HESS LAKE

BATHYMETRY AND SEDIMENT DEPTH REPORT

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PREPARED FOR:

HESS LAKE IMPROVEMENT BOARD

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1.0 Bathymetric Survey of Hess Lake

Spicer Group completed a bathymetric survey of Hess Lake at the end of April, 2010. Spicer Group collected cross sections on the lakes spaced 75 to 100 feet apart using a 200 kHz and 24 kHz dual frequency echo sounder and developed a two foot interval contour map as a final product of the survey. See Appendix A, map one.

Spicer Group collected the dual frequency data for future use for Hess Lake property owners in case they desired a more detailed study of the bottom characterization. This information could be used for other projects such as dredging, phosphorus stabilization or development of a comprehensive lake management plan. The following is a description of lake bed characterization if that is a study desired in the future.

1.1 METHOD:
The proposed methodology to be utilized for future lakebed characterization is described in the following section:
Echo digitization is a sampling of a voltage varying with time as the acoustic energy of the returning echo is converted to electrical energy at the transducer. The data contains water column and lakebed information. The data quality depends on the capabilities of the analogue to digital circuitry and signal pre-conditioning. To minimize data volumes, a time window surrounding the lakebed is retained and subjected to further signal pre-conditioning, before submittal to echo description algorithms.

A series of digital signal processing algorithms is applied to the digitized echo. These algorithms extract different kinds of information from the data. Each algorithm generates a series of values or features. The features are concatenated to form one long string, or Full Feature Vector (FFV). The FFV constitutes the echo description.

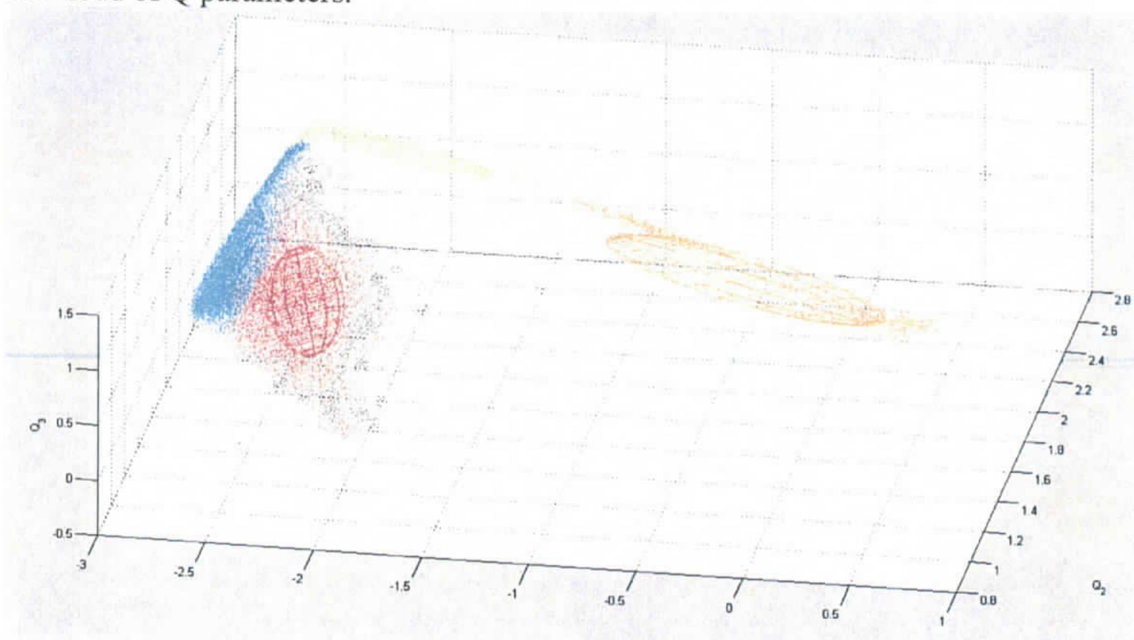
Principal components analysis (PCA) is used to reduce each FFV to three principle components. A reference data set (either a subset of data or the entire echo population depending o the quantity of data) is submitted to the analysis. The most useful features to describe lake bed variability are chosen. Results are given in terms of the most important principal components. Quester Tangent Corporation (QTC) research has determined that three principal components effectively describe each echo. These components are labeled Q1, Q2, and Q3.

