EXHIBIT E

THERMAL PLUME SURVEYS ON THE CHICAGO SANITARY AND SHIP CANAL NEAR WILL COUNTY STATION JUNE-SEPTEMBER 2002

Part 1 of 4

Thermal Plume Surveys on the Chicago Sanitary and Ship Canal Near Will County Station, June-September 2002

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1. INTRODUCTION

Thermal plume surveys were conducted during 2002 in the Chicago Sanitary and Ship Canal (CSSC) near Will County Station. The objective of these surveys was to obtain information concerning near-field thermal plume characteristics for the generating facility under a variety of summer operating, river flow, and meteorological conditions. Seasonal thermal plume surveys conducted in 1993-94[1] at the Will County Power Plant, supported the observation that due to natural buoyancy, thermal plumes are primarily a surface phenomenon but also indicated that the plumes can have a depth component. Therefore, the 2002 surveys included surface plume measurements on all dates and three-dimensional (3-D) profiles on approximately half the dates.

The near field thermal water quality standards that apply to Will County Station are the Secondary Contact and Indigenous Life Standards. These standards require that temperatures shall not exceed 93 F more than 5 percent of the time or 100 F at any time at the edge of the mixing zone (35 Illinois Administrative Code Section 302.408). The two-dimensional extent of the surface plume mapping was intended to delineate the 93 F and 100 F temperature contours and the areas encompassed by these contours relative to the 26-acre mixing zone allowed. The mixing zone must allow for a zone of passage (which occupies at least 75% of the cross-sectional area) in which water quality standards are met. Information on zone of passage was obtained from the 3-D temperature profiles.

The 5 F contour above natural temperature was also mapped and compared to the General Use thermal water quality standard [Section 302.211(d)]. The temperature at the transect above the intake was used as the reference, ambient temperature. The General Use standard requires that the maximum temperature rise above natural temperatures cannot exceed 5 F and could be a potential near-field compliance standard for this facility sometime in the future. This standard is presently in effect beginning at the I-55 Bridge, which is 19 miles downstream of Will County Station.

EA Engineering, Science and Technology (EA) was contracted by Midwest Generation to perform these studies.

[1] ENSR, 1995. Upper Illinois Waterway Study Summary Report: Physical - Chemical Study of the Upper Illinois Waterway, Summer 1993 - Spring 1994. Report by ENSR to Commonwealth Edison Company, Chicago Illinois

2. METHODS

Eight thermal plume surveys were conducted along the Chicago Sanitary and Ship Canal at Will County Station. Each survey consisted of surface plume mapping along predetermined transects and vertical profiles. Four surveys consisted of surface plume mapping and vertical profiles only at the center of each transect (centerline survey). The remaining four surveys were comprehensive 3-D plume surveys that included both surface plume mapping and 3 to 4 vertical profiles along each transect. This resulted in the collection of surface and centerline vertical profile temperatures on eight occasions and complete three-dimensional plume data on four occasions. One centerline survey was conducted in June, two 3-D surveys and one centerline survey were conducted in both July and August, and one centerline survey was conducted in September. Thermal plume surveys were performed during months when worst case conditions were expected to occur.

2.1 TRANSECTS

The thermal plume mapping surveys at Will County Station were performed along 11 transects that were located from 3,700 ft upstream of the discharge to 5,000 ft downstream of it. Each thermal survey consisted of surface plume mapping and vertical temperature profiles. The surface plume mapping was performed first by starting at the upstream-most transect and then proceeding in a downstream direction. This was followed immediately by the vertical profiles, which proceeded from downstream to upstream. In addition to the 11 transects, the surface plume mapping included a diagonal (e.g., moving from the left end of Transect 1 to the right end of Transect 2) or a centerline transect between each of the 11 transects. The transect locations are summarized in the following table.

Will County Station	
Transect	Distance from Discharge (ft)
1	Upstr (-3,700)
2	-250
3	0
4	180
5	525
6	1,000
7	1,500
8	2,200
9	3,000
10	4,000
11	5,000

When 3-D surveys were conducted, vertical profiles were performed at 34 stations. All transects except Transect 3 (the discharge) contained 3 vertical stations. The stations were located at one-quarter, one-half, and three-quarters of the distance from the left to right bank (when facing downstream). Transect 3, the discharge location, contained 4 vertical stations; 1/5, 2/5, 3/5, and 4/5 of the distance from left to right bank. The 4/5 station was located approximately in the center of the discharge canal opening. The 11 thermal plume survey transects and vertical station locations are illustrated in Figure 2-1, corresponding GPS coordinates are provided in Appendix E.

2.2 SURVEY METHODS

All surveys were performed from a boat equipped with a temperature measuring system and a differential Trimble GPS system. The surface plume mapping was performed first in a downstream direction, immediately followed by the vertical profiles from downstream to upstream. The GPS system stored the x,y coordinates of the temperature probe position at 1-sec intervals to internal memory. Temperature was recorded continuously to a data logger at a 1-sec interval.

The temperature system consisted of a YSI-011-44018 probe interfaced with a Deban 500 module. The Deban module receives the signal from the thermistor and sends a voltage that responds linearly with temperature to the datalogger. According to the manufacturer, the YSI/Deban temperature system has an accuracy of 0.1% full span, which corresponds to 0.05° C. The output from the thermistor was stored at 1-sec intervals to a Campbell CR10X datalogger. The temperature and GPS data were recorded along both the 11 established horizontal transects and the diagonal transects in between.

During a surface plume survey, the boat was driven along an established lateral transect, turned as close as possible to the shoreline, and then moved on a diagonal to the next transect, producing a zigzag pattern. The thermistor was attached to a fixed strut mounted on the side of the boat. The sampling depth was between 1 ft and 1.5 ft, depending on wave action at the time of the survey. When wave action was significant, the thermistor was positioned at a 1.5-ft depth to prevent it from coming out of the water when the boat was riding a wave. At these times, the 1.5-ft sampling depth was still representative of a surface temperature because the upper 1.5-ft of the water column was well mixed due to wave action. A 1-ft sampling depth was used during the majority of the surveys.

Plume definition within the water column was obtained by measuring vertical temperature profiles from surface to bottom at pre-established locations along the 11 transects. A total of 34 vertical-profiling stations were established along the transects near Will County Station (Section 2.1). Vertical profiles were measured using a Seabird CTD profiler (model SBE 19 plus). The instrument was set to collect temperature and depth data at 0.25-sec intervals as the unit was slowly lowered to the bottom and pulled back up to the surface. This typically resulted in the collection of 4 to 6 data points within every 1-ft depth interval. GPS was used to position the boat at the same vertical-profiling stations during all surveys.

2.3 INSTRUMENT CALIBRATION

2.3.1 Seabird CTD Profiler

The Seabird CTD Profiler received a pre- and post-calibration by the manufacturer. The pre-calibration was performed on 20 June 2002 (temperature) and 8 April 2002 (pressure). These calibration results are provided in Appendix Tables A-1 and A-2. The post-calibration was performed on 5 October 2002 for both temperature (Table A-3) and pressure (Table A-5). The pre- and post-calibration results for temperature indicated that the sensor drift was +0.00977 C (Table A-4). The pressure calibration was within 0.06-percent full scale during the pre- and within 0.04-percent full scale during the post-calibration.

2.3.2 Surface Temperature System

During the June to September survey period, four probe combinations were employed in the field as summarized in following table.

Combination	Survey	Probe	Deban Module
1	27 June, 10 July	P4	285
2	24 July	E2-5	352
3	31 July, 8 and 16 August	E2-5	352 extended range
4	29 August, 4 September	E2-2	352 extended range

Probe Combination 1

Probe combination 1 was calibrated both before and after it was used in the field. The pre-calibration (10 June) was performed over a temperature range of 15 C to 25 C and resulted in the regression equation:

$$Tcalib = 1.0116\ T - 0.323 \quad (R^2 = 0.9999)$$

The post-calibration (6 August) was performed over the temperature range of 20 C to 36 C and resulted in the regression equation:

$$Tcalib = 0.9964\ T + 0.013 \quad (R^2 = 0.9999)$$

Over the temperature range of 25 C to 30 C, which was typical of the 27 June and 10 July surveys, both calibrations resulted in temperature adjustments not exceeding 0.1 C. Since a 0.1 C calibration adjustment was considered representative of the accuracy of the calibration, the survey data were used without further correction. The temperature data for the pre- and post-calibrations are provided in Appendix Table A-6.

Probe Combination 2

The combination of probe E2-5 and Deban module 352 was calibrated by Deban prior to the thermal surveys (Appendix Table A-7). Over a temperature range of 15 C to 40 C, the temperature deviation did not exceed 0.021 C. The survey data was used as recorded with no additional adjustment.

Probe Combination 3 and 4

Between the 24 July and 31 July surveys, the Deban module was returned to the manufacturer and the output range was extended (Combination 3). Prior to the 29 August survey, probe E2-5 was replaced with probe E2-2 (Combination 4). The pre-calibration of probes E2-5 and E2-2, both using module 352, were nearly identical. Deviation for Probe E2-5 did not exceed 0.021 C (Table A-7) and probe E2-2 deviation did not exceed 0.030 C (Table A-8) over a temperature range of 15 C to 40 C. This indicates that these two YSI probes are nearly identical, and any subsequent differences are a function of the Deban Module. The combination of probe E2-2 with module 352 was post-calibrated on 4 October. The calibration over a temperature range of 26 C to 39 C resulted in the regression equation:

$$Tcalib = 0.9696\ T + 1.6141 \quad (R^2 = 0.9998)$$

The above equation results in a calibration adjustment that increased the recorded temperature by 0.85 C at 25 C, with the adjustment decreasing to 0.55 C at 35 C. The temperature calibration data are provided in Appendix Table A-9. The above regression equation was applied to the 31 July to 4 September surveys. This calibration is associated with the modification of the Deban module, which was common to both probe combinations 3 and 4.

2.4 DATA PROCESSING

The survey data were processed into standard file formats and converted to degrees Fahrenheit. The surface plume mapping data were displayed as surface temperature values from left to right bank at each of the 11 transects. All of the vertical temperature profile data were placed in tables. Data processing procedures were also developed to provide surface plume areas, downstream distances, and cross-sectional profile statistics. The data processing procedures are discussed in the following sections.

2.4.1 CTD Profiler

The CTD unit records temperature and depth readings continuously every 0.25 second during the profile as the instrument is lowered and pulled back up to the surface. The data recorded during each vertical profile were averaged into 1-ft intervals from surface to bottom. Following manufacturer recommendations, only the data from the lowering were used in the analysis. When the probe is lowered, "new" water continuously flows

pass the probe, which is located near the bottom of the instrument. During the retrieval, the instrument housing may cause entrainment of "old" water.

Data in the 0.5-ft surface layer was averaged and reported as a 0.25-ft depth. The remaining data were averaged in 1-ft vertical intervals from surface to bottom and reported as the mid-depth of the interval. For example, data in the 0.5-ft to 1.5-ft interval were reported as 1 ft and the data in the 1.5-ft to 2.5-ft interval were reported as 2 ft. Pre- and post-calibrations of the CTD profiler performed by the manufacturer indicated that no additional calibration adjustment of recorded data was necessary (Section 2.3). All of the vertical temperature data were placed in tables.

