
301	66	P	20	36.35	0.00113	0.00004				
302	66	P	20	25.03	0.00108	0.00007				
303	66	P	20	23.81	0.00129	0.00008				
304	66	P	20	46.25	0.00180	0.00009				
305	66	P	20	31.30	0.00103	0.00003				
306	66	P	20	34.07	0.00125	0.00005				
	66			196.81	0.00758	0.00035				
	66			**32.80**	**0.00126**	**0.00006**	**0.45**	**0.65**	**495**	**23**
307	60	P	15	39.33	0.00173	0.00010				
308	60	P	15	38.96	0.00171	0.00010				
309	60	P	15	53.27	0.00234	0.00016				
310	60	P	15	41.45	0.00182	0.00008				
311	60	P	15	52.33	0.00245	0.00009				
312	60	P	15	48.42	0.00211	0.00010				
	60			273.76	0.01215	0.00063				
	60			**45.63**	**0.00202**	**0.00011**	**0.60**	**0.91**	**794**	**41**
313	65	P	13	35.85	0.00172	0.00010				
314	65	P	13	30.32	0.00136	0.00010				
315	65	P	13	37.32	0.00167	0.00011				
316	65	P	13	45.28	0.00227	0.00018				
317	65	P	13	43.80	0.00184	0.00014				
318	65	P	13	29.50	0.00133	0.00012				
	65			222.07	0.01019	0.00075				
	65			**37.01**	**0.00170**	**0.00013**	**0.50**	**0.53**	**481**	**35**
319	61	P	10	33.99	0.00151	0.00013				
320	61	P	10	26.11	0.00114	0.00011				
321	61	P	10	33.35	0.00132	0.00010				
322	61	P	10	31.67	0.00128	0.00010				
323	61	P	10	38.84	0.00153	0.00012				
324	61	P	10	28.96	0.00105	0.00011				
	61			192.92	0.00784	0.00068				
	61			**32.15**	**0.00131**	**0.00011**	**0.60**	**0.43**	**342**	**30**
325	62	P	21	49.02	0.00112	0.00003				
326	62	P	21	56.53	0.00128	0.00012				
327	62	P	21	40.43	0.00091	0.00004				
328	62	P	21	31.46	0.00134	0.00014				
329	62	P	21	20.43	0.00086	0.00010				
330	62	P	21	43.16	0.00144	0.00011				
	62			241.03	0.00696	0.00054				
	62			**40.17**	**0.00116**	**0.00009**	**0.50**	**0.93**	**530**	**42**
331	64	P	27	58.90	0.00171	0.00006				
332	64	P	27	26.16	0.00085	0.00009				
333	64	P	27	54.93	0.00151	0.00008				
334	64	P	27	31.34	0.00090	0.00010				
335	64	P	27	29.95	0.00075	0.00005				
336	64	P	27	49.97	0.00145	0.00009				
	64			251.25	0.00717	0.00047				
	64			**41.88**	**0.00120**	**0.00008**	**0.55**	**1.37**	**773**	**51**