The processing flow follows the QTC approach to lakebed classification: waveform analysis (where echo trace data exist), FFV generation and validation, clustering/cataloguing and classification. The flow is entered at one of two places in the data stream dependent on data type acquired. A number of data formats and collection methods can be supported by this system. The raw data files from the sonar source have navigation data together with the waveform data in the same raw data files.

The waveform view and conditioning tasks include quality control and bottom picking. Quality control is exercised by identifying traces that are unsuitable for classification. Bottom picking is particularly important as it defines the lakebed / water column interface, as well as the reference window for echo description. Quality control is exercised by setting the parameters for accurate picking and then reviewing the results.

As part of the lake management plan Spicer Group would process existing data and gather any necessary additional data to create a map of the bottom characteristics of Hess Lake. To create the map, Spicer Group would use QTC Impact software to statistically categorize the 200 kHz echo sounder data into four classes to provide a direct correlation to collected sample results.

Spicer Group would then use the QTC Impact program to mine hundreds of characteristics from raw echo sounder data and summarize the characteristics into three representative parameters Q1, Q2 and Q3 for each collected ping of the echo sounder. The program was then used to create a statistical best fit of the four bottom classes into the cloud of Q parameters.



Each collected echo sounding would then be assigned its resulting bottom type which would then be shown on a lakebed map.

When Q1, Q2, and Q3 for each record are plotted in Q-Space, acoustically similar lakebeds will form clusters. IMPACT's cluster analysis tools (shown above) identify various data clusters and labels them as classes. All data falling within that portion of Q-Space identified with a class will be assigned that particular class identification. Useful information about the diversity or homogeneity of the data set is available from the confidence and probability values.

