Marsh, Hemimarsh, and Open Water restoration potential of Square Marsh at the north end of Lake Calumet

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Square Marsh[1]

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[1] Photo of Square Marsh looking northeast from the Harborside International Golf Course.

Summary

The Lake Calumet Conservation Area's Square Marsh (hereinafter the Marsh) is a 138.6-acre open water area owned by the Illinois International Port District at the Port of Chicago at the north end of Lake Calumet. The Marsh is located adjacent to the Harborside International Golf Center, just west of S. Stoney Island Ave. and north of the open waters of Lake Calumet (Figure 1). The Marsh can be characterized as a turbid, open water body approximately 6.5 feet deep (maximum depth 6.7 feet) with a few small islands totaling 1.5 total acres. An additional 1.7-acre pool (hereinafter the NE pool) is found at the northeast corner of the main pool that is perched approximately 3.8 feet higher in surface water elevation, i.e. the NE pool is elevated relative to the main pool and there is no direct hydrologic connection between them. The golf course borders much of the shoreline to the north and west of the pools. The remaining shoreline is dominated by common reed *(Phragmites australis*), with some of the eastern shoreline characterized by weedy trees, shrubs, forbs, and/or other grasses. Most of the shoreline is relatively steep as it was created by dumping fill into the deeper waters at the north end of Lake Calumet, including dredge spoil, slag, concrete, bricks, gravel and various types of construction debris. The slope along the central portion of the north shore is more gradual where gravel and rubble was deposited to create a shallow zone and islands. The Marsh has been in its current configuration since the 1980's.

Figure 1. A 2018 satellite image of Square Marsh at the north end of Lake Calumet outlined in white, with islands outlined in green. The 140.6 acres or water are owned by the Port Authority. Imagery courtesy of Google Earth.

The hydrology of the Marsh is primarily driven by local runoff, with water levels controlled by gravity at two dropbox outlet structures that empty into Lake Calumet along the western portion of the south shoreline. Water level in the main pool currently varies around 582.5 to 582.7 feet

above mean sea level (MSL) relative to the North American Vertical Datum of 1988 (NAVD88) due to the dynamics of precipitation, runoff, and evaporation. The maximum interior water surface elevation is set by the stop logs currently in place, with an overflow elevation of approximately 583.1 feet MSL. The current water surface elevation is approximately six inches higher than the invert[2] elevation because the stop logs in place prevent drainage to the outlet opening inside the dropbox (the horizontal tube to Lake Calumet where the bottom point in the opening determines the invert elevation). With the current high water conditions in Lake Michigan, these same stop logs are now functioning to prevent water from periodically flowing north into the Marsh from Lake Calumet, which is currently experiencing extremely high water levels (80-day *mean* of 582.59 feet MSL from 1 June 2019 through 20 August 2019 at the Calumet Harbor gauge).

There is significant potential to restore a marsh community and the conditions under which hemimarsh might develop within the main pool of the Marsh depending on the how water levels and the restoration process are managed. Success within the main pool will also depend upon the cooperation of Lake Michigan, i.e., if it follows historical patterns so that water drops below the current near-record levels. A key element to this effort would be the installation of a new water level control structure that would allow water levels to be periodically lowered to accomplish restoration goals and to periodically mimic the dynamics of a natural marsh system. Lowering water levels initially will be a critical first step in order to access invasives along the shoreline, dry and consolidate flocculant sediments, stimulate seed germination, and eliminate invasive common carp (*Cyprinus carpio*). The elimination of common carp is a critical factor in that there is little chance to restore hemimarsh conditions or marsh vegetative structure with common carp in the system as they are the primary ecosystem driver maintaining turbid water and eliminating vegetation. As it stands now, there is little potential to develop a marsh community within the NE pool as there isn't a hydrologic connection to the main pool and the very steep rip-rap shoreline precludes wetland plant establishment.

If we assume that the current water level is the long-term target elevation, up to 12.6 acres of native marsh vegetation could potentially develop, with hemimarsh developing in depths out to 2.5 feet under an appropriate water management strategy. Adopting a lower water level target elevation would increase the extent of shallow and deep marsh that could be developed, e.g., lowering the long-term pool elevation from 582.5 to 581.5 feet MSL could increase the marsh footprint by up to an additional 3.3 acres (see Appendices 1 through 4). Although the extent of marsh that could be developed is a relatively small proportion of the entire system (a maximum of 12.6 acres or 9% of the pool footprint at 582.5 feet MSL), the potential to develop an extensive, diverse, and higher quality submersed plant community in the much larger open water zone is very high (again, depending upon the successful eradication of common carp). The success of the restoration will ultimately depend on a commitment to adaptively manage the marsh once major restoration activities have been completed.

Site Description

[2] The invert of a water control structure is the lowest point or elevation at the overflow opening. It is that part of the structure that controls the interior water level elevation in that water may not drain below the invert elevation. Structurally, it is the lowest point of the outlet.

