Final

Stewart's Creek
Planning Document

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Table of Contents

List of Figures

EXECUTIVE SUMMARY

The purpose of this Planning Document is to provide the Town of Barnstable (Town) with a synopsis of the post-construction monitoring program findings, and then make recommendations to further the restoration goals at Stewart's Creek. Of primary concern to the saltmarsh restoration is the invasive species *Phragmites australis*, which has not died back as expected with the reintroduction of saltwater tidal flow and, in fact, appears to have expanded. The monitoring program determined that following culvert replacement, the restored high tides in Stewarts Creek were not high enough to inundate the marsh plain and inhibit *Phragmites*, which also has a significant freshwater groundwater input to draw from. Therefore, further dieback of *Phragmites* that would allow native saltmarsh vegetation to recolonize the marsh plain is unlikely. Additionally, the restored tidal flow was insufficient to remove the layer of fine sediment within the system, inhibiting restoration within the intertidal and subtidal areas.

Woods Hole Group then conducted a wide-ranging evaluation of available methods and best management practices (BMPs) that could be implemented to further restore salt marsh habitat in Stewarts Creek, which included elements of hydrodynamics, sediment, and vegetation management, especially related to *Phragmites*. A specific set of recommended actions were then identified in an Action Plan intended to formularize implementation of the selected recommended actions. The Action Plan includes information on steps, methods, timelines, and costs based on our experience with restoration projects and our knowledge of the site. This Action Plan was submitted for discussions purposes to the Town (dated April 15, 2020) and later the Army Corps of Engineers (USACE). The Action Plan made the following recommendations briefly described here and can be read in full in Appendix A:

- Mow, remove biomass, and apply wetland-approved herbicides to emergent *Phragmites* at Stetson Lane that is replacing freshwater vegetation that has died back as a result of restoring saltwater flow to the system.

- Perform trial *Phragmites* eradication in established areas between Studley Road and Ocean Avenue (~2+acres on east side of lower basin) for a 3+ year incremental program that includes four (4) test plots:

    - Test #1 – Mowing and biomass removal on an annual basis over the entire ~2+ acres when *Phragmites* are dormant in fall and winter.

    - Establish three (3) smaller 2,500 sq.ft. test plots within this larger area that receive the following additional treatments:

        - Test #2 – Apply herbicide to the emergent "witches broom" in the spring after mowing.

        - Test #3 – Apply herbicide to late season stalks in the fall to poison rhizomes during senescence period.

        - Test #4 – Work with mosquito control to establish a perimeter ditch to drain freshwater from upland along with interior ditch to convey salt water. Herbicide could also be employed here.

    - Consider supplemental trials with salt marsh vegetation planting / plugging to accelerate system response within the test plots.

    - After the 3-year trial period was complete, expand and refine Phragmites treatments that prove successful to other test plots and areas within the system.

- Recommended BMPs for the greater Stewarts Creek system including keeping the stop logs removed, cleaning the safety screen, limiting fertilizer use, maintaining the upstream sediment retention basin, and continued monitoring. Other longer-term solutions such as dredging and marsh plain excavation were explored depending on the results of the test plots.

When discussing the Plan, the Town indicated that recent developments had brought to the forefront the potential health and environmental concerns with a commonly herbicide known as Glyphosate a.k.a. "Roundup", which had resulted in significant limitations on its use for Town lands including for the purposes of invasive species management. This required that a different but equally effective approach to be taken. Therefore, a more direct solution, marsh plain excavation, was brought to the forefront based on discussions with the USACE who indicated support for this active removal method. A revised plan was developed that included excavation of the entire the 4.2-acre area of *Phragmites* encompassing Stetson Lane, Studley Road, and Ocean Avenue and documented in an August 27, 2020 Memorandum (Appendix B). This method would include first mechanical removal and disposal of *Phragmites*, and then excavating the marsh plain. For planning purposes, a 2 ft excavation was assumed that would produce approximately 16,000 cubic yards of excavated material. This 2-foot reduction in the marsh plain elevation would be refined as part of engineering and permitting, to ensure the target reduced marsh plain elevation would be sufficient to allow for the reintroduction of high tides and needed saltwater to stymie *Phragmites*, and promote recolonization of native saltmarsh species. Costs were developed based on discussions with qualified contractors and estimated to be $1.25M if excavated material could be beneficially reused onsite, or $3.7M if excavated material needed to be disposed offsite.

This document and its associated appendices are considered to be a working document, and it is understood that recommended actions will require further engineering design, environmental permitting, public and stakeholder input, and funding sources that were not determined here.

1.0 INTRODUCTION

Historically, Stewart's Creek was an estuarine system, but since Ocean Avenue became a closed causeway in the 1880's, Stewart's Creek had very limited tidal action, and had mostly been a freshwater impoundment. The USACE restored tidal flow to Stewart's Creek in 2013 by replacing the dilapidated, undersized culvert with a larger box culvert, along with water control features including the ability to accept stop logs on the upstream side and a mechanically controlled tide gate on the downstream side. A safety grate is also located on the upstream inlet to prevent people and pets from getting sucked into the culvert. The Town of Barnstable (Town) was tasked by the USACE with operating and maintaining the culvert as well monitoring the restoration of Stewart's Creek for a five (5) year period based on the monitoring protocols in the Operations and Maintenance (O&M) plan. These data included tide and salinity measurements, vegetation surveys, sediment sampling and testing, benthic invertebrate sampling and sorting, and elevation surveys within the marsh system. Based on the results of the 5-year monitoring program and input from the Town and stakeholders, Woods Hole Group developed this Planning Document at the request of the Town to evaluate the monitoring data further to determine recommendations for eradicating phragmites, managing sediment, and control of water with the intention of accelerating marsh restoration.