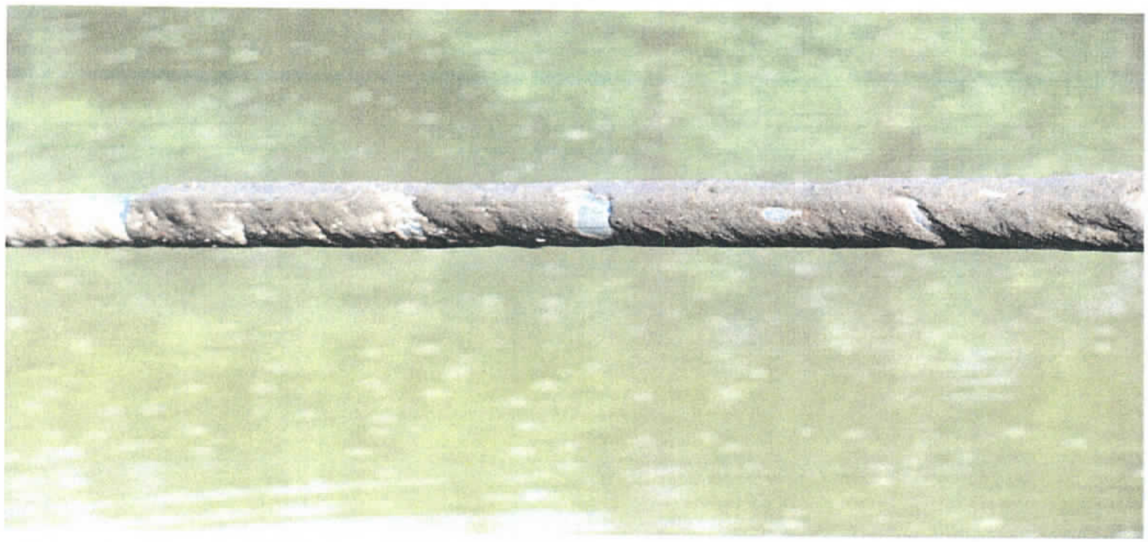
2.0 Summary of Sediment Depth Probing

On the morning of July 1, 2010, Spicer Group staff met with Dick Besser at the Hess Lake public boat launch and received a copy of the Hess Lake contour map with specific areas of interest labeled for assessment by probing. The letter of agreement for this study on the sediment depth called for a minimum of 50 "probes" into the lake's bottom (benthic zone) to establish the depth to "hard" surface and a basic characterization of the types of sediment encountered during the probes. A total of 214 probes were completed during the time spent on Hess Lake. Each pole probe had its location by latitude and longitude and the depth of sediment recorded. Additional notes were added to most locations to indicate the type of material adhering to the pole.

2.1 METHOD:
The pole used was a 0.75 inch diameter aluminum conduit with incremental measurements marked on the poles exterior surface. The poles were assembled in 10 foot segments with connecting hardware so a total length of 40 feet could be attained. The bottom probe pole had an eye bolt and ¼ inch diameter nylon rope attached to help with removal of the apparatus from deep sediment and to assure retrieval of all equipment from the deeper regions of Hess Lake. The aluminum conduit was used as it transmits sound well and this assisted in distinguishing sands and gravels. The rough exterior of the aluminum conduit allows sediment to adhere for a record of the sediment characteristics. See Appendix A, map two.

2.2 DISCUSSION:
The southern boundary of Hess Lake has a moderate amount of sediment. The south eastern portion of the lake where the 15 foot deep section of the lake is has a significant amount of sediment which can be characterized as mostly organic materials. The pole had mucky-dark sediment attached to it at times; also decaying plant matter was attached also. At times we experienced the smell of decaying organics when stirring up the bottom sediments. The depth of sediment in the deeper hole of this region ranges from 11 to 13+ feet.

For the most part these organic sediments were found in the prominent "bays" on either side of the prominent point, west of the Wheeler Drain, along the lakes southern boundary and in the southwestern most region of the lake, south of the public boat launch. The map produced utilizes a dark red color to indicate where the probes were into organic materials. Clayey – silty sediments are indicated by orange circles; sand is represented by yellow and gravel is a grey color. We did encounter a lot of sediment that was more of a light sandy to light grey color, clayey-silty type of sediment which had debris of small clams and snail shells imbedded in it (see picture above). This clayey-silty material was "sticky" in nature, not heavy clay, as it contained silty sediments which interrupted its cohesiveness. Other times we encountered this same material, but it was beneath a layer of darker, organic material which coated the underlying clayey silty sediment. (See picture below)



The shoreline along the north and eastern perimeter seemed to be predominantly sand with some areas of gravel noted. The southern perimeter of the lake had sections (reaches) of sand; however, as the map indicates, there are areas of organic sediments noted. When we probed along the 6 foot depth contour in the bay by the Wheeler Drain we noted organic and clayey-silty sediments. In the center of the lake we noted mostly sands and clays. But there could be organic materials in the deeper regions. We could only successfully probe one deep region and had over 12.5+ feet of sediment encountered. If organic material was present it washed off before the end of the probe reached the surface. We discontinued probing in the deeper portions of the lake as we encountered retrieval problems with the equipment because of the depth of the water, and the nature of the sediment to adhere to the pole. All equipment was retrieved from the lake. Based on the depth of sediment in other regions of the lake we would anticipate all of the deeper regions to have a significant layer of sediment in them also. See Appendix A, map three.

3.0 Summary of Water Quality Data for Hess Lake

A water quality sampling was performed on July 1, 2010 by staff from Spicer Group. The parameters obtained were temperature, specific conductivity, dissolved oxygen, pH, Total Dissolved Solids, turbidity and use of a Secchi disk to determine water clarity. A Quanta Water Quality Monitoring System developed by HYDROLAB was utilized to obtain all sample results and an attached Secchi disk for water clarity.

