APPENDIX D

Engineering and Hydrological Information: Dresden Nuclear Station Operations and Hydrothermal Analysis

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1.0 LOCATION

The Dresden Nuclear Station (DNS) is located in Northern Illinois, approximately 15 miles southwest of Joliet at the confluence of the Des Plaines and Kankakee Rivers where they join to form the Illinois River. DNS operates two nuclear generating units capable of generating 2,006 net megawatts. Unit 1, the original nuclear generating unit, was permanently shut down in 1978.

The cooling pond for DNS is located southeast of the Station. The cooling pond was formed by constructing an impervious earth-fill ring dike having an area of approximately 1,275 acres. It extends north of Lorenzo Road/Pine Bluff Road from Dresden Road to the BