DOW CHEMICAL COMPANY
THERMAL PLUME MIXING ZONE STUDY RESULTS
OUTFALL 001 INTO PERE MARQUETTE LAKE
LUDINGTON, MICHIGAN

prepared for:

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1.0 INTRODUCTION

Dow Chemical Company of Ludington Michigan Facility's NPDES permit No. MI0003026 requires under Part 1, Section A: Effluent Limitation And Monitoring Requirements that a thermal plume study be conducted to determine the thermal mixing characteristics of outfall 001 in Pere Marquette Lake. This report presents the results of a thermal plume study conducted on the Dow Chemical Company of Ludington, Michigan Facility outfall 001. A local site map is presented as Figure 1.

Westshore Consulting conducted the thermal plume study on March 7, 2001. Background temperatures were determined for Pere Marquette Lake and compared to the temperature in and near the outfall. These results were then plotted in map view and in cross section to show the mixing characteristics of the outfall. Findings of the thermal plume study are presented in tabular as well as graphical format.

2.0 METHODOLOGIES

2.1 Measurement Collection

Temperature readings were collected using a Yellow Springs Instrument Company, Model #3000 temperature meter with a 100-foot cable (marked with feet from the measurement probe) attached to the probe. The meter has an accuracy of ±0.5° F. Direct measurement of the water temperature was taken with the meter by lowering the probe into the water. Once the temperature reading was stable the temperature was recorded in a field book along with the depth measurement from the water or ice surface and the probe lowered to the next sampling depth.

By definition the thermal plume study was to be conducted when the plant was at optimum running conditions and had been running at optimum for a minimum of 4 hours prior to the start of the sampling. Westshore conducted the thermal plume study on March 7, 2001. Sampling began at 7:30 AM and the study was concluded at approximately 7:00 PM. Prior to the beginning of the study, Westshore contacted Mr. Mike Ryder of Dow Chemical Ludington Plant to determine the operating conditions of the plant. At the time of the study the outfall had been running at near maximum volume output for over a day to allow the plant to "catch up" after several days of downtime. Weather conditions were obtained from the Dow Ludington plant (site wind speed and direction) for the hours proceeding and during the study. Significant weather parameter changes such as wind direction and precipitation were noted. Outfall temperature and flow monitoring data were also obtained from Dow for the hours preceding and during the study.

Temperature measurements occurred in an open boat or through the ice that was approximately 18 inches thick at the time of the study. Locating data points was accomplished by establishing station locations in reference to a grid system. The grid system has its x, y origin at the outfall structure at the seawall. The x-axis parallels the seawall while the y- axis is normal to the seawall. A map of the measurement stations is included as Figure 2.

Four (4) lake temperature background locations were selected outside the influence of the discharge (Figure 3). Background temperature readings were recorded at each of the four locations at two-foot intervals until the lake bottom was encountered. Unique background temperature values were defined for various depths. Given the definition of the plume boundary as water temperatures 2°F above background, the plume was defined as waters associated with the outfall at least 2°F above background.

Once background lake temperature was defined at various depths, Westshore began to define the thermal plume associated with outfall 001. Frequency and spacing of the temperature measurements were determined in the field, based on the measurement results. As the data was collected, the sample spacing was adjusted to accurately delineate the edge of the thermal plume. The first readings were taken near the point of discharge and extended outward. At each location, readings were collected from the surface and then at two-foot to five-foot depth increments until the bottom of the lake was encountered. The depth to the lake bottom was recorded at each sampling location (Figure 3). Sample collection continued in this manner until the horizontal extent of the temperature plume was defined to 2° F above background for the depth interval measured. Because the depth to the bottom of the lake varies, lake bottom

background temperature values (which were warmer than shallower depths) were "shifted" for comparison to the appropriate depth interval near the outfall.

2.2 Sampling Through Ice

At the time of the study ice covered Pere Marquette Lake near the study area with the exception of the area near outfall 001 (Figure 4). Sampling conducted through the ice was completed by boring a hole through the ice and taking direct measurements as described above. The distance between the last open water sample location taken in the boat and the first location taken through the ice was determined solely on the basis of safe ice conditions as defined in the Health & Safety Plan.

2.3 River Flow and Current Definition

Westshore used a Teledyne Gurley Model 622 velocity meter to define the flow velocity of Pere Marquette Lake. The flow meter has an accuracy of ±0.01 feet/second with a minimum flow velocity of 0.05 feet/second required. Readings of flow velocities were taken in the area where the background measurements were recorded.

2.4 Reporting

At the completion of the study the sample locations were plotted on a site map and the temperature plume contoured in map view and in cross-section (Figure 2). On temperature maps the first contour is equal to background. On cross-sections, the plume boundary is dashed and the lowest temperature contour is equal to the lowest background value used. Outfall temperature, flow, and wind conditions are recorded in Table 1. Background temperature data is reported in Table 2. All temperature measurements are reported in Table 3.

3.0 RESULTS

During most of the study, the plant was operating at or near capacity to make up for the loss of production during a shut down due to a power failure that lasted from March 1, 2001 to March 5 2001. Therefore, the results should indicate a near "worst case" scenario. As discussed, the study occurred between approximately 7:30 am and 7:00 pm on March 7, 2001. Table 1 shows the temperature and flow rate of outfall 001, as well as the wind speed and direction on an hourly basis from 12:00 am until 8:00 pm on March 7, 2001. The flow rate was between 9.53 and 10.33 mgpm (thousand gallons per minute) prior to and throughout the study until at least 5:00 pm (Table 1). By 6:00 pm the flow had dropped to 6.63 mgpm (Table 1). Winds were generally light at 8-10 mph from the south and west at the beginning of the study. Wind speed increased to 13 to 17 mph from 1:00 pm to 6:00 pm. The last hour of the study winds increased to 26 mph and were from the west. An attempt to measure current flow in Pere Marquette Lake was made. No measurable flow (above the 0.05 feet/second detection limit of the flow meter) was observed. A total of 41 stations were occupied to define the thermal plume to 2°F above background.

3.1 Background Determinations

Background measurements were taken at four locations (B1–B4) in an area 400 to 500 feet south-southwest of outfall 001 at the Dow Plant (Figure and 2). Table 2 shows the background temperatures at each depth for each station as well as the average temperature at each depth. The average temperatures at the background stations ranged from 32.5°F at the surface to 35°F at the lake bottom (the 33 foot depth). An increase in temperature of 1°F was noted in the bottom five feet of the water column at each background station. Lake depth measurements indicate the lake bottom in the vicinity of the outfall is shallower (by approximately five (5) to six (6) feet) than in the area where background measurements were made (Figure 3). Therefore, in the vicinity of the outfall lake bottom, background temperatures were correlated with five (5) to six (6) foot shallower depths.

3.2 Thermal Plume

Figure 3 through 12 shows the thermal plume in map view at different depths and in cross-section. Temperature readings within the study area are summarized in Table 3 and ranged from below background to a maximum of 68.9°F at station #8 just in front of outfall 001(Figure 5). The maximum width of the plume from east to west was approximately 55 feet at a depth of 2 feet (Figure 5). The maximum length of the plume normal to the break wall was approximately 80 feet at a depth of 5 feet (Figure 6). The maximum depth where the temperature was 2°F above background (associated with the outfall) was 25 feet (Figure 10). Using maximum coordinates to define a three-dimensional body, the total volume that serves to dilute the discharge in Pere Marquette Lake is conservatively calculated to be approximately 825,000 gallons.

4.0 DISCUSSION

The data collected during this study has defined the thermal plume associated with the discharge from outfall 001 within the specified requirement (i.e. to 2°F above back ground). The plant was running at optimum conditions resulting in above average flow and temperature during the study period indicating the thermal plume was near its maximum extent at the time of the study. The flow rate dropped during the last one to two hours of the study. Although the drop was significant (Table 1) it does not appear the plume boundary was altered because the majority of the plume definition had been completed at the time of the drop.

Wind was relatively calm during most of the study but increased to 26 mph during the last hour of the study. Although the wind was brisk toward the end of the study, this did not appear to significantly affect the plume size or shape. This is probably because of the ice cover over much of the study area and because over 90% of the study was completed prior to the increase in wind speed.

The objectives of this study have been met, based on the MDEQ approved work plan. Specifically, the effluent was monitored before the thermal plume data collection to document effluent characteristics; the plant was operating at or near full capacity under normal conditions; the data points were collected in sufficient density to document the vertical and horizontal extent of the thermal plume; lake bottom depth was determined through the plume; and a relatively calm day was selected for the study to minimize the effect on the thermal plume mixing zone.

