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Final Report for

HENNEPIN WELL SITE, DETROIT RIVER, MI

WELL LOCATION INVESTIGATION

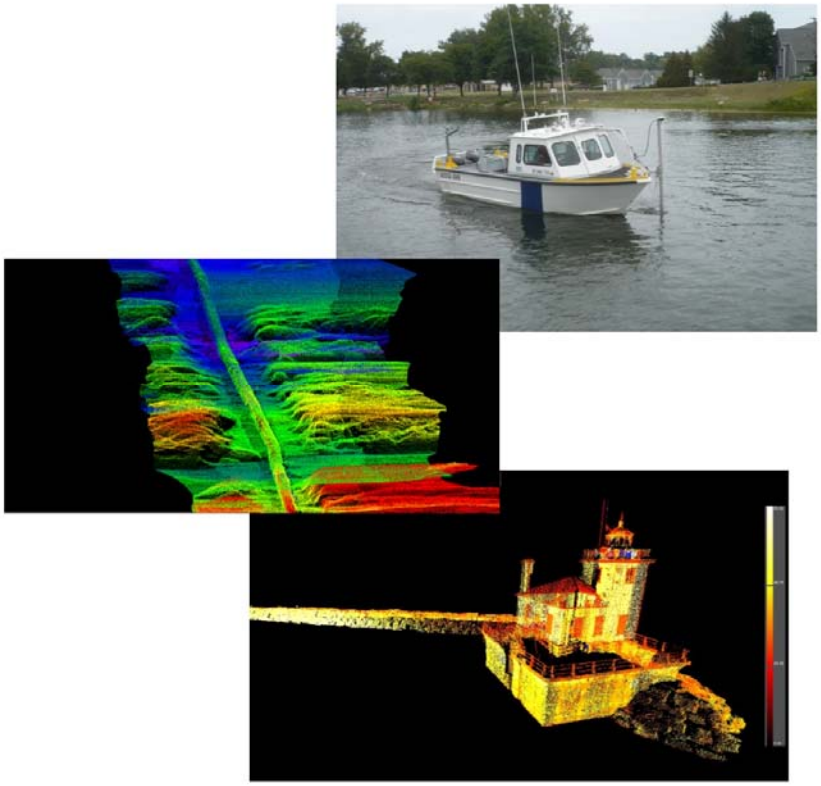
ECT Environmental Consulting & Technology, Inc.

Prepared for:
ECT
220 Commonwealth Blvd.
Ann Arbor, MI 48105

Prepared By:

SEAWORKS GROUP, LLC

185 E. Main, Suite 414, Benton Harbor, MI 49022 269-277-3005



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Phone: 269-277-3005
Email: chris@seaworksgroup.com

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1.0 Project Details

1.1 Project Description

Seaworks was tasked by Environmental Consulting and Technology (ECT) with performing an investigation to locate 24 abandoned saline well heads throughout a site on the Detroit River. The purpose was to determine position of the well heads to allow for future engineering of a marine habitat. Water Quality measurements were also collected to ensure wells were properly capped and sealed. The survey area was located in a flat, shallow bay between the Trenton Channel and Grosse Ile, with water depths between 3 and 10 feet. Data was collected by Seaworks and dive subcontractor Ballard Marine on various dates between September 2019 and April 2020.

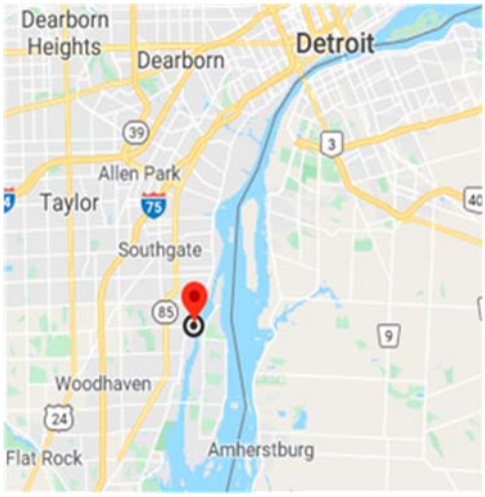


Figure 1.1 – Project Location

Figure 1.2 – Survey Area

1.2 Project Timeline

Date	Task Performed	Results
9/17/19 - 9/18/19	Magnetometer Investigation & Sidescan Survey	Magnetometer Completed / Vegetation too thick to complete sidescan
12/11/2019	Dive Investigation	Vegetation too thick to complete
12/13/2019	Salinity Testing	Data collected
3/24/2020	Sidescan Survey	Sidescan Completed
4/1/20 - 4/2/20	Dive Investigation	Completed- priority wells probed and under water metal detector used