2.4.2 Surface Temperature System

As discussed in Section 2.2, surface temperatures were recorded with a YSI probe interfaced with a Deban 500 module. The resulting output was recorded on a Campbell CR10 datalogger. Each survey resulted in a data file of temperature data and a second data file of the corresponding GPS coordinates, both at 1-sec intervals. The two files were examined for spurious data using several techniques. The examination of the surface data included calculating the minimum, maximum, and mean temperature along each transect. The GPS data was plotted to display the course steered by the boat during the survey. A calibration adjustment was applied to the data as indicated Section 2.3. The resulting calibrated temperature file and the GPS coordinate file were merged using the survey times recorded in each file for synchronization. The system clocks on the datalogger and the Trimble GPS unit were set in the field to identical times at the beginning of each survey.

Figures displaying surface temperatures at each of the 11 transects were generated for each survey. In these figures, temperatures were displayed at a distance from left to right bank (when facing downstream). For convenience in generating these figures, the survey data was transformed by calculating the distance of each data point from the known location of the left bank shoreline and by averaging the data into 3-ft horizontal intervals along each transect.

2.4.3 Plume Area and Cross-Sectional Characteristics

Surface plume areas enclosed by various temperatures were calculated primarily from the thermal survey data at the 11 horizontal transects. A computer program searched the survey data and identified the plume width of a specified temperature at each of the 11 transects. Areas were then calculated by multiplying the average plume width at two transects by the distance between the two transects. Downstream of the discharge, if a temperature contour ended between two transects, the downstream extent of the plume was calculated by interpolation. A downstream distance was determined by interpolating the specified temperature between the maximum observed temperatures at the two transects.

The distance between the -250-ft upstream transect and the upstream-most transect

(-3,700 ft) was too large for linear interpolation. In addition, thermal survey data indicated that on some days the plume intruded upstream with a pronounced temperature variation at its upstream edge. The distance to which the plume extended upstream of the -250 ft transect was determined by examining the centerline horizontal surface transect between the upstream -3,700 ft and -250 ft transects. The plume area upstream of the -250 ft transect was estimated by multiplying the plume width at the -250 ft transect by the upstream plume length weighted by a factor of 0.67 to account for geometry.

The cross-sectional areas enclosed by specified temperatures were calculated at each of the 11 transects for the four 3-D surveys when all 34 vertical stations were performed. Each cross-sectional profile was sub-divided into 1-ft by 5-ft segments. The 1-ft segment height corresponded to the vertical interval of the processed profile data. A layer of 0.5 ft segments was employed at the surface. The vertical profile data was mapped onto the sub-divided cross-section. Temperatures at segments between vertical stations were interpolated. The vertical profile temperature at each depth was assigned between the outer vertical stations and the shoreline. After a temperature was assigned to each segment, cross-sectional area statistics were generated for a range of temperatures and summarized in tables as a percentage of the cross-sectional area.

3. THERMAL SURVEY RESULTS

The data collected during the eight Will County Station thermal plume mapping surveys is displayed in a series of figures and tables. The surface plume mapping data at the 11 transects extending from 3,700 ft upstream of the Station to 5,000 ft downstream of it are displayed as a set of figures in Appendix B. In each figure, the surface temperature data are presented as a function of the distance from left bank to right bank. Typically, 3 transects were grouped on each figure, requiring 4 figures to display the entire survey. The vertical profiles were preformed at up to four stations along each transect (Figure 2-1). During four surveys, the complete set of 34 stations were monitored (3-D survey), and during the remaining four surveys only the 11 centerline vertical stations were monitored (centerline survey). As discussed in Section 2.4, the vertical profile data were averaged into 1-ft vertical intervals. All of the resulting vertical temperature data are displayed as tables in Appendix C. The following table summarizes the June to September survey dates, corresponding appendix figure and table numbers, and indicates whether a complete set of verticals (3-D Survey) were preformed or whether only the centerline vertical stations were monitored.

Survey	Survey Type	Figures	Tables
27 June	Centerline	B-1 a-d	C-1 a-b
10 July	3-D	B-2 a-d	C-2 a-f
24 July	3-D	B-3 a-d	C-3 a-f
31 July	Centerline	B-4 a-d	C-4 a-b
8 August	3-D	B-5 a-d	C-5 a-f
16 August	Centerline	B-6 a-d	C-6 a-b
29 August	3-D	B-7 a-d	C-7 a-f
4 September	Centerline	B-8 a-d	C-8 a-b

The time intervals when each surface plume mapping survey and each vertical survey were performed are provided in Table 3-1.

3.1 SURVEY CONDITIONS

Hourly Will County Station operating conditions on the day of each survey are provided in Appendix Tables D-1 to D-8. These tables include power production, intake temperature, discharge temperature, delta temperature rise through the station, and station circulation water flow. The tables also include the Chicago Sanitary and Ship Canal flow at the USGS gage in Romeoville. Daily average station operating conditions and river flow are summarized in the bottom half of Table 3-1.

Table 3-1 indicates that daily average power production on survey days varied between 675 MWe on 8 August to 967 MWe on 27 June. The station circulating flow was a constant 2,006 cfs during all surveys except for a 1,863-cfs flow on 10 July. Because of the uniformity in circulating water flow, it would be expected that the delta temperature rise through the station would be proportional to power production. The highest daily average delta temperature rise of 17.4 F occurred on 10 July when circulating water flow

was reduced. On the remaining days when power production exceeded 800 MWe, delta temperatures were greater than 12.5 F, decreasing to 10.7 F on 24 July with a lower 675 MWe power production level.

Daily average flow in the Chicago Sanitary and Ship Canal varied between 2,617 cfs (27 June) and 3,372 cfs (29 August).

Hourly power production at Will County Station is characterized by a daily cycle. Examination of Tables D-1 to D-8 indicates that in the early morning, preceding 0800 hrs, power production is typically below 500 MWe. Over the next several hours power production increases, typically reaching 1,000-1,100 MWe by 1300 hrs. Power production then decreases during the evening after 1800 hrs.

The survey times in Table 3-1 indicate that the surface plume mapping surveys were usually performed in the late morning between 1000 and 1200 hrs and the vertical surveys were usually performed in the early afternoon between 1200 and 1400 hrs. The thermal surveys were therefore performed during a period of increasing power production. During the late morning surface plume mapping, temperatures at downstream transects may reflect lower power production (and lower heat rejection) levels associated with plant operation several hours previous. Additional temperature variation and build up may occur during the several hour period between the beginning the surface plume mapping and the end of the vertical survey.

3.2 SUMMARY DESCRIPTION OF SURVEYS

A short description of the plume features during each of the eight Will County Station thermal surveys is provided in the following section. As previously discussed, the surface temperature plume mapping data are presented as a series of figures and tables in Appendix B and all the vertical profile data are provided as tables in Appendix C. A three dimensional presentation of surface plume mapping data for each survey is also provided in Figures 3-1 to 3-8. Plume areas and cross-sectional characteristics are presented in Section 4.

The average upstream transect temperature during the surface mapping and the vertical profiles are provided in Table 3-1 for the eight thermal surveys. Examination of these data indicate that the upstream temperature typically increases by 0.3 to 0.8 F during the period of several hours from the beginning of the surface plume mapping to the end of the vertical profile surveys. This variation is attributed to the natural daily warming cycle. The daily average intake temperature was usually within the range of the two survey temperatures except on 27 June and 24 July. On these two dates, the CSSC flows were the lowest of the 8 surveys. A low flow condition would more easily allow the upstream intrusion of water from the discharge to the intake.

Will County Station - 27 June

At Will County Station, the surface temperature at the upstream-most transect was 78.6-78.8 F and increased to 85.5-85.8 F at the transect 250-ft upstream of the discharge canal (Figure B-1a). The vertical profile in front of the discharge canal provided a surface temperature of 91.45 F (Transect W0-4/5, Table C-1a). Surface temperatures along the downstream transects were typically between 87.0 and 87.6 F (Figure B-1c, B-1d). The vertical profile at the upstream transect displayed a uniform 78.9-79.0 F temperature approximately two-hours after a 78.6-78.8 F temperature was observed during the surface plume survey. At the 180-ft transect, a surface to bottom differential of 5.6 F (89.1 surface vs 83.5 bottom) was observed, whereas the surface/bottom differential at the next transect was only 1.1 F. Downstream of the 1,500-ft transect, the vertical temperature profiles were very uniform with less than 0.4 F variation (Table C-1b).

Will County Station – 10 July

During the 10 July survey (Figure B-2, Table C-2), temperatures at the two upstream transects were nearly identical. This was usually not the case. During most surveys, the surface temperatures at the –250-ft transect were elevated compared to the upstream-most transect, indicating upstream intrusion of the buoyant surface plume. The two surveys when this did not occur, 10 July and 29 August, had higher river flows (above 3,000 cfs) (Table 3-1). On 10 July, surface temperatures at the 180-ft transect varied from 86.5 to 93.0 F (left to right bank). Downstream of the 1,500-ft transect, temperatures were more uniform from bank to bank, as well as decreasing from approximately 88.5 F to 86.5 F in a downstream direction. The vertical temperature data (Table C-2), indicates that temperatures near the bottom of the water column were up to approximately 5 F lower than surface temperatures at the 525-ft transect. The vertical temperature difference decreased to approximately 1.0 F at the 5,000-ft transect.

Will County Station – 24 July

During the 24 July surface plume mapping (Figure B-3, Table C-3), temperature increased from the 82.9 F at the upstream-most transect to 90 F at the -250-ft transect, indicating upstream intrusion. The daily average river flow of 2,735 cfs on the 24th was the second lowest of the eight surveys. At the 0-ft transect, temperatures increased from 90.2 F to 94.0 F from left to right bank. At the 1,500-ft to 5,000-ft downstream transects, lateral temperatures were fairly uniform within the 89-90 F range. During the vertical survey, temperature at W0-4/5 ranged up to 95 F, slightly below the plant reported 96.5 F discharge temperature at the time of the survey (Table D-3). Vertical temperature stratification decreased from 3.5 F at the 1,000-ft transect to about 0.5 F at the 5,000-ft transect.

Will County Station – 31 July

During the 31 July surface plume mapping (Figure B-4), the 80.6 F temperature at the upstream-most transect increased to 87.0 F at the –250-ft and the 0-ft transects. Along

the 0-ft transect, temperatures near the Will County discharge were 91.0 F slightly below the reported station discharge temperature of 91.6-94.6 F at the time of the survey (1110-1214 hrs). Downstream of the 525-ft transect, temperatures were fairly uniform horizontally with temperatures in the 87.5-88.5 F range. At both the upstream-most and –250-ft transects, temperatures were higher during the verticals than during the earlier surface mapping. During the plume mapping, surface temperatures increased from 80.6 F to 87.0 F between the upstream and –250-ft transect, while during the verticals temperatures at these locations increased from 84.5 F to 89.9 F. Surface temperatures at the downstream transects were also slightly higher during the early afternoon verticals than the morning plume mapping. This temperature increase may have resulted from several factors including daily solar warming and changes in heat rejection associated with the typical late morning increase in power production.