TABLES

TABLE 1

Table 1 - Outfall 001 temperature, Flow and Wind Data - March 7, 2001				
Date/Time	Temp, F	Flow, mgpm	Wind mph	Direction Degrees
3/7/01 0:00	68.87	9.98	8.5	1
3/7/01 1:00	69.23	10.03	8.0	359
3/7/01 2:00	69.24	9.95	11.3	2
3/7/01 3:00	68.83	9.95	8.3	11
3/7/01 4:00	69.16	10.04	5.8	356
3/7/01 5:00	68.93	9.93	8.6	347
3/7/01 6:00	69.03	9.85	6.3	350
3/7/01 7:00	68.95	10.14	5.4	359
3/7/01 8:00	69.07	10.19	4.5	351
3/7/01 9:00	69.17	10.07	5.9	342
3/7/01 10:00	69.02	9.97	7.2	281
3/7/01 11:00	69.09	10.06	7.9	274
3/7/01 12:00	69.06	10.33	10.5	241
3/7/01 13:00	69.30	10.24	13.2	231
3/7/01 14:00	69.38	10.08	16.9	220
3/7/01 15:00	69.37	10.14	17.5	219
3/7/01 16:00	69.33	10.30	17.4	219
3/7/01 17:00	68.24	9.53	14.3	215
3/7/01 18:00	65.63	7.97	17.2	224
3/7/01 19:00	65.63	6.63	26.4	291
3/7/01 20:00	64.78	6.68	22.3	290
3/7/01 21:00	65.03	6.52		
3/7/01 22:00	64.38	6.53		
3/7/01 23:00	65.27	6.76		

TABLE 2

Table 2 - Background Data, Thermal Plume Study - March 7, 2001						
Depth	Temp (°F)	Temp (°F)	Temp (°F)	Temp (°F)	Average Temp	Background +2σ
Station ID >	B1	B2	B3	B4		
1	32.2	32.2	33.1	32.7	32.5	34.5
3	33.1	33.1	33.3	33.3	33.2	35.2
4	33.1	33.1	33.3	33.3	33.2	35.2
6	33.1	33.1	33.3	33.3	33.2	35.2
8	33.1	33.1	33.3	33.3	33.2	35.2
10	33.1	33.1	33.3	33.1	33.1	35.1
12	33.1	33.1	33.3	33.1	33.1	35.1
14	33.1	33.1	33.3	33.1	33.1	35.1
16	33.1	33.1	33.3	33.3	33.2	35.2
18	33.1	33.1	33.3	33.1	33.1	35.1
20	33.3	33.3	33.3	33.3	33.3	35.3
22	33.4	33.4	33.4	33.3	33.4	35.4
24	33.4	33.4	33.4	33.4	33.4	35.4
26	33.6	33.4	33.8	33.4	33.6	35.6
28	34.0	33.8	34.2	33.8	33.9	35.9
30	34.2	34.3	34.7	34.2	34.3	36.3
32	34.9	34.9	35.1	34.7	34.9	36.9
33	34.9	34.9	35.2	34.9	35.0	37.0

TABLE 3

Table 3 - Thermal Plume Data - March 7, 2001						
Station ID	X	Y	Z (feet)	Temp (°C)	Temp (°F)	Comments
#1	-55	0	0	0.6	33.1	Next to seawall.
	-55	0	2	0.6	33.1	
	-55	0	4	0.7	33.3	
	-55	0	6	0.7	33.3	
	-55	0	8	0.7	33.3	
	-55	0	10	0.7	33.3	
	-55	0	12	0.7	33.3	
	-55	0	14	0.7	33.3	
	-55	0	16	0.9	33.6	
	-55	0	18	1.6	34.9	
	-55	0	20	1.8	35.2	
	-55	0	22	2.4	36.3	
	-55	0	24	2.3	36.1	
	-55	0	25	2.4	36.3	Bottom
#2	-45	0	0	0.5	32.9	On seawall, South of outfall
	-45	0	2	0.6	33.1	
	-45	0	4	0.6	33.1	
	-45	0	6	0.6	33.1	
	-45	0	8	0.7	33.3	
	-45	0	10	0.7	33.3	
	-45	0	12	0.7	33.3	
	-45	0	14	0.9	33.6	
	-45	0	16	1.8	35.2	
	-45	0	18	1.9	35.4	
	-45	0	20	2.0	35.6	
	-45	0	22	2.0	35.6	
	-45	0	24	2.1	35.8	
	-45	0	25	2.1	4.0	Bottom
#3	-35	0	0	0.6	33.1	On seawall, South of outfall
	-35	0	2	0.7	33.3	
	-35	0	4	0.6	33.1	
	-35	0	6	0.6	33.1	

Station ID	X	Y	Z (feet)	Temp (°C)	Temp (°F)	Comments
	-35	0	8	0.7	33.3	
	-35	0	10	0.7	33.3	
	-35	0	12	1.6	34.9	
	-35	0	14	1.7	35.1	
	-35	0	16	1.7	35.1	
	-35	0	18	1.8	35.2	
	-35	0	20	1.8	35.2	
	-35	0	22	1.8	35.2	
	-35	0	24	1.8	35.2	
	-35	0	25.5	1.8	35.2	Bottom
#4	-27	0	0	0.7	33.3	11:30 am, 8.0 mph wind from SSE
	-27	0	2	0.6	33.1	
	-27	0	4	0.7	33.3	
	-27	0	6	0.7	33.3	
	-27	0	8	0.7	33.3	
	-27	0	10	0.7	33.3	
	-27	0	12	1.1	34.0	
	-27	0	14	1.3	34.3	
	-27	0	16	1.7	35.1	
	-27	0	18	1.8	35.2	
	-27	0	20	1.9	35.4	
	-27	0	22	2.0	35.6	
	-27	0	24	1.9	35.4	
	-27	0	25.5	2.0	35.6	Bottom
#5	4	0	0	7.9	46.2	1:05 pm, 13.5 mph wind from S
	4	0	2	8.3	46.9	
	4	0	4	3.3	37.9	
	4	0	6	1.0	33.8	
	4	0	8	2.1	35.8	
	4	0	10	3.0	37.4	
	4	0	12	2.0	35.6	
	4	0	14	1.9	35.4	
	4	0	16	2.4	36.3	

Station ID	X	Y	Z (feet)	Temp (°C)	Temp (°F)	Comments
	4	0	18	2.4	36.3	
	4	0	20	1.9	35.4	
	4	0	22	1.8	35.2	
	4	0	24	1.9	35.4	
	4	0	26	1.8	35.2	Bottom
#6	13	0	0	8.4	47.1	
	13	0	2	1.2	34.2	
	13	0	4	0.9	33.6	
	13	0	6	0.8	33.4	
	13	0	10	0.7	33.3	
	13	0	15	0.9	33.6	
	13	0	20	1.2	34.2	
	13	0	25	1.7	35.1	Bottom
#7	22	0	0	5.6	42.1	
	22	0	2	4.5	40.1	
	22	0	4	1.8	35.2	
	22	0	6	1.1	34.0	
	22	0	8	0.9	33.6	
	22	0	10	0.9	33.6	
	22	0	12	1.2	34.2	
	22	0	14	1.3	34.3	
	22	0	16	1.3	34.3	
	22	0	18	1.3	34.3	
	22	0	20	1.4	34.5	
	22	0	22	1.5	34.7	
	22	0	24	1.5	34.7	
	22	0	26	1.8	35.2	Bottom
#8	-5	0	0	19.8	67.6	At outfall
	-5	0	2	20.2	68.4	
	-5	0	4	20.5	68.9	
	-5	0	6	2.3	36.1	
	-5	0	8	2.3	36.1	
	-5	0	10	1.4	34.5	
	-5	0	12	1.6	34.9	
	-5	0	14	1.7	35.1	

Station ID	X	Y	Z (feet)	Temp (°C)	Temp (°F)	Comments
	-5	0	18	1.9	35.4	
	-5	0	22	1.8	35.2	Bottom
#9	-13	0	0	14.8	58.6	
	-13	0	2	16.3	61.3	
	-13	0	4	3.3	37.9	
	-13	0	6	1.7	35.1	
	-13	0	8	1.4	34.5	
	-13	0	10	1.3	34.3	
	-13	0	14	1.8	35.2	
	-13	0	18	1.7	35.1	
	-13	0	22	1.8	35.2	
	-13	0	23	1.8	35.2	Bottom
#10	13	10	0	4.4	39.9	
	13	10	2	4.0	39.2	
	13	10	4	1.0	33.8	
	13	10	6	0.9	33.6	
	13	10	8	0.7	33.3	
	13	10	12	0.7	33.3	
	13	10	14	1.4	34.5	
	13	10	18	1.5	34.7	
	13	10	22	1.7	35.1	
	13	10	25.5	1.9	35.4	Bottom
#11	0	10	0	14.0	57.2	
	0	10	2	3.4	38.1	
	0	10	4	1.6	34.9	
	0	10	6	1.8	35.2	
	0	10	8	2.5	36.5	
	0	10	10	2.3	36.1	
	0	10	12	2.1	35.8	
	0	10	14	1.4	34.5	
	0	10	18	1.4	34.5	
	0	10	22	1.6	34.9	
	0	10	25.5	2.0	35.6	Bottom
#12	-10	10	0	14.4	57.9	2:13 pm, 20.6 mph wind from S

Station ID	X	Y	Z (feet)	Temp (°C)	Temp (°F)	Comments
	-10	10	2	10.3	50.5	
	-10	10	4	8.3	46.9	
	-10	10	6	5.2	41.4	
	-10	10	8	3.4	38.1	
	-10	10	10	3.3	37.9	
	-10	10	12	2.4	36.3	
	-10	10	14	2.5	36.5	
	-10	10	18	2.5	36.5	
	-10	10	22	2.3	36.1	
	-10	10	25.5	2.3	36.1	Bottom
#13	-20	10	0	12.8	55.0	
	-20	10	2	6.7	44.1	
	-20	10	4	4.8	40.6	
	-20	10	6	6.4	43.5	
	-20	10	8	2.7	36.9	
	-20	10	10	2.7	36.9	
	-20	10	12	1.5	34.7	
	-20	10	14	1.3	34.3	
	-20	10	18	1.6	34.9	
	-20	10	22	2.0	35.6	
	-20	10	25	2.4	36.3	Bottom
#14	-30	10	0	0.8	33.4	
	-30	10	2	0.8	33.4	
	-30	10	4	0.7	33.3	
	-30	10	6	0.7	33.3	
	-30	10	8	0.7	33.3	
	-30	10	10	0.7	33.3	
	-30	10	12	0.7	33.3	
	-30	10	14	0.7	33.3	
	-30	10	18	1.8	35.2	
	-30	10	22	2.0	35.6	
	-30	10	25	2.2	36.0	Bottom
#15	-40	10	0	0.8	33.4	
	-40	10	2	0.7	33.3	
	-40	10	4	0.7	33.3	