Table F-1. Yield Calculations

				Laboratory Results						
Sample #	**Site Loc. #**	**Plant Species**	**Density (plants/sf)**	**Dry Wt. (g)**	**N (lbs)**	**P (lbs)**	**Fraction of Viable Stalks**	**Dry Wt. (lbs/sf)**	**N (lbs/ac)**	**P (lbs/ac)**
337	33	P	7	21.26	0.00073	0.00005				
338	33	P	7	31.46	0.00094	0.00008				
339	33	P	7	28.85	0.00128	0.00006				
340	33	P	7	70.60	0.00268	0.00023				
341	33	P	7	39.05	0.00127	0.00009				
342	33	P	7	35.09	0.00118	0.00007				
	33			226.31	0.00806	0.00058				
	33			**37.72**	**0.00134**	**0.00010**	**0.60**	**0.35**	**246**	**18**
343	32	P	19	21.05	0.00054	0.00003				
344	32	P	19	33.87	0.00071	0.00007				
345	32	P	19	24.66	0.00064	0.00005				
346	32	P	19	33.26	0.00100	0.00006				
347	32	P	19	29.46	0.00086	0.00005				
348	32	P	19	15.64	0.00044	0.00003				
	32			157.94	0.00418	0.00029				
	32			**26.32**	**0.00070**	**0.00005**	**0.40**	**0.44**	**230**	**16**
349	10	P	21	55.84	0.00166	0.00010				
350	10	P	21	37.01	0.00098	0.00007				
351	10	P	21	21.41	0.00058	0.00004				
352	10	P	21	37.51	0.00107	0.00007				
353	10	P	21	37.62	0.00097	0.00007				
354	10	P	21	33.28	0.00081	0.00005				
	10			222.67	0.00607	0.00040				
	10			**37.11**	**0.00101**	**0.00007**	**0.50**	**0.86**	**463**	**30**
355	44	P	15	12.30	0.00070	0.00006				
356	44	P	15	30.86	0.00096	0.00007				
357	44	P	15	26.39	0.00078	0.00005				
358	44	P	15	24.68	0.00070	0.00005				
359	44	P	15	26.43	0.00058	0.00003				
360	44	P	15	24.10	0.00070	0.00004				
	44			144.76	0.00441	0.00030				
	44			**24.13**	**0.00074**	**0.00005**	**0.65**	**0.52**	**312**	**21**
361	45	p	15	15.41	0.00042	0.00002				
362	45	P	15	20.16	0.00054	0.00003				
363	45	P	15	16.59	0.00055	0.00004				
364	45	P	15	26.68	0.00066	0.00004				
365	45	P	15	17.53	0.00045	0.00003				
366	45	P	15	25.04	0.00078	0.00004				
	45			121.41	0.00340	0.00021				
	45			**20.24**	**0.00057**	**0.00003**	**0.60**	**0.40**	**222**	**14**
367	41	P	12	12.88	0.00043	0.00004				
368	41	P	12	16.77	0.00051	0.00004				
369	41	P	12	24.74	0.00064	0.00005				
370	41	P	12	21.59	0.00052	0.00005				
371	41	P	12	30.71	0.00087	0.00005				
372	41	P	12	18.46	0.00041	0.00003				
	41			125.15	0.00338	0.00025				
	41			**20.86**	**0.00056**	**0.00004**	**0.65**	**0.36**	**191**	**14**
373	42	P	12	24.26	0.00054	0.00003				
374	42	P	12	18.39	0.00051	0.00003				
375	42	P	12	41.54	0.00103	0.00004				
376	42	P	12	32.38	0.00097	0.00006				
377	42	P	12	29.53	0.00091	0.00005				
378	42	P	12	17.46	0.00049	0.00003				
	42			163.56	0.00446	0.00023				
	42			**27.26**	**0.00074**	**0.00004**	**0.60**	**0.43**	**233**	**12**