Will County Station – 8 August

During the 8 August survey (Figure B-5, Table C-5), the temperature increased from 80.2 F at the upstream-most transect to 85.4 F at the –250-ft transect. At the discharge transect, temperatures increased from 86 F at the far bank to 90.2 F near the discharge. Temperatures at vertical profile W0-4/5 was as high as 92.9 F. The reported plant discharge temperature was 93.0 F (1100-1200 hrs). Downstream of the 525-ft transect, lateral surface temperatures were very uniform, as well as decreasing from approximately 87.0 F at the 1,000-ft, to 86.6 F at the 3,000-ft, and 86.0 F at the 5,000 ft transect. Approximately 3 hours later during the vertical survey, the upstream temperature was typically 80.8 F. Temperatures below 81.5 F were present in the lower portion of the water column downstream to the 180-ft transect. The magnitude of vertical temperature stratification decreased from 6.5 F (82.6-89.1 F) at the 1,000-ft transect, to 1.6 F (87.0-88.6 F) at the 3,000-ft transect, and 0.5 F (86.4-86.9 F) at the 5,000-ft transect.

Will County Station – 16 August

During the 16 August surface plume mapping (Figure B-6, Table C-6), temperature increased from 80.1 F at the upstream-most transect to 87.2-87.6 F at the –250-ft transect, indicating upstream intrusion of the buoyant plume. At the 0-ft transect, surface temperatures were 92.6 F near the right (discharge) bank. At the time of the surface plume survey (1100-1200 hrs), the station reported discharge temperatures of 95.7-96.1 F. Temperatures of about 92.5 F were also present near the right bank of the 180-ft transect. Downstream of the 180-ft transect, all temperatures during the surface plume mapping survey were less than 90.1 F and were 88.2 F at the 5,000-ft transect. Several hours latter during the vertical survey, temperatures at the upstream-most transect had increased slightly from 80.1 to 80.8-81.6 F (Table C-6a). Temperatures below 81.5 F were present near the bottom of the water column downstream to the 180-ft transect. At the 1,000-ft transect, vertical temperature stratification decreased to 1.6 F (87.5-89.1 F), while at the 4,000-ft and 5,000-ft transects, temperatures throughout the water column were fairly uniform (88.4-88.6 F).

Will County Station – 29 August

During the 29 August surface plume mapping (Figure B-7, Table C-7), the 78.1 F temperature at the upstream-most transect increased only slightly to approximately 78.3 F at the –250-ft transect. The lack of upstream intrusion during this survey is the result of river flow. The 3,372-cfs river flow on 29 August was the highest of the eight surveys (Table 3-1). In addition, the river flow in the hours preceding the 29 August survey was even higher, 3,800-4,000 cfs. The 86.4 F temperature near the discharge bank (0-ft transect) was slightly below the 87-89 F discharge temperature reported by the plant at the time of the survey (1000-1100 hrs). Lateral surface temperature variation decreased from 4.6 F at the 180-ft transect to less than 1 F at the 525-ft and 1,000-ft transects. Downstream of 1,000 ft, lateral temperatures remained uniform and were approximately 82.6 F at the 3,000-ft transect and 82.0-82.4 F at the 5,000-ft transect. During the vertical survey, temperatures below 78.8 F were present in the water column downstream to the 0-ft transect. Vertical temperature stratification was 1.7 F at both the 1,000-ft (83.4-85.1 F) and 1,500-ft (82.7-84.4 F) transects. Between these transects, vertical stratification was 0.5 to 1.0 F.

Will County Station – 4 September

During the 4 September surface plume mapping (Figure B-8, Table C-8), the temperature increased from 79.3 F at the upstream-most transect to 83.3-83.7 F at the –250-ft transect. Along the 0-ft transect, temperatures increased from 85.2-85.4 F near the left bank to 90.1 F near the discharge at the right bank. A similar lateral increase was present at the 180-ft transect. Little lateral change was seen at the remaining transects and surface temperatures were consistently around 86-87. Several hours latter during the vertical survey, upstream temperatures were 79.7-80.2 F. Temperatures near the bottom of the water column were less than 81 F at the –250-ft transect, increasing to 83 F at W0-1/5. At the 180 ft transect, the surface/bottom differential was about 6 F, compared to about 4 F at the 525 ft transect, and ≤ 2 F at all remaining transects.

4. PLUME CHARACTERISTICS

4.1 PLUME AREA AND DOWNSTREAM LENGTH

Plume areas enclosed by temperature contours between 84 F and 94 F were calculated for each of the eight Will County Station thermal plume surveys and these results are provided in Tables 4-1 to 4-8. The methodology for performing these calculations was discussed in Section 2.4.3. The tables also include the downstream and upstream plume length and the plume width as a percentage of the transect width at each of the 11 transects. The plume area statistics includes a column indicating the temperature increase above ambient temperature. The ambient temperature was assumed to be the average temperature at the upstream-most (-3,700 ft) transect during the surface plume mapping survey.

During the eight thermal plume surveys at Will County Station, a 93 F temperature contour existed only on 24 July, on which date, the enclosed area of the 93 F contour was 0.2 acres (Table 4-3). The 24 July survey contained the highest daily average intake temperature of 83.5 F (Table D-3), and the highest temperature at the upstream transect during the surface plume mapping of 82.9 F.

During seven of the eight surveys, the 5 F above ambient temperature contour extended downstream approximately to or beyond the 5,000-ft transect. The temperature associated with the 5F contour during these seven surveys varied between 84 F and 88 F. On 29 August, the 5 F above ambient temperature contour (83.1 F) extended downstream to only the 1,500-ft transect. River flow on the 29th was the highest among the eight survey dates.

4.2 ZONE OF PASSAGE AND CROSS-SECTIONAL AREA

A zone of passage for aquatic life is required when mixing zones are allowed. Under Title 35 Illinois Administrative Code Section 302.102, the mixing zone must allow for a zone of passage in which water quality standards are met. Under these regulations, the following zone of passage requirement applies: "The area and volume in which mixing occurs, alone or in combination with other areas and volumes of mixing must not contain more than 25% of the cross-sectional area or volume of flow of a stream except for those streams where the dilution ratio is less than 3: 1." In other words, the zone of passage must occupy at least 75% of the cross-sectional area or flow volume.

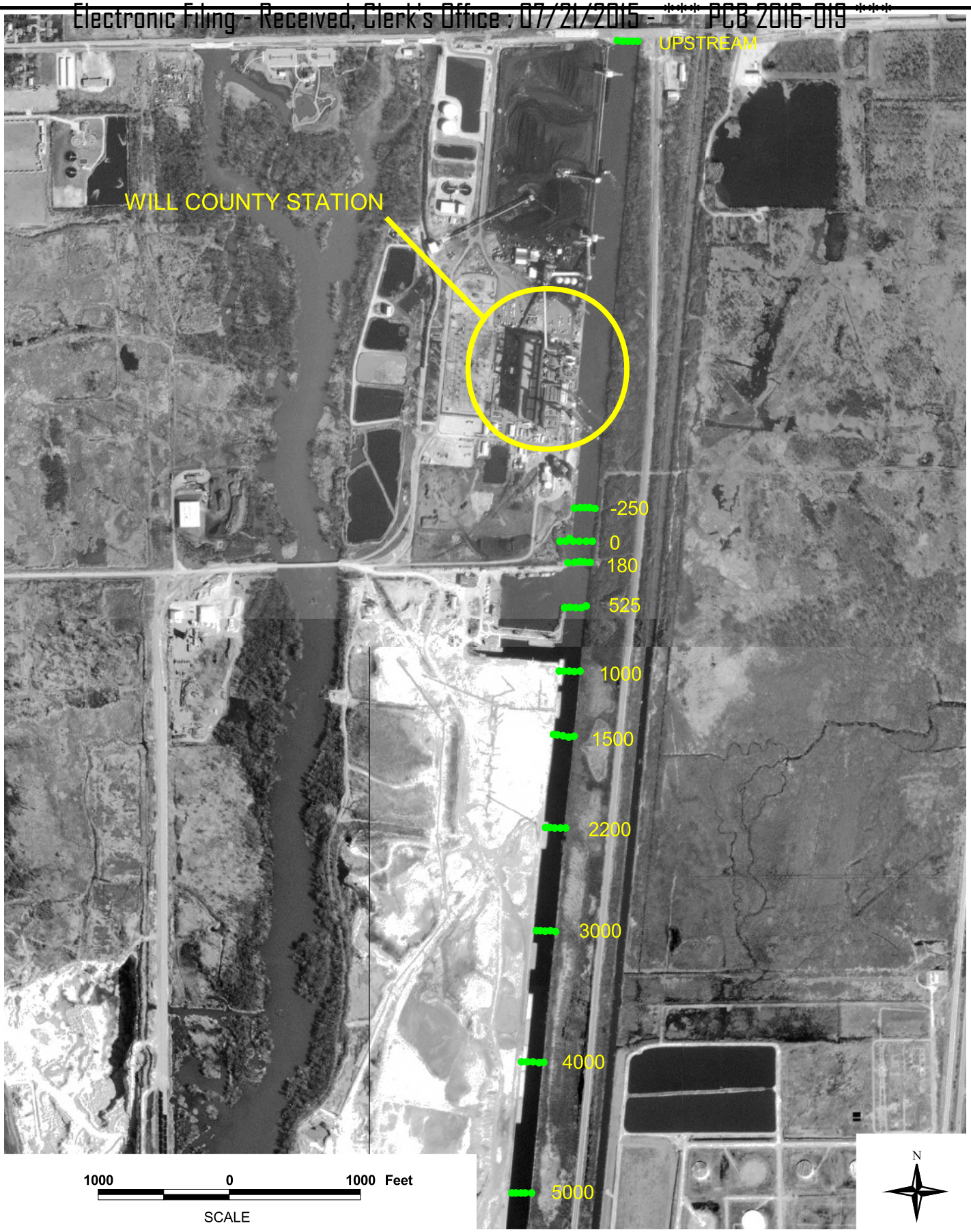
The thermal water quality standards that apply to Will County Station's mixing zone are Illinois' Secondary Contact and Indigenous Life Standards. These standards require that temperatures shall not exceed 93 F more than 5 percent of the time or 100 F at any time at the edge of the mixing zone (35 Illinois Administrative Code Section 302.408).

Cross-sectional areas enclosed by temperature contours between 84 F and 94 F were calculated for the four Will County Station thermal plume surveys (10 July, 24 July, 8 August, and 29 August) that employed the full set of 34 vertical profile stations. The

resulting cross-sectional areas reported as a percentage of the total cross-sectional area are provided in Tables 4-9 to 4-12. The zone of passage during all the surveys was greater than 75 %. At no time did water temperature exceed 100 F in the mixing zone. The highest temperature recorded was 94.9 F during the 24 July survey. During this survey 86.7 % of the water column at the discharge (0-ft) transect contained water temperatures lower than 93 F.

Tables 4-9 to 4-12 include a delta temperature column based on the average temperature of the three vertical profiles at the upstream transect. These tables indicate that the range of temperature variation in the cross-section at the discharge (0-ft) transect was 10.6 to 12.1 F and in general, the CSSC approaches a fully mixed condition at the 5,000-ft transect.

The cross-sectional area distribution as a function of delta temperature rise above the upstream temperature (ambient) is provided in Figure 4-1 for the 180-ft transect and in Figure 4-2 for the 1000-ft transect. In both figures, the temperature/area distribution for three surveys are generally very similar, while the 29 August survey lies at a slightly lower delta temperature for a given cross-sectional area. This behavior is attributed to the 29 August survey being conducted during the largest flow (3,372 cfs) in the CSSC (Table 3-1), thus providing increased dilution. The second highest flow was 3,212 cfs on 10 July. However, during the 10 July survey, Will County Station had a significantly higher delta temperature rise of 17.4 F compared to 10-12 F on the other three survey days. The larger Station delta temperature on 10 July is evident in Figure 4-1 by the higher delta temperatures associated with cross-sectional areas less than 30 percent. The higher delta temperature on this date is related to the reduced circulating water flow during the survey. During July 10 the average circulating water flow was 1863 cfs while during the other surveys flow average station flow was 2006 cfs.



ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	MIDWEST GENERATION THERMAL PLUME MAPPING NEAR JOLIET, ILLINOIS							SAMPLING LOCATIONS AT THE WILL COUNTY STATION	
PROJECT MGR.	DESIGNED BY	DRAWN BY	CHECKED BY	DATE	SCALE	PROJECT NO.	FILE NAME	DRAWING NO.	FIGURE NO.
JV		MGL	JV	DEC 2002	AS SHOWN	-			2-1

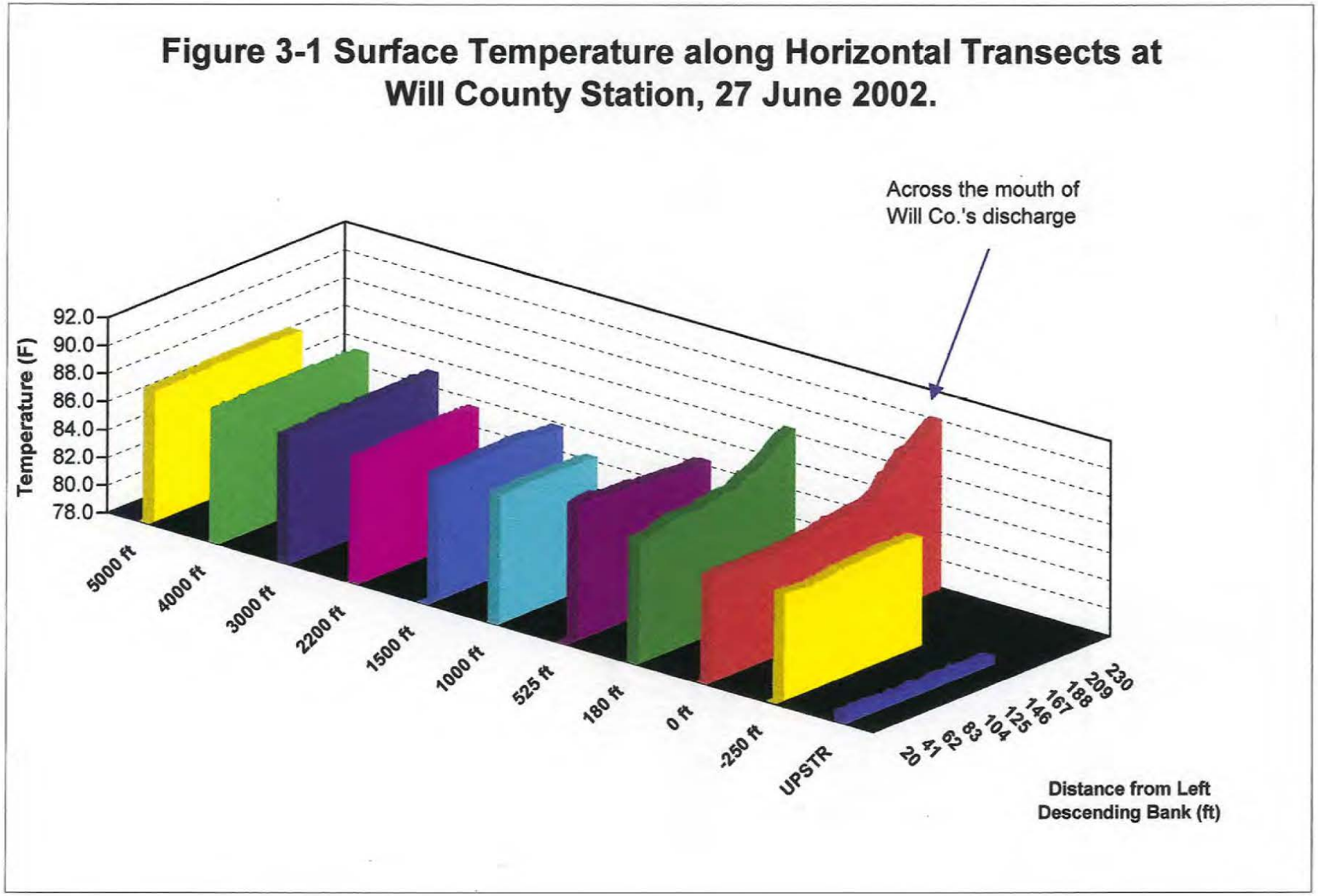


Figure 3-1 Surface Temperature along Horizontal Transects at Will County Station, 27 June 2002.
Across the mouth of Will Co.'s discharge
Temperature (F)
92.0
90.0
88.0
86.0
84.0
82.0
80.0
78.0
5000 ft
4000 ft
3000 ft
2200 ft
1500 ft
1000 ft
525 ft
180 ft
0 ft
-250 ft
UPSTR
20
41
62
83
104
125
146
167
188
209
230
Distance from Left Descending Bank (ft)

Figure 3-2 Surface Temperature along Horizontal Transects at Will County Station, 10 July 2002.

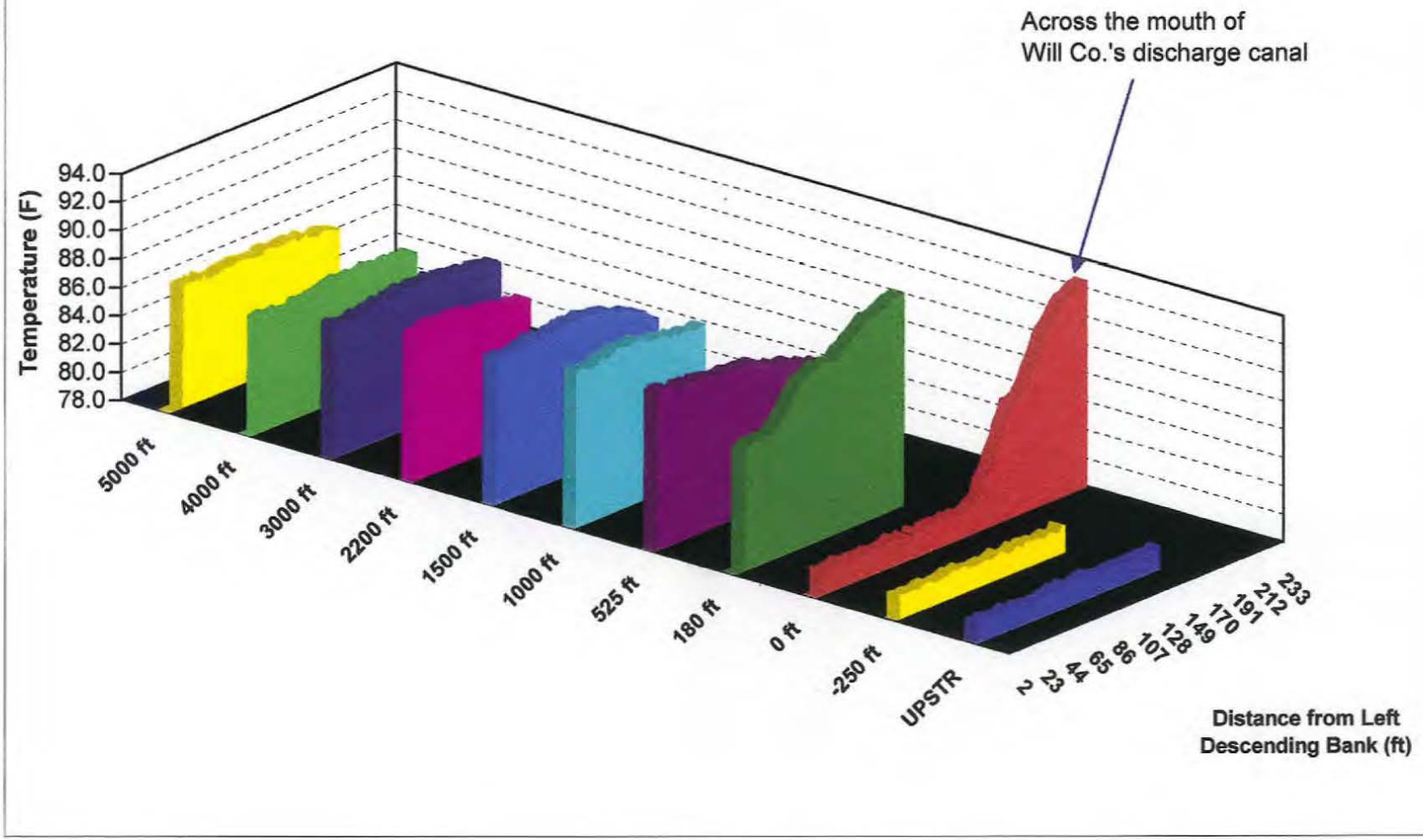


Figure 3-3 Surface Temperature along Horizontal Transects at Will County Station, 24 July 2002.