This document builds up prior work completed for the project including the following documents:

- 2006 Stewart's Creek Restoration Environmental Assessment from U.S. Army Corp of Engineers
- 2013 Stewart's Creek Restoration Project Pre-Construction Monitoring Report by Martha Rheinhardt
- 2014 Stewart's Creek Operation, Maintenance, Repair, Rehabilitation, and Replacement (O&M) Manual from U.S. Army Corp of Engineers
- 2015 Phase I Technical Memorandum by Woods Hole Group
- 2016 Phase II Monitoring Report by Woods Hole Group
- 2019 Year 5 Monitoring Report by Woods Hole Group

2.0 MONITORING PROGRAM REVIEW AND RECOMENDATIONS

2.1 MONITORING PROGRAM REVIEW

The purpose of the monitoring program was to document how the Stewarts Creek system transitioned from a non-tidal freshwater marsh to a tidal saltmarsh system following culvert replacement. The USACE conducted the original pre-construction monitoring to establish baseline conditions prior to the culvert replacement in 2013. The Woods Hole Group was contracted by the Town to conduct monitoring in 2015 (2 years after construction) and then again in 2018 (5 years after construction) to fulfill the five (5) year post-construction monitoring requirement from the USACE. The goal of the post-construction monitoring program intended to collect data that could be directly compared to the pre-construction data to demonstrate how the hydrodynamics, benthic, sediment, and benthic, vegetation, and wildlife communities have changed. Sampling was conducted in both Stewart's Creek and the Halls Creek (Figure 1), the reference site established by the USACE during pre-construction monitoring. Woods Hole Group completed the monitoring in cooperation with the Town of Barnstable Public Works Department Survey Team to obtain elevation data and with the Cape Cod Conservation District (CCCD) to obtain vegetation, pore water, and benthic samples. With the Year 5 monitoring complete, the following general statements can be made about the state of the Stewart's Creek restoration:

- Hydrodynamic regime – Tidal action has been restored to the system as a result of the culvert installation. Prior to the culvert replacement, Stewart's Creek was a perched mostly freshwater system with little to no tidal flushing and degraded water quality. Following culvert replacement, the restored mean tidal range was measured to be 1.30 ft in 2015, which was lower than the USACE modeled tide range of 1.77 ft. In 2018, the mean tidal range increased to 1.67 with most of the gains on the lower low tides, likely resulting from locating the gauge closer to the inlet.

- Marsh creek and basin sediment - Topographic survey data indicate limited localized erosion of the intertidal and subtidal areas occurred along with the establishment of a shallow flow channel along the western shoreline; however, there remains a significant layer of fine (muddy) sediments throughout much of the system. A flood shoal located upstream from the culvert following construction is composed entirely of sand that appears to have grown since the culvert was replaced.

- Marsh plain elevation – The marsh plain has been relatively stable. Margins where *Phragmites* is most densely colonized are above the restored high tide levels in Stewart's Creek; in fact, higher than the high tide levels in Lewis Bay. There also is a flood shoal within Stewart's Creek in the main embayment near the culvert, but it appears to be relatively stable since 2015 and has not been colonized by vegetation. While the elevation surveys for the main basin indicate a localized portion of the inter/sub-tidal flat in the main basin eroded following culvert replacement, there remains a substantial amount of fine (muddy) sediment throughout the system. In

addition, a main flow channel has established along the southern and western portions of the main basin of Stewart's Creek, apparently following its historic pathway.

- Marsh Plain Porewater – Porewater sampling from the marsh plain has indicated that a largely fresh lens is under the marsh plain, meaning that the *Phragmites* have a freshwater source even though saltwater tidal flow has been restored to the system. This groundwater supply will likely not change without significant physical changes or intervention.

- Benthic and wildlife community – The benthic invertebrate community has increased in species richness and abundance since the culvert was installed. Notable changes resulted between the pre-project and post-project condition measured in 2015. Since 2015, the populations have remained relatively stable. The 2018 sampling of benthic infauna indicated species richness and abundance is comparable to 2015, suggesting the quality of benthic habitat within Stewart's Creek has stabilized. Stewart's Creek is equilibrating in terms of benthic restoration, especially if no further restoration actions are taken. Of note, the field team observed many birds, small fish, and other intertidal animals while conducting the field survey. Residents confirm active fish, bird, and other wildlife in the system, a marked improvement from the pre-project condition.

- Vegetation Community - The vegetation surveys along the three established transects showed no meaningful retreat of *Phragmites*, which is still the dominant marsh plain species throughout the Stewart's Creek system. This is likely due to the fact that the high tides are not high enough to inundate the marsh plain with saltwater to stunt or kill *Phragmites*. The porewater sampling in the marsh indicated there is a freshwater lens providing an ample supply of freshwater for the *Phragmites*.

