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Lake Harmony Biobase Scan
October 2021

Prepared for:
Lake Harmony Watershed Preservation Group
PO Box 791
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Sonar Scan and Mapping

In response to excessive muck accumulation and decreasing depth, the Lake Harmony Watershed Preservation Group contracted with Clean-Flo to design and install an oxygenation-inversion system, and to do routine maintenance and biological product applications on Lake Harmony. The Clean-Flo restoration program was designed to oxygenate and mix the entire lake, to accelerate organic muck decomposition, and to increase the lake's depth and volume. The system was installed, and application program began in 2018.

In order to design the system, a preliminary scan was conducted on September 13, 2017. This scan established the baseline conditions against which the annual scans would be compared. Based on Lake Harmony's priority of increasing depth and changing the bottom composition, the scans have focused on improvements in these areas. Since the project started, annual or biannual scans have been performed to evaluate the progress of the restoration program. The scan on which this report is based was performed on October 21, 2021.

Scans are accomplished with a Lowrance HDS7 fish finder/chart plotter with broadband sounder technology, built-in GPS antenna and high-definition mapping. The data collected consists of a tremendous number of discrete points (in the case of Lake Harmony, greater than 30,000 points for each category). The data obtained is then uploaded to Biobase GIS, a cloud-based mapping service, to produce a visual analysis that is depicted in the form of bathymetric and bottom composition maps of the lake, quantitative analyses of the depth and volume, and quantitative analyses of the bottom composition.

The scan on which this report is based was performed on October 21, 2021. It is the fifth progress scan since the system was installed. The results of this scan indicated the following year-to-year changes that have resulted from the restoration effort:

- Consistent increases in maximum depth
- Consistent increases in average depth
- Consistent increases in volume
- Consistent shifting of the bottom composition from soft, organic sediment to hard, inorganic sediment

A summary of depth and volume increases, and corresponding sediment reduction, is shown in Table 1. There have been consistent improvements since the system was installed, with the exception of the period between the 10/3/19 and 4/6/21 scans. Those differences are discussed in more detail in the April 2021 report. However, in a nutshell we attribute the regression seen in 2020 primarily to the change in dosing strategy used that year. In order to target areas that had greater amounts of vegetation, the distribution of Clean & Clear (enzyme product) was changed. Consequently, the deeper areas of the lake – where we have historically seen the greatest gains in depth and sediment reduction– received less product and showed net decreases for those metrics.

Having said that, with resumption of the original dosing strategy in 2021, improvements in depth, volume, and sediment reduction returned to the average gains we had recorded since the project's beginning. In 2021, we saw a 0.7% increase in average depth and volume, which offset the 3.8 acre-ft loss between 2019 and 2021. In addition the lake's volume increased by 3 acre-ft. It should be noted that this improvement was accomplished in only the six months between April and October of 2021, and it would be reasonable to expect that if the scans had been one year rather than six months apart, even greater improvements would have been recorded. We will see if this is proven by the annual scan to be performed in the fall of 2022. As an aside, the reason there is no data from the 2020 scan is that the data collected in October 2020 was corrupted, and the results of the analysis were therefore not reliable.

Taken together, since the system began operation and product applications began in 2018, there have been increases in average depth, maximum depth, and volume of 6.1%, 5.6%, and 6.2%, respectively. This is equivalent to the increase of the lake's volume by 315.1M gallons, and the effective removal of 102,414 tons of sediment, or approximately 6,828 tri-axle dump truck loads. These results are concrete evidence of the effectiveness of Clean-Flo's bio-dredging concept and continual achievement of the goals that the Clean-Flo effort is intended to accomplish. We expect further improvements in the years to come, but it should be noted that the year-to-year improvements will taper off over time as the relative proportion of inorganic sediment on the bottom of the lake further predominates over the organic fraction of the bottom composition (see 2021 changes in composition indicated in Figures 3 and 4).