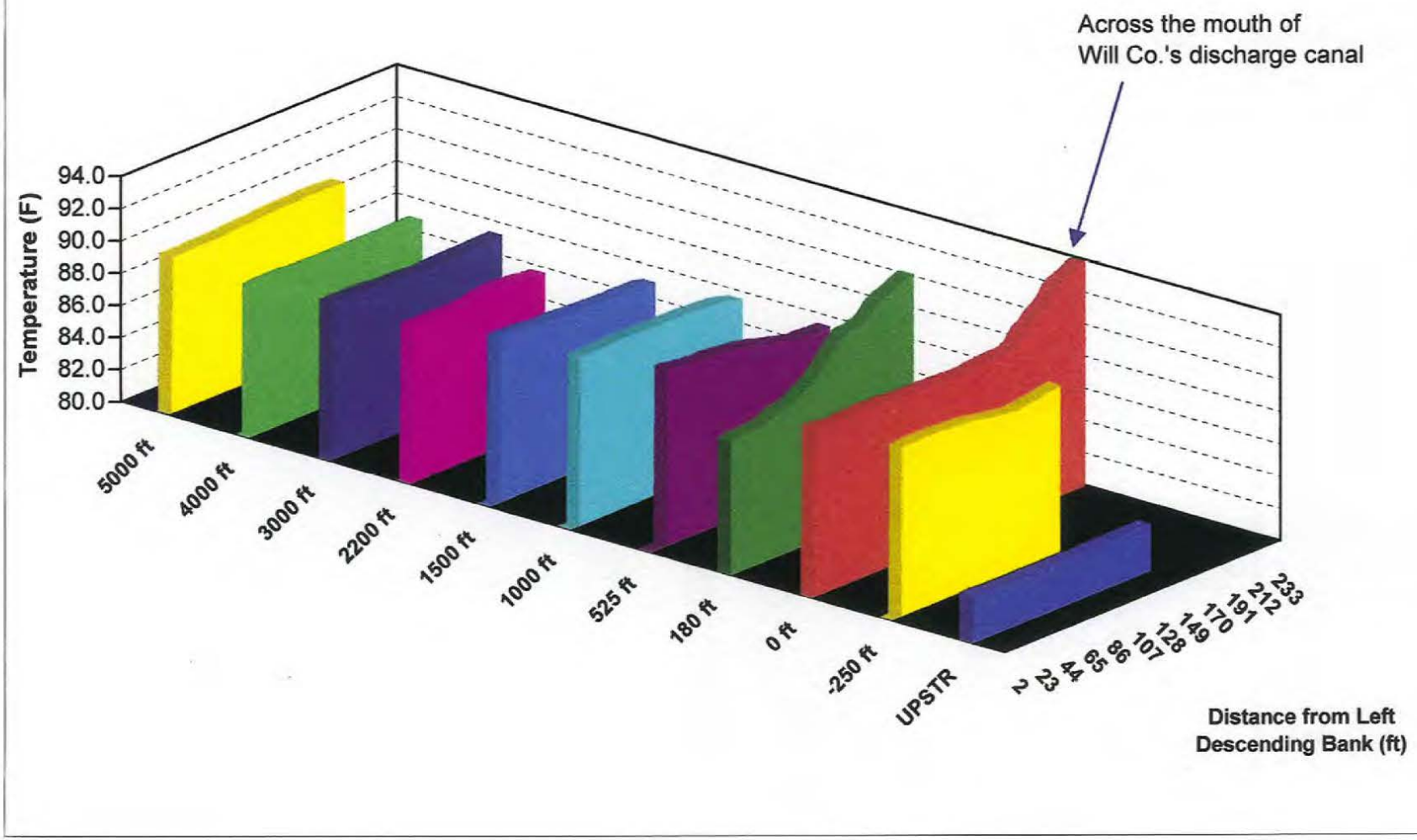


Figure 3-4 Surface Temperature along Horizontal Transects at Will County Station, 31 July 2002.

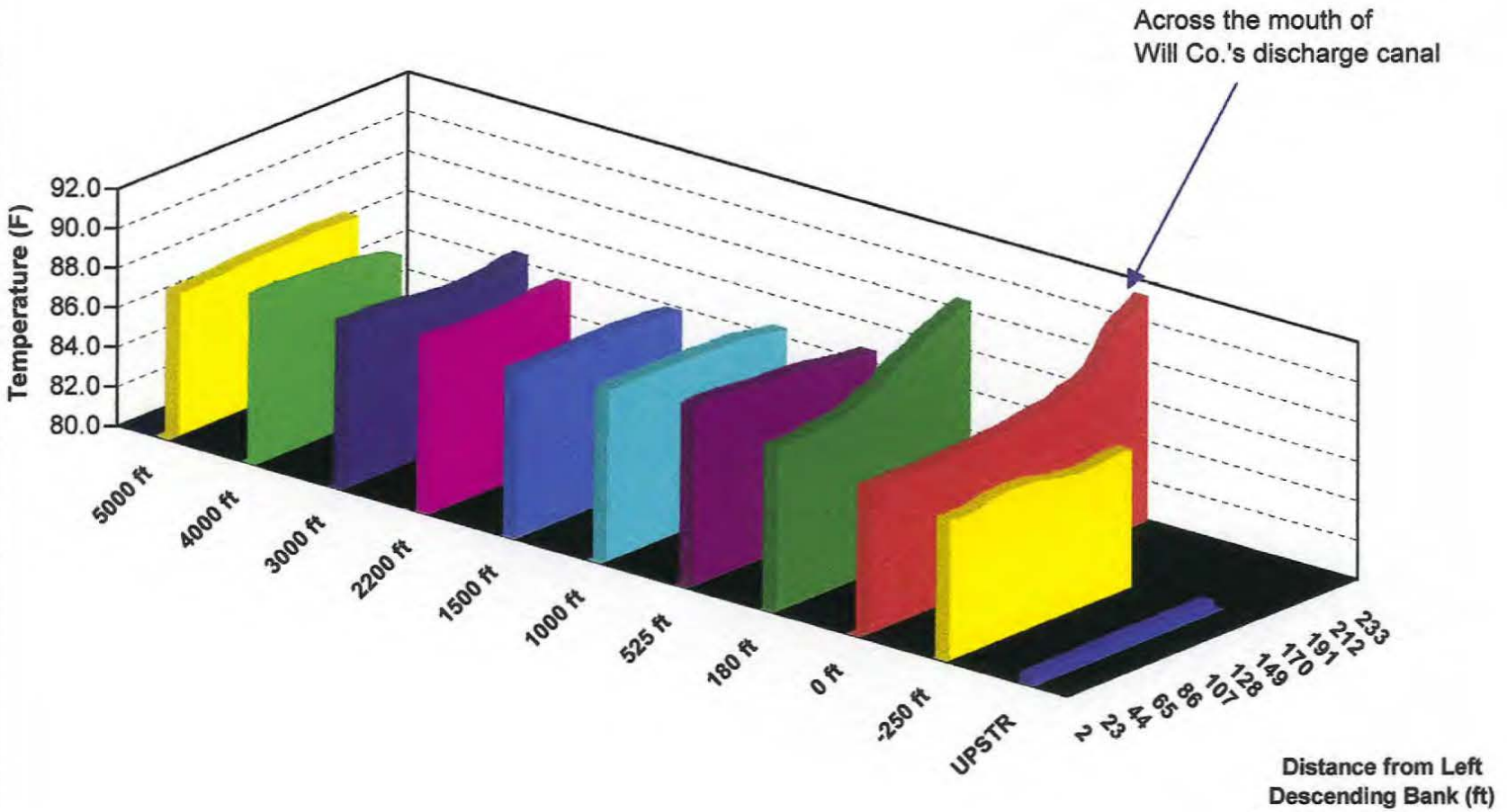


Figure 3-5 Surface Temperature along Horizontal Transects at Will County Station, 8 August 2002.

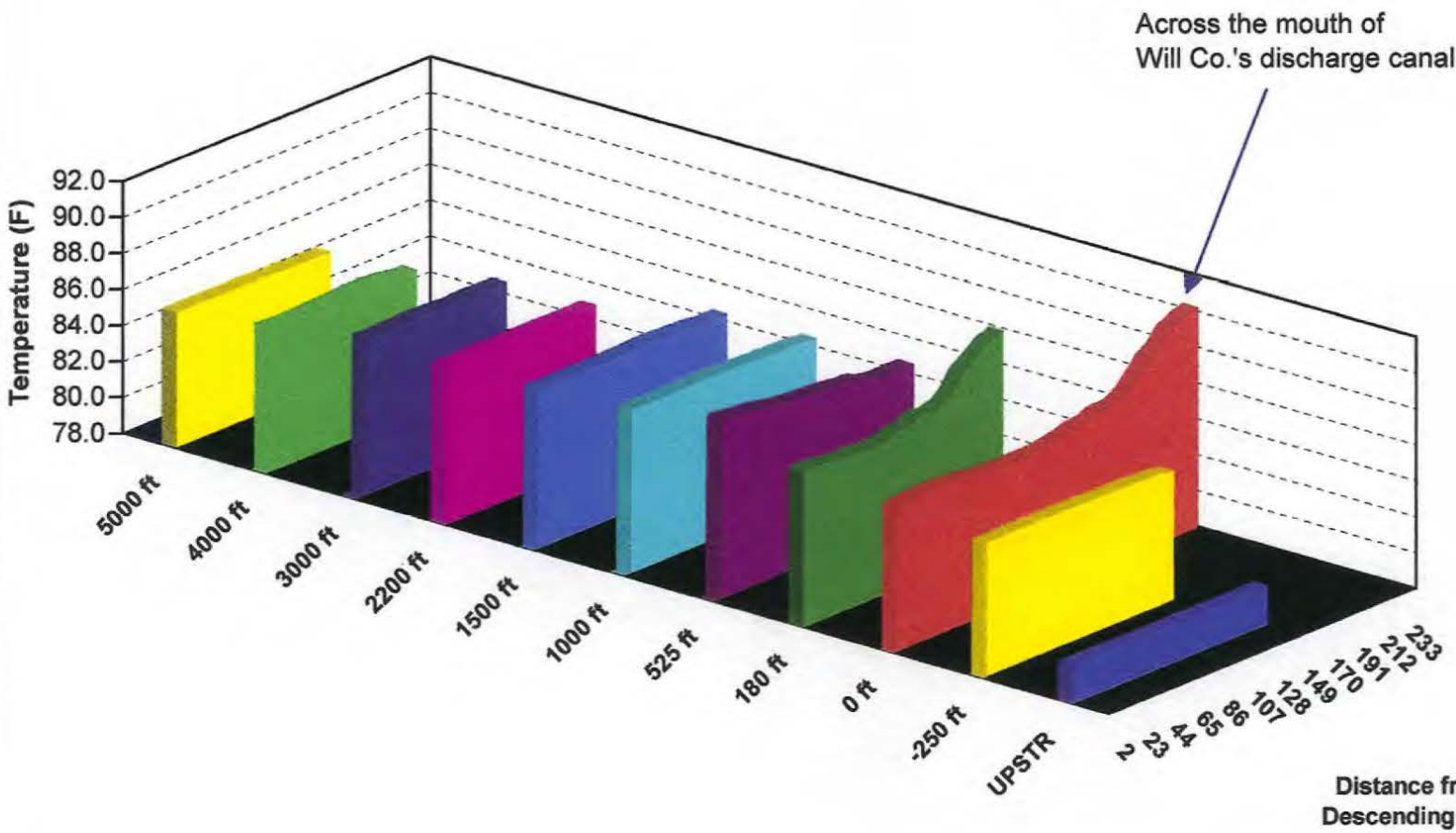


Figure 3-6 Surface Temperature along Horizontal Transects at Will County Station, 16 August 2002.