Overall, the benthic community improved substantially in the 2 years following culvert replacement, but has remained relatively steady in Stewart's Creek since the last round of sampling in 2015. This advances the project objective to restore estuary habitat. However, a project objective for more diverse native salt marsh vegetation and *Phragmites* retreat has not yet been achieved as of 2018, nor is it expected to occur given prevailing conditions since the marsh plain is perched above the intertidal zone and has an available source of freshwater. The marsh fringe and intertidal areas have not been colonized by *Spartina* species. Therefore, additional actions, such as physical removal and/or herbicide application would be required to reduce or eradicate the *Phragmites* to allow for native saltmarsh species to colonize. Control of water and sediment management are two ongoing operation and maintenance items that are key to the long-term success of the project.

Figure 1. Overview of Stewart's Creek (outlined red) and the reference site Hall's Creek (outlined yellow).

2.2 MONITORING PROGRAM RECOMMENDATIONS

While there is no continued monitoring requirement past the five (5) years post-construction, Woods Hole Group recommends continuing the monitoring program at Stewarts Creek but with modifications that are designed to capture data over a wider area that are more representative of the entire system while discontinuing monitoring that is not providing useful information. The monitoring should continue to be conducted in late summer or early fall for both consistency and when vegetation is at its peak growth. The following modified scope is recommended for the monitoring program:

- Expand vegetation monitoring – Currently only 3 transects are sampled in a small section of Stewart's Creek, which does not capture changes that may have occurred throughout the rest of the system. Considering the dense stands the *Phragmites* throughout much of the system, it is recommended that aerial drone survey be conducted so that vegetation mapping can be completed for all of Stewart's Creek. This

drone survey would be verified by on the ground field survey to confirm the presence and extent of different species.

- Elevation surveys – Elevation surveys should be continued as well to monitor any changes to the marsh plain elevation or shoaling and/or scouring of the channel/basin. However, the vast expanse of *Phragmites* on the marsh plane combined with the soft, fine sediment bottom throughout much of Stewarts Creek makes collecting elevation data difficult. As a result, only limited topographic survey data has been collected. Compounding that is there has not be more a recent LIDAR survey released since the Phase II report. Therefore, it is recommended that drone survey be conducted once again so that accurate elevation data could be used to map the entire system. The survey could even be conducted with a LIDAR capable drone in order to improve the accuracy of the elevation data. The elevation data could even be collected using the same drone and on the same flight as the aerial survey of vegetation, which would provide significant cost savings. As with the recommended drone survey, an on the ground survey is recommended to help confirm the ground elevations, especially in areas of dense *Phragmites* or flow channels where the potential for false positive returns in remotely sensed data are possible. Both the vegetation and elevation ground surveys could potentially be completed during the same field trip as well.

- Porewater Monitoring – Porewater monitoring should be continued so as to monitor whether saltwater is intruding into the marsh plain. In addition, surface water salinity measurements from within Stewarts Creek itself should be taken as the same time for reference.

- Water Level (tide) and Salinity monitoring – The Stewart's Creek system has achieved a tidal equilibrium with Lewis Bay, and there is not likely be any further changes to the tidal regime in the system without major modifications to the culvert itself. Therefore, water level and salinity measurements are likely to show anything meaningful in the future.

- Benthic Sampling – Since the benthic community abundance and diversity appears to have plateaued, we recommend that the Town considers discontinuing the program as the system has likely achieved the level that it can obtain.

- Sediment sampling – Discontinue unless major changes, scour or shoaling, are observed in the system since the sediment cores will not show any difference otherwise.

- Reference Site Hall's Creek – Recommend discontinuing monitoring for the reference site since the traditional vegetation transects and benthic sampling is recommended to be discontinued and there will not be any comparable data.

3.0 HYDRODYNAMICS AND CONTROL OF WATER

The Stewart's Creek system connects to Lewis Bay and Nantucket sound through a 6 ft wide by 4 ft tall box culvert installed by the USACE in 2013. The culvert has two water control systems including a tide gate and stop logs as well as a safety grate on the upstream side. The tide gate is manually operated and typically has only been closed to prevent storm surge from inundating Stewart's Creek and low-lying properties surrounding it during large forecasted storm events. Additionally, the upstream inlet to the culvert has slots to accept stop logs to control the water surface elevation, i.e. amount of ponding, at low tide. Initially after construction, some stop logs were in place to maintain some open water in the basin and the tide gate was operated by the O&M Plan for storms. Currently the system operates with no stop logs in place because they were effectively damming freshwater and detritus at low tide, which is a hindrance to the saltmarsh restoration. In addition, the safety grate was catching detritus that contributed to the damming of water flow, requiring frequent cleaning. The tide gate is also not operated as regularly as originally intended by the O&M Plan.

After the conclusion of the Phase II report, it was recommended that the town experiment with the control of water in an attempt to help accelerate restoration of the system. One idea that was implemented was to close the tide gate on a spring high tide to effectively inundate the higher areas of *Phragmites* for longer periods of time with salt water. The rational was that the elevation on a spring high tide would be high enough to inundate part or a large portion of the marsh plain with saltwater in an effort to drown and kill phragmites. Then the tide gate would be opened during a low tide, which would cause a high rate of outflow from Stewart's Creek. It was anticipated the velocity of the water would be high enough to mobilize and flush fine sediments out of the system. The Town made two (2) attempts at flooding the marsh plain. The first attempt was abandoned after a large rain event flooded the marsh plain with freshwater, effectively fertilizing the marsh plain with nutrient laden runoff. A second attempt was made later, but it was found that the dammed water turned to freshwater very quickly indicating there is a significant freshwater input to the system likely due to stream input, surface water, and groundwater input.