Table 1. 2017-2021 Depth and Volume Changes by Scan Date

	DATE							
CATEGORY	**9/13/2017**	**10/9/2018**	**4/4/2019**	**10/3/2019**	**4/6/2021**	**10/21/2021**	**2021 Increase**	**Overall Increase**
Average Depth (ft)	7.65	7.92	7.98	8.09	8.06	8.12	0.7%	6.1%
Maximum Depth	14.5	14.84	15.01	15.05	15.00	15.31	2.1%	5.6%
Volume (acre-ft)	910.22	943.68	950.59	964.16	960.36	967.03	0.7%	6.2%
Volume (Mgal)	296.6	307.5	309.7	314.2	312.9	315.1	0.7%	6.2%
2017-2021 Sediment Reduction by Scan Date								
Muck Removed (cu. yd)	NA	53,982	11,148	21,893	(6,131)	10,761	10,761	102,414
Triaxle Truck Equivalents (loads)	NA	3,599	743	1,460	(409)	717	717	6,828

Contour Maps

The contour maps from April 2021 and October 2021, along with color-coded scales, are shown below. The scale goes from light blue (shallowest) to dark blue (deepest). Contours are in 1-foot intervals. The maps show a few different changes that have taken place. First, the acreage of the deepest contours of the lake have decreased since the April scan, but this change has been offset both by the reappearance of the 15-foot contour in the deepest location and increasing size of the 9-foot and 10-foot contours in the east end of the lake.