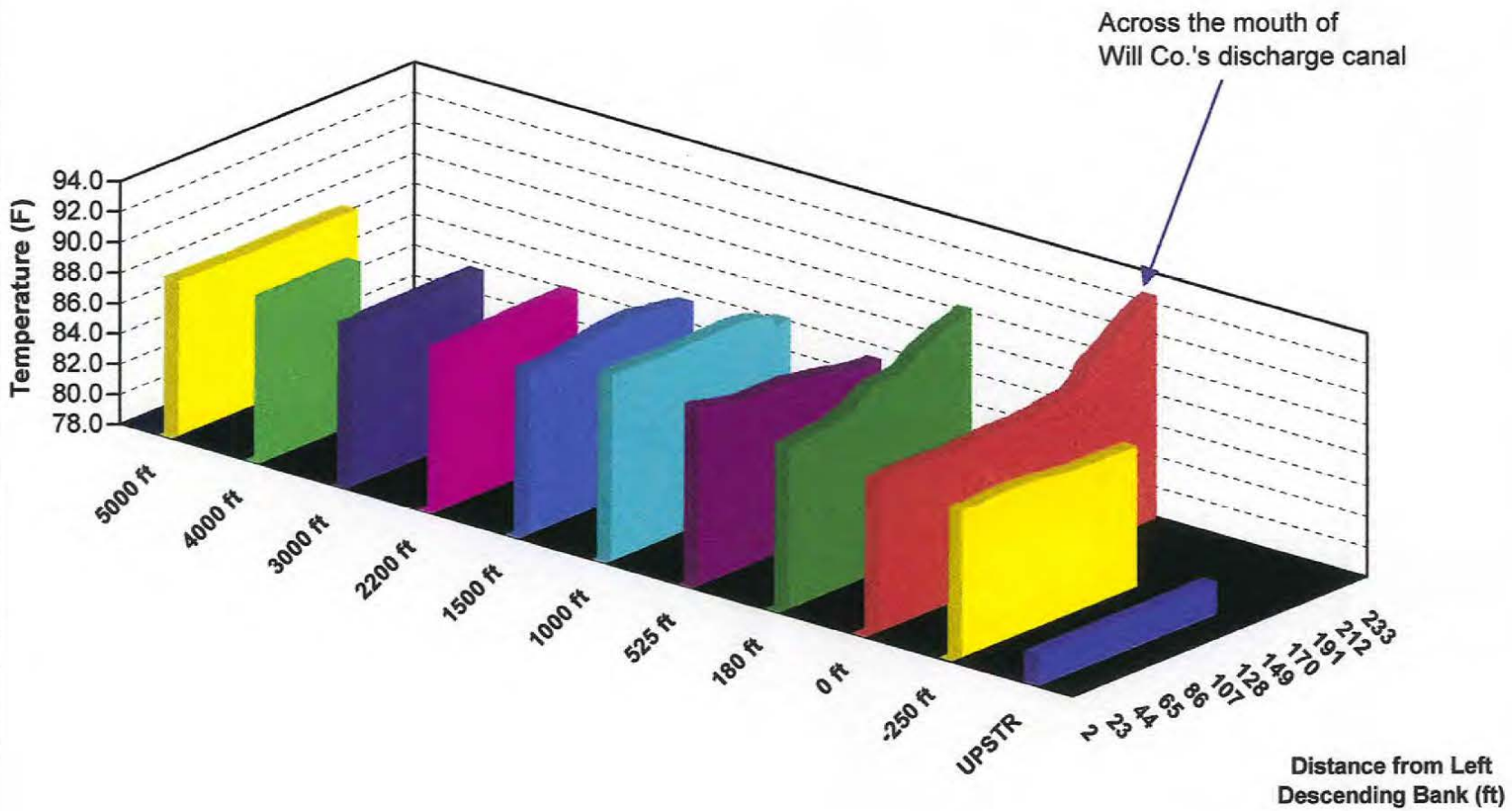


Figure 3-7 Surface Temperature along Horizontal Transects at Will County Station, 29 August 2002.

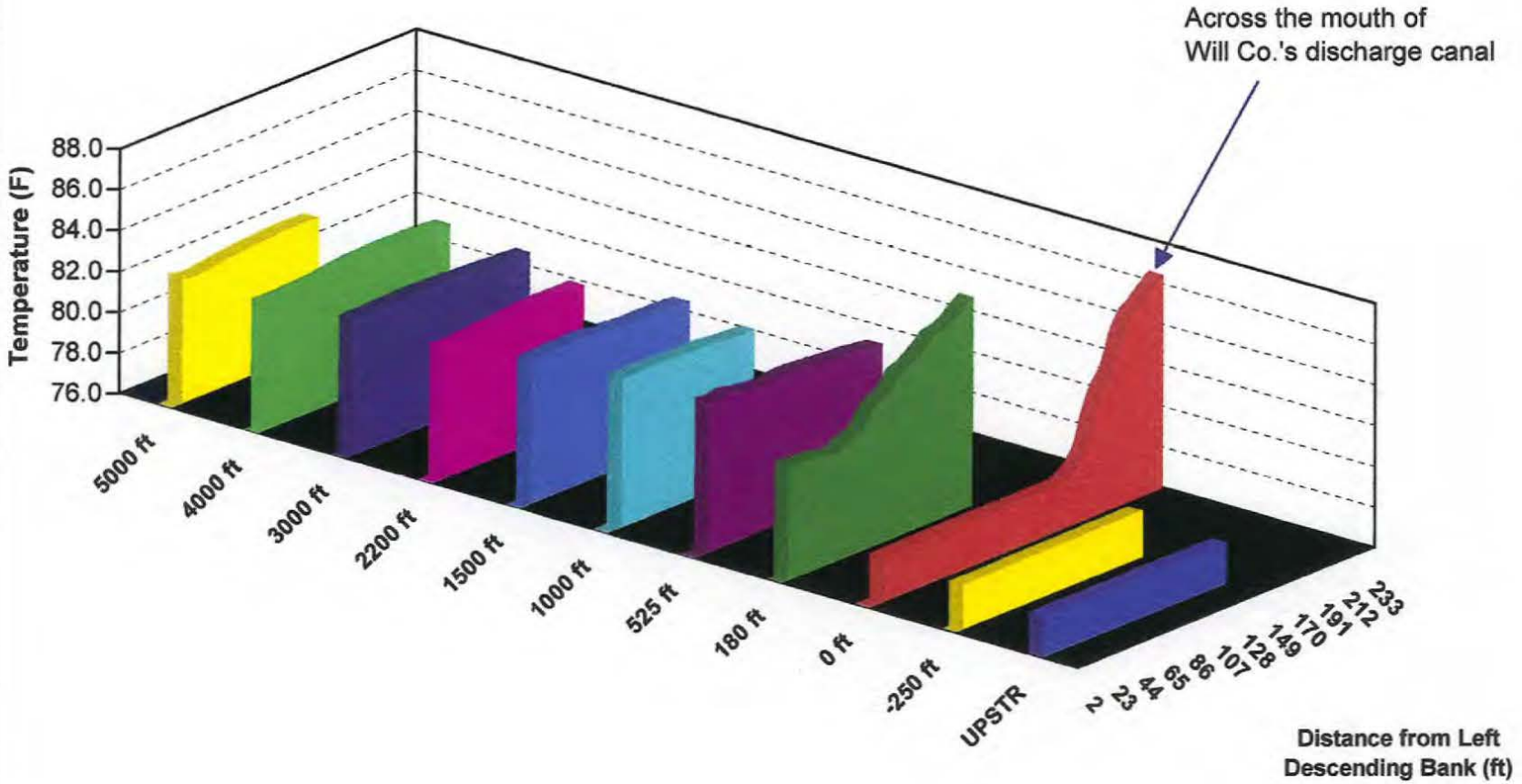


Figure 3-8 Surface Temperature along Horizontal Transects at Will County Station, 4 September 2002.

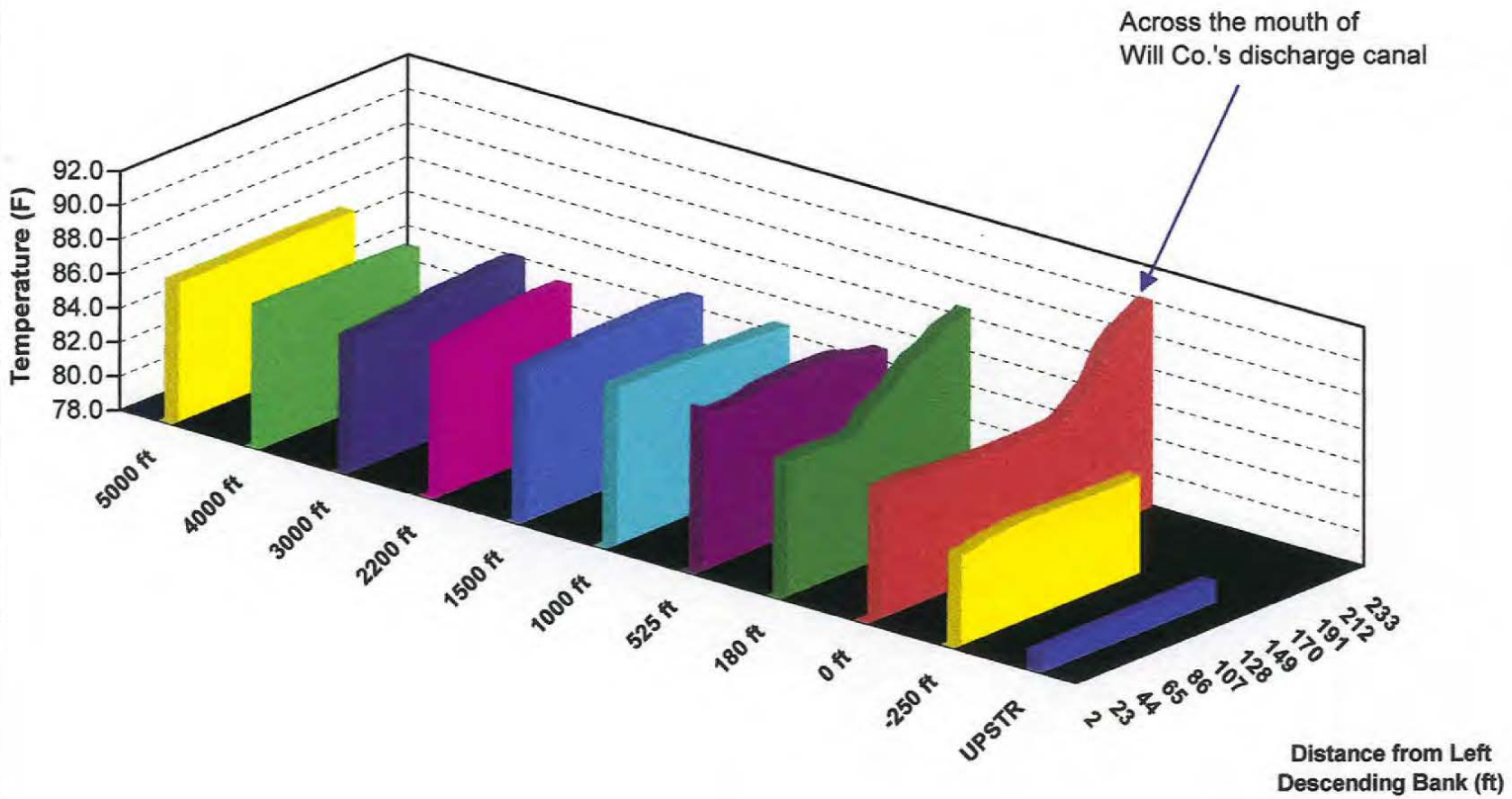


Figure 4-1 Cross-Sectional Area Temperature Distribution at the 180-ft Transect During Four Will County Station Vertical Surveys