1.3 Project Datums

Horizontal

Datum: North American Datum of 1983 (NAD83)
Grid: Michigan Coordinate System, South Zone
Units: International Feet

Vertical

Datum: North American Vertical Datum (NAVD88)
Geoid: Continental US (CONUS) 2012a

1.4 Survey Control

The Michigan DOT VRS network was used for RTK GPS corrections on the survey vessel. Network accuracy was verified by performing a QC check using a Trimble R8 rover against a local NGS control monument (NE0516). QC points checked in to within 0.10' horizontally and vertically.

Figure 1.3 – NE0516

ID	Easting	Northing	NAVD88 Elev.	Description
NE0516	13,442,499.97	219,063.31	581.68	NGS BM Disk

2.0 Equipment

2.1 Survey Vessels

Survey Vessel Mary Rose

The 25' Mary Rose is a heavily-built aluminum, DGPS-equipped, automated hydrographic survey vessel with an environment-controlled cabin capable of transporting up to 6 passengers. The Mary rose also features push knees, extra-large fuel tanks, twin 150hp 4-stroke outboards, and a 3000W generator.

Specifications:
Length: 25'
Horsepower: 300
Cruising/max speed: 25/35kts
Generator: 3,000W
Fuel Capacity: 150 gallons
Passenger capacity: 6
Trailer: Galvanized, twin axle

Figure 2.1 – Mary Rose

Survey Vessel Jessica Jean

The 24' Jessica Jean is a heavily-built aluminum, DGPS-equipped, automated hydrographic survey vessel with an environment-controlled cabin capable of transporting up to 6 passengers. The Jessica Jean also twin 140hp 4-stroke outboards and a 3000W generator.

Specifications:
Length: 24'
Horsepower: 280
Cruising/max speed: 25/35kts
Generator: 3,000W
Fuel Capacity: 75 gallons
Passenger capacity: 6
Trailer: Aluminum, twin axle

Figure 2.2 – Jessica Jean

2.2 Sonar Equipment

Edgetech 4125

The Edgetech 4125 side-scan sonar is a 600/1,600Khz dual simultaneous frequency system designed for high-resolution search and mapping applications. The dual frequencies provide a combination of long range search capability and ultra high resolution images for detail and detection of very small objects.

The 4125 system utilizes Edgetech's Full Spectrum CHIRP technology, which provides higher resolution imagery at ranges up to 50% greater than comparable systems. The system has an operating ranges of 120m @ 600Khz and 35m @ 1,600Khz. It has a horizontal beam width of 0.20° and an across-track resolution of 0.6cm.

The sonar towfish is typically towed behind the survey vessel at an optimal altitude above the bottom to maximize detection and image quality. In shallow waters it is deployed from the side of the vessel using an outrigger davit.

Figure 2.3 – Edgetech 4125

2.3 Positioning & Orientation System

Applanix POS MV 120

Horizontal and vertical positioning were accomplished using an Applanix POS MV 120 Position & Orientation system. The POS MV 120 package uses RTK (Real Time Kinematic) GPS technology which is capable of receiving both L1 & L2 frequencies as well as the GLONASS satellites. Equipment is capable of achieving positioning accuracies of up to +/-0.10', both horizontally and vertically. The RTK positioning equipment is be capable of rapid update rates >5Hz, allowing it to be used for real-time heave compensation.

Figure 2.4 – POS MV 120

A two-antenna "moving baseline RTK" system is used by the POS to provide high-accuracy heading in addition to vessel position. Heading sensing equipment is capable of maintaining at least +/-0.10° heading accuracy under most conditions.

The final component of the system is a precision motion sensor which is used for vessel pitch and roll corrections. The sensor was calibrated/zeroed with the vessel at rest, and then mounting offsets were determined by a patch test performed prior to mobilization. Motion sensing equipment is capable of angular measurement accuracy of at least +/-0.04°.

2.4 Metal Detecting Equipment

Geometrics G-882

The Geometrics G-882 Cesium Vapor Marine Magnetometer is used to locate ferrous objects by detecting distortions they create in the earth's magnetic field. The magnetometer's sensitivity is better than 1.0 gamma and sampling intervals are as low as 1hz. This translates to detection capabilities varying from >30m for 1 ton of steel to 10m for 30lb of steel.