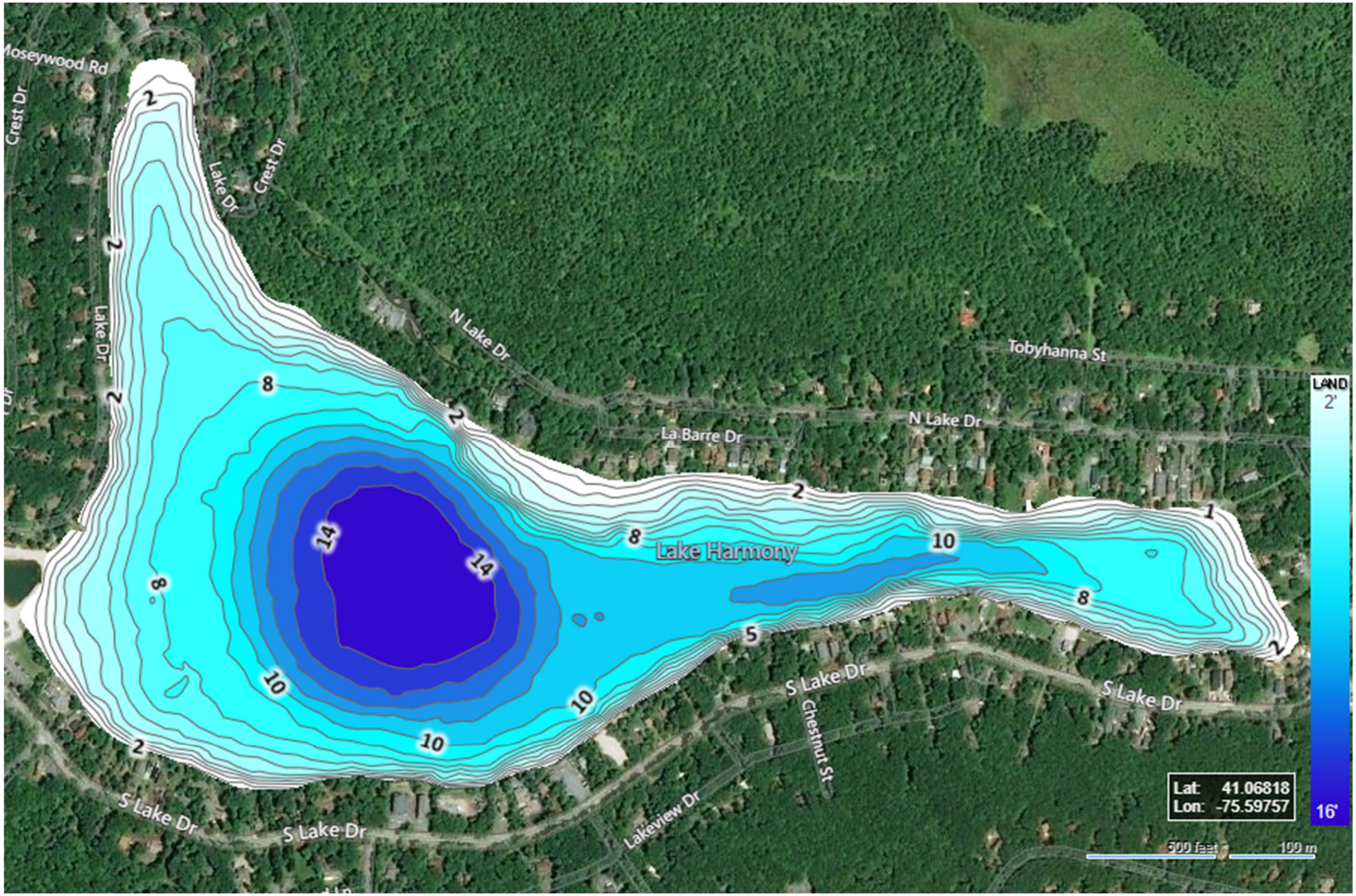

Figure 1: April 2021 Bottom Contour Map

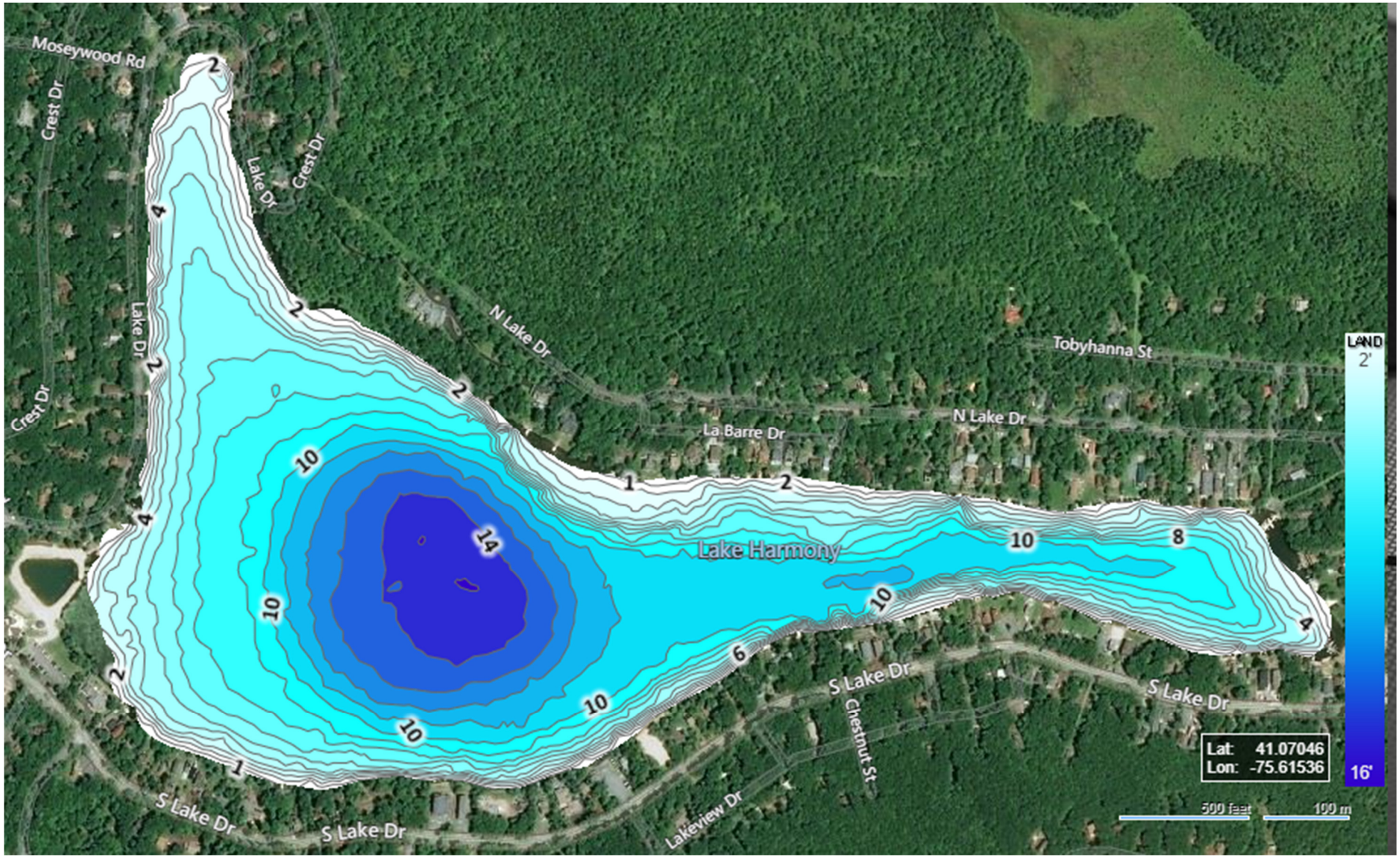

Figure 2: October 2021 Bottom Contour Map

Bottom Composition Maps

Figures 3 and 4 are maps of the bottom composition in April and October of 2021, with color-coded scales. The scale goes from light tan to brick-red. Lighter coloring indicates softer sediments, and darker coloring indicates harder sediments. The softer sediments typically contain a higher proportion of organic matter (decaying leaves, vegetation, algae, microorganisms, and fish), and the harder sediments contain a higher proportion of inorganic matter (clay, silt, sand, and rock). For the sake of making interpretation easier, we have broken the scale into four discrete categories: soft (light tan), medium-soft (brownish orange), medium-hard (reddish orange), and hard (red).

The maps demonstrate considerable changes in bottom composition between April and October 2021. The softest sediment has disappeared altogether. Medium-soft sediment has been considerably reduced. Medium-hard sediment has been considerably increased, and the hardest sediment has increased marginally. The locations of the hardest sediment have also changed. The charts in Figures 5 and 6 provide a more quantitative assessment of changes in bottom composition.

It is also notable that there has been significant hardening of the bottom in the cove arm of the lake since April 2021, which is even more dramatic when compared to earlier scans. The bottom in this area has historically consisted of thick organic muck, and the surface has been dominated by lily pads. As described above, the 2020 product application strategy was changed to target areas of problematic plant growth, and this area was specifically one of the targets that year. It is possible that although this strategy appeared to be counterproductive overall, the disproportionate distribution of product in 2020 actually had effects on the sediment decomposition in this area into 2021, when the original application strategy was resumed and applications in this area were reduced accordingly.