3.1 SAMPLING STRATEGY:

Hess Lake was sampled once during the summer of 2010 when Spicer Group was on site obtaining sediment depths. With the warm summer the lake was thermally stratified at approximately 15 feet. The sampling occurred at two deep locations in the lake. The site's were "marked" with a GPS unit and were in approximately the same location as the sampling done in 2009.

3.2 METHOD:

The Quanta unit was able to test six parameters at for this sampling, which were: temperature, specific conductivity, dissolved oxygen, pH, Total Dissolved Solids, and turbidity. The Quanta also has a depth meter and is lowered into the lake at measured intervals on its attached data cable and readings are taken from the hand held data unit. Since the unit does an efficient task of data collection we were able to collect data at two foot intervals in order to provide a profile of the water column at the deepest portion of the lake. A table of results is on the last page of this report along with a Dissolved Oxygen profile in a graphic format.

The Secchi Disk was attached to the Quanta unit's probe, as the unit was lowered, depth was measured and recorded.

3.3 DISCUSSION:

This data set represents just a sampling necessary to continue to record the health of Hess Lake. Typically, sampling is done at the spring turnover (usually April) and again in the late summer (August or September), when the lake typically is thermally stratified. The sampling collected during the July 1st visit to the lake represents water quality samples collected when the water was warm and biological plant productivity was generally at its greatest capacity. The trophic state of a lake can be assessed over time to determine effects of land use changes and other human influences on the lake. Hess Lake is in the Southern Michigan/Northern Indiana Drift Plains region and is the second largest ecoregion in Michigan. From 2001 to 2005 the United States Geological Services and the Michigan Department of Natural Resources and Environment (DNRE, formerly MDEQ) performed a significant amount of water quality testing on lakes throughout the state and in this particular region and data gathered can be used for comparative analysis.

Overall, the results of these tests showed the water column has stratified and were consistent with past results. The temperature was fairly consistent from the surface down to about 15 feet, varying only about 2.0 degrees Fahrenheit, but it began to drop quickly after that depth. See Appendix B for results and oxygen profile charts.

The **Specific Conductivity (SpC)**, which is the ability of the water to conduct electricity, is an indicator of dissolved solids in the water. When the lake is stratified this level raises as the probe approaches the bottom. This occurs because in low oxygen, or no oxygen (anoxic) conditions the bottom sediments release more dissolved materials such as phosphorus, iron, and manganese. The results obtained during this sampling did not show much variation until about 18 feet down in the lake. At that point the SpC indicated more dissolved solids in the water column as would be expected in the lower oxygen and pH conditions encountered.

Dissolved Oxygen (DO) is a critical factor in a lake system mainly because oxygen is a major part of many biological and chemical processes. DO is dependent on temperature, the cooler the water the better the water can absorb and hold oxygen, the warmer the water the less oxygen it will hold normally. The saturated value of DO in water is modest and on the order of 8 to 15 mg/L depending on temperature and salinity. The DO in Hess Lake was very good during this sampling; it was higher at the surface (10.33 to 9.89 mg/L) as expected as this is where the atmospheric interface takes place. As the probe approached the bottom the oxygen level decreased to ~2.55 mg/L. What we noted was the DO remaining quite good down to the 15 foot level with a reading of 8.95 mg/L. These high levels may be attributed to the time of day we did the testing, early afternoon on a sunny day with the aquatic plants and any algae contributing to the oxygen levels. We would anticipate these levels of DO to go down during the evening hours. Once below 15 feet the oxygen began to quickly deplete.

Minimum amounts of DO required for a healthy fish population may be as high as 5 – 8 mg/L for active species of fish, or as low as 3 mg/L for less desirable species such as carp.

The **pH** did not display a wide variation. It is a measure of the hydrogen ion activity in the lake water. Typically lakes in this region of Michigan display pH of 7.5 to 8.4. The range for water quality is from 6.5 to 9.0. There was a little more variation of pH in the water column when compared to the 2009 spring sampling. The pH was lower as the probe approached the bottom of the water column. The range of pH was 9.2 at the surface to 7.3 at depth.