Figure 2.5 – Geometrics G-882

The magnetometer is typically towed behind the survey vessel at a distance where readings are not affected by metal on the vessel itself. In deeper water it is towed beneath the surface, in shallower water it is towed on the surface by attaching it to floats.

Minelab Excalibur II

The Excalibur II is a deep diving metal detector for use by divers while performing underwater investigations. It is submersible to 66 meters. With multiple modes and control settings it allows the user to dial in location of ferrous objects found. The Excalibur has 17 frequencies separating it from most common metal detectors.

An adjustable discrimination feature rejects junk targets. Targets can be easily identified using multi-tone target discrimination.

Figure 2.6 – Excalibur II

2.5 Water Sampling Equipment

YSI Professional Plus Water Quality Instrument

Figure 2.7 – YSI Pro Plus

The YSI Pro Plus Water Quality Instrument is a versatile multi parameter water testing probe. It features a rugged design with military-spec connectors and extra-durable cables. The multi parameter sonde can accommodate a wide variety of sensors, depending on project specifications. The configuration used included temperature, conductivity, pH, salinity, and depth sensors.

3.0 Personnel

Chris Ebner, P.E. (MI & IL) was the Project Manager and Lead Hydrographer for the operation. Chris is a Hydrographer certified by the Hydrographic Society of America and the National Society of Professional Surveyors (THSOA/NSPS) with twelve years of experience in hydrographic surveying.

Doug Tosa, Wade Whitfield, and Ed Lopez were the Project Surveyors for field data collection and processing. Doug and Wade have relevant education backgrounds, work experience, and extensive hands-on experience using the hydrographic systems described above.

4.0 Procedures

4.1 Field Procedures

Side-Scan Survey

The side-scan sonar is normally deployed directly off a side-mounted davit in shallow water and towed behind the vessel in deeper water, in order to maintain a desired altitude of 2-5m throughout the survey area. Survey line orientation is generally parallel to the river channel. Survey track pattern is varied to

optimally image items of interest. A minimal survey speed is used for optimal data density and resolution.

Side-scan sonar operating parameters:

- Sonar Frequency: 1,600/600Khz
- Coverage Width: 25/50m
- Survey Speed: 3.0Kts
- Tow Cable Length: 0m (hung from davit)
- Average Altitude: 1-2m (due to shallow depths)

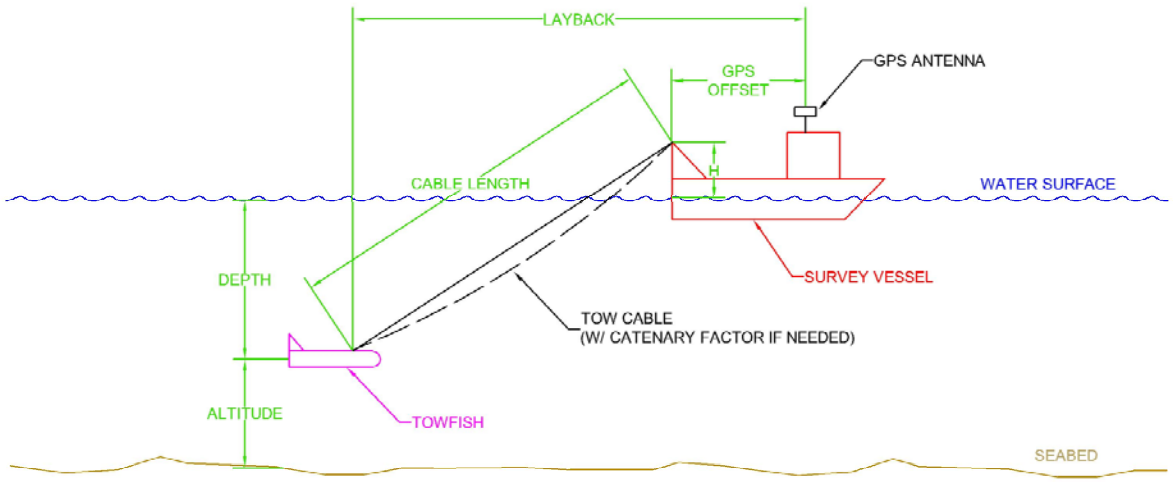


Figure 4.1 – Towed Sonar Layback

Magnetometer Survey

During the magnetometer phase, the device was towed about 40' behind the survey vessel. This distance was selected to minimize interference from the vessel itself, while still maintaining control to maneuver the vessel along banks and obstacles. Due to shallow water depths at the site, the magnetometer was towed on the surface by attaching it to foam floats. In deeper water it can also be towed below the surface in order to maintain an altitude of 20' or less. Survey line orientation was parallel to the river channel with a nominal line spacing of 20'. The line spacing was selected to maximize coverage and minimize any chance of missing small targets between lines.