Square Marsh is a 138.4-acre open water area located at the north end of Lake Calumet (Figure 1). The Marsh is located just west of S. Stoney Island Ave., east and south of the Harborside International Golf Center, and north of a berm and dirt track separating it from the open waters of Lake Calumet. The Marsh is owned by the Illinois International Port District at the Port of Chicago. The open water pool, once part of the open waters at the north end of Lake Calumet (Figure 2), became isolated from the rest of the lake by the ongoing deposition of various materials from 1900 through 1980 (Kay et al. 1997). The Marsh can now be characterized as an open water body up to approximately 6.5 feet deep with a few small islands totaling 1.5 acres in size. The shoreline along the golf course is highly managed, while other areas are dominated by common reed *(Phragmites australis*) and a mixture of weedy trees, shrubs, forbs, and grasses. The near-shore area is relatively steep as it was created as the lake was filled by dredge spoils, slag, municipal waste, construction debris, and other materials as it was pushed in from the edges. Consequently, only a small proportion of the pool is found in shallow depths (11.6% of the pool occurs at or below three feet in depth), while 88.4% of the pool is greater than 3.0 feet in depth. Currently, the Marsh can only be viewed from shore along the Harborside Golf Course as Port Authority property is not open to the public.

Figure 2. A 1939 aerial image of the north end of Lake Calumet. The future location of Square Marsh is outlined in yellow (Illinois State Geological Survey 1939).

Hydrology

Our knowledge of the Marsh's hydrology is based on four 2019 bathymetric surveys conducted on June 18, 26, 27 and August 14. The surveys were conducted to determine the distribution of depths and other relevant information characterizing the site. Inputs to the main pool appear limited to local surface runoff from the golf course, although we cannot rule out the presence of springs beneath the surface. When the water surface elevation of Lake Calumet exceeds that of the Marsh outlet invert elevation, then water may also flow into Square Marsh from the lake if the stop logs in the water control structure are not in place. The Lake Calumet water surface elevation on the August 14 survey was measured at 582.83 feet MSL (real time kinematic GPS survey), 3.6 inches higher than the Marsh pool that day (582.52 feet MSL). Although the current high water levels in Lake Michigan (Figure 3) prevent the Marsh from draining into Lake Calumet (mean of 582.62 feet MSL throughout this summer: NOAA 2019a), the 100-year average of 579.3 feet MSL (more than 3.0 feet lower than the current level) suggests this trend may reverse within a year or two (NOAA 2019 b; Figure 4). Until then, the outlet stop logs will be required to keep Lake Calumet water out of the Marsh if Lake Michigan continues to rise.

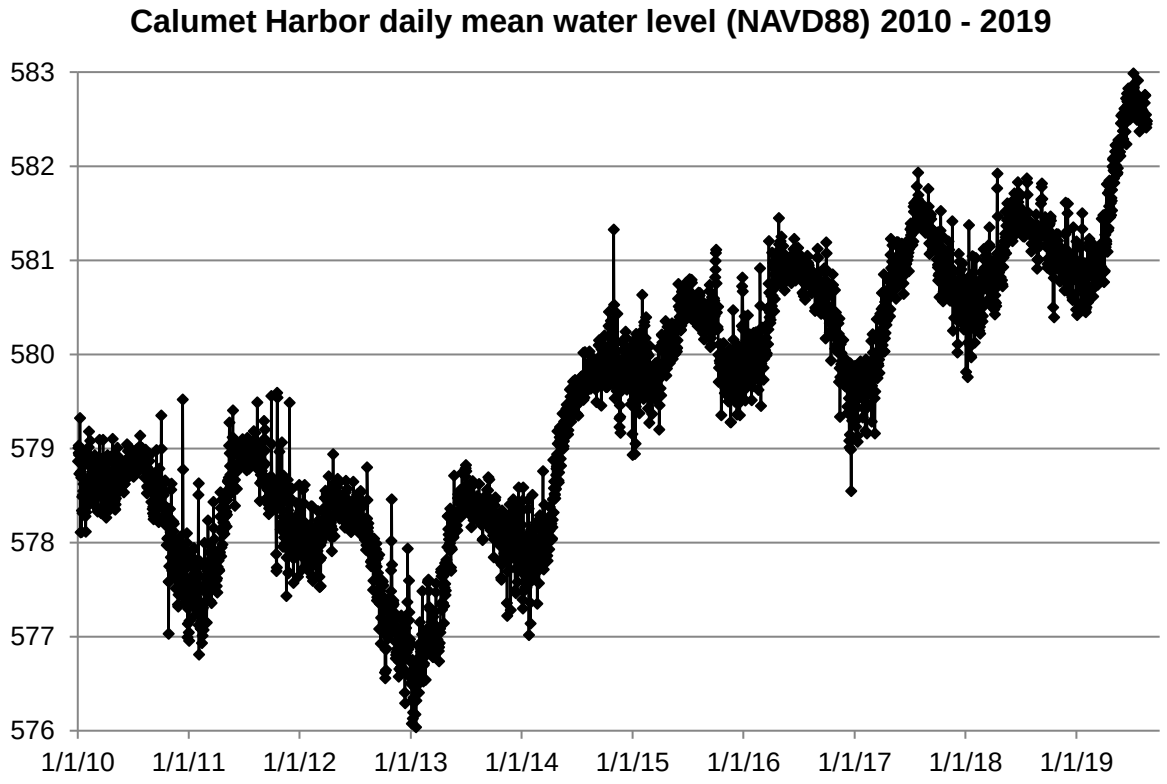

Figure 3. Mean daily surface water elevations of Lake Michigan measured at the Calumet Harbor gauge (station 9087044) from January 2010 through August 2019 in feet above mean sea level relative to the North American Vertical Datum of 1988 (NOAA 2019a).