4.0 SEDIMENT MANAGEMENT

The Town currently maintains the approach channels on the upstream and downstream sides of the culvert using an excavator to prevent shoaling. Sandy material removed is currently being placed, and should continue to be, on the downdrift beaches on Lewis Bay above the high tide line to help maintain the beach system. During the initial phase of the project, there was a plan to dredge a portion of the main basin to create open water, however, there was a joint decision between the USACE and Town to not include this in the final permit application due to concerns over costs, permitting, and disposal long-arm excavator, dredge, and drag line, while also considering preventive maintenance of the approach channel from the beach.

The coring results from the pre-construction monitoring report indicated there was a 0.5 – 1 ft layer of fine, silty sediment overlying a sandy layer with some cores showing a peat layer underneath as well spread throughout the Stewarts Creek basin and creek (outside of

maintained channels). The post-construction coring results two years later (2015) indicated that much of this layer appeared to be still present. Without manual removal via dredging it is unlikely that this layer of fine material will be flushed from the system.

Dredging the Stewarts Creek wetland system presents the following challenges:

- Limited access to the system
- Relatively shallow water depths within the system
- Relatively small dewatering area(s)
- Sediment size; fine sediments limit disposal opportunities
- Level of investment required

Another consideration will be the disposal location for the dredged sediments. The sediments with a high sand content potentially could be re-used within the Town and therefore would be the least costly to dispose. Dredged sediments with a high percentage of fine-grained material will most likely have to be disposed of at a municipal landfill either at Bourne or off Cape, or reused onsite. Fine sediments are not considered beach-compatible; therefore, unlikely useful for beneficial reuse on adjacent beaches. The cost of disposal will depend on the sediment characteristics and the needs of the landfill at the time of disposal. The sediment characteristics will depend on the location of the dredging, which in turn depends on the goals and objectives of the dredging project. If marsh plain excavation is incorporated into the restoration strategy, beneficial reuse of this dredged material could be incorporated into the design to grade the post-cut marsh plain with the clean sand to achieve finish grades with this stable material.

Previously in the 2016 Report, we had estimated that assuming a rough dredge quantity of 3,000 cubic yards, mobilization would be on the order of $150,000, dredging would be around $45/cubic yard, and offsite disposal including dewatering, trucking, and disposal fees would be approximately $85/cubic yard. A total rough estimate for planning purposes for dredging and offsite removal of 3,000 cubic yards would thus be approximately $550,000 plus engineering, permitting, and site restoration/mitigation as required. Disposal options would depend upon volume and quality of sediment and may include wetland creation, beach nourishment, and/or offsite disposal. Permits are in-place for modest removal of sediment from the USACE basin on the north side of the culvert; beyond there may require separate or extended design and permitting.

5.0 VEGETATION MANAGEMENT

5.1 BACKGROUND ON PHRAGMITES

Given the importance of *Phragmites* control to this project, it is important to understand more about the plant. *Phragmites* is a clonal plant that can grow from a single plant and rhizome source. The plant seeds are not very viable and the plant most often spreads by a section of

plant breaking off and establishing elsewhere in the estuary. Most commonly, the rhizomes become water born through erosion of the channel bank and are carried through a system to a potential new area to establish. Since this type of erosion often occurs during a storm and high water it is well-suited for transporting the rhizome up into an area above the normal high salinity line (MHHW). Ideal places for the rhizome to land are fresh water break out locations and higher plains where salt water does not regularly flood. These can be natural ground water, septic or other sources of fresh water the mother plant can access.

The plant can survive high salinity water during this migration processes as long as it lands in an area where there is a source of freshwater (or low salinity). Once in-place, the plant sends a root down that develops a rhizome at its terminus. Once the rhizome is established it will send out more roots and continue to generate more rhizomes. These additional rhizomes will do two things. First, some of the rhizomes will quickly establish new growth and send up shoots generating more plants. Second, as the plant matures over the years, additional rhizomes will develop that can remain dormant. These dormant rhizomes can remain below ground for decades. However, if the mother plant is injured or dies, the dormant rhizomes can become active and send up new shoots. The other way the plant spreads (can be quite quickly) is when the green stems fall over. When on the ground, the stem will send roots down and establish new plants generating more roots and rhizomes.

With a plant that can spread in a 30+ ft diameter in one year, the plant can reach into areas where there is salt. This is a region where if it was a single plant or rhizome landed; the *Phragmites* would be stressed and most likely would not grow. However, since the plant is still connected to the mother plant in the upland or in an area where there is a freshwater source, the mother plant can send fresh water to all the clones allowing them to grow in a saltier area. Once established, the plants grow and start to terra form. They raise the elevation by producing a large number of rhizomes and through the prolific leaf and stem litter deposited on the marsh plain. This increases the marsh plain elevation, and if located in a marginal region, can elevate the marsh plain from a salty to a brackish elevation allowing for more stability and *Phragmites* expansion.