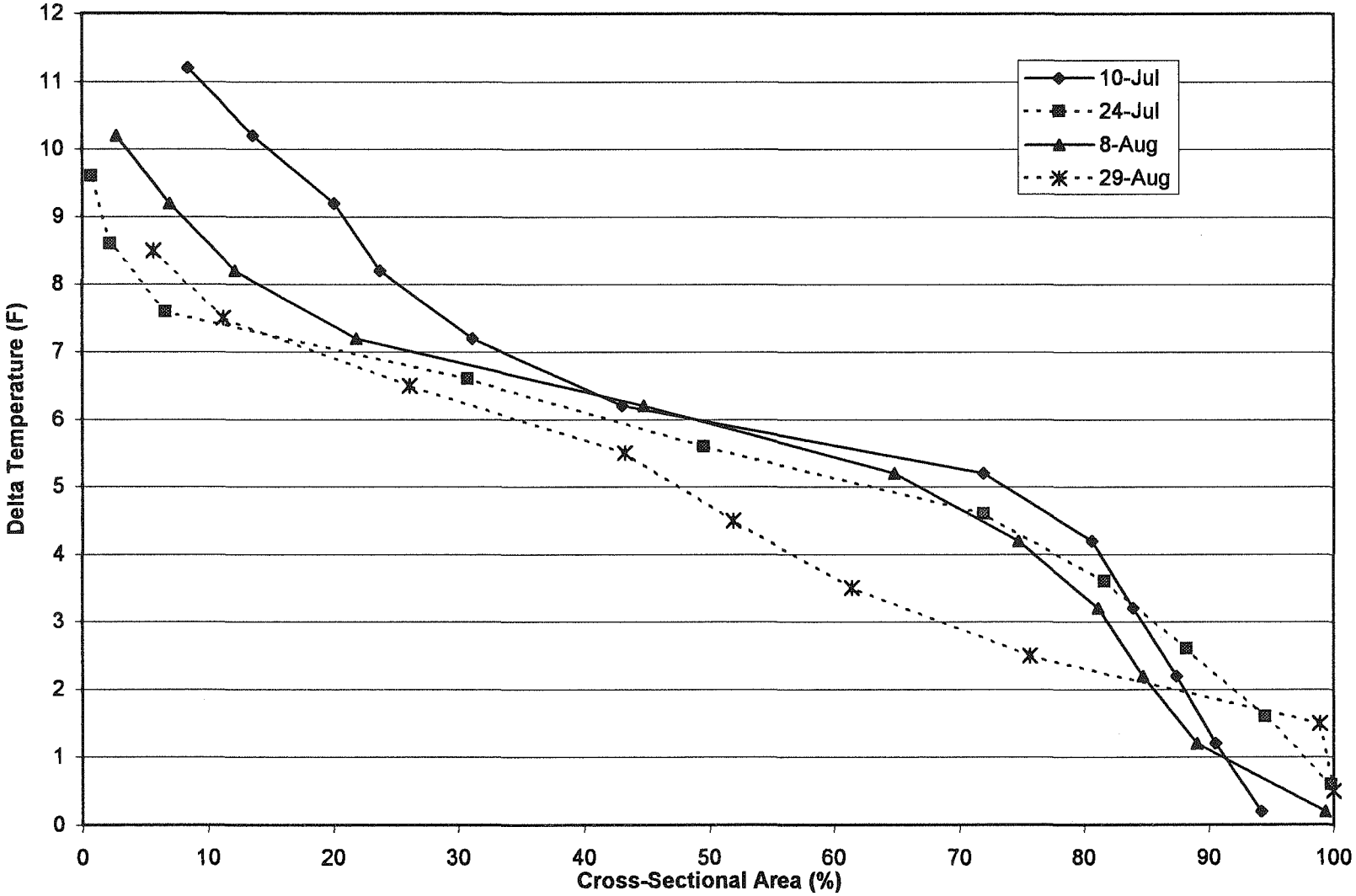


Figure 4-2 Cross-Sectional Area Temperature Distribution at the 1000-ft Transect During Four Will County Station Vertical Surveys

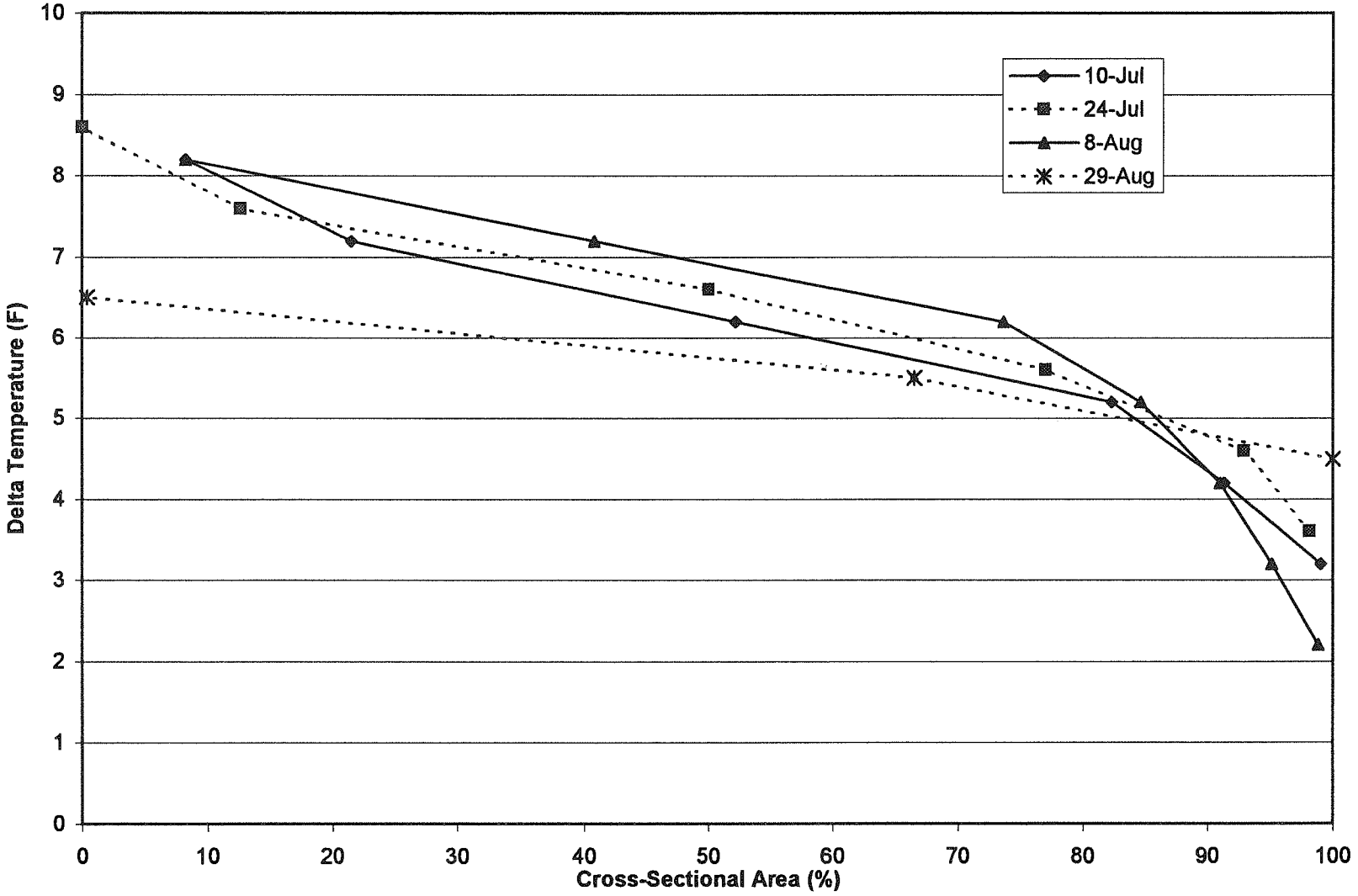


Table 3-1 Survey Times and Daily Average Will County Station Operating Parameters During the Plume Surveys

Survey	Surface Survey (time)	Vertical Survey (time)	Type
27 June	0850 -0928	0943 -1031	CL
10 July	1112 -1155	1213 -1359	3D
24 July	1023 -1152	1215 -1424	3D
31 July	1110 -1215	1225 -1353	CL
8 August	1058 -1155	1219 -1446	3D
16 August	1117 -1215	1232 -1326	CL
29 August	1001 -1047	1101 -1241	3D
4 Sept	0941 -1032	1042 -1140	CL

Daily Average Station Operating Data

Survey	PowProd (Mwe)	DelT (F)	Intake Temp (F)	Survey Temp (F) at Upstr. Transect		Intake Flow (cfs)	Canal Flow (cfs)
				Surface	Vertical		
27 June	967	12.9	79.9	78.7	78.8	2006	2617
10 July	774	17.4	79.8	79.5	79.8	1863	3212
24 July	760	10.5	83.5	82.9	83.4	2005	2735
31 July	828	12.5	82.3	80.6	83.1	2005	2871
8 August	675	10.7	80.6	80.2	80.8	2005	2772
16 August	788	12.9	80.6	80.1	80.9	2006	2804
29 August	765	11.1	78.0	78.1	78.5	2006	3372
4 Sept	885	13.5	79.7	79.3	79.8	2006	2983

Table 4-1 Will County Station Plume Areas and Surface Plume Widths at Transects During the 27 June 2002 Survey

Temperature		Del T	Area	Plume Length (ft)	
(F)	(C)	(F)	(acres)	Downstr.	Upstr.
84	28.9	5.3	>22.0	>5000	1135
85	29.4	6.3	>21.8	>5000	1080
86	30.0	7.3	>18.6	>5000	247
87	30.6	8.3	>15.9	>5000	187
88	31.1	9.3	0.5	497	127
89	31.7	10.3	0.2	355	66
90	32.2	11.3	0.1	213	6
91	32.8	12.3	0	0	0
92	33.3	13.3	0	0	0
93	33.9	14.3	0	0	0
94	34.4	15.3	0	0	0

Averge Temperature (F) at Upstr. Transect	78.7

	Surface Plume Width (%) at Survey Transects										
Transect	84 F	85 F	86 F	87 F	88 F	89 F	90 F	91 F	92 F	93 F	94 F
Upstr	0	0	0	0	0	0	0	0	0	0	0
-250 ft	100	100	0	0	0	0	0	0	0	0	0
0 ft	100	100	42.8	26.1	20.6	11.7	4.8	0	0	0	0
180 ft	100	100	100	83.8	34.8	18.6	8.2	0	0	0	0
525 ft	100	100	100	87.7	0	0	0	0	0	0	0
1,000 ft	100	100	100	100	0	0	0	0	0	0	0
1,500 ft	100	100	100	35.4	0	0	0	0	0	0	0
2,200 ft	100	100	100	75.6	0	0	0	0	0	0	0
3,000 ft	100	100	100	100	0	0	0	0	0	0	0
4,000 ft	100	100	100	100	0	0	0	0	0	0	0
5,000 ft	100	100	100	100	0	0	0	0	0	0	0

Table 4-2 Will County Station Plume Areas and Surface Plume Widths at Transects During the 10 July 2002 Survey

Temperature		Del T	Area	Plume Length (ft)	
(F)	(C)	(F)	(acres)	Downstr.	Upstr.
84	28.9	4.5	>18.4	>5000	170
85	29.4	5.5	>18.4	>5000	151
86	30.0	6.5	>17.4	>5000	131
87	30.6	7.5	11.3	3680	111
88	31.1	8.5	6.6	3013	91
89	31.7	9.5	1.6	1375	71
90	32.2	10.5	0.6	458	51
91	32.8	11.5	0.3	365	31
92	33.3	12.5	0.2	273	11
93	33.9	13.5	0	0	0
94	34.4	14.5	0	0	0

Averge Temperature (F) at Upstr. Transect	79.5

	Surface Plume Width (%) at Survey Transects										
Transect	84 F	85 F	86 F	87 F	88 F	89 F	90 F	91 F	92 F	93 F	94 F
Upstr	0	0	0	0	0	0	0	0	0	0	0
-250 ft	0	0	0	0	0	0	0	0	0	0	0
0 ft	32.4	30.9	29.1	22.9	21	18.7	16.9	12.9	7.6	0	0
180 ft	100	100	100	78.5	71.9	67.5	58.9	38.6	30.1	0	0
525 ft	100	100	100	84.7	61.2	13.9	0	0	0	0	0
1,000 ft	100	100	100	100	100	35.8	0	0	0	0	0
1,500 ft	100	100	100	87.3	70.7	0	0	0	0	0	0
2,200 ft	100	100	100	100	51.9	0	0	0	0	0	0
3,000 ft	100	100	100	94.4	2	0	0	0	0	0	0
4,000 ft	100	100	72.6	0	0	0	0	0	0	0	0
5,000 ft	100	100	100	0	0	0	0	0	0	0	0