The 1.5-acre pond located at the northeast corner of the site is hydrologically isolated by a berm standing approximately 5.0 feet above the Marsh. Although the pond surface on August 14 was perched 3.8 feet above the main pool, water levels in the pond are dynamic and may fluctuate widely as they are fed by surface water runoff from the golf course and water from a culvert draining the ditch alongside the rail line just east of the Marsh. During periods of heavy

precipitation or snow melt, the pool may flood and overtop the berm standing approximately 5.0 feet above the Marsh, or conversely dry out during periods of drought.

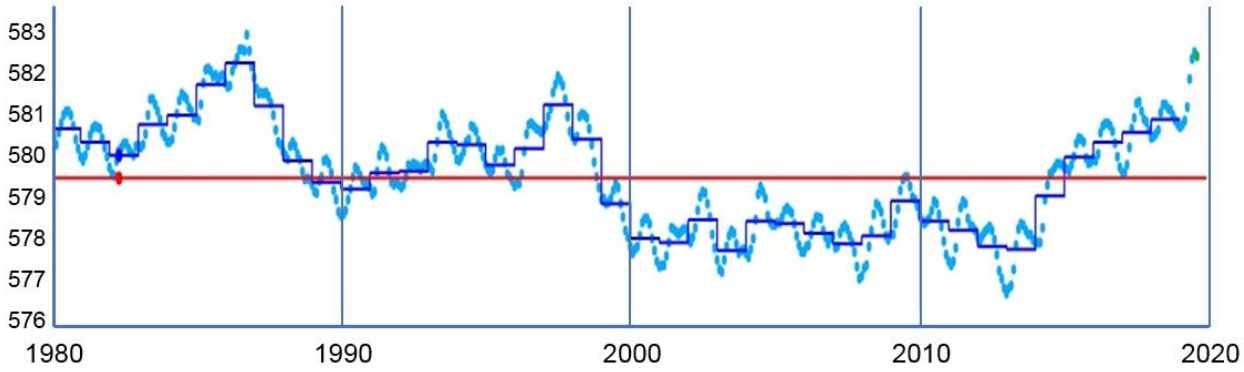

Figure 4. Mean monthly (dots), annual (blue line), and 100-year average (red line) surface water elevations of Lake Michigan in feet above mean sea level relative to the North American Vertical Datum of 1988 from 1980 to the present (NOAA 2019b). The period includes the highest water surface elevations ever recorded on Lake Michigan (October 1986) and the lowest (January 2013). July 2019 has the second highest monthly mean water surface elevation recorded.

Bathymetry

The bathymetry of the Marsh can be characterized as a relatively steep sided body of water, most of which is found from 4.5 to 6.5 feet in depth, with an area of shallower water surrounding artificial islands in the north central portion of the pool (Appendix 1). The steep edges resulted from the way in which the Marsh shore was created, i.e. the north end of Lake Calumet was filled to the north, east, and west over a period of years with dredge spoil, slag, construction debris, and various other materials being pushed into the basin (see Figure 2). Additional construction debris and other material was added later to create islands and peninsulas in the northern portion of the basin. Due to the distribution of large chunks of concrete, bricks, steel, and other materials in this area, depth was measured relative to the base layer on which they protrude.

Assuming a surface elevation of 582.5 feet MSL, more than 2/3 of the pool is found between 5.0 and 6.5 feet in depth (94.5 acres; Table 1). The maximum depth measured was 6.7 feet, although very little area was found more than 6.3 feet in depth. With another 27.7 acres found between 3.0 and 5.0 feet in depth, 122.2 acres of the 138.6-acre pool exceeded the depth limit of most emergent marsh vegetation (88.2% of the total). Since the edges of the pool were relatively steep sided other than around the islands, the smallest portion of the pool occurred between 0.0 and 1.0 feet in depth (4.3 acres). An additional 5.5 acres occurred between one and two feet deep, and 6.6 acres between two and three feet deep.

Table 1. The distribution depths within the in the main pool of Square Marsh based on bathymetric surveys conducted in June and August of 2019 (The Wetlands Initiative).

0.5-ft. elevation intervals	depth range	acres / depth interval	% of total acres
575.5 - 576.0	6.5 - 7.0	0.01	0.00%
576.0 - 576.5	6.0 - 6.5	24.24	17.49%
576.5 - 577.0	5.5 - 6.0	45.81	33.05%
577.0 - 577.5	5.0 - 5.5	24.43	17.63%
577.5 - 578.0	4.5 - 5.0	12.81	9.24%
578.0 - 578.5	4.0 - 4.5	6.25	4.51%
578.5 - 579.0	3.5 - 4.0	4.89	3.53%
579.0 - 579.5	3.0 - 3.5	3.78	2.72%
579.5 - 580.0	2.5 - 3.0	3.78	2.73%
580.0 - 580.5	2.0 - 2.5	2.83	2.04%
580.5 - 581.0	1.5 - 2.0	2.67	1.92%
581.0 - 581.5	1.0 - 1.5	2.84	2.05%
581.5 - 582.0	0.5 - 1.0	2.95	2.13%
582.0 - 582.5	0.0 - 0.5	1.31	0.94%
575.5 - 582.5	**0.0 - 7.5**	**138.60**	**100.00%**