Magnetometer operating parameters:

- Line Spacing: 20'
- Survey Speed: 3.5Kts
- Tow Cable Length: Average 40'
- Average Altitude: 3-6' (towed on surface)

YSI Probe Sampling

During the water sampling phase the survey vessel was used to maneuver around the work site. Background sample were taken up-current of the project site to establish a background levels for the measurement parameters. Samples were then taken immediately down current of the well heads, 2-4' off the river bottom.

Dive Team Investigation

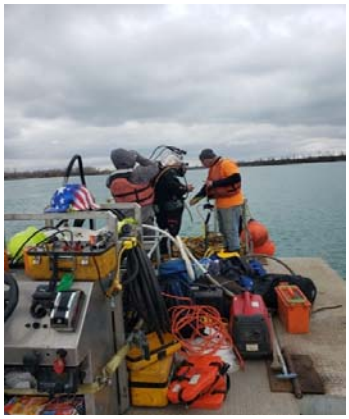


Figure 4.2 – Dive Preparations

Dive team was guided to given positions based upon the Magnetometer investigation results. At each location the vessel was anchored and the diver deployed, using the Excalibur metal detector and a probe to try to locate the well head. If the well was found to be buried, the riverbed was physically dug up using a shovel to try and expose the well. Once the well was exposed, a survey rod was placed vertically on the top of the well, and a depth measurement to the waterline was recorded. A surveyor above then collected a GPS fix on the rod using a handheld RTK GPS, and also recorded the current water elevation. The water elevation, minus the measured depth was used to compute the NAVD88 elevation of the top of well.

4.2 Processing & Deliverables

Magnetometer Investigation

Magnetometer data was processed using Hypack 2019 Single-Beam editor. Data was adjusted for layback, then converted to XYGamma format and processed in the TIN utility to generate contour drawings showing relative gamma values. Magnetometer data was overlayed with the sidescan mosaic to help better identify any sidescan anomalies. From the contour files the probable well locations were identified.

Sidescan Survey

Side scan data was processed using the Chesapeake Sonarwiz 7 program. The water column was digitized and positioning and heading smoothing were applied. Time Varied Gain (TVG) values were adjusted as needed for the best visual appearance. Data was analyzed line by line for items of interest, and a target database was generated. Finally, individual side-scan passes were georeferenced and mosaicked into a 0.5'x0.5' resolution Geotiff image, using Cover Up overlay methods.

Dive Investigation

Once the dive investigation was completed, the results of all surveys were compiled in a spreadsheet and the results plotted in the attached maps.

5.0 Site Conditions

The majority of the survey area was located in a bay outside of the Trenton Channel which led to no delays due to vessel traffic. During various phases of work over an 8 month period, a variety of weather conditions were encountered but none of it impacted operations. The surveys took place during a period of unusually high water which was beneficial to survey operations. The entire site could be accessed by a 25' survey boat which would not have been the case during lower water.

Figure 5.1 – Aquatic Vegetation

Throughout the work area the aquatic vegetation was found to be very thick. The magnetometer survey was conducted as planned in September, as the data was unaffected by the vegetation. However the vegetation obscured the river bottom so usable sidescan sonar data could not be collected. It was also determined that safe dive operations were impossible because of concerns with dive equipment becoming tangled in the vegetation. For this reason the project was put on hold until March 2020 after the winter vegetation die-off. In late March conditions were found to be optimal and sidescan survey and dive operations took place as planned.

6.0 Results and Discussion

Magnetometer Investigation

The well locate that Seaworks' was tasked with involved several rounds of data collection using various approaches. The first round of magnetometer surveying in September 2019 went well and was not impacted by the dense vegetation. The side scan survey was not possible in September due to vegetation, but the magnetometer data could be used to determine the general location of the wells. Magnetometer surveying was performed at a relatively dense, 20' line spacing, so the accuracy of the locations was estimated to be 10-20'.

Sidescan Survey

Figure 6.1 – Well OS-14

Once the sidescan survey was performed in late March 2020, the majority of wells were determined buried under river sediment. The sidescan imagery was carefully reviewed, and one well was clearly visible at the surface, OS-14. One other well may have also have been found near the surface, OS-22. There was an object found right at the expected OS-22 well location, however it does not have the expected appearance of a well head.