Table 4-3 Will County Station Plume Areas and Surface Plume Widths at Transects During the 24 July 2002 Survey

Temperature		Del T	Area	Plume Length (ft)	
(F)	(C)	(F)	(acres)	Downstr.	Upstr.
84	28.9	1.1	>21.8	>5000	1060
85	29.4	2.1	>21.7	>5000	1040
86	30.0	3.1	>21.7	>5000	1015
87	30.6	4.1	>21.6	>5000	985
88	31.1	5.1	>21.5	>5000	960
89	31.7	6.1	>21.1	>5000	920
90	32.2	7.1	6.8	5000	865
91	32.8	8.1	0.7	510	214
92	33.3	9.1	0.5	403	142
93	33.9	10.1	0.2	296	70
94	34.4	11.1	0	189	0

Averge Temperature (F) at Upstr. Transect	82.9

	Surface Plume Width (%) at Survey Transects										
Transect	84 F	85 F	86 F	87 F	88 F	89 F	90 F	91 F	92 F	93 F	94 F
Upstr	0	0	0	0	0	0	0	0	0	0	0
-250 ft	100	100	100	100	100	100	79.3	0	0	0	0
0 ft	100	100	100	100	100	100	100	23.4	16.8	11.8	0
180 ft	100	100	100	100	100	67.9	54.2	46.8	38.7	22.2	5.2
525 ft	100	100	100	100	100	100	63.4	0	0	0	0
1,000 ft	100	100	100	100	100	100	92.8	0	0	0	0
1,500 ft	100	100	100	100	100	100	40.3	0	0	0	0
2,200 ft	100	100	100	100	100	100	0	0	0	0	0
3,000 ft	100	100	100	100	100	100	0	0	0	0	0
4,000 ft	100	100	100	100	100	100	0	0	0	0	0
5,000 ft	100	100	100	100	100	100	31.9	0	0	0	0

Table 4-4 Will County Station Plume Areas and Surface Plume Widths at Transects During the 31 July 2002 Survey

Temperature		Del T	Area	Plume Length (ft)	
(F)	(C)	(F)	(acres)	Downstr.	Upstr.
84	28.9	3.4	>21.9	>5000	1095
85	29.4	4.4	>21.3	>5000	870
86	30.0	5.4	>20.9	>5000	710
87	30.6	6.4	>19.7	>5000	320
88	31.1	7.4	12.5	4408	211
89	31.7	8.4	0.9	603	147
90	32.2	9.4	0.4	403	84
91	32.8	10.4	0.1	270	20
92	33.3	11.4	0	0	0
93	33.9	12.4	0	0	0
94	34.4	13.4	0	0	0

Averge Temperature (F) at Upstr. Transect	80.6

	Surface Plume Width (%) at Survey Transects										
Transect	84 F	85 F	86 F	87 F	88 F	89 F	90 F	91 F	92 F	93 F	94 F
Upstr	0	0	0	0	0	0	0	0	0	0	0
-250 ft	100	100	100	58.5	0	0	0	0	0	0	0
0 ft	100	100	100	100	30.4	18.6	14.7	5.9	0	0	0
180 ft	100	100	100	100	100	53.9	37.3	19.6	0	0	0
525 ft	100	100	100	100	100	17.6	0	0	0	0	0
1,000 ft	100	100	100	100	100	0	0	0	0	0	0
1,500 ft	100	100	100	100	100	0	0	0	0	0	0
2,200 ft	100	100	100	100	100	0	0	0	0	0	0
3,000 ft	100	100	100	100	42.5	0	0	0	0	0	0
4,000 ft	100	100	100	100	55.3	0	0	0	0	0	0
5,000 ft	100	100	100	100	0	0	0	0	0	0	0

Table 4-5 Will County Station Plume Areas and Surface Plume Widths at Transects During the 8 August 2002 Survey

Temperature		Del T	Area	Plume Length (ft)	
(F)	(C)	(F)	(acres)	Downstr.	Upstr.
84	28.9	3.8	>21.8	>5000	1065
85	29.4	4.8	>20.3	>5000	440
86	30.0	5.8	14.3	4217	221
87	30.6	6.8	2.9	1385	169
88	31.1	7.8	0.4	515	116
89	31.7	8.8	0.2	342	64
90	32.2	9.8	0	143	12
91	32.8	10.8	0	0	0
92	33.3	11.8	0	0	0
93	33.9	12.8	0	0	0
94	34.4	13.8	0	0	0

Averge Temperature (F) at Upstr. Transect	80.2

Transect	Surface Plume Width (%) at Survey Transects										
	84 F	85 F	86 F	87 F	88 F	89 F	90 F	91 F	92 F	93 F	94 F
Upstr	0	0	0	0	0	0	0	0	0	0	0
-250 ft	100	100	0	0	0	0	0	0	0	0	0
0 ft	100	100	68.7	23.8	18.7	12.7	5.4	0	0	0	0
180 ft	100	100	100	41.4	25.6	16.8	0	0	0	0	0
525 ft	100	100	100	72.5	0	0	0	0	0	0	0
1,000 ft	100	100	100	71.3	0	0	0	0	0	0	0
1,500 ft	100	100	100	0	0	0	0	0	0	0	0
2,200 ft	100	100	100	0	0	0	0	0	0	0	0
3,000 ft	100	100	100	0	0	0	0	0	0	0	0
4,000 ft	100	100	39.1	0	0	0	0	0	0	0	0
5,000 ft	100	100	0	0	0	0	0	0	0	0	0

Table 4-6 Will County Station Plume Areas and Surface Plume Widths at Transects During the 16 August 2002 Survey

Temperature		Del T	Area	Plume Length (ft)	
(F)	(C)	(F)	(acres)	Downstr.	Upstr.
84	28.9	3.9	>22.1	>5000	1190
85	29.4	4.9	>21.8	>5000	1065
86	30.0	5.9	>21.4	>5000	890
87	30.6	6.9	>20.3	>5000	445
88	31.1	7.9	>18.3	>5000	236
89	31.7	8.9	4.0	1947	184
90	32.2	9.9	1.0	1103	132
91	32.8	10.9	0.3	371	81
92	33.3	11.9	0.1	260	29
93	33.9	12.9	0	0	0
94	34.4	13.9	0	0	0

Averge Temperature (F) at Upstr. Transect	80.1

	Surface Plume Width (%) at Survey Transects										
Transect	84 F	85 F	86 F	87 F	88 F	89 F	90 F	91 F	92 F	93 F	94 F
Upstr	0	0	0	0	0	0	0	0	0	0	0
-250 ft	100	100	100	100	0	0	0	0	0	0	0
0 ft	100	100	100	100	42.4	26.4	22.1	15.1	8.3	0	0
180 ft	100	100	100	100	100	68.4	55.4	32.1	18.2	0	0
525 ft	100	100	100	100	82	23.5	0	0	0	0	0
1,000 ft	100	100	100	100	100	97.2	72.8	0	0	0	0
1,500 ft	100	100	100	100	100	51	0	0	0	0	0
2,200 ft	100	100	100	100	100	0	0	0	0	0	0
3,000 ft	100	100	100	100	100	0	0	0	0	0	0
4,000 ft	100	100	100	100	100	0	0	0	0	0	0
5,000 ft	100	100	100	100	100	0	0	0	0	0	0

Table 4-7 Will County Station Plume Areas and Surface Plume Widths at Transects During the 29 August 2002 Survey

Temperature		Del T	Area	Plume Length (ft)	
(F)	(C)	(F)	(acres)	Downstr.	Upstr.
81	27.2	2.9	>18.4	>5000	167
82	27.8	3.9	>17.9	>5000	136
83	28.3	4.9	4.0	1721	105
84	28.9	5.9	0.5	448	75
85	29.4	6.9	0.2	325	44
86	30	7.9	0.1	202	13
87	30.6	8.9	0	0	0
88	31.1	9.9	0	0	0
89	31.7	10.9	0	0	0
90	32.2	11.9	0	0	0
91	32.8	12.9	0	0	0

Averge Temperature (F) at Upstr. Transect	78.1

	Surface Plume Width (%) at Survey Transects										
Transect	81 F	82 F	83 F	84 F	85 F	86 F	87 F	88 F	89 F	90 F	91 F
Upstr	0	0	0	0	0	0	0	0	0	0	0
-250 ft	0	0	0	0	0	0	0	0	0	0	0
0 ft	24.3	21.9	17.9	16.0	12.9	5.7	0	0	0	0	0
180 ft	100	59.1	50.4	39.6	26.0	8.8	0	0	0	0	0
525 ft	100	100	70.7	0	0	0	0	0	0	0	0
1,000 ft	100	100	100	0	0	0	0	0	0	0	0
1,500 ft	100	100	32.3	0	0	0	0	0	0	0	0
2,200 ft	100	100	0	0	0	0	0	0	0	0	0
3,000 ft	100	100	0	0	0	0	0	0	0	0	0
4,000 ft	100	100	0	0	0	0	0	0	0	0	0
5,000 ft	100	97.2	0	0	0	0	0	0	0	0	0

Table 4-8 Will County Station Plume Areas and Surface Plume Widths at Transects During the 4 September 2002 Survey

Temperature		Del T	Area	Plume Length (ft)	
(F)	(C)	(F)	(acres)	Downstr.	Upstr.
84	28.9	4.7	>19.3	>5000	242
85	29.4	5.7	>19.1	>5000	202
86	30.0	6.7	>15.6	>5000	162
87	30.6	7.7	5.4	2470	122
88	31.1	8.7	0.5	451	82
89	31.7	9.7	0.3	337	43
90	32.2	10.7	0.1	223	3
91	32.8	11.7	0	0	0
92	33.3	12.7	0	0	0
93	33.9	13.7	0	0	0
94	34.4	14.7	0	0	0

Averge Temperature (F) at Upstr. Transect	79.3

	Surface Plume Width (%) at Survey Transects										
Transect	84 F	85 F	86 F	87 F	88 F	89 F	90 F	91 F	92 F	93 F	94 F
Upstr	0	0	0	0	0	0	0	0	0	0	0
-250 ft	0	0	0	0	0	0	0	0	0	0	0
0 ft	100	90.3	28.4	23.2	20.6	15.3	5.5	0	0	0	0
180 ft	100	100	59.8	51.9	41.4	29.3	15.2	0	0	0	0
525 ft	100	100	100	61.2	0	0	0	0	0	0	0
1,000 ft	100	100	100	58.1	0	0	0	0	0	0	0
1,500 ft	100	100	100	63.4	0	0	0	0	0	0	0
2,200 ft	100	100	100	70	0	0	0	0	0	0	0
3,000 ft	100	100	63.4	0	0	0	0	0	0	0	0
4,000 ft	100	100	68.4	0	0	0	0	0	0	0	0
5,000 ft	100	100	100	0	0	0	0	0	0	0	0