Table F-1. Yield Calculations

				Laboratory Results						
Sample #	Site Loc. #	Plant Species	Density (plants/sf)	Dry Wt. (g)	N (lbs)	P (lbs)	Fraction of Viable Stalks	Dry Wt. (lbs/sf)	N (lbs/ac)	P (lbs/ac)
379	43	P	18	41.81	0.00112	0.00006				
380	43	P	18	32.04	0.00086	0.00005				
381	43	P	18	32.10	0.00085	0.00005				
382	43	P	18	35.30	0.00093	0.00007				
383	43	P	18	37.12	0.00109	0.00007				
384	43	P	18	26.24	0.00067	0.00006				
	43			204.61	0.00552	0.00036				
	43			**34.10**	**0.00092**	**0.00006**	**0.60**	**0.81**	**433**	**28**
385	39	P	7	32.19	0.00077	0.00006				
386	39	P	7	39.84	0.00097	0.00010				
387	39	P	7	37.22	0.00090	0.00007				
388	39	P	7	29.80	0.00082	0.00006				
389	39	P	7	28.60	0.00073	0.00006				
390	39	P	7	49.96	0.00139	0.00009				
	39			217.61	0.00558	0.00044				
	39			**36.27**	**0.00093**	**0.00007**	**0.75**	**0.42**	**213**	**17**
391	40	P	12	29.96	0.00071	0.00003				
392	40	P	12	23.82	0.00061	0.00002				
393	40	P	12	19.15	0.00046	0.00003				
394	40	P	12	27.55	0.00069	0.00003				
395	40	P	12	24.95	0.00064	0.00002				
396	40	P	12	21.36	0.00057	0.00002				
	40			146.79	0.00367	0.00015				
	40			**24.47**	**0.00061**	**0.00002**	**0.75**	**0.49**	**240**	**10**
397	14	P	14	26.53	0.00071	0.00004				
398	14	P	14	27.40	0.00074	0.00005				
399	14	P	14	41.73	0.00137	0.00010				
400	14	P	14	26.90	0.00092	0.00007				
401	14	P	14	19.10	0.00060	0.00005				
402	14	P	14	21.35	0.00067	0.00005				
	14			163.01	0.00502	0.00035				
	14			**27.17**	**0.00084**	**0.00006**	**0.70**	**0.59**	**357**	**25**
403	38	P	13	46.86	0.00151	0.00008				
404	38	P	13	30.73	0.00099	0.00007				
405	38	P	13	25.06	0.00066	0.00008				
406	38	P	13	27.90	0.00094	0.00006				
407	38	P	13	23.03	0.00076	0.00006				
408	38	P	13	18.78	0.00055	0.00005				
	38			172.36	0.00541	0.00039				
	38			**28.73**	**0.00090**	**0.00007**	**0.65**	**0.54**	**332**	**24**
409	34	P	11	16.21	0.00044	0.00003				
410	34	P	11	19.82	0.00058	0.00004				
411	34	P	11	18.68	0.00051	0.00003				
412	34	P	11	19.52	0.00063	0.00004				
413	34	P	11	30.59	0.00086	0.00003				
414	34	P	11	15.57	0.00054	0.00003				
	34			120.39	0.00355	0.00021				
	34			**20.07**	**0.00059**	**0.00003**	**0.60**	**0.29**	**170**	**10**
415	35	P	12	12.84	0.00030	0.00002				
416	35	P	12	12.96	0.00034	0.00002				
417	35	P	12	40.53	0.00105	0.00006				
418	35	P	12	29.45	0.00069	0.00004				
419	35	P	12	20.29	0.00047	0.00003				
420	35	P	12	33.15	0.00075	0.00004				
	35			149.22	0.00360	0.00020				
	35			**24.87**	**0.00060**	**0.00003**	**0.65**	**0.43**	**204**	**11**