Water Quality Investigation

Salinity testing revealed no evidence of leakage from the wells. Salinity results were all very consistent between the four background samples and 24 well samples, all between 0.12 – 0.13ppt. Additionally surveyors and divers both reported no visual evidence of leakage, and no unusual disturbances in the riverbed were noted in sidescan sonar imagery.

Dive Investigation

For the dive investigation, ECT provided a priority area where construction was planned at the upriver end of the site. It was decided that the dive investigation would exclusively focus on that area.

Diving began at well OS-14, which had been identified by sidescan, in order to give the divers an idea of what they were working with and tune their metal detecting equipment. Work then progressed to 6 other high-priority wells. Two additional wells OS-8 and OS-1 were located and uncovered by digging through 1-2' of sediment. At one other well, OS-7, a strong metal detector ping was observed. However the well was not able to be probed or uncovered even after about an hour of digging. Three other wells were not able to be located with the metal detector, although efforts were capped at about an hour each due to time and budget constraints. The results confirm what was initially observed in sidescan data, which is that the marjority of wells are buried under river sediment.

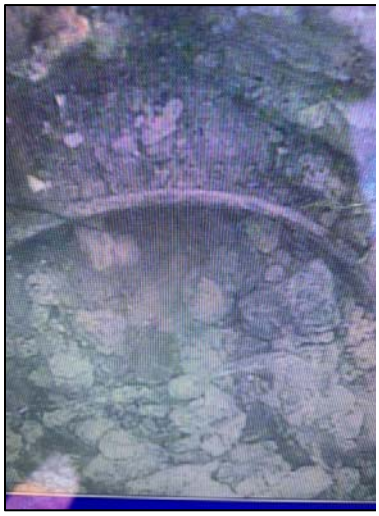


Figure 6.2 – Uncovered Well

Historical records provided by ECT suggest that wells have a 16" diameter casing near the surface which is consistent with diver findings. 2 of the 3 uncovered wells had the appearance of an open pipe, one was capped.

The dive approach to locating the wells was moderately successful given the short time window available. It is believed that if need and budget allows in the future, a continuation of the operation using the same basic approach would yield additional successful well locations.

Results Summary

Seaworks has provided a plot with representation of 3-4 different locations for each well. Two of the locations were provided by the client based upon historical maps and locations. Seaworks' well locations from the magnetometer survey have been overlayed with the historic data. Based upon all information, the magnetometer results would represent the most accurate well locations, except for the 3 wells uncovered by divers which would be the most conclusive. The three wells uncovered by divers were determined to be within 8-14' of the magnetometer locations which is consistent with Seaworks' 20' accuracy estimate for the magnetometer data.

The well that was located with the diver metal detector but not uncovered, OS-7, was determined to be within 27' of the magnetometer location. This is a bit farther than expected. While the diver metal detection is most likely the well head, that cannot be conclusively be confirmed since divers were unable to dig it up in the time window available.