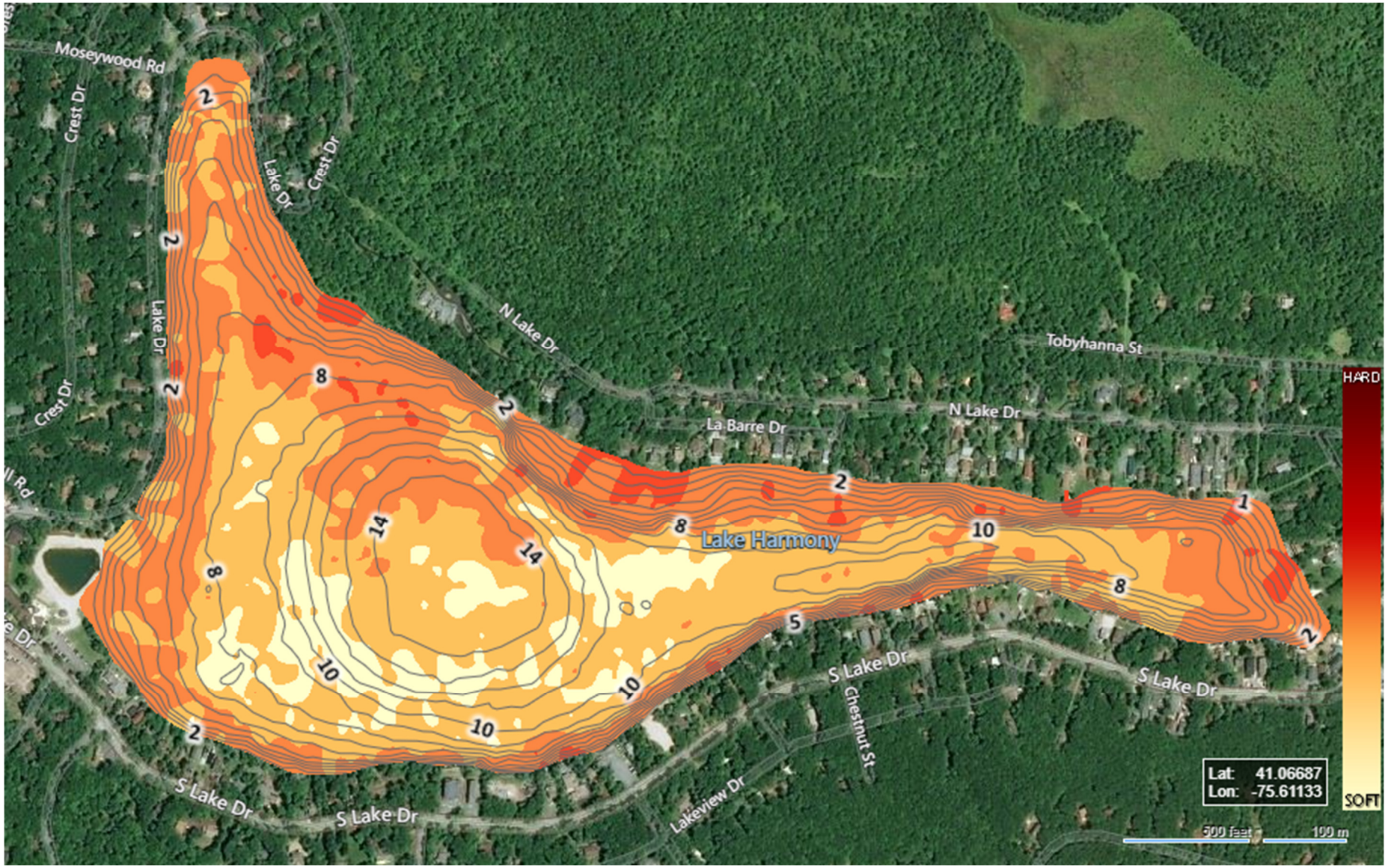

Figure 3: Bottom Composition April 2021

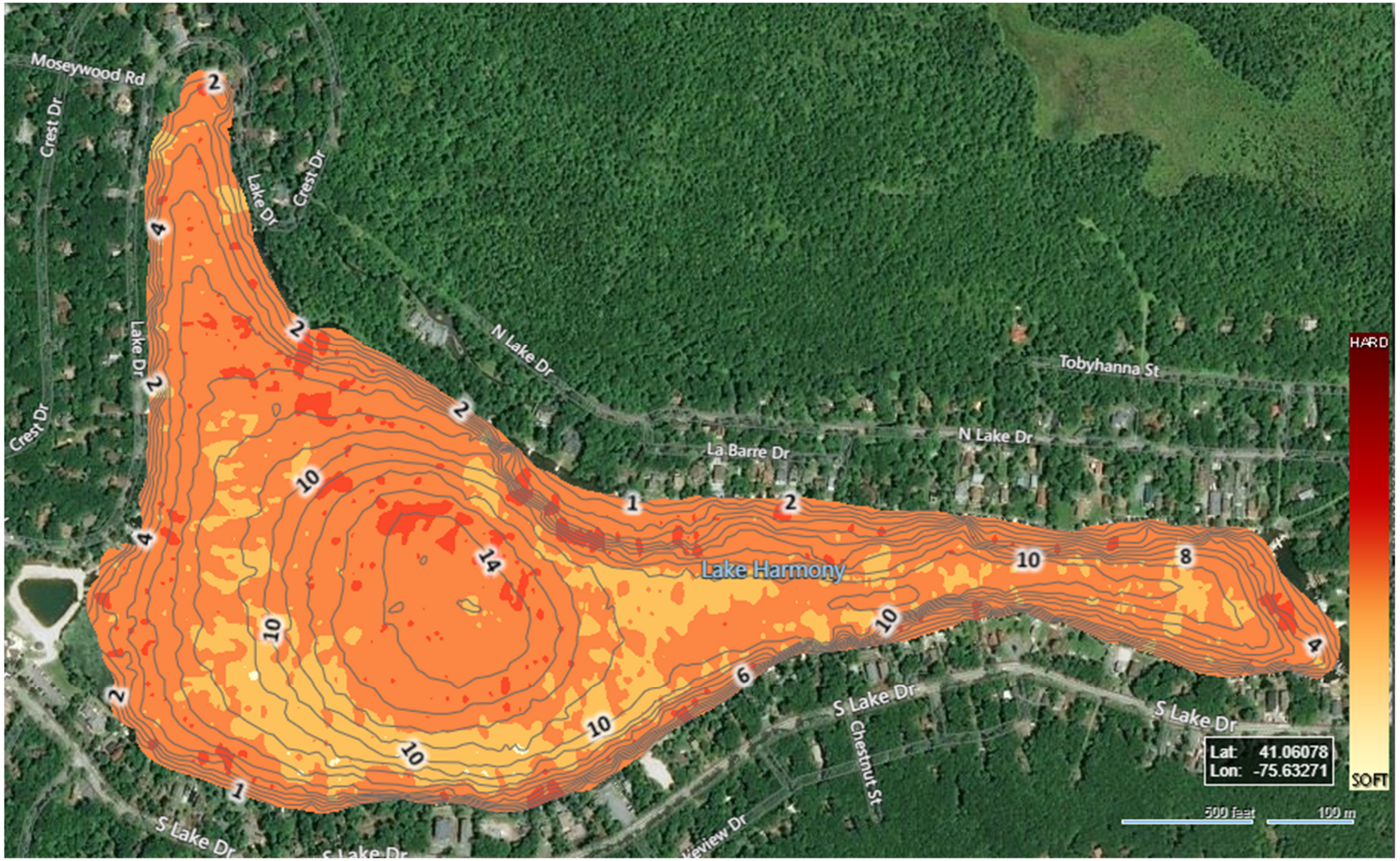

Figure 4: Bottom Composition October 2021

The pie charts in Figures 5 and 6 show the relative proportions of soft, medium-soft, medium-hard, and hard bottom sediments recorded in the April and October 2021 scans. The April scan indicated 8%, 59%, 30%, and 2% in these categories, respectively. The October scan indicated 0.2%, 39%, 58%, and 3% in these categories, respectively. Substantial decreases in medium-soft and substantial increases in medium-hard sediment are observed. The results reflect the quantitative improvements in depth and volume described above and correlate directly to overall organic sediment reduction.