Table F-1. Yield Calculations

				Laboratory Results						
Sample #	**Site Loc. #**	**Plant Species**	**Density (plants/sf)**	**Dry Wt. (g)**	**N (lbs)**	**P (lbs)**	**Fraction of Viable Stalks**	**Dry Wt. (lbs/sf)**	**N (lbs/ac)**	**P (lbs/ac)**
421	37	P	21	15.92	0.00046	0.00003				
422	37	P	21	25.25	0.00076	0.00006				
423	37	P	21	21.64	0.00092	0.00005				
424	37	P	21	13.92	0.00067	0.00002				
425	37	P	21	20.28	0.00091	0.00004				
426	37	P	21	14.12	0.00066	0.00003				
	37			111.13	0.00439	0.00023				
	37			**18.52**	**0.00073**	**0.00004**	**0.45**	**0.39**	**301**	**16**
427	76	P	34	36.02	0.00156	0.00006				
428	76	P	34	34.57	0.00137	0.00007				
429	76	P	34	27.86	0.00119	0.00007				
430	76	P	34	26.77	0.00099	0.00004				
431	76	P	34	28.56	0.00113	0.00006				
432	76	P	34	21.20	0.00085	0.00005				
	76			174.98	0.00708	0.00036				
	76			**29.16**	**0.00118**	**0.00006**	**0.35**	**0.77**	**612**	**31**
433	77	P	37	23.06	0.00088	0.00005				
434	77	P	37	15.59	0.00064	0.00003				
435	77	P	37	19.88	0.00082	0.00003				
436	77	P	37	66.22	0.00292	0.00010				
437	77	P	37	12.03	0.00042	0.00002				
438	77	P	37	22.06	0.00082	0.00004				
	77			158.84	0.00651	0.00027				
	77			**26.47**	**0.00108**	**0.00005**	**0.35**	**0.76**	**612**	**26**
439	80	P	20	23.99	0.00077	0.00005				
440	80	P	20	55.26	0.00191	0.00011				
441	80	P	20	17.80	0.00069	0.00005				
442	80	P	20	19.74	0.00081	0.00006				
443	80	P	20	51.57	0.00174	0.00010				
444	80	P	20	17.82	0.00055	0.00003				
	80			186.18	0.00648	0.00040				
	80			**31.03**	**0.00108**	**0.00007**	**0.45**	**0.62**	**423**	**26**
445	79	P	14	27.99	0.00089	0.00004				
446	79	P	14	17.04	0.00065	0.00005				
447	79	P	14	34.74	0.00104	0.00006				
448	79	P	14	17.48	0.00061	0.00003				
449	79	P	14	29.35	0.00093	0.00005				
450	79	P	14	27.86	0.00100	0.00006				
	79			154.46	0.00511	0.00030				
	79			**25.74**	**0.00085**	**0.00005**	**0.60**	**0.48**	**311**	**18**
451	78	P	10	33.20	0.00141	0.00012				
452	78	P	10	44.49	0.00186	0.00017				
453	78	P	10	40.03	0.00161	0.00013				
454	78	P	10	30.57	0.00136	0.00009				
455	78	P	10	35.56	0.00158	0.00016				
456	78	P	10	11.92	0.00050	0.00006				
	78			195.77	0.00833	0.00072				
	78			**32.63**	**0.00139**	**0.00012**	**0.50**	**0.36**	**302**	**26**
457	13	P	10	30.53	0.00141	0.00009				
458	13	P	10	49.74	0.00228	0.00018				
459	13	P	10	16.62	0.00059	0.00007				
460	13	P	10	40.27	0.00165	0.00014				
461	13	P	10	32.75	0.00107	0.00009				
462	13	P	10	15.30	0.00081	0.00010				
	13			185.21	0.00781	0.00067				
	13			**30.87**	**0.00130**	**0.00011**	**0.50**	**0.34**	**283**	**24**

Table F-1. Yield Calculations

				Laboratory Results						
Sample #	**Site Loc. #**	**Plant Species**	**Density (plants/sf)**	**Dry Wt. (g)**	**N (lbs)**	**P (lbs)**	**Fraction of Viable Stalks**	**Dry Wt. (lbs/sf)**	**N (lbs/ac)**	**P (lbs/ac)**
463	74	P	12	42.03	0.00165	0.00017				
464	74	P	12	66.89	0.00224	0.00025				
465	74	P	12	30.88	0.00107	0.00012				
466	74	P	12	32.72	0.00116	0.00011				
467	74	P	12	47.56	0.00181	0.00018				
468	74	P	12	45.22	0.00156	0.00014				
	74			265.30	0.00949	0.00096				
	74			**44.22**	**0.00158**	**0.00016**	**0.60**	**0.70**	**496**	**50**
469	75	P	15	22.05	0.00082	0.00007				
470	75	P	15	25.28	0.00089	0.00009				
471	75	P	15	23.55	0.00089	0.00007				
472	75	P	15	48.58	0.00187	0.00016				
473	75	P	15	19.53	0.00084	0.00008				
474	75	P	15	34.91	0.00122	0.00008				
	75			173.90	0.00653	0.00054				
	75			**28.98**	**0.00109**	**0.00009**	**0.60**	**0.58**	**427**	**35**
475	36	P	25	39.06	0.00140	0.00006				
476	36	P	25	35.18	0.00133	0.00009				
477	36	P	25	20.85	0.00088	0.00005				
478	36	P	25	25.55	0.00096	0.00007				
479	36	P	25	14.49	0.00047	0.00002				
480	36	P	25	21.30	0.00087	0.00003				
	36			156.43	0.00592	0.00033				
	36			**26.07**	**0.00099**	**0.00005**	**0.40**	**0.57**	**430**	**24**
							Mean =	**0.593**		
							Standard Deviation =	**0.233**		

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