Station ID	X	Y	Z (feet)	Temp (°C)	Temp (°F)	Comments
	-40	10	6	0.7	33.3	
	-40	10	8	0.7	33.3	
	-40	10	10	0.7	33.3	
	-40	10	12	0.7	33.3	
	-40	10	14	0.7	33.3	
	-40	10	18	0.8	33.4	
	-40	10	22	2.0	35.6	
	-40	10	25	2.1	35.8	Bottom
#16	-54	10	0	0.8	33.4	
	-54	10	5	0.7	33.3	
	-54	10	10	0.7	33.3	
	-54	10	15	0.7	33.3	
	-54	10	20	2.0	35.6	
	-54	10	25	2.4	36.3	Bottom
#17	-60	33	0	0.7	33.3	
	-60	33	2	0.7	33.3	
	-60	33	5	0.7	33.3	
	-60	33	10	0.7	33.3	
	-60	33	15	0.7	33.3	
	-60	33	20	1.2	34.2	
	-60	33	25	2.3	36.1	
	-60	33	26.5	2.4	36.3	Bottom
#18	-50	33	0	0.7	33.3	
	-50	33	2	0.7	33.3	
	-50	33	5	0.7	33.3	
	-50	33	10	0.7	33.3	
	-50	33	15	0.7	33.3	
	-50	33	20	1.3	34.3	
	-50	33	25	2.8	37.0	
	-50	33	27	3.1	37.6	Bottom
#19	-40	33	0	0.8	33.4	
	-40	33	2	0.8	33.4	
	-40	33	5	0.8	33.4	
	-40	33	10	0.7	33.3	
	-40	33	15	0.7	33.3	

Station ID	X	Y	Z (feet)	Temp (°C)	Temp (°F)	Comments
	-40	33	20	1.4	34.5	
	-40	33	25	2.6	36.7	
	-40	33	26	2.9	37.2	Bottom
#20	-30	33	0	0.9	33.6	
	-30	33	2	0.8	33.4	
	-30	33	5	0.8	33.4	
	-30	33	10	0.8	33.4	
	-30	33	15	0.8	33.4	
	-30	33	20	1.9	35.4	
	-30	33	25	2.2	36.0	Bottom
#21	-20	33	0	9.5	49.1	
	-20	33	2	8.3	46.9	
	-20	33	5	8.7	47.7	
	-20	33	10	1.8	35.2	
	-20	33	15	2.8	37.0	
	-20	33	20	3.6	38.5	
	-20	33	25	3.9	39.0	Bottom
#22	-10	33	0	15.0	59.0	
	-10	33	2	8.3	46.9	
	-10	33	5	3.6	38.5	
	-10	33	10	3.2	37.8	
	-10	33	15	2.6	36.7	
	-10	33	20	2.4	36.3	
	-10	33	25.5	2.8	37.0	Bottom
#23	0	33	0	8.4	47.1	
	0	33	2	4.2	39.6	
	0	33	5	1.8	35.2	
	0	33	10	1.3	34.3	
	0	33	15	1.8	35.2	
	0	33	20	1.9	35.4	
	0	33	25	2.2	36.0	Bottom
#24	12	33	0	8.0	46.4	
	12	33	2	6.1	43.0	
	12	33	5	6.3	43.3	
	12	33	10	1.1	34.0	

Station ID	X	Y	Z (feet)	Temp (°C)	Temp (°F)	Comments
	12	33	15	1.0	33.8	
	12	33	20	1.8	35.2	
	12	33	25.5	1.9	35.4	Bottom
#25	0	40	0	4.3	39.7	3:25 pm, 17 mph wind from S
	0	40	2	6.5	43.7	
	0	40	5	3.9	39.0	
	0	40	10	3.3	37.9	
	0	40	15	0.9	33.6	
	0	40	20	1.6	34.9	
	0	40	26	2.5	36.5	Bottom
#26	0	50	0	6.0	42.8	
	0	50	2	3.2	37.8	
	0	50	5	1.3	34.3	
	0	50	10	2.9	37.2	
	0	50	15	2.6	36.7	
	0	50	20	2.5	36.5	
	0	50	25	2.4	36.3	
	0	50	27	3.1	37.6	Bottom
#27	0	60	0	2.0	35.6	At ice
	0	60	2	1.2	34.2	
	0	60	5	1.0	33.8	
	0	60	10	0.8	33.4	
	0	60	15	2.2	36.0	
	0	60	20	2.4	36.3	
	0	60	25	2.7	36.9	
	0	60	26.5	3.2	37.8	Bottom
#28	10	50	0	1.2	34.2	
	10	50	2	0.9	33.6	
	10	50	5	0.9	33.6	
	10	50	10	0.8	33.4	
	10	50	15	0.7	33.3	
	10	50	20	1.9	35.4	
	10	50	26	2.8	37.0	Bottom
#29	-10	50	0	1.2	34.2	

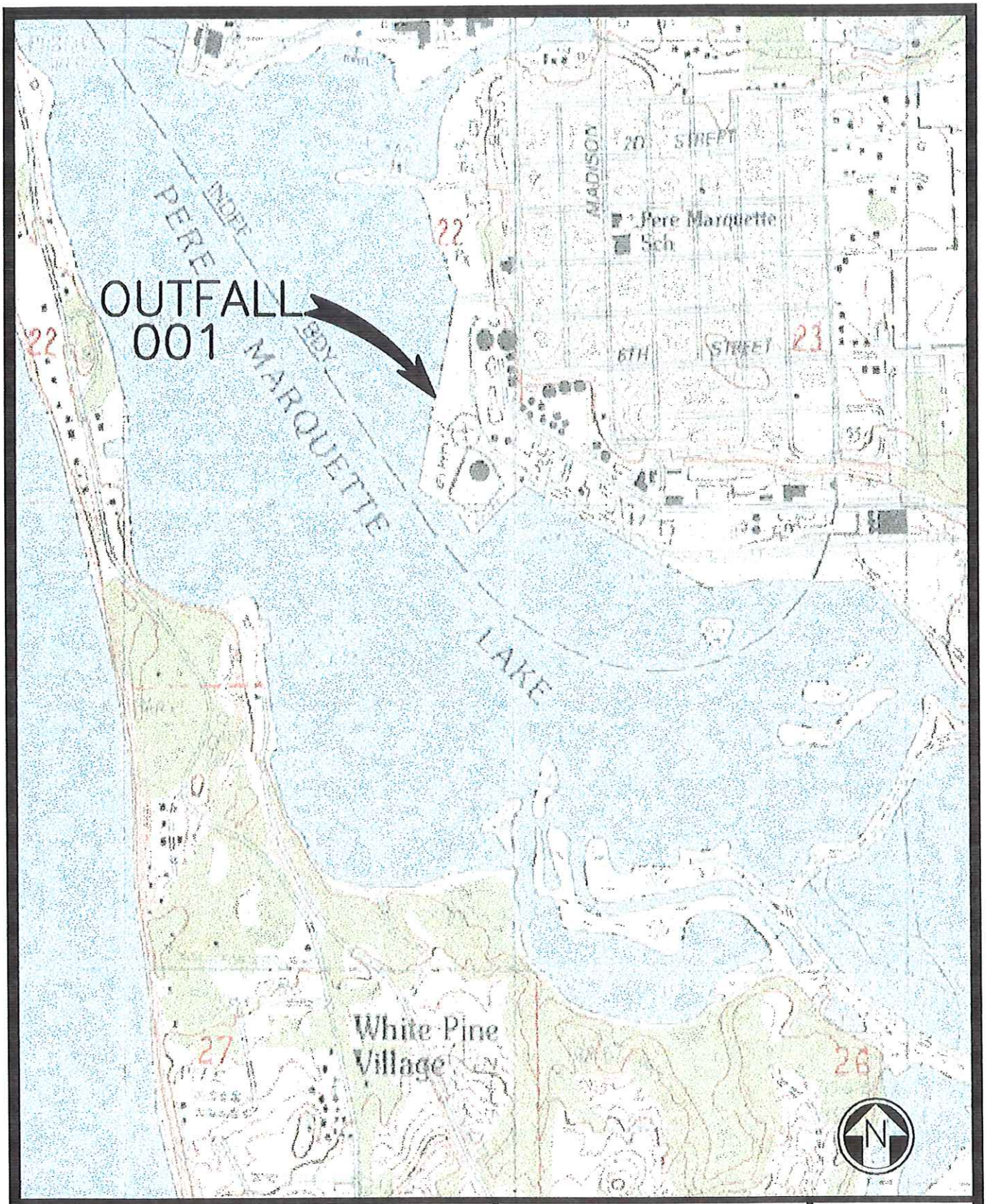
Station ID	X	Y	Z (feet)	Temp (°C)	Temp (°F)	Comments
	-10	50	2	5.6	42.1	
	-10	50	4	5.2	41.4	
	-10	50	6	3.7	38.7	
	-10	50	10	2.3	36.1	
	-10	50	15	2.1	35.8	
	-10	50	20	2.1	35.8	
	-10	50	25	2.3	36.1	
	-10	50	27	3.3	37.9	Bottom
#30	-20	50	0	0.7	33.3	
	-20	50	2	0.8	33.4	
	-20	50	5	0.8	33.4	
	-20	50	10	0.9	33.6	
	-20	50	15	1.0	33.8	
	-20	50	20	1.4	34.5	
	-20	50	25	2.3	36.1	
	-20	50	27	2.5	36.5	Bottom
#31	-30	50	0	0.6	33.1	
	-30	50	2	0.7	33.3	
	-30	50	5	0.7	33.3	
	-30	50	10	0.7	33.3	
	-30	50	15	0.7	33.3	
#32	-20	60	0	0.7	33.3	
	-20	60	2	0.7	33.3	
	-20	60	5	0.7	33.3	
	-20	60	10	0.7	33.3	
	-20	60	15	0.7	33.3	
	-20	60	20	1.4	34.5	
	-20	60	25	1.7	35.1	
	-20	60	27	1.4	34.5	Bottom
#33	-10	60	0	5.0	41.0	Ice , 5-feet W
	-10	60	2	4.5	40.1	
	-10	60	5	4.7	40.5	
	-10	60	10	2.6	36.7	
	-10	60	15	3.0	37.4	
	-10	60	20	2.7	36.9	