Current Habitat and Invasive Species

There is little vegetation growing in the Marsh other than common reed (*Phragmites australis*), Eurasian water milfoil (*Myriophyllum spicatum*), and a few others in the shallows around the margins in relatively shallow water. Common reed occurs along most of the shoreline that is not actively managed by the golf course or where wave action has eroded the shore to create steep banks rising up to six feet above the water surface. Where common reed does occur, it may grow clonally from a few feet above the shoreline out to three feet or more in depth. The lack of other emergents is primarily due to the deep near-shore depths, but both emergents and submersed species are unable to prosper in the turbid waters due to the activity of common carp (*Cyprinus carpio*), which dig up rooted vegetation and suspend sediments as part of their feeding behavior. Uprooting directly kills aquatic plants, while the suspended sediments reduce water clarity to levels precluding the germination and establishment of new plants. Water clarity may be further reduced due to blooming planktonic algae responding to the high nutrient loads typically associated with runoff from golf courses.

Hemimarsh Restoration Potential

There are several factors that make the potential challenging for the restoration of both submersed and emergent plants under conditions consistent with the development of hemimarsh habitat at this site. The first is in regard to water levels, which are relatively static under the control of a stop log structure on the west side of the berm separating the Marsh from Lake Calumet. The invert at the structure absent stop log control is at approximately 582.0 feet MSL, which is below the current water level in Lake Michigan. In order to lower water levels to mimic natural dynamics or achieve management goals (assuming Lake Michigan levels fall again), a new water control structure would have to be installed with a lower invert (e.g. 579.4 feet MSL, the 100-year average in Lake Michigan). Although water levels couldn't be drained lower today

due to the near-record high water levels in Lake Michigan, these levels are likely to fall in the next year or so based on historical Great Lakes records over the past 100 years (Figure 4). A new, lower water control structure would allow water to be maintained at a lower level, varied to mimic natural dynamics, manage invasive species, consolidate flocculant sediments, and/or stimulate the germination of marsh plant species.

The second challenge to be overcome is removing common carp, which would have to be eliminated in order to establish native submersed and emergent vegetation. The feeding behavior of common carp is to nose their way through loose sediments in search of invertebrates, which are 'vacuumed up' and filtered out, an action that digs up plants and suspends sediments in the water column. Plants are killed in this dynamic and the resulting turbidity prevents enough light penetration to germinate seeds to replace the ravaged vegetation. The resulting turbid, vegetation-free conditions competitively favor the common carp population at the expense of native fish species. Since carp can only be eliminated with a piscicide, lowering water levels with a new water control structure would be critical for reducing the water volume to be treated as success is contingent upon achieving a killing concentration of the natural product Rotenone®. The lower water can be lowered, the less the very costly piscicide is needed to be effective. Once carp have been successfully eliminated from the system, an additional modification to the new water control structure should be incorporated into the design to keep common carp from reinvading in the future. Relatively clean water draining from the marsh into Lake Calumet will be strongly attractive to carp both as a source of food and as breeding habitat. Both screens and a drop from the marsh pool to Lake Calumet should be incorporated and maintained to keep fish from Lake Calumet out of the Marsh.

The next challenge is the extensive debris field covering native sediments in the shallower water zones in the northern portion of the Marsh. Although there are some areas in the shallow zone with fine sediments conducive to supporting native marsh vegetation, much of the shallow can be characterized by the deposition of rocks, concrete, bricks, slag, steel, and other materials. Much of this material projects up off the bottom and occasionally above the surface (see photos in Appendices). The extent of the debris zone has not been mapped quantitatively, in large part due to the extremely poor water transparency in addition to the difficulty of navigating the area on foot or by boat. Although the subsurface debris will likely make restoration work and later management difficult and potentially dangerous in some areas, some plants will still be able to grow up and around the materials where they are less dense. However, it would be extremely beneficial to remove the most egregious of these materials (if not all) once water levels can be reduced sufficiently to provide access and if the financial resources are available. One last factor to consider in this regard is simply aesthetics in that the restored wetland will likely become an important public resource where people are drawn to the rich diversity of wildlife. Support for this and similar future projects would be enhanced if the wetland both functions and looks like a natural part of the landscape.

The last major challenge is simply the bathymetry. Due to the relatively steep shoreline, at the current water level there are only 12.6 acres, or 9.1% of the total pool area between shore and a depth of 30 inches (Appendix 2), the depth range of most emergent marsh species. Some species may grow deeper under dynamic water levels and otherwise good conditions to a depth of three feet or more, but 30 inches is a reasonable estimate of maximum hemimarsh depth. Maintaining

a target water level one foot lower (581.5 feet MSL) would shift these numbers to 15.9 acres of marsh out to 30 inches deep (11.8% of the lower pool area; Appendix 3). Maintaining a target water level an additional foot lower (580.5 feet MSL) would shift these numbers to 21.5 acres of marsh (16.7% of the lower pool area; Appendix 4). Regardless of the depth around which to maintain water levels, the Marsh is always going to be dominated by deeper water with a narrow fringe of emergent vegetation around the shoreline and a somewhat wider apron around the islands.