Total Dissolved Solids (TDS) is a measure of dissolved solids or *salts*. As water passes through soils and rocks it picks up cations such as sodium, calcium, magnesium, potassium and anions such as chloride, sulfate and bicarbonate. As a rough approximation fresh water typically has less than 1.5 g/L of TDS. The Hess Lake profile for TDS was 0.2 g/L to 0.5 g/L. It was a consistent 0.2 g/L until the probe approached the sediments at the bottom of the lake. There it rose to 0.3 and 0.5 respectively for the two locations.

Turbidity is an indicator of suspended solids in a water column. Turbidity is linked to the "look" of water and, therefore, the public's perception of water quality. People generally prefer water of high clarity for recreation and consumption. The turbidity of the water is determined by the type of lake or stream bottom, the pollutants, or the plant and animal life in the lake or stream. Turbidity is commonly linked to total suspended solids (TSS) because water with high TSS levels typically looks murkier and have higher turbidity measurements. Common suspended solids are clay, silt, and sand from soils, phytoplankton (suspended algae), bits of decaying vegetation, industrial wastes and sewage. The results show a moderately clear water column that gets slightly more turbid as the probe approaches the bottom sediments.

Secchi Disk the visibility of the Secchi disk was comparable to last years sampling, still roughly 3 feet before loosing sight of the disk.

4.0 Recommendations:

1. Complete a map of the lake bottom with comprehensive sediment sampling to characterize the lake bed and provide a regional approach to dredging if that is a proposed task for the future.
2. Complete sediment testing in proposed areas for future dredging to determine if the dredged material meets Department of Natural Resources and Environment disposal criteria.
3. Determine a final phosphorus strategy for Hess Lake.
4. Implement BMPs on Wheeler and Alger Drain to decrease the amount of nutrients and sediment being transported into Hess Lake.
5. Continue implementation of the lakefront overlay zone ordinance.
6. Continue aquatic plant management on Hess Lake.
7. Continue bi-annual monitoring of phosphorus levels in the lake.