Station ID	X	Y	Z (feet)	Temp (°C)	Temp (°F)	Comments
	-10	60	25	2.3	36.1	
	-10	60	27	2.3	36.1	Bottom
#34	-10	70	0	0.7	33.3	
	-10	70	2	1.2	34.2	
	-10	70	5	2.9	37.2	
	-10	70	10	2.4	36.3	
	-10	70	15	1.1	34.0	
	-10	70	20	1.3	34.3	
	-10	70	25	1.8	35.2	
	-10	70	27	1.9	35.4	Bottom
#35	-12	87	2	0.6	33.1	Ice, 1-foot thick
	-12	87	5	0.7	33.3	
	-12	87	10	0.7	33.3	
	-12	87	15	0.7	33.3	
	-12	87	20	0.8	33.4	
	-12	87	25	1.6	34.9	
	-12	87	28	1.7	35.1	Bottom
#36	-30	90	2	0.8	33.4	
	-30	90	5	0.8	33.4	
	-30	90	10	0.7	33.3	
	-30	90	15	0.7	33.3	
	-30	90	20	0.8	33.4	
	-30	90	25	1.3	34.3	
	-30	90	27.5	1.5	34.7	Bottom
#37	0	90	2	0.7	33.3	6:25 pm, 12-feet from ice, wind SW
	0	90	5	0.7	33.3	
	0	90	10	0.7	33.3	
	0	90	15	0.7	33.3	
	0	90	20	1.5	34.7	
	0	90	25	1.5	34.7	
	0	90	27	2.2	36.0	Bottom
#38	15	83	2	0.6	33.1	
	15	83	5	0.7	33.3	
	15	83	10	0.7	33.3	

Station ID	X	Y	Z (feet)	Temp (°C)	Temp (°F)	Comments
	15	83	15	0.7	33.3	
	15	83	20	0.7	33.3	
	15	83	25	2.0	35.6	
	15	83	28	2.2	36.0	Bottom
#39	20	50	2	0.6	33.1	
	20	50	5	0.7	33.3	
	20	50	10	0.6	33.1	
	20	50	15	0.6	33.1	
	20	50	20	1.1	34.0	
	20	50	26	2.2	36.0	Bottom
#40	24	35	2	0.6	33.1	
	24	35	5	0.7	33.3	
	24	35	10	0.6	33.1	
	24	35	15	0.7	33.3	
	24	35	20	1.2	34.2	
	24	35	25	2.3	36.1	Bottom
#41	24	15	2	0.7	33.3	
	24	15	5	0.7	33.3	
	24	15	10	0.6	33.1	
	24	15	15	0.6	33.1	
	24	15	20	1.7	35.1	
	24	15	25	2.2	36.0	Bottom

FIGURES

FIGURE 1



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DOW (PERE MARQUETTE LAKE)

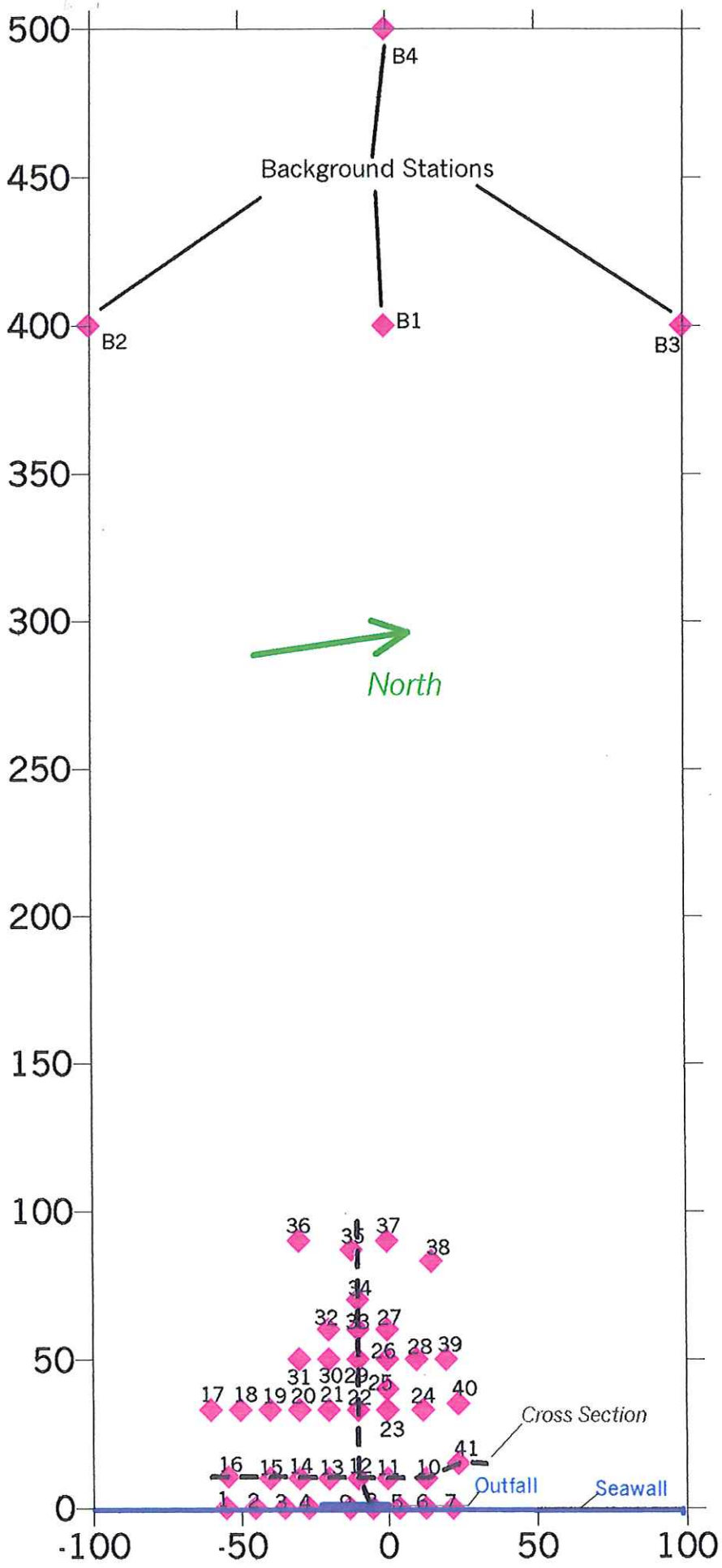
MASON COUNTY
MICHIGAN

LOCATION MAP

Checked:	AWH
Date:	6/19/01
Drawn by:	BJA
Date:	6/19/01
File No.:	1201-1
Figure:	1