The relatively small proportion of the Marsh that may be developed into marsh and/or hemimarsh habitat should not be used to justify a decision to not proceed. Even if only 12.6 acres of higher quality marsh habitat could be restored, this is a significant number in the Calumet Region of Chicago where this once abundant habitat is exceedingly scarce and the opportunities for marsh development rare. Moreover, with the entire water body less than seven feet deep, there appears little reason an extensive and diverse submersed aquatic plant community could not be developed to support native fishes, herps, and migratory waterfowl. The potential to develop a diverse mosaic of marsh and open water habitat in this region is an opportunity that should not be undervalued or missed by the Chicago conservation community.

Ecotoxicology

One significant unknown that could potentially become a serious challenge is the extent to which, if any, environmental toxins, metals, or organics are polluting the waters or sediments of the Marsh, or the extent to which they might be released by restoration activities. It would be prudent to 1) review all previous relevant studies conducted at this site determine the extent to which the environment at the site might be compromised, 2) conduct further environmental review on any areas not previously examined, and 3) determine if any ecotoxicology issues that exist can be mitigated and what action needs to be conducted in order to do so before a final decision is made to go forward. Lastly, it should be determined if water entering the site from the golf course or rail line culverts presents any water quality concerns.

Recommendations

If a decision is made by the Port Authority or another future owner to develop diverse marsh and open water habitat at the Marsh, then a number of specific actions are recommended. The first of these has already recently been accomplished, i.e. to survey and map the bathymetry of the system to ascertain the acreage at each depth. The interaction of bathymetry and water level will not only determine the extent of marsh habitat that can be developed, but it will also be the basis under which all future water level management decisions are made. Following up on the recently completed survey, surface water elevations in the pool should be monitored using the newly installed staff gauge to determine how the pool reacts to local weather patterns, precipitation events, and Lake Calumet water levels. Since water levels in the Marsh cannot be lowered below that of Lake Calumet by gravity, Lake Michigan will determine the minimum level to which water can be lowered in the marsh for management purposes. The optimal time to lower water levels extensively will coincide with low-water years in Lake Michigan. Specific recommendations include the following:

- Ecotoxicology: review all relevant studies previously conducted or in need of being conducted to determine if the restoration will be compromised by environmental toxins, metals, or organics,
- Hydrology: install and utilize a new dropbox water level control structure with greater capacity to lower water levels, i.e. so that they can be adjusted lower for restoration and ongoing management,
- Hydrology: monitor and record water levels throughout the year to better understand the hydrology and to inform the water level management strategy,
- Invasive plant species: initiate a program to eliminate common reed, reed canary grass, and other invasive plants,
- Fish community:
    - plan and execute a strategy to eliminate the invasive common carp,
    - introduce a community of native fish associated with marsh and shallow open water ecosystems,
- Enhance diversity: plant emergent and submersed species during drawdowns to establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community,
- Topography/bathymetry: where possible, remove large debris and other materials to clean up the pool and facilitate management actions,
- Topography/bathymetry: if possible, re-contour steep shoreline areas to create a more extensive wetland to upland transition zone,
- Long-term management: utilizing an adaptive management approach, develop a strategy learn from mistakes and implement steps that can be taken to sustain and enhance the marsh and open water plant communities.

We believe that the estimates of marsh area to be restored or developed at the Marsh to be reasonable given the potential to manipulate water levels by gravity at the site. Incorporating shoreline modification into the restoration plan will also influence and increase the potential extent and distribution of shallow marsh that might be developed. The ultimate balance between the marsh and open water habitat will in turn determine the potential extent of hemimarsh that can develop at the Marsh, which could be up to 15% of the total pool area under specific management regimes. The successful development of a marsh community will be entirely dependent upon the eradication of common carp and keeping them from reinvading the system. Since carp eradication will also result in the loss of the native fish community, native species adapted to these systems could and should also be reintroduced. As in all restorations, the success of the efforts will ultimately depend upon the development and implementation of a well-conceived plan to adaptively manage the marsh once major restoration activities have been completed. If properly restored and managed, the Marsh could potentially become the largest higher quality hemimarsh and open water systems in the Calumet Region.