5.2 MECHANICAL REMOVAL OF PHRAGMITES

There are different mechanical methods that could be used to help eradicate *Phragmites* and these include:

1. **Mowing** - Mechanically removing the stands of *Phragmites* and their biomass from the system can be accomplished during their dormant season (fall – spring), however, these efforts will likely fail long-term if no other action is taken as the plants can grow back even more robustly.

2. **Ditching** - A perimeter ditch can be dug around the marsh edge to intercept freshwater from the upland and effectively isolate the stands of *Phragmites* and surround them in saltwater, hopefully penetrating the marsh plain.

3. **Burning** – Dense stands of *Phragmites* may be cut and then burned in an effort to kill the roots, however, it likely will be difficult to burn through such a dense biomass layer and damage roots and rhizomes.

4. **Marsh plain excavation** – Involves physically excavating the marsh plain surface to a lower elevation so that it is inundated with saltwater to kill and prevent reestablishment of Phragmites. Although this type of wetland modification or marsh plain skimming has been practiced on the east coast, it is not common in this region and could be costly and subject to careful regulatory review.

5.3 CHEMICAL METHODS

Mechanical removal alone likely will not be enough to eradicate *Phragmites* since killing, damaging, or destroying the above ground plant will not kill the rhizomes and the plant will return. Therefore, controlling *Phragmites* starts with a need to kill the rhizomes. Herbicides can effectively control *Phragmites* when the herbicide accesses the rhizomes. Herbicide is applied by dripping, spraying, or wiping; however, Board of Health Reg's § 332 prohibits spraying herbicide within 100' of wetlands so only dripping or wiping will be permissible. This is best done in the fall when the plant begins to senesce. When a plant senesces, it is translocating sugars from the leaves to the root and rhizomes to store energy for over-wintering.

The following is a typical successful sequence of events that could be employed at Stewart's Creek:

- If this is a mature stand of *Phragmites* it is best to first remove the dead canes. This can be done in the late fall or early spring after *Spartina* and other species have senesced and/or before they start to grow in the spring. The dead canes can be mowed mechanically, cut by hand, or burned. Removing the dead canes allows more efficient herbicide application to the plant.
- In the fall after the plant begins to senesce the herbicide is applied by dripping, spraying, or wiping. The most common herbicide to use is a glyphosate-based herbicide. Rodeo is currently registered and approved for aquatic use. Glyphosate is a photosynthesis blocker and prevents the plant from generating amino acids through photosynthesis. When applied over mud, over spray binds almost instantly to the fine-grained sediments and remains bound.
- A mature stand of Phragmites can take several applications to eradicate the plant (especially considering dormant rhizomes mentioned above). The best application method is to spray the plant in year one, allow growth in year two, remove the dead standing at the end of year two, and then re-spray in year or season three. It may take longer to fully eradicate the plants, and takes a long-term commitment with monitoring and adaptive management.

5.4 SALTMARSH PLANTINGS

Although it is possible colonization may occur naturally over the next 5 to 10 years, there may be a need to supplement the natural seed source in the system even after the *Phragmites* have been eradicated. The salt marsh could be seeded or planted with live plugs to accelerate restoration, however seeding with *Spartina* tends to have unpredictable results and low rates of success. In addition, seeding of the mud flats may also be inhibited by a combination of high ebb velocities across the relatively unstable soils on the flats. Therefore, planting with live Spartina plugs would likely have greater success, but comes with a much higher cost. The most prudent method may be to mechanically overturn the marsh surface in an effort to expose the natural buried seed bank in the marsh, which has been shown in other saltmarsh restoration projects, such a Tidmarsh in Plymouth, to see rapid recolonization of dormant plants. Due to the dominance of Phragmites, this likely will only be able to be implemented after *Phragmites* removal has been addressed.

Additionally, the marsh may see an added benefit by planting woody species along the upland perimeter of the marsh. These species would help to intercept incoming groundwater and help take up nutrients before they reach the marsh in an effort to make the marsh less suitable for *Phragmites* and reintroduce native species to help restore a functioning native system.

ATTACHMENT A. ACTION PLAN MEMORANDUM

Draft Stewarts Creek Action Plan

The purpose of this document is for Woods Hole Group to present the draft Stewart's Creek Action Plan with recommendations for the Town of Barnstable to review and comment, as the basis for discussion and defining the path forward to adopt. This is not a formal deliverable; rather, it is the basis for discussion. The final Action Plan will become part of a larger Planning Document detailing results of the monitoring program, potential next actions and steps, and formalizing the actual implementation of selected actions with steps, methods, and timelines.

Recommended Actions (Years 1-3+):

1. Mow, remove biomass, and aggressively apply wetland-approved herbicides to emergent *Phragmites* where previously established freshwater vegetation is transitioning as indicated by the red outline in Figure 1 (e.g., end of Stetson Lane)
    a. Recent developments at the Town have brought to the forefront potential health and environmental concerns with Glyphosate a.k.a. "Roundup", where some recent research is indicating its potential as a carcinogen. These concerns were brought before the Town resulting in potentially significant limitations on its use for Town lands. We understand it has halted treatment of Phragmites at Sandy Neck. While the Town deliberates on its future applications, potential Glyphosate alternatives, including organic herbicides, will be explored that will meet current Town regulations; thus, this action remains in this draft action plan for discussion.

2. Limit fertilizer use adjacent to waterway
    a. Investigate local regulations and guidelines on fertilizer such as from the Town Board of Health to determine whether these guidelines affect recommended action plan.