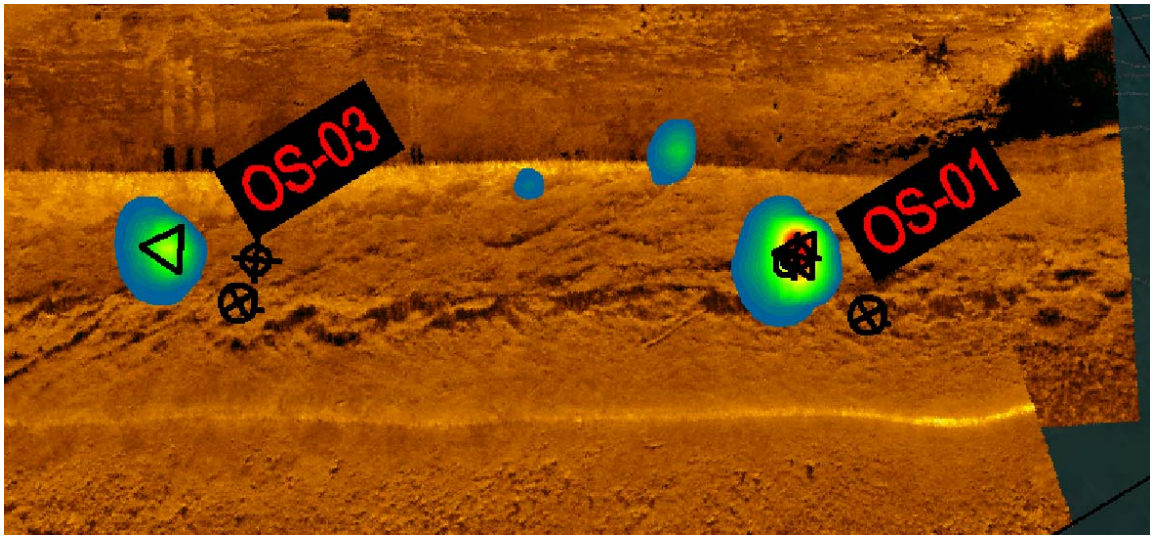
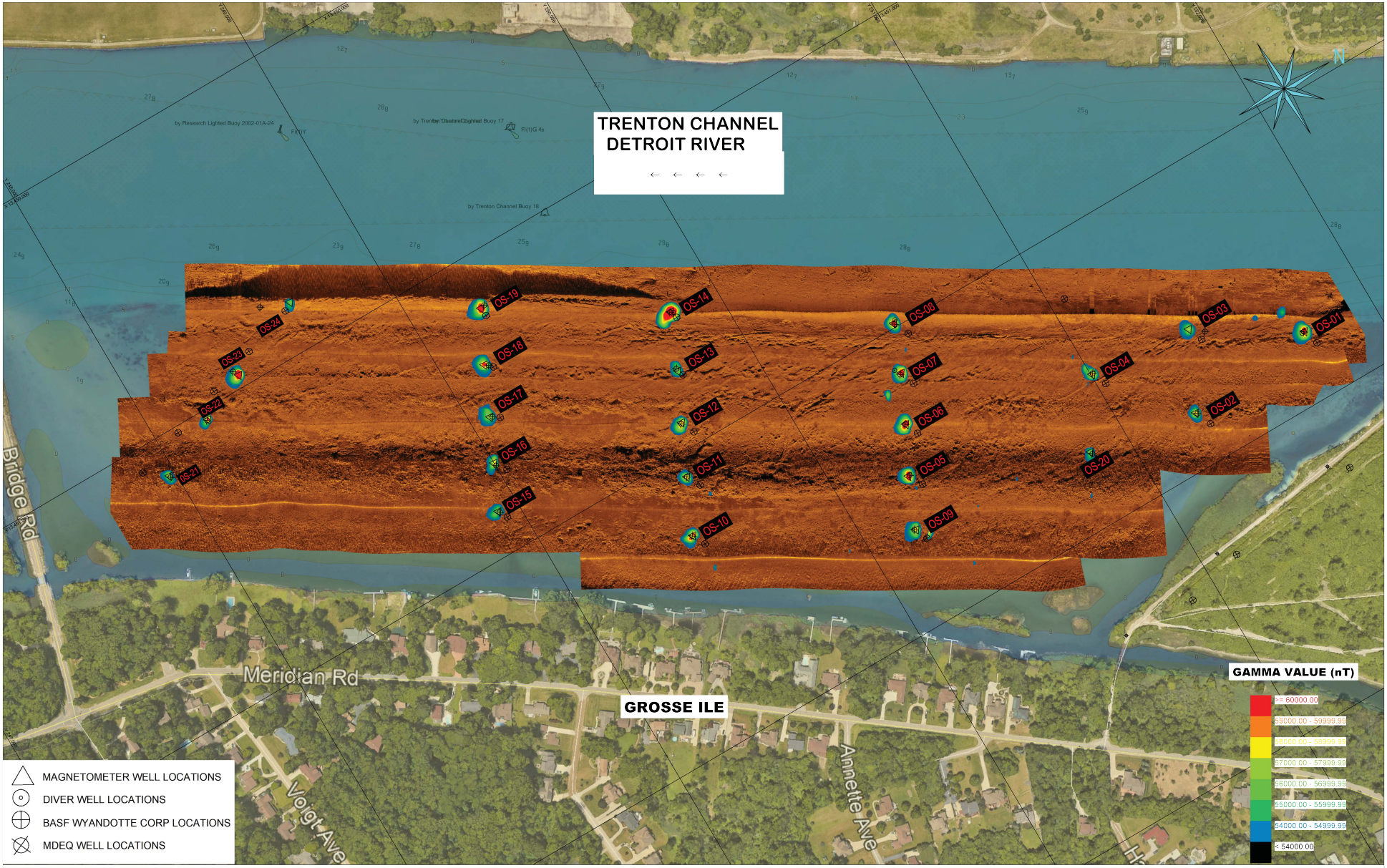


Figure 6.3 – Well locations from various sources shown in black

7.0 Attachments

- Plot including side scan, magnetometer, diver investigation and historical data
- Salinity testing results table
- Magnetometer and Dive Investigation results table