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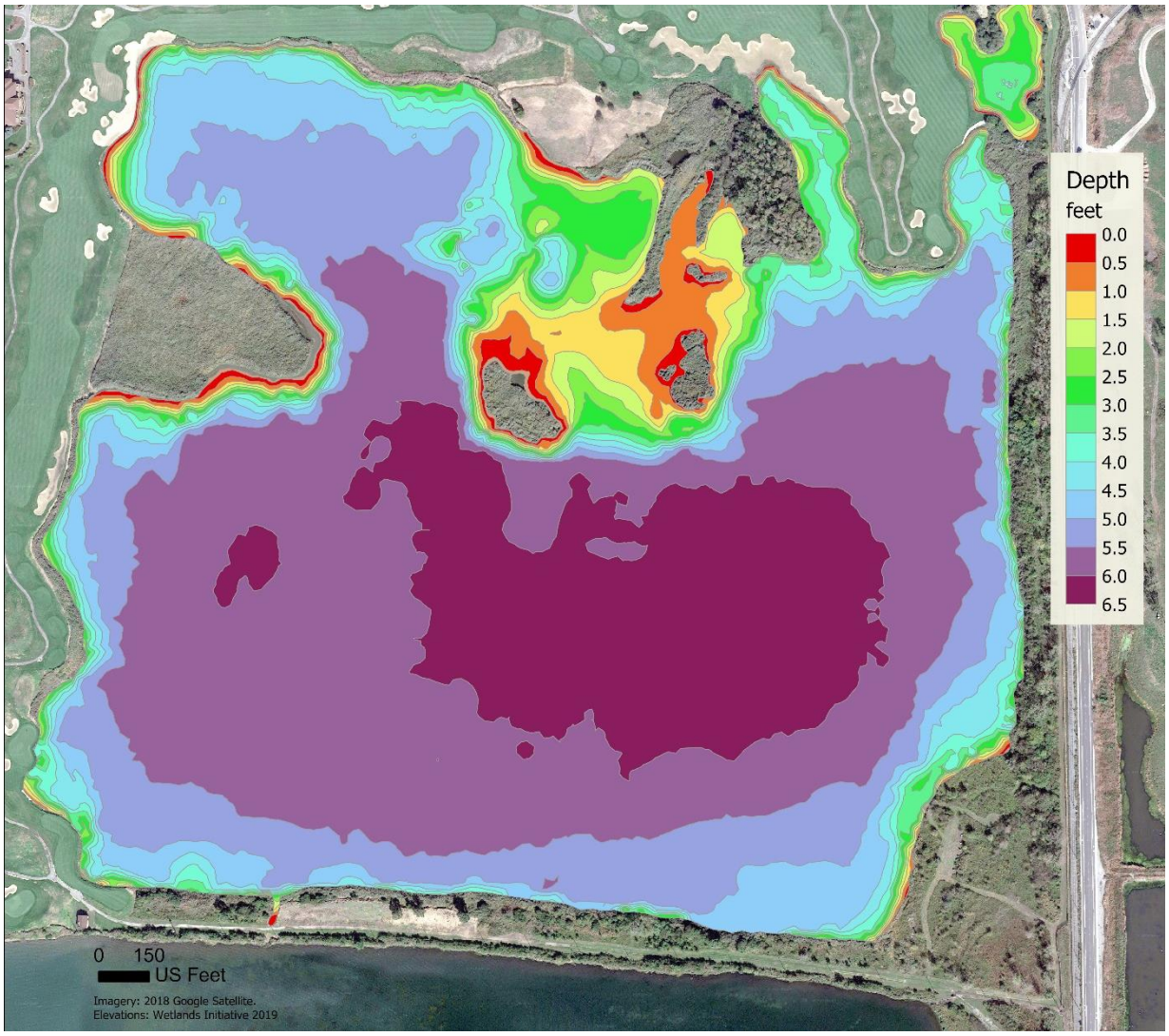