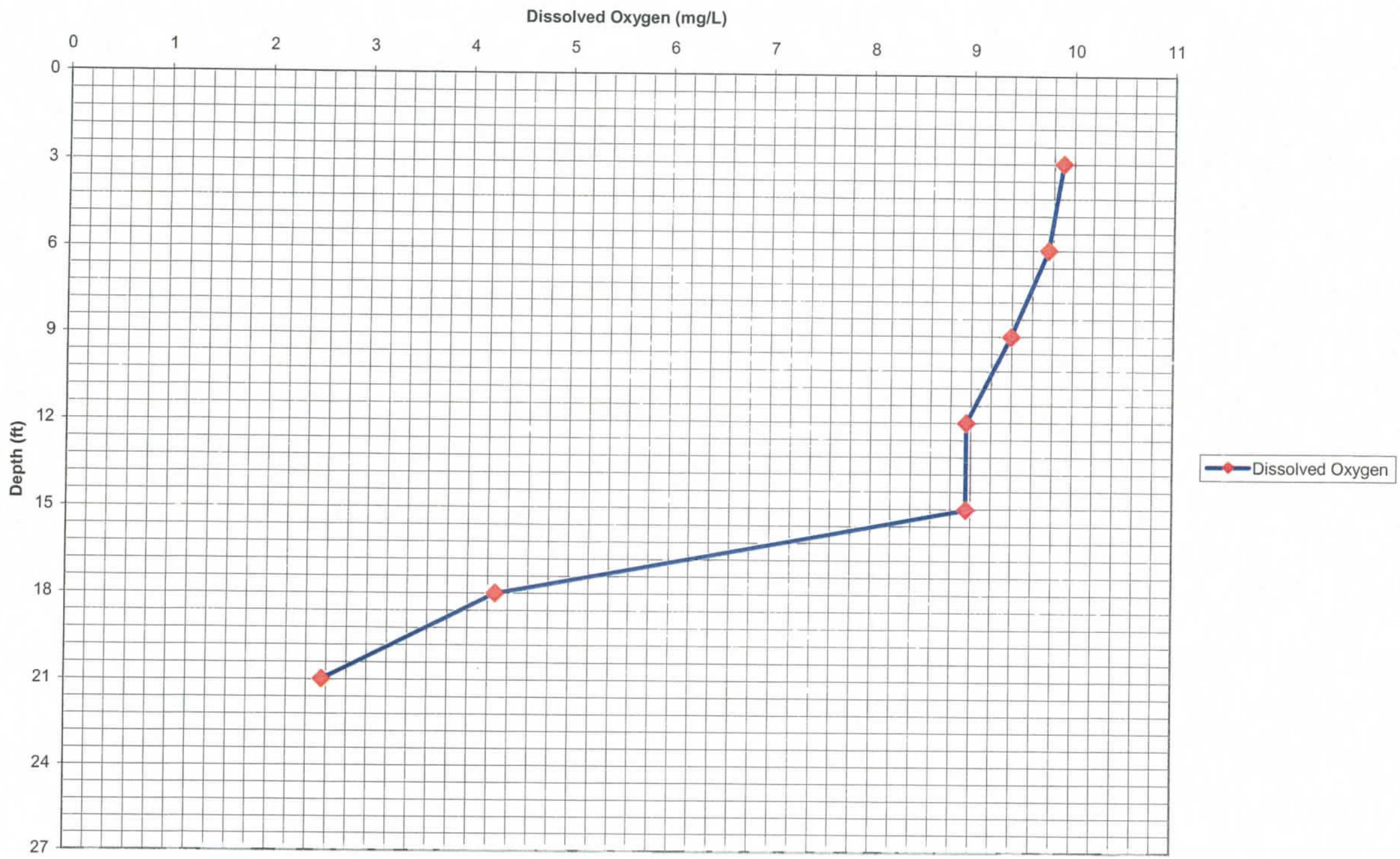
APPENDIX A

Hess Lake, Newaygo County, MI

Location #1	N43° 23' 18.22"	W85° 46' 9.91"					
Weather	Sunny, light breeze Temp 78F, water surface, relatively calm, waves ~3-6 inches						
Depth (ft)	**3**	**6**	**9**	**12**	**15**	**18**	**21**
Temp (F)	74.4	73.6	73.3	73.0	72.5	63.3	60.4
SpC (mS/cm)	0.31	0.316	0.313	0.315	0.312	0.416	0.482
D.O (mg/L)	9.89	9.75	9.39	8.95	8.95	4.27	2.55
pH (units)	9.21	9.21	9.20	9.12	9.12	7.70	7.49
TDS (g/L)	0.2	0.2	0.2	0.2	0.2	0.3	0.3
Turbidity (NTU)	22.9	23.7	23.3	29.7	28.9	18.5	otc
Secchi Disk	Lost sight at 30 inches						

Location #2	N43° 23' 1.52"	W85° 45' 49.87"							
Weather	Sunny, light breeze Temp 78F, water surface, relatively calm, waves ~3-6 inches								
Depth (ft)	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**
Temp (F)	74.6	74.2	73.7	72.9	72.9	72.7	72.5	69.0	66.3
SpC (mS/cm)	0.315	0.312	0.315	0.317	0.314	0.316	0.317	0.388	0.838
D.O (mg/L)	10.33	10	9.69	9.19	9.18	9.38	8.95	4.55	2.54
pH (units)	9.22	9.21	9.21	9.59	9.53	9.17	9.09	8.02	7.33
TDS (g/L)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.5
Turbidity (NTU)	27.0	25.9	28.8	28.2	31.7	33.2	39.1	35.6	otc
Secchi Disk	Lost sight at 3.0 ft								

Dissolved Oxygen Profile - Hess Lake, (PL-1)