DRAWING NOTES:

1. MAGNETOMETER DATA WAS COLLECTED ON 9/17/19 - 9/18/19 USING GEOMETRIC G-882 MARINE MAGNETOMETER.
2. BACKGROUND IMAGE GENERATED FROM GOOGLE EARTH AND SHOULD BE CONSIDERED APPROXIMATE.
3. COLOR CONTOURS INDIDCATE MAGNETOMETER DETECTION STRENGTH IN nT.
4. SIDE SCAN MOSAIC WAS GENERATED USING 0.5' X 0.5' RESOLTUION AND COVERUP OVERLAY METHOD.

Scale: 1 Inch = 150.00 Feet
100 200 400 600 800 Feet

INFO / EQUIPMENT	
SURVEY DATE:	03/24/20
PERSONNEL:	EL, WW
VESSEL:	MARY ROSE
ECHOSOUNDER:	EDGETECH 4125
SONAR FREQUENCY:	600/1600 KHZ
SOUND VELOCITY:	
POSITIONING:	APPLANIX POS MV MI DOT VRS NETWORK

PROJECT DETAILS	
HORIZONTAL DATUM:	NAD 83
GRID:	MICHIGAN SOUTH
VERTICAL DATUM:	N/A
REFERENCE PLANE:	N/A
UNITS:	INT'L FT
BASE POINT:	
W/L REFERENCE PT:	

REVISIONS

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185 E. MAIN ST. STE 414, BENTON HARBOR, MI 49022
269-277-3005

DATE: 04/14/20
DRAWN BY: SPM
APPROVED BY: CE
SCALE: 1:150
JOB #: 10066
FILE: 10066 WELL LOCATE_2020

CLIENT: ECT Environmental Compliance Technology Inc.

JOB TITLE: HENNEPIN WELL SITE
DETROIT RIVER, DETROIT, MI

DRAWING TITLE: WELL HEAD LOCATIONS
MAG AND SIDESCAN DATA OVERLAY

SHEET #: P1

PAGE 1 OF 1

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Detroit River Well Head Water Sampling

Collected 12/13/19 using YSI Pro Plus M4

Point ID	Time	Water Temp	Conductivity	Salinity	Depth	Ph level	Latitude	Longitude
Background 1	920	36.1 F	143.6 us/cm	0.12 ppt	2'	7.83	42 11 16 N	083 09 1.5848 W
Background 2	924	36.1 F	147.8 us/cm	0.12 ppt	2.5'	7.83	42 11 19.3564 N	083 09 1.3396 W
Background 3	930	36.3 F	155.4 us/cm	0.13 ppt	2'	7.8	42 11 18.4987 N	083 09 5.5146 W
Background 4	934	36.3 F	150.7 us/cm	0.13 ppt	4'	7.78	42 11 16.2334 N	083 09 7.678 W