3. Perform trial *Phragmites* eradication in established areas on nominal ~2,500 sq ft plots (separate them if possible; 4 tests as outlined below); 3+ year incremental program. Any action will require a design and permitting scope of work.
    a. Test #1 – Mowing and Biomass removal
        i. Mow a large section (~2+acres on east side of lower basin) when dormant in fall / winter, remove biomass, and establish other sample test plots within this larger area
        ii. Key is to resolve access (e.g., Studley Road?) and biomass removal options
        iii. Need a specialist contractor with low impact tread machine (brush-hog type)
        iv. Whole area (except test #3 below) will be mowed annually
    b. Mow, remove biomass and apply herbicides
        i. Test #2 (~2,500 sq ft within Test #1) – Following spring after mowing application of herbicide to the emergent "witches broom"
        ii. Test #3 (~2,500 sq ft within Test #1) – Following fall application to late season stalks so herbicide affects rhizomes during senescence period

c. Test #4 (2,500 sq ft within Test #1) – Mow, remove biomass, and establish perimeter ditch to drain freshwater from upland along with interior ditch to convey salt water cooperatively with mosquito control
    i. Decide whether Test #4 also includes herbicide application and when
d. Consider supplemental trials with salt marsh vegetation planting / plugging to accelerate system response. Initially considered a later phase step; however, recent experience in other areas indicates potential for success. May also require some level of accompanied soil stabilization with fiber rolls or other measure. Will be a site-specific consideration in design process for Tests.
    i. Possibly utilize plantings to stimulate colonization in areas where Phrag is eradicated (i.e., any of the Tests #1 - #4)
    ii. Possibly plant farther upstream where freshwater vegetation has died back, leaving possibility for Phragmites to colonize. Promote more desirable vegetation through plantings.

4. Hydraulic controls
    a. Keep the stop logs out
    b. Regular detritus removal at the safety screen
    c. Install fiber rolls to train / channelize flow at upstream location
        i. Key point of discussion with USACE – Need to consider how flow / channel is evolving and relative benefits and logistics of anchoring, etc.
    d. Tide / flood gate O&M plan
        i. Regularly test the flood gate to ensure operability when needed (frequency? Responsibility)
        ii. Ensure following flood management plan based on weather forecasts, etc.

5. Sediment management
    a. Maintain the sediment retention basin upstream
    b. Maintain the downstream channel and place clean beach-compatible sand downdrift
        i. Key point of discussion – where can Town access the beach?; consider placement above / below MHW and regulatory implications

6. Monitoring
    a. Vegetation cover / type – drone imagery (1-2 x/yr) with limited ground-truthing; coordinate with permitting requirements; consider having control plots within Stewarts Creek as basis for performance monitoring
    b. Marsh plain elevation survey – drone LiDAR to obtain high res terrain map; help resolve whether marsh evolution for test plots is elevation-based
    c. Porewater sampling annually
    d. Discontinue certain aspects of monitoring
        i. Tides
        ii. Benthic community monitoring

iii. Halls Creek

7. Project Governance & Adaptive Management
    a. Form advisory and adaptive management team
    b. Include public outreach component
    c. Regular reviews / decisions
    d. Fund raising / grant writing – KEY asap at least for aspects of first phase and monitoring

<u>Next Phases (TBD) - Adaptive Management Plan:</u>

- Expand and refine *Phragmites* treatments that prove successful
- Refine ditching program if successful
- Seed or plug *Spartina alterniflora*
    - Maybe year 2 depending upon colonization of mowed areas; need to see how / whether / what natural seed stock evolves
    - Expand Spartina seeding
    - Plug Spartina if seeding not successful
- Marsh plain excavation if needed
    - Use sediment from marsh plain excavation to establish berms and / or marsh islands to enhance flow training with fiber rolls
- Restore the flood shoal to salt marsh habitat using combination of fiber rolls and Spartina plugs / seed
- Dredging channels and / or basins
- Establish woody shrub buffer between upland and marsh
- Improve the safety debris screens to capture less vegetation and detritus
- Expand culvert
- Actions previously considered, but not recommended at this time would be discussed further and include the following: :
    - Pumping or damming salt water on marsh plain at key times of year – this was already tried and failed due to freshwater input
    - Burning Phragmites has not been shown to be an effective measure for long term management. There are also concerns with the proximity of homes to potential fires and the noxious clouds of black smoke that burning would produce.

Figure 1. ***Stewart's Creek proposed draft Action Plan for Phragmite mitigation.***

ATTACHMENT B. COSTING MEMORANDUM

WOODS HOLE GROUP FOR EARTH, FROM SPACE
A CLS COMPANY

WOODSHOLEGROUP.COM

MEMORANDUM

DATE August 27, 2020

TO Griffin Beaudoin, P.E.
Town Engineer
Barnstable Department of Public Works
382 Falmouth Road
Hyannis, MA 02601

FROM Adam Finkle, PWS, CERP
Coastal Scientist
Woods Hole Group
508-495-6272
afinkle@woodsholegroup.com

Robert P. Hamilton, Jr.
President
Woods Hole Group
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Sent via email to: Philip.Beaudoin@town.barnstable.ma.us

Stewart's Creek: Preliminary Opinion of Cost for Supplemental Wetland Restoration

Based on the April 2020 conference call between the Town of Barnstable (Town), the United States Army Corps of Engineers (USACOE), and Woods Hole Group, the following preliminary opinion of cost for planning purposes was developed to help inform municipal decision making. The April 2020 conference call discussed three (3) specific project components:

- Excavation of +/-4 acres of *Phragmities australis*, common reed, and restoration of salt marsh vegetation on the east side of Stewart's Creek.
- Excavation of the tidal shoal located directly upstream of the culvert to improve flushing and tidal exchange.
- Re-routing and reinforcement of the existing stream channel to improve flushing and tidal exchange.