C:\Land Projects R2\1201-1\dwg\FIGURE 1.dwg 06/19/2001 03:52:06 PM EDT

FIGURE 2



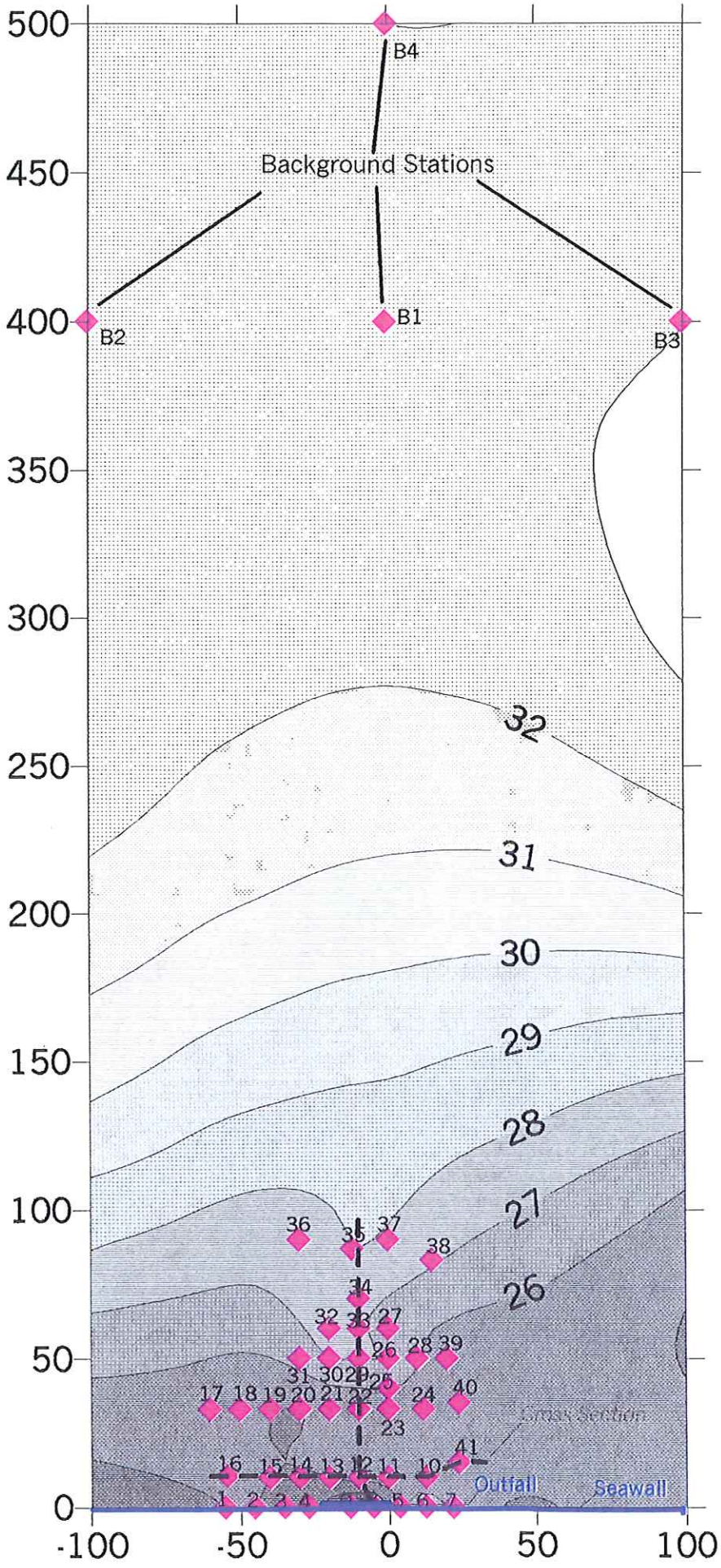
Dow Chemical Co.

Measurement Locations

March 7, 2001
1 inch=50ft.

Figure 2

FIGURE 3



Dow Chemical Co.

Lake Depth

March 7, 2001
1 inch=50ft.; Contour Interval = 1 foot

Figure 3

FIGURE 4

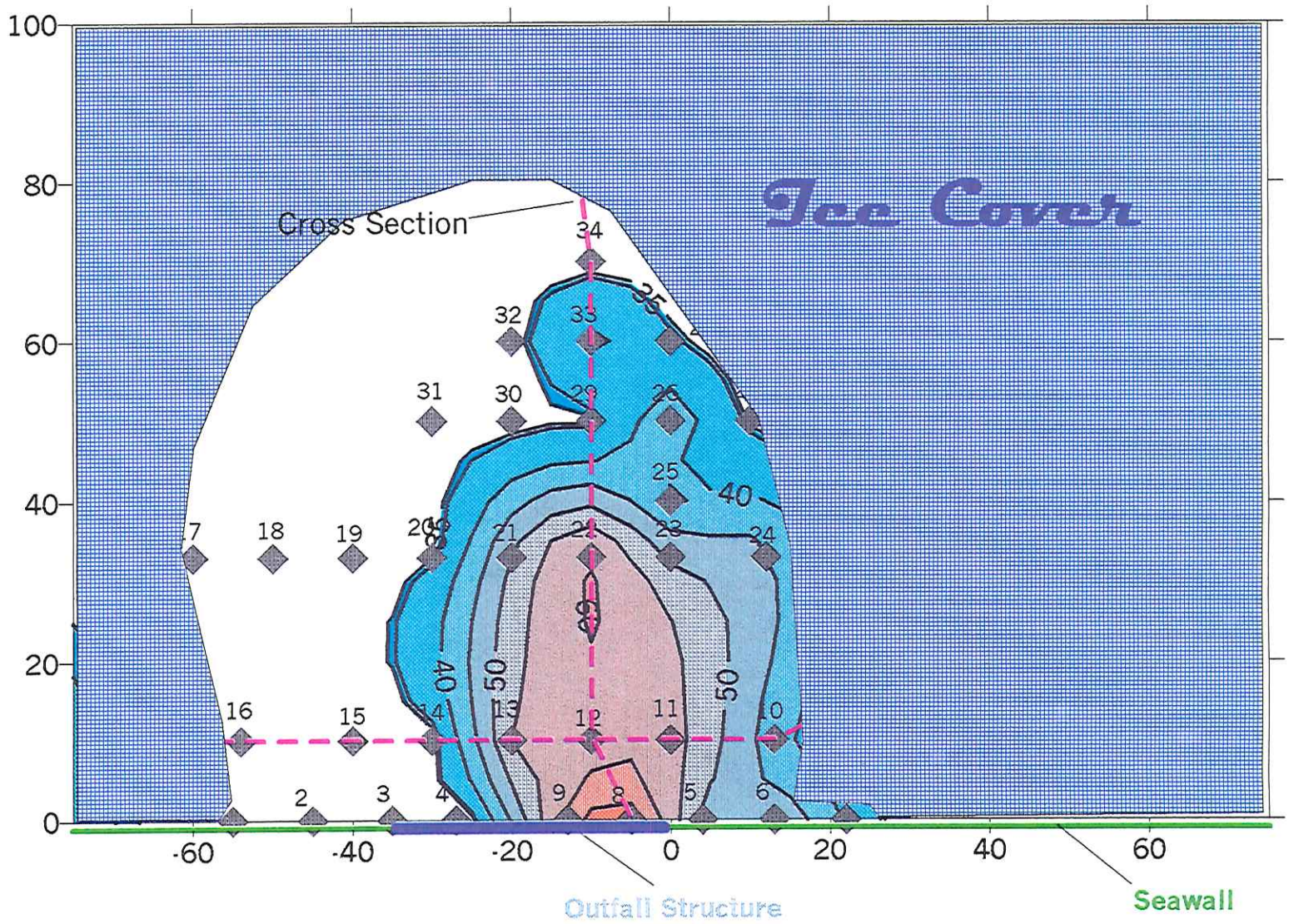


Figure 4 Surface Temperature (Farenheit), 1"=20', Minimum Contour = 34.5 F

FIGURE 5

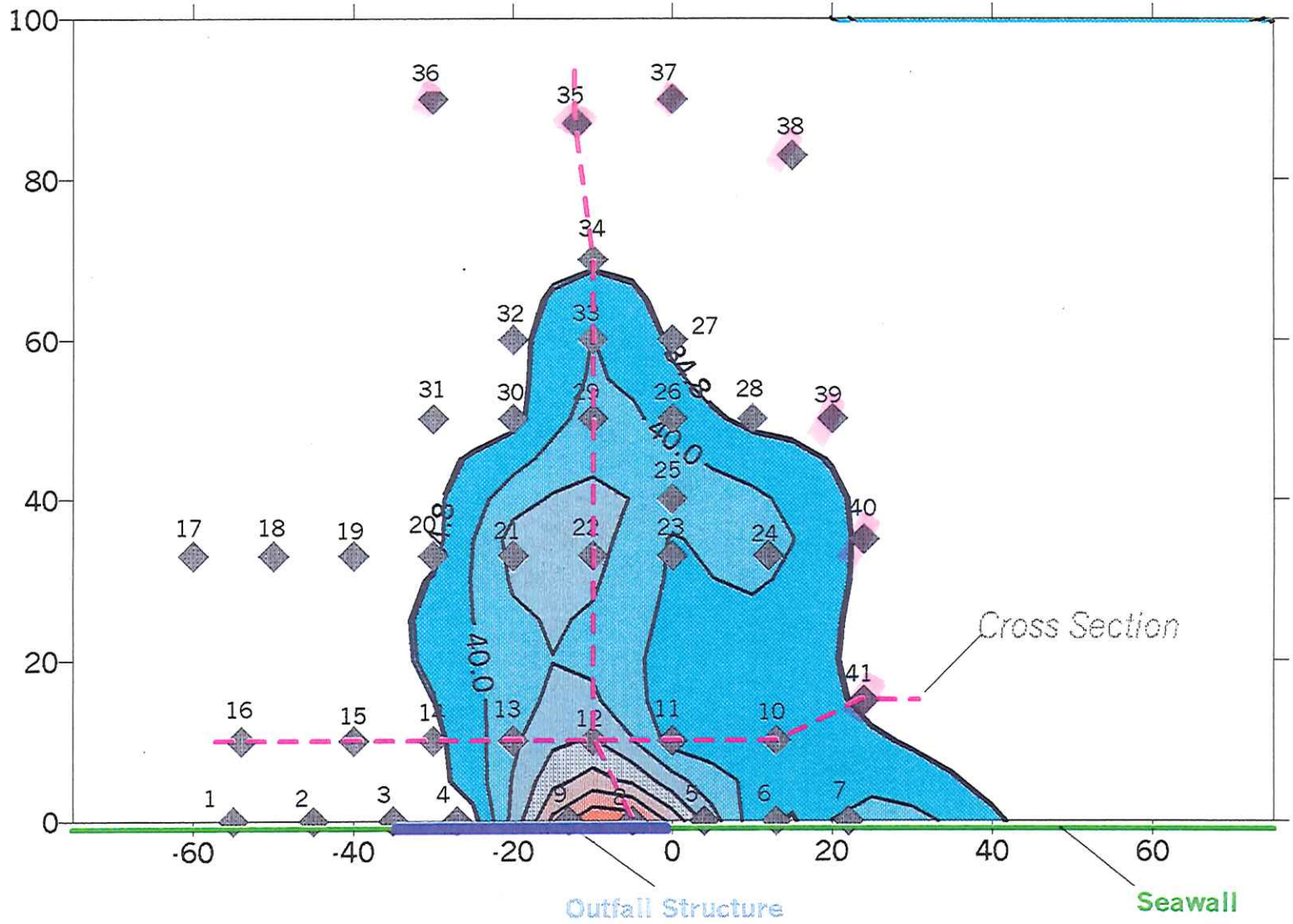


Figure 5 Two Foot Depth Temperature (Farenheit), 1"=20', Minimum Contour = 34.8 F