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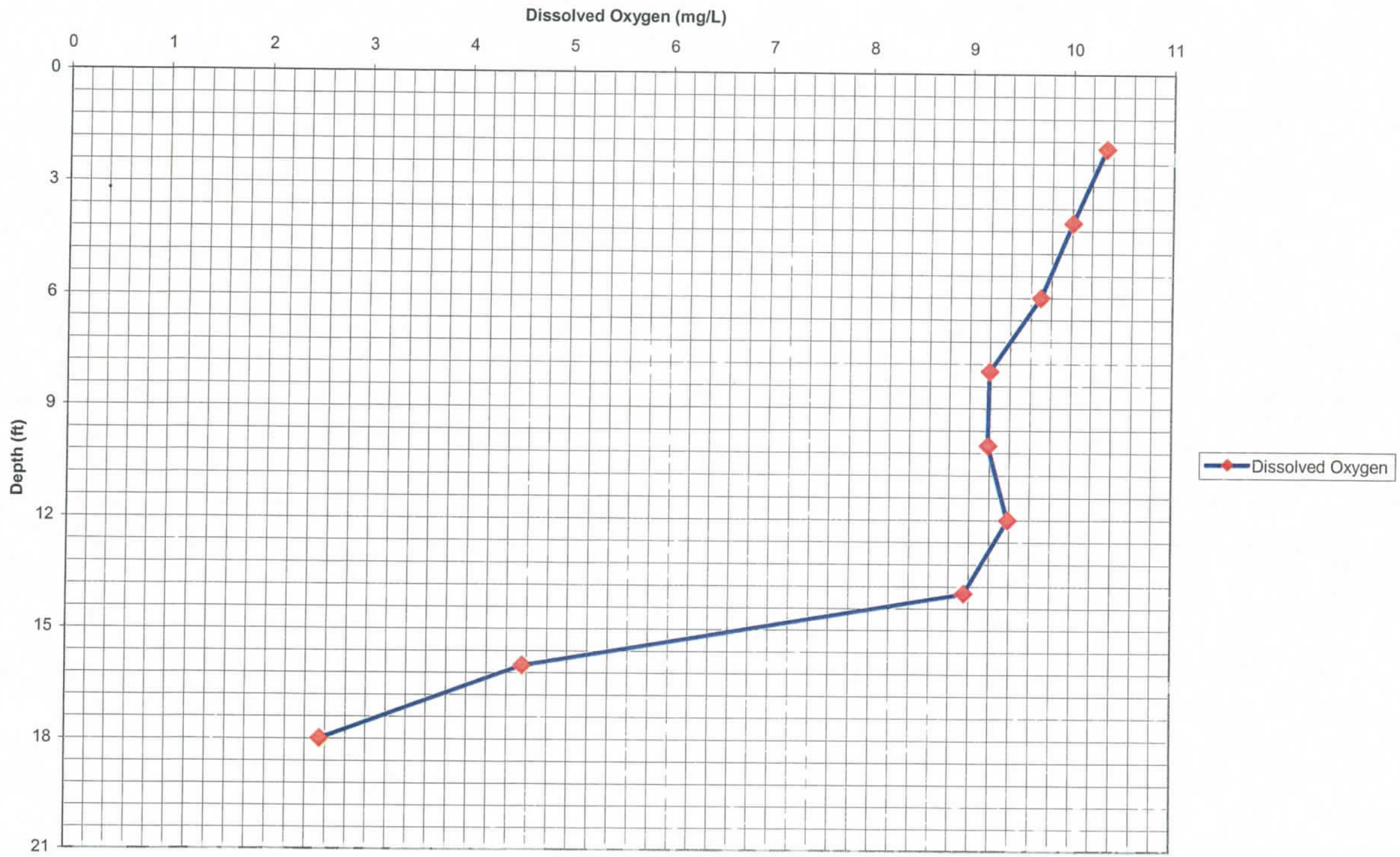
Dissolved Oxygen Profile - Hess Lake, (PL-2)



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