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The costs estimated herein outline the first step in the process – excavation of the *Phragmities* and restoration of the marsh plain. As we evaluated costs for managing the upstream tidal shoal and re-routing the channel, it became clear that preliminary design plans and specifications would be needed to accurately estimate the costs of those steps in the process. To review, an outline of the proposed components of the project, construction access, and staging areas are outlined in Figure 1.

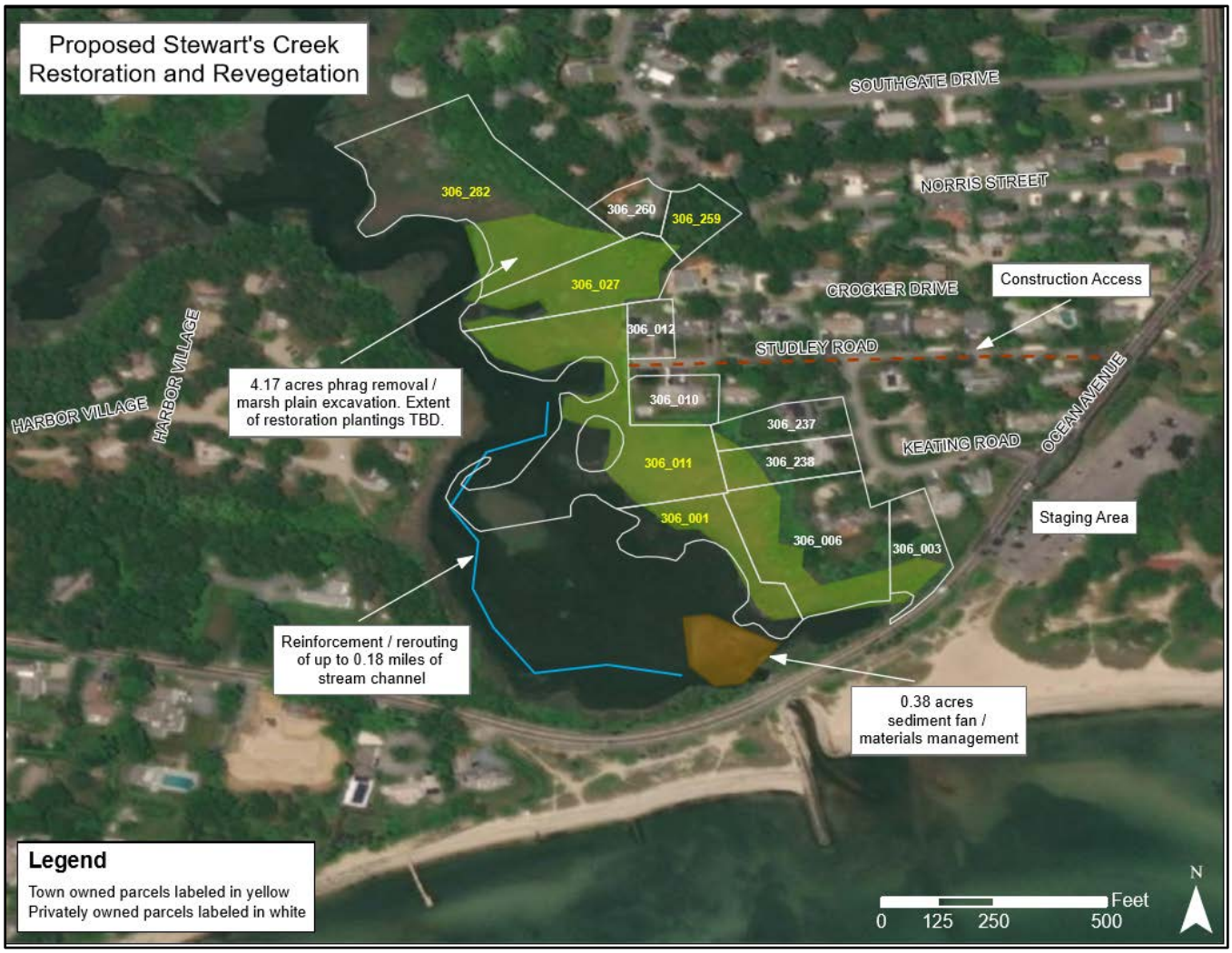

Figure 1 – Proposed project components, parcel ownership, construction access, and staging area for improvements to Stewart's Creek.

It is important to note that the proposed improvements may extend onto several private parcels shown in white text in Figure 1 (Parcel no. (306_012), (306_010), (306_237), (306_238), (306_006), (306_003) moving from north-south). Town-owned parcels are shown in yellow text in Figure 1 (Parcel no. (306_

282), (306_259), (306_027), (306_011), (306_001) moving from north-south). The adjacent, privately-owned parcels may receive some ancillary benefits (invasive species treatment, improved storm damage protection, etc.) resulting from the project. It will be important for the Town to approach said owners to discuss any necessary easements prior to designing and constructing the project.