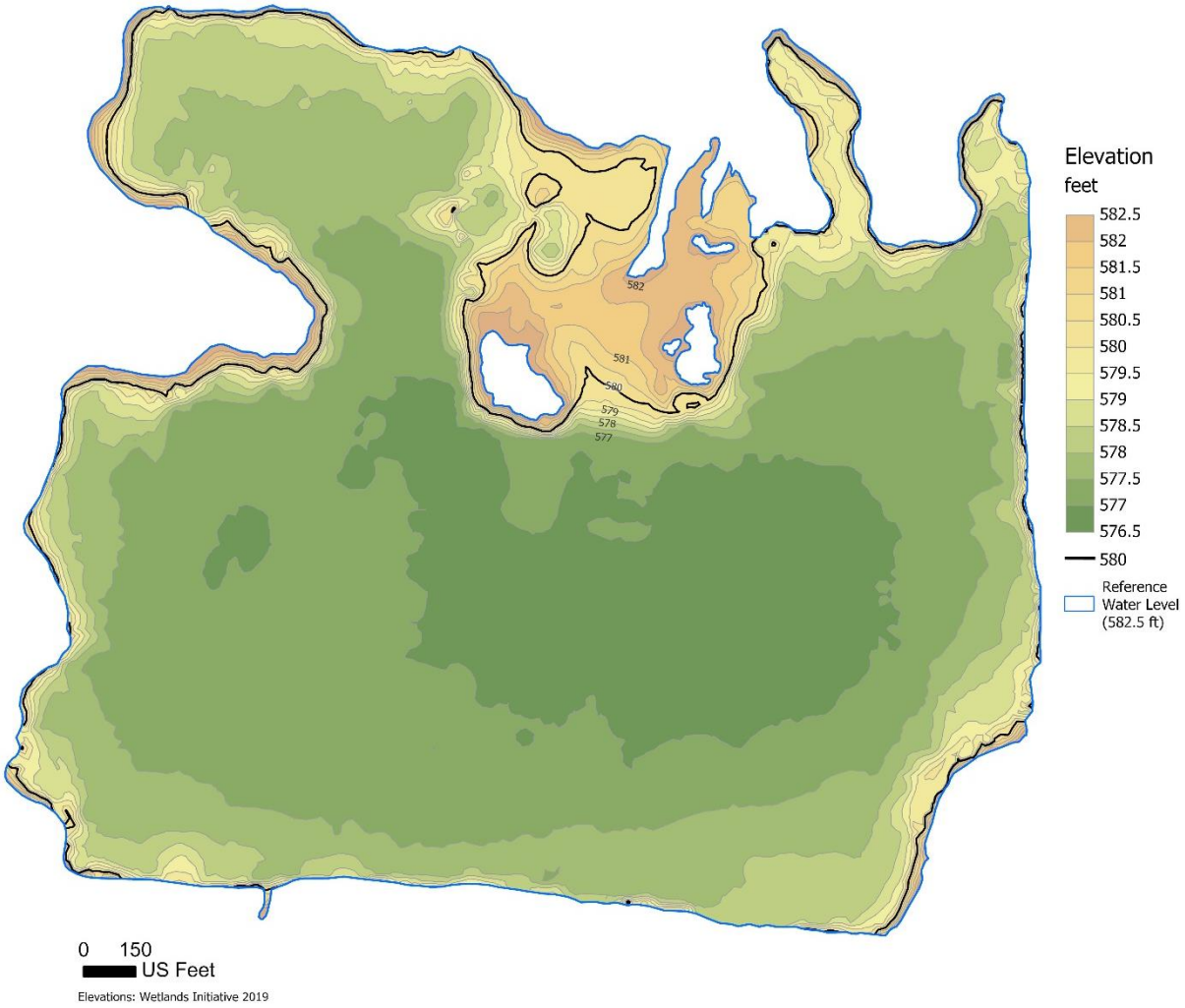
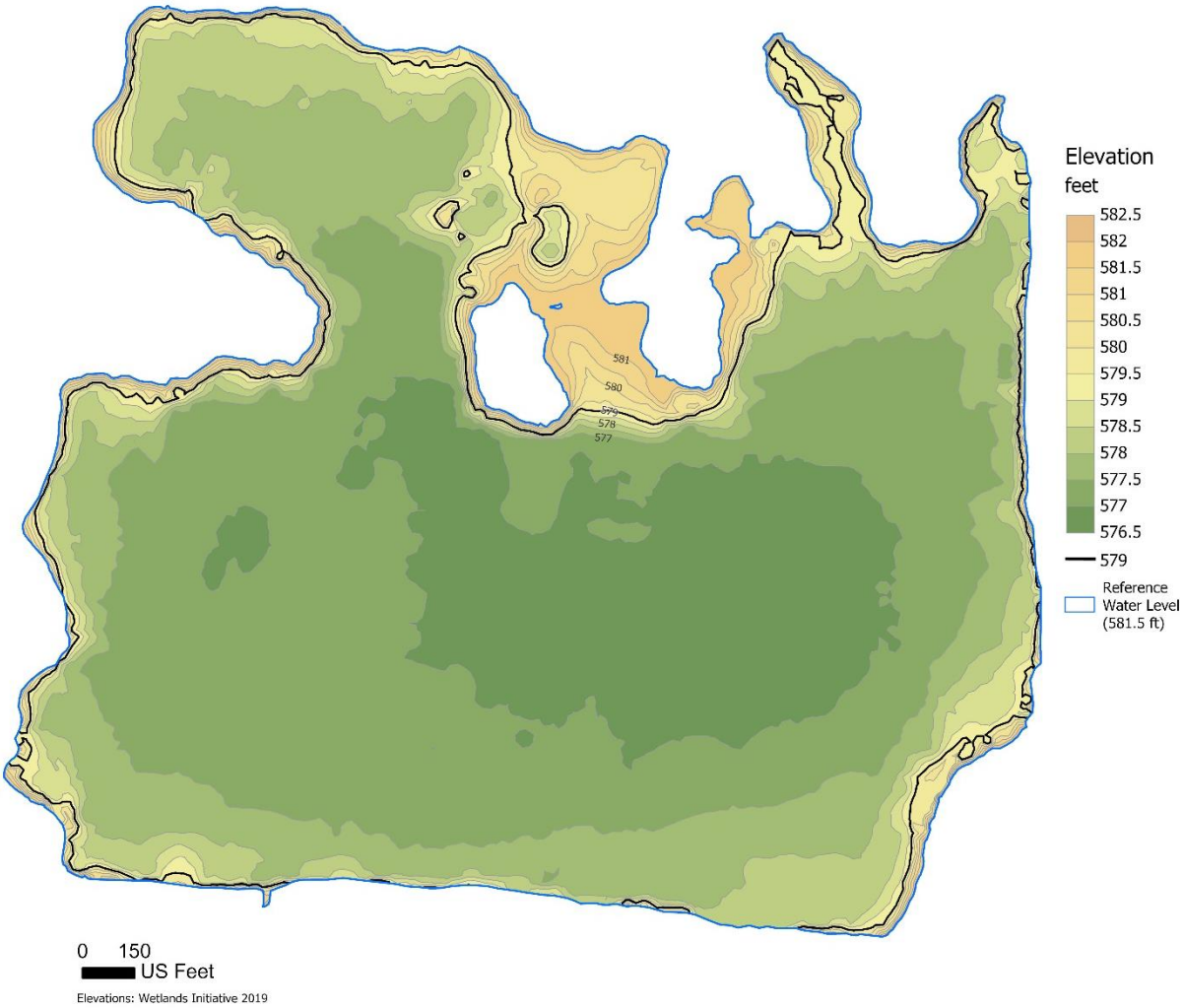
Appendices