Point ID	Time	Water Temp	Conductivity	Salinity	Depth	Ph level	Latitude	Longitude
OS-24	956	36.1 F	143.5 us/cm	0.12 ppt	4'	7.73	42 10 32.9568 N	083 09 31.2455 W
OS-23	1003	36.1 F	143.3 us/cm	0.12 ppt	4'	7.73	42 10 29.6172 N	083 09 29.6144 W
OS-22	1007	36.0 F	143.3 us/cm	0.12 ppt	3'	7.73	42 10 28.3256 N	083 09 28.2286 W
OS-21	1010	36.0 F	143.9 us/cm	0.12 ppt	3'	7.73	42 10 26.2642 N	083 09 27.1385 W
OS-15	1016	36.1 F	142.6 us/cm	0.12 ppt	3'	7.73	42 10 35.3873 N	083 09 17.512 W
OS-16	1019	36.1 F	143.9 us/cm	0.12 ppt	3'	7.71	42 10 36.1209 N	083 09 19.5095 W
OS-17	1022	36.1 F	142.8 us/cm	0.12 ppt	3'	7.71	42 10 36.8559 N	083 09 21.5068 W
OS-18	1025	36.1 F	143.5 us/cm	0.12 ppt	3'	7.71	42 10 37.6529 N	083 09 23.5116 W
OS-19	1029	36.1 F	143.2 us/cm	0.12 ppt	3'	7.71	42 10 38.8492 N	083 09 26.19 W
OS-14	1034	36.1 F	142.7 us/cm	0.12 ppt	5'	7.71	42 10 44.2426 N	083 09 21.2355 W
OS-13	1037	36.1 F	141.5 us/cm	0.12 ppt	4'	7.72	42 10 43.4348 N	083 09 18.4698 W
OS-12	1040	36.1 F	142.8 us/cm	0.12 ppt	3'	7.74	42 10 42.5313 N	083 09 16.3138 W
OS-11	1043	36.1 F	143.5 us/cm	0.12 ppt	4'	7.74	42 10 41.6828 N	083 09 13.8662 W
OS-10	1047	36.1 F	144.0 us/cm	0.12 ppt	3'	7.76	42 10 40.8541 N	083 09 11.4419 W
OS-09	1052	36.1 F	143.4 us/cm	0.12 ppt	4'	7.77	42 10 47.8011 N	083 09 6.3763 W
OS-05	1055	36.1 F	141.6 us/cm	0.12 ppt	4'	7.77	42 10 48.3757 N	083 09 8.6577 W
OS-06	1058	36.1 F	142.4 us/cm	0.12 ppt	4'	7.76	42 10 49.2812 N	083 09 10.9039 W
OS-07	1102	36.1 F	143.0 us/cm	0.12 ppt	4'	7.76	42 10 50.1241 N	083 09 13.0193 W
OS-08	1109	36.1 F	144.3 us/cm	0.12 ppt	5'	7.77	42 10 50.8059 N	083 09 15.1804 W
OS-20	1114	36.1 F	142.3 us/cm	0.12 ppt	3'	7.83	42 10 54.4493 N	083 09 4.9186 W
OS-04	1117	36.1 F	143.6 us/cm	0.12 ppt	4'	7.8	42 10 55.8331 N	083 09 8.2623 W
OS-02	1121	36.1 F	143.1 us/cm	0.12 ppt	3'	7.83	42 10 58.3526 N	083 09 4.0628 W
OS-03	1125	36.1 F	142.5 us/cm	0.12 ppt	5'	7.81	42 10 59.4641 N	083 09 8 W
OS-01	1127	36.1 F	142.5 us/cm	0.12 ppt	3'	7.82	42 11 3.0422 N	083 09 4.6704 W

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Detroit Well Head Magnetometer Data and Diver Observations

ECT Environmental Consulting & Technology, Inc.

Magnetomter data collected between 9/17/19 and 9/18/19 | Equipment: Geometrics G-882 Marine Magnetometer

Diver observations completed between 4/1/20 and 4/2/20 | Equipment: Mine Lab Excalibur II / RTK Rover

Grid Coordinates: NAD83, Michigan South Zone, International Feet | Vertical Datum: Feet NAVD88

Well ID	Magnetometer Easting	Magnetometer Northing	RTK GPS Easting	RTK GPS Northing	Delta (Ft)	Depth Below W/L	W/L (NAVD88)	Top Elev (NAVD88)	Diver Notes
OS-01	13,452,755.7	251,737.8	13,452,756.5	251,727.2	10.6	7.1	575.8	568.7	Cap on pipe, 1.5' burial
OS-02	13,452,810.6	251,254.6							
OS-03	13,452,538.8	251,384.5							Dove, Not Located
OS-04	13,452,503.6	251,005.0							Dove, Not Located
OS-05	13,452,484.0	250,253.7							
OS-06	13,452,319.0	250,340.0							Dove, Not Located
OS-07	13,452,152.4	250,419.4	13,452,131.2	250,403.4	26.6	Not Uncovered			Strong metal detector ping, probe/dig 2', no recovery
OS-08	13,451,985.9	250,486.0	13,451,976.4	250,496.3	14.0	14.4	575.8	561.4	Open pipe, 1.5' burial
OS-09	13,452,662.5	250,180.3							
OS-10	13,452,276.0	249,481.1							
OS-11	13,452,083.4	249,569.4							
OS-12	13,451,906.7	249,652.1							
OS-13	13,451,740.3	249,733.9							
OS-14	13,451,545.8	249,819.4	13,451,550.5	249,826.5	8.5	11.8	575.9	564.1	Open pipe, close to surface
OS-15	13,451,847.6	248,924.7							
OS-16	13,451,690.7	249,000.0							
OS-17	13,451,541.6	249,071.4							
OS-18	13,451,370.0	249,148.9							
OS-19	13,451,189.7	249,240.4							
OS-20	13,452,739.6	250,858.7							
OS-21	13,451,141.5	247,975.5							
OS-22	13,451,037.4	248,197.2							
OS-23	13,450,955.9	248,373.2							
OS-24	13,450,823.3	248,663.4							