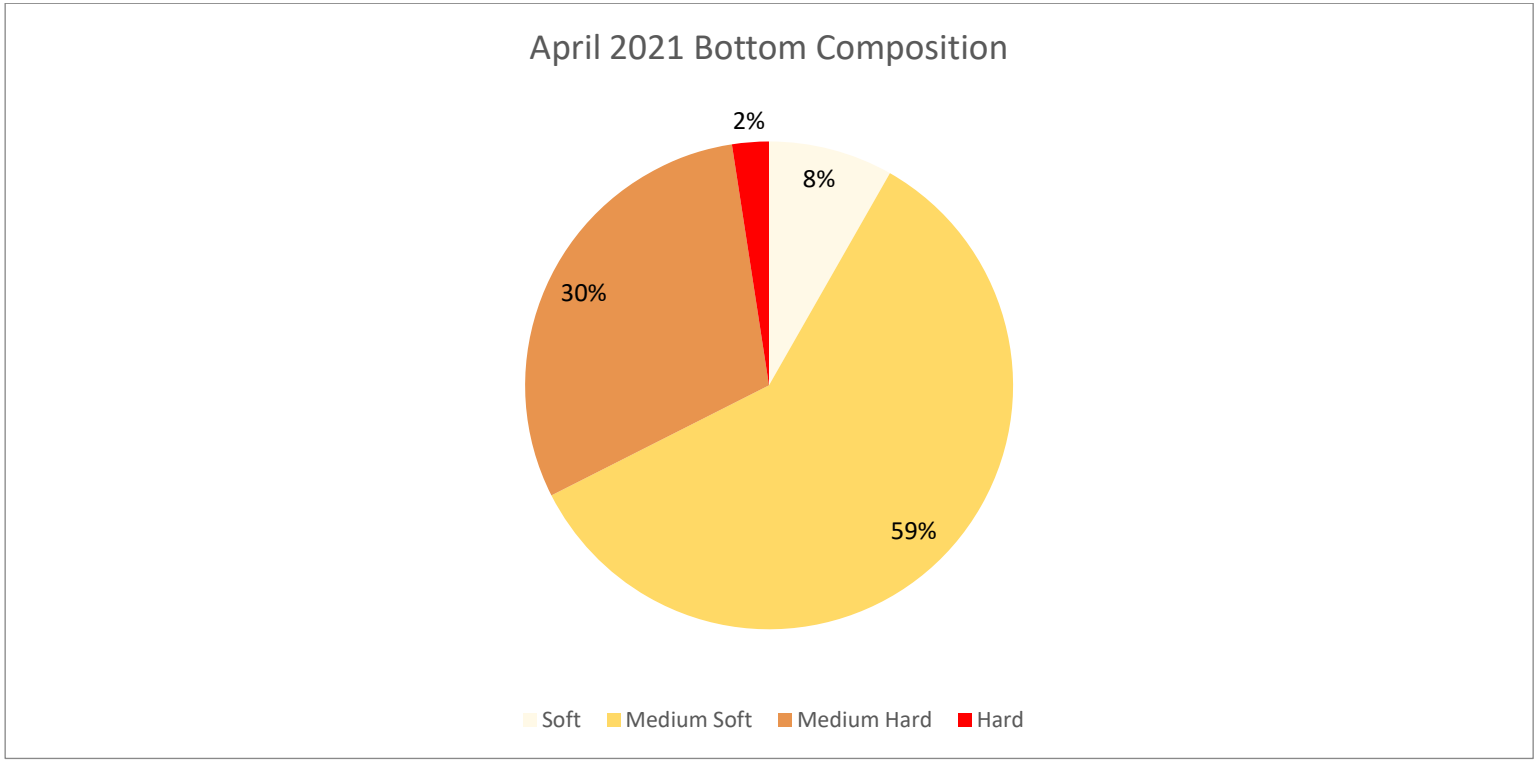

Figure 5: Bottom Composition Breakdown by Percentage April 2021

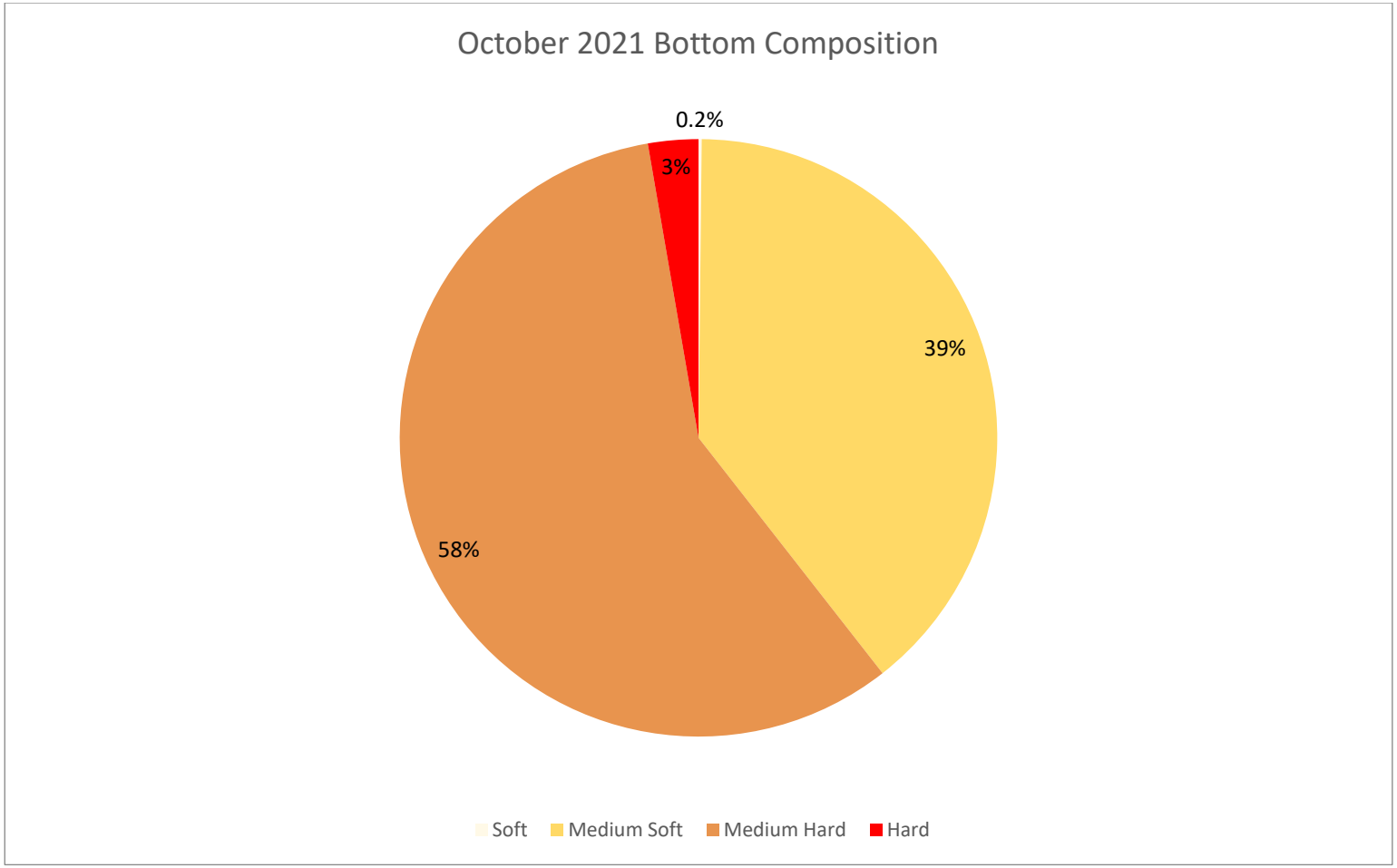

Figure 6: Bottom Composition Breakdown by Percentage October 2021

Summary

In summary, Clean-Flo's oxygenation-inversion system and product applications continue to achieve exemplary results on Lake Harmony. The maximum depth, average depth, and volume of the lake have increased steadily over time. The bottom composition has hardened consistently from year to year. The overall increase in volume and corresponding sediment reduction have amounted effectively to a tremendous removal of material from the lake that through conventional dredging would have cost millions of dollars. Clean-Flo's bio-dredging approach to sediment reduction has been proven effective, and the unit cost of the approach shown to be a small fraction

of the cost of and dramatic departure from the logistical nightmare and destructive effects on property of conventional dredging. Furthermore, factors that have improved that have not been evaluated by Clean-Flo's annual scans, but that have been reported anecdotally, are that the fishery and general recreational use in the lake have been significantly improved. This is largely due to the added benefits of full oxygenation and mixing of the lake brought about by the oxygenation-inversion system, and to the continual reduction of nutrients in both the bottom sediment and water column.

Recommendations

Clean-Flo strongly recommends that Lake Harmony continue to operate the oxygenation-inversion system and follow an annual program of product applications. As future progress scans are performed, the application strategy will be revisited from year-to-year to account for greater necessity or diminishing returns. Even after the bottom sediment has been converted primarily to a hardened, inorganic composition, and most of the organic matter has been reduced, it will still be beneficial to continue the system operation. This will maintain a consistent, incremental reduction of the remaining organic matter and offset the inevitable organic inputs that enter the lake during heavy rain events and natural leaf drop at the end of summer.

Finally, Because of the positive results that have been observed by year-round operation of the system, we also recommend that the system remain in operation through the winter. This will maintain the aerobic microbial community in the bottom sediments that is responsible for the continuing reduction of organic sediment responsible for increasing the lake's depth and volume. Further reductions of organic composition will be evaluated in future years.