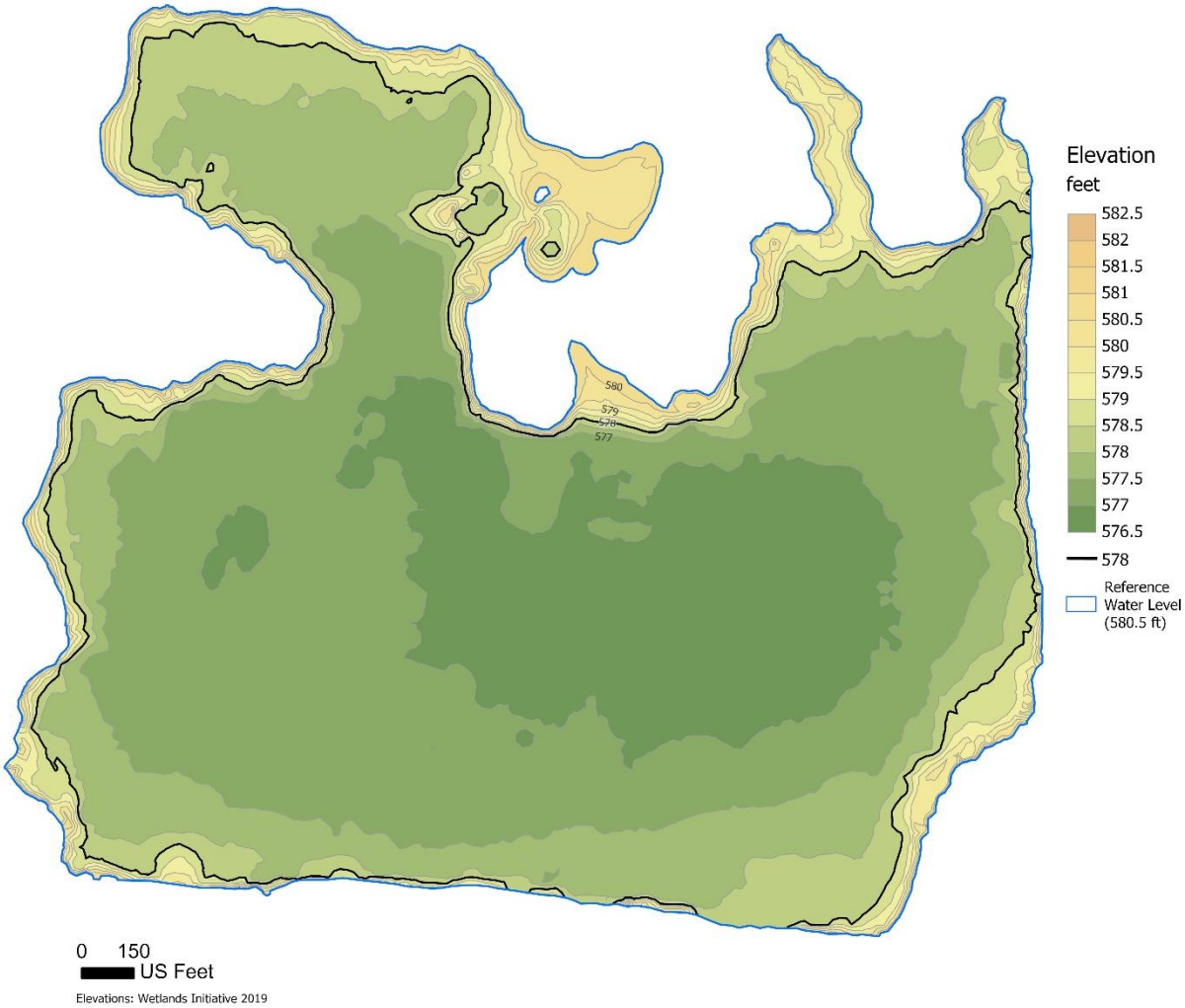
Appendix 1. Square Marsh bathymetry showing depth contours at 6-inch intervals on a 2018 satellite image courtesy of Google Earth. Depth is based on a water surface elevation of 582.5 feet MSL NGVD88 (The Wetlands Initiative).



Appendix 2. The potential 12.6-acre marsh restoration footprint at Square Marsh delineated between the reference water level (582.5 feet MSL) and the black 30-inch depth contour (580.0 feet MSL; The Wetlands Initiative).



Appendix 3. The potential 15.9-acre marsh restoration footprint at Square Marsh delineated between the reference water level (581.5 feet MSL) and the black 30-inch depth contour (579.0 feet MSL; The Wetlands Initiative).



Appendix 4. The potential 21.5-acre marsh restoration footprint at Square Marsh delineated between the reference water level (580.5 feet MSL) and the black 30-inch depth contour (578.0 feet MSL; The Wetlands Initiative).

Appendix 5. Photos of survey area illustrating debris field projecting above surface, with eroded and slag shorelines.

1. Concrete above and below the surface

2. Bricks and stone covering portions of the bottom

3. Concrete projecting above the surface

4. Eroded banks along the eastern shoreline

5. Solid slag deposited along north shore.

6. Steel projecting above surface along common reed shoreline.