Below is a rough breakdown of costs for the restoration and revegetation of the +/-4 acres of marsh heavily inundated with *Phragmities*. The estimate is based on the excavation and revegetation of the marsh plain that will accelerate the restoration process and minimize the need for herbicide.
As documented previously, the existing marsh plain elevation exceeds the high tide elevation, including in the Sound. As the plan evolves and as engineering plans are developed and drafted, it will be possible to refine this preliminary estimate. A couple of important notes and assumptions as you review the estimate:

- A 15% project contingency, costs for a construction performance bond, and costs to restore the proposed construction access point at the end of Studley Road were included under Line Item #1 - *Mobilization*.
- Line Item #2 - S*urvey Work* includes site control (vertical and horizontal), and an as-built.
- The overall scope is based on being able to excavate, stockpile, dewater, and grade the material coming off the marsh somewhere on site, potentially along the existing coastal bank abutting private property. For planning purposes, the preliminary estimate assumes a 2' cut across the entire treatment area, totaling approximately 16,000 cubic yards (cy).
    - This strategy may help improve the resilience of adjacent municipal infrastructure (roads, stormwater management, utilities, etc.) and provide increased flood damage protection to adjacent, private parcels.
    - At the same time, this strategy would result in some level of wetland habitat conversion (e.g., where the material is placed may result in conversion from land under the ocean to salt marsh or salt marsh to bordering vegetated wetland), which is a significant assumption that requires more planning and careful consideration from a permitting perspective (e.g., potentially referencing restoration project aspects of the Massachusetts Wetlands Protection Act).
    - This strategy was considered because it is significantly more cost effective to beneficially reuse the material on-site rather than re-handle, reload, and dispose of thousands of cubic yards of material littered with invasive vegetation at an off-site facility;– this offshore disposal cost would be on the scale of millions of dollars.
        - Line items #4-5 illustrate the costs associated with on-site disposal i.e. excavation of +/- 16,000 cy of material (Line Item #4; $337,000) and stockpiling and grading of the material along the landward edge of the marsh (Line Item #5; $155,000). The total cost for on-site disposal/beneficial reuse of the material is estimated at $492,000.

  - The *Alt.-1* Line Item was included to illustrate the substantial increase in cost associated with off-site disposal of +/-$16,000 cy of excavated material ($3,656,450). Combined with the cost to excavate the material ($337,000), the cost for off-site disposal is estimated at $3,993,450. The key to the off-site disposal cost estimate is trucking distance, which is contingent on identifying a location that is willing to accept the material.
- Assumed spacing for Line Item #7 – *Salt Marsh Plantings* is 18" on center (o.c.) over the entire 4.17 acres. If excavated material were beneficially reused on-site (occupying a portion of the marsh plain), this quantity would go down significantly. This assumption would be similar for Line Item #8 - *Herbivory Fencing*.
- Although the Town indicated that there was a desire to minimize or eliminate the use of herbicides, we have included the Line Item - *Alt-2* estimate for follow-up herbicide treatments over 3 years to be used as a reference. Herbicide treatment may also be necessary if we create an on-site upland area using the spoils and/or around the edges of the newly created marsh where *Phragmities* tends to establish first. The amount of herbicide used in this manner is a fraction of what it would be if we were to treat the entire marsh as per the original plan.
- This opinion of cost is focused on the construction aspects. Related services associated with engineering, permitting, bid process, contractor selection, and monitoring / compliance reporting and typically in the range of 15-20% of construction costs for a restoration project of this type.

Item	Description	Total
1	Mobilization, Contingency, Bond, Restore Access Point	$227,500
2	Survey, Site Control, As-Built	$32,250
3	Phragmities Mowing and Disposal (4.17 Acres)	$93,825
4	Phragmities Excavation & Stockpiling (4.17 Acres - Assuming 2' Cut)	$337,000
5	Stockpile Grading & Capping (On-Site)	$155,000
6	Upland Seeding and Planting (Tree/Shrub)	$32,150
7	Salt Marsh Plantings @ 18" On-Center (Plugs)	$242,220
8	Herbivory Fencing	$127,500
Alt-1	Off-Site Disposal (Non-Hazardous)	$3,656,450
Alt-2	Targeted Herbicide Applications (3 Years Post-Construction)	$15,000
	Preliminary Cost Estimate	**$1,247,445**

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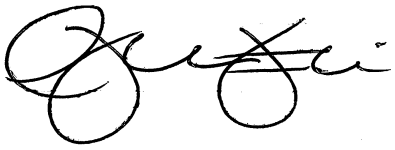
The Woods Hole Group collaborated with preferred contractor(s) to assemble this preliminary opinion of cost. We ask that you please keep costs associated with specific line items confidential. As the project continues to evolve, this preliminary estimate may shift accordingly; however, we feel these costs offer a realistic snapshot of what will be required to complete the first phase of work. As plans are developed for subsequent phases (tidal shoal management and/or channel reconfiguration), the cost estimate can be expanded to include the full proposed scope of work.

We look forward to continuing the conversation and reviewing these costs with you soon, and please call or email with any questions or comments.

Sincerely,



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