FIGURE 6

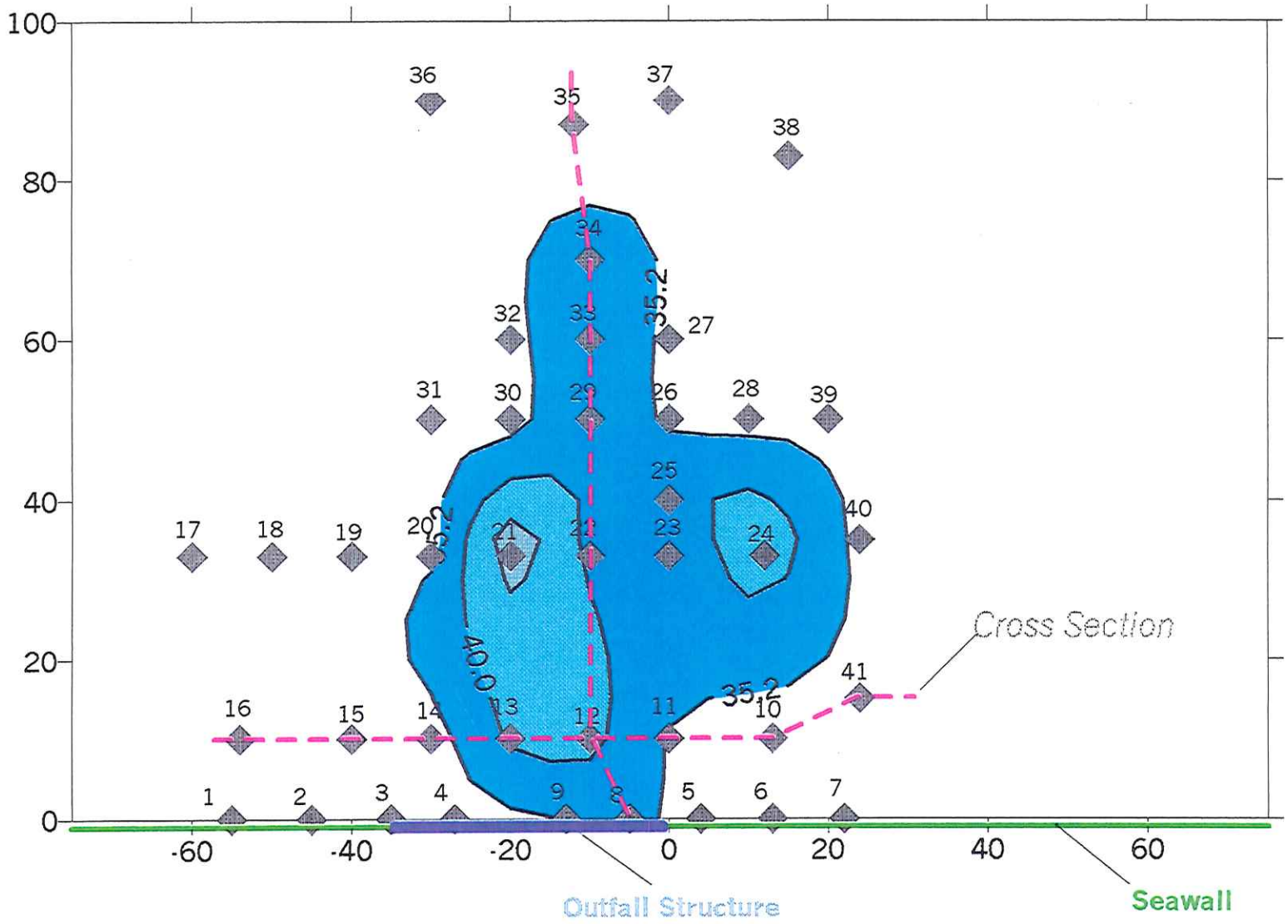


Figure 6 Five Foot Depth Temperature (Farenheit), 1"=20', Minimum Contour = 35.2 F

FIGURE 7

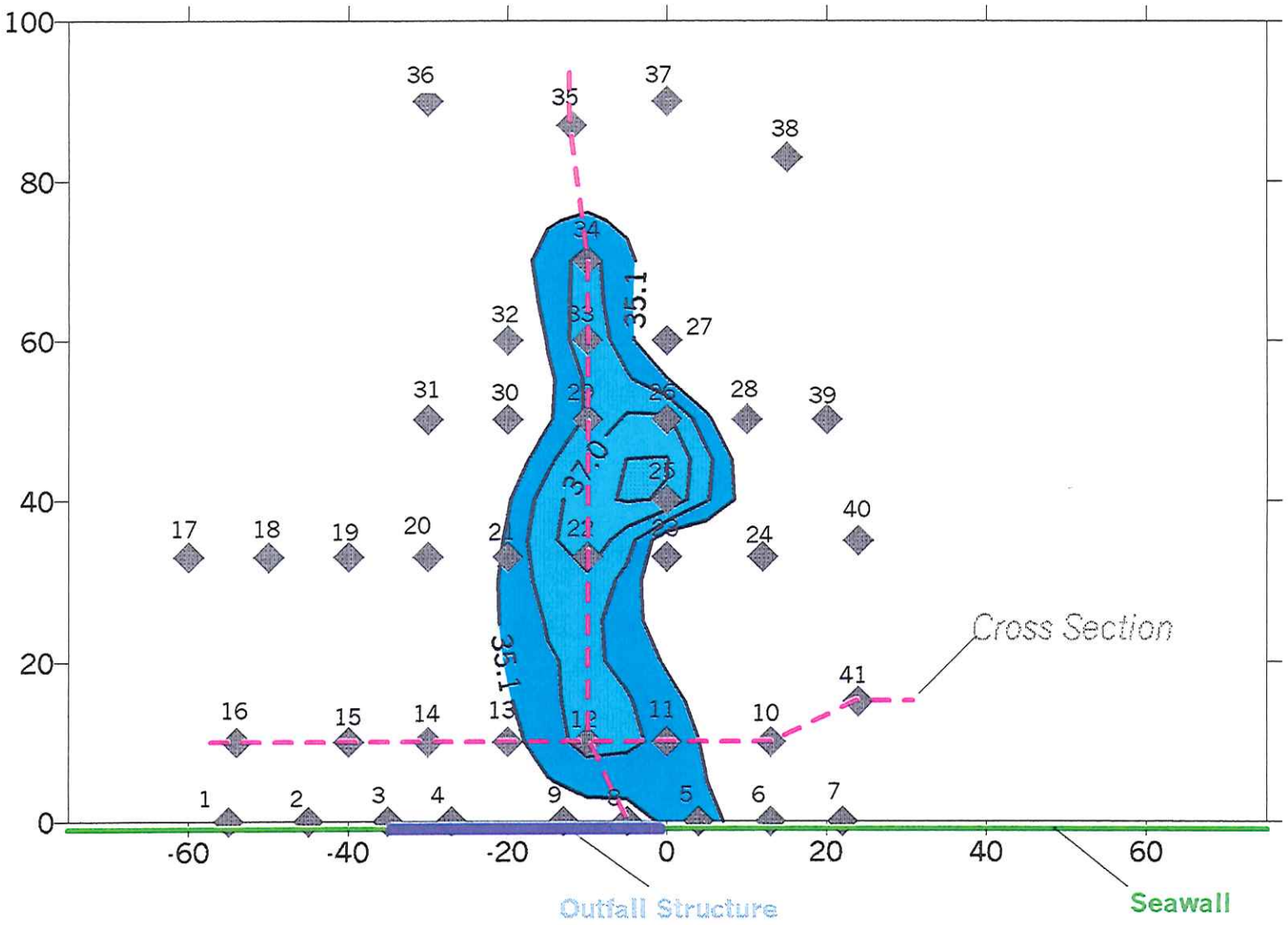


Figure 7 Ten Foot Depth Temperature (Farenheit), 1"=20', Minimum Contour = 35.1 F

FIGURE 8

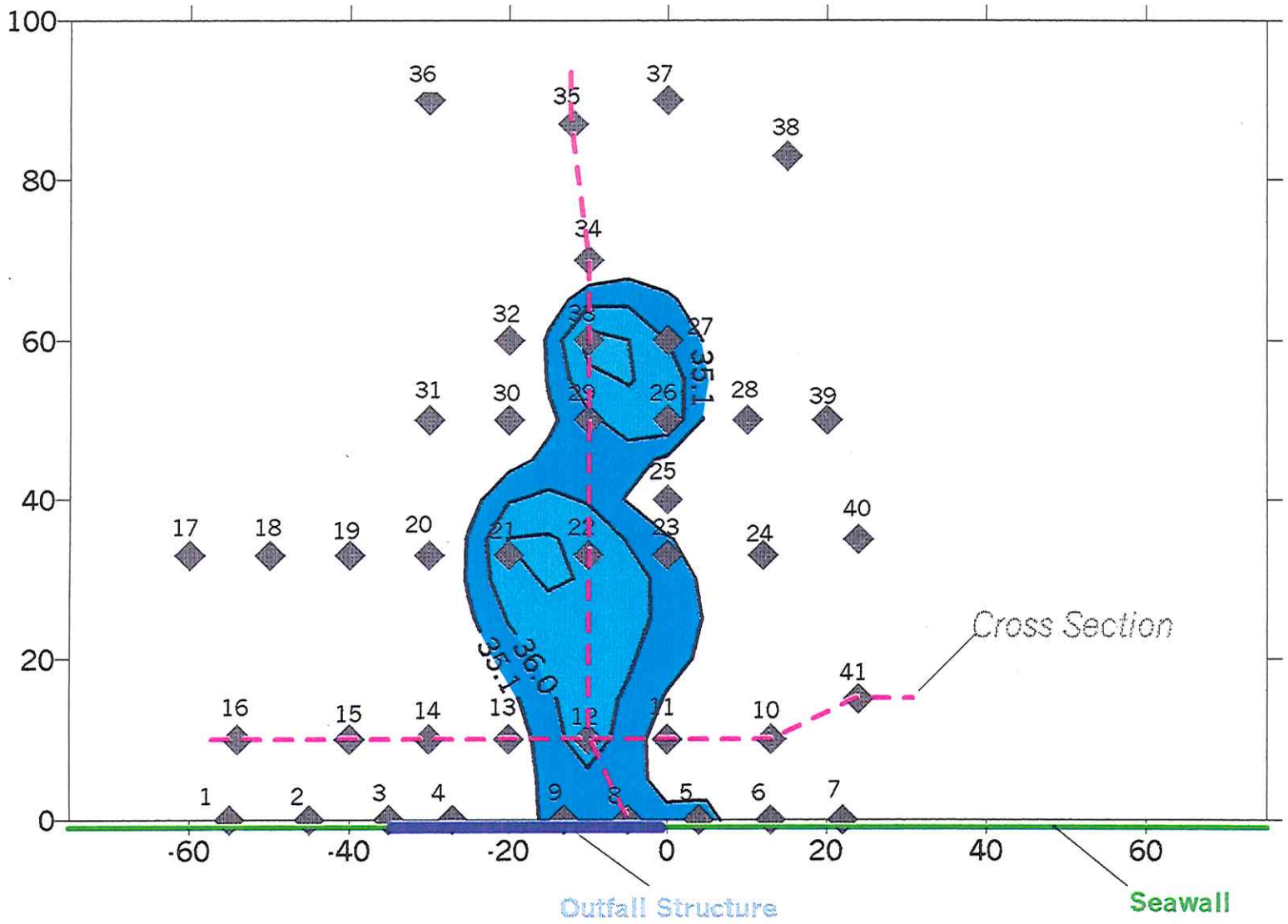


Figure 8 Fifteen Foot Depth Temperature (Farenheit), 1"=20', Minimum Contour = 35.1 F

FIGURE 9

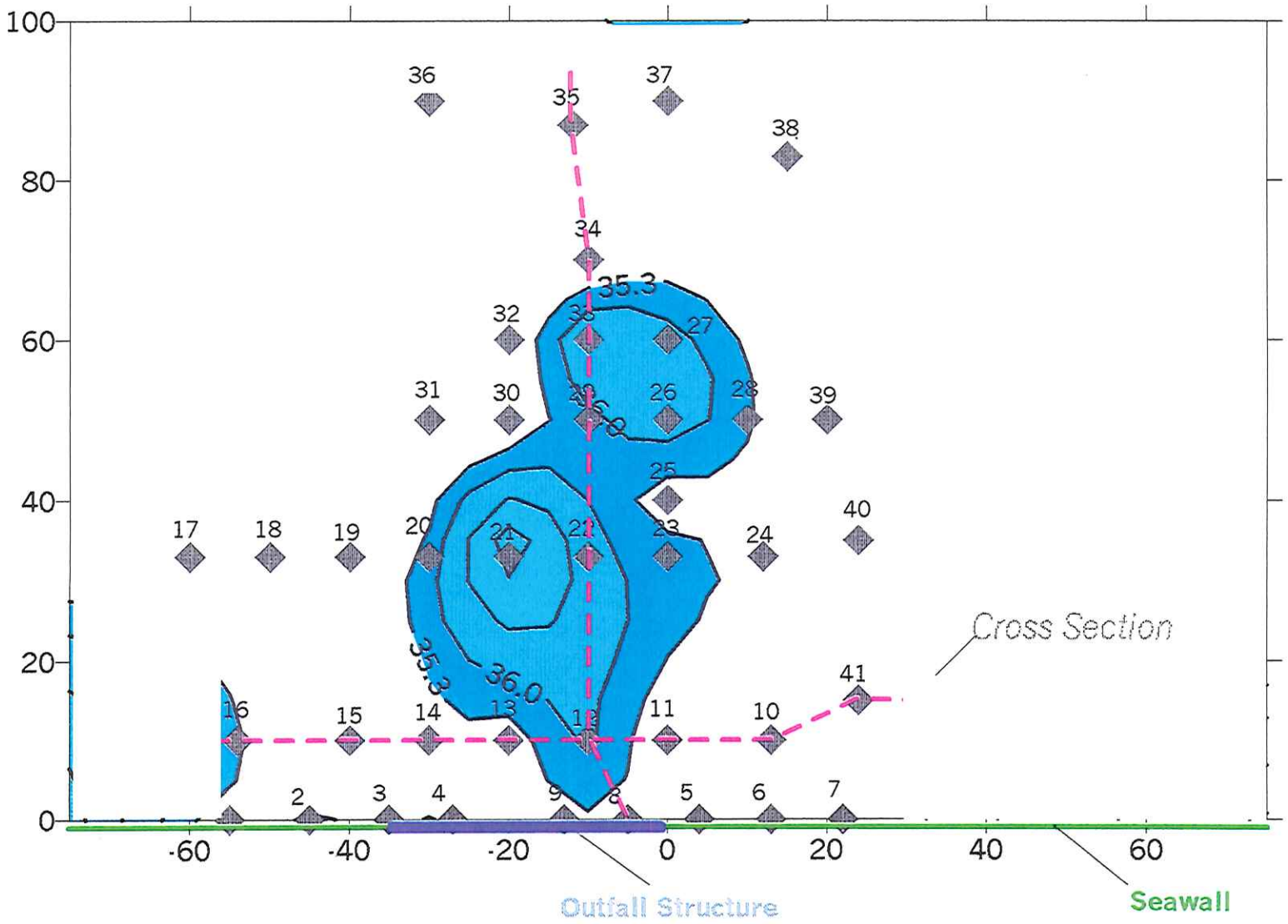


Figure 9. Twenty Foot Depth Temperature (Farenheit), 1"=20', Minimum Contour = 35.3 F

FIGURE 10

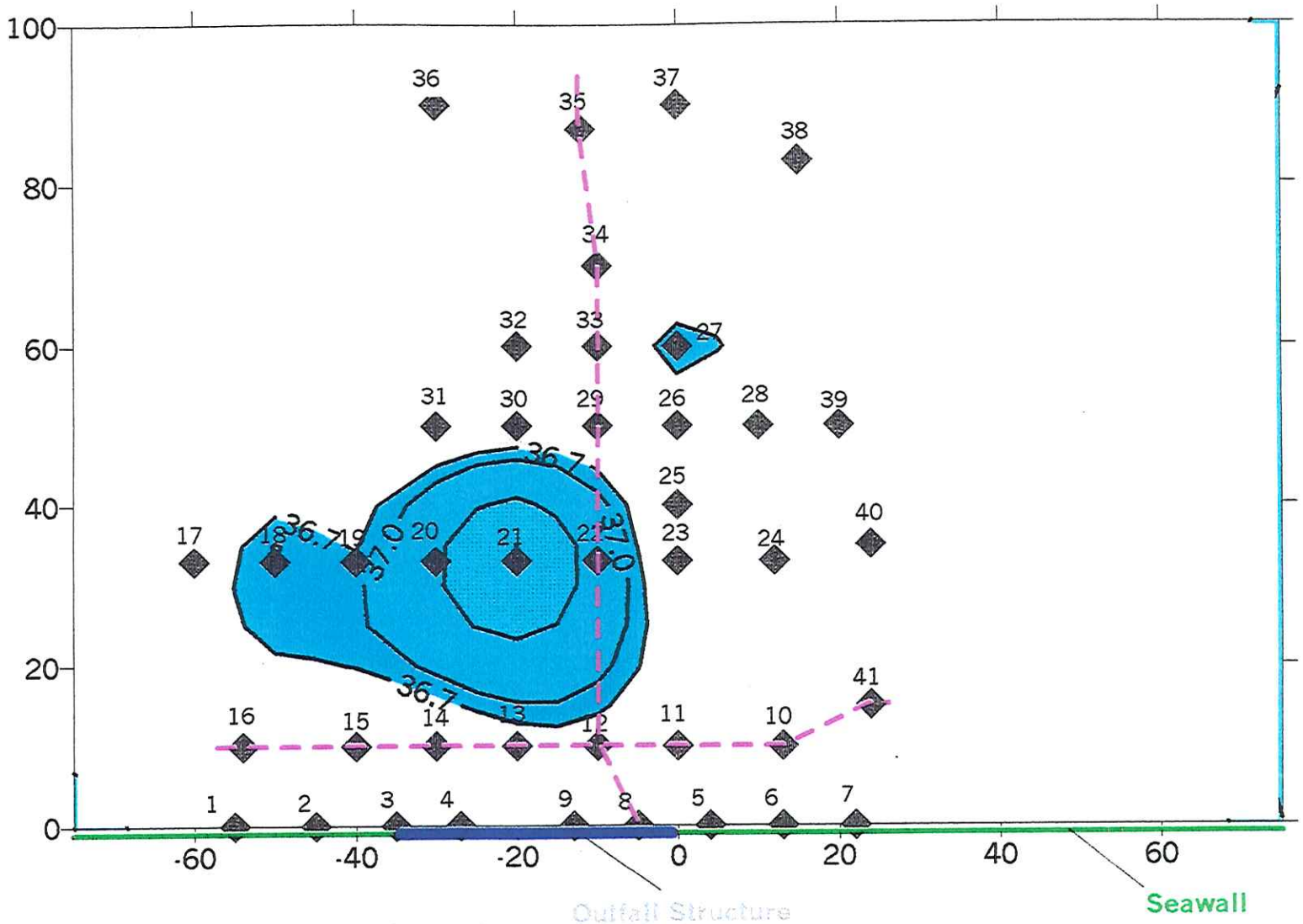


Figure 10. Twenty-five Foot to Bottom Depth (Approximately 27 Feet) Temperature (Farenheit), 1"=20', Minimum Contour = 36.7 F (2 degrees > Bottom Background)

Note: Lake water temperatures on March 7, 2001 were significantly warmer within 3 feet of the lake bottom both offshore (where background temperatures were obtained (Table 2)) and near the outfall (where the investigation occurred). Lake bottom depth is approximately 6 feet shallower near the outfall than further offshore where background measurements were acquired (Figure 3). Therefore, to evaluate lake temperature measurements near the outfall, offshore background measurements from the bottom 3 feet of the lake were correlated to the corresponding 3-foot zone near the outfall (lake bottom to 3 feet above lake bottom).

FIGURE 11

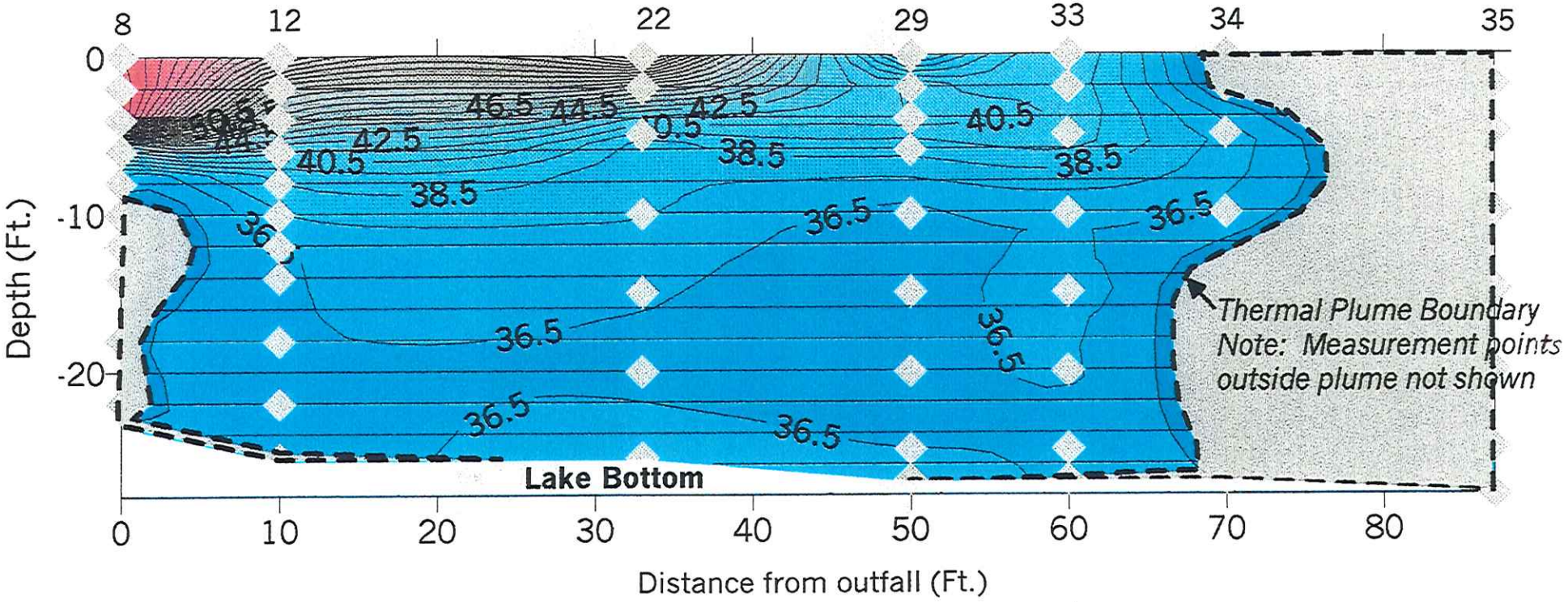


Figure 11. Thermal Plume Temperature (Farenheit) Longitudinal Cross Section, 1" = 20 '

Note: Lake water temperatures on March 7, 2001 were significantly warmer within 3 feet of the lake bottom both offshore (where background temperatures were obtained (Table 2)) and near the outfall (where the investigation occurred). Lake bottom depth is approximately 6 feet shallower near the outfall than further offshore where background measurements were acquired (Figure 3). Therefore, to evaluate lake temperature measurements near the outfall, offshore background measurements from the bottom 3 feet of the lake were correlated to the corresponding 3-foot zone near the outfall (lake bottom to 3 feet above lake bottom).

FIGURE 12

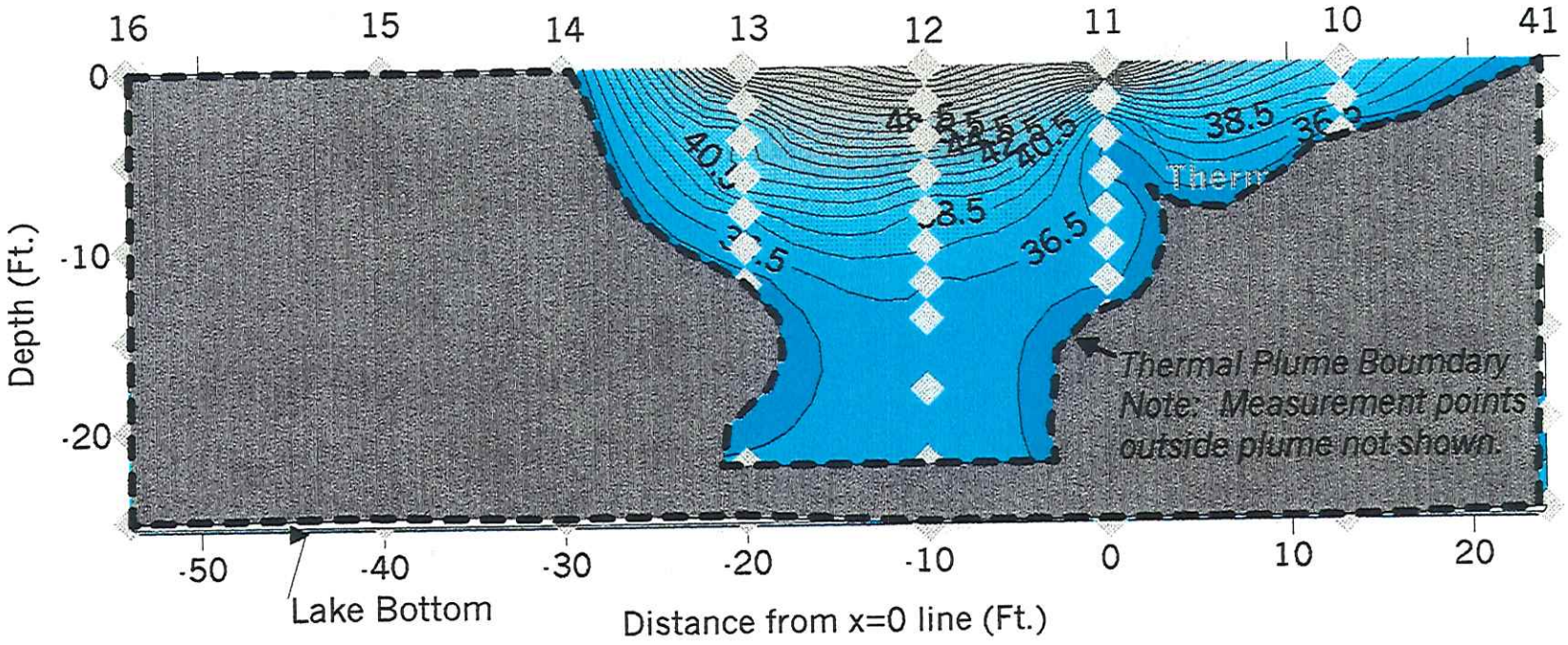


Figure 12. Thermal Plume Temperature (Farenheit) Traverse Cross Section, 1" = 20'

Note: Lake water temperatures on March 7, 2001 were significantly warmer within 3 feet of the lake bottom both offshore (where background temperatures were obtained (Table 2)) and near the outfall (where the investigation occurred). Lake bottom depth is approximately 6 feet shallower near the outfall than further offshore where background measurements were acquired (Figure 3). Therefore, to evaluate lake temperature measurements near the outfall, offshore background measurements from the bottom 3 feet of the lake were correlated to the corresponding 3-foot zone near the outfall (lake bottom to 3 feet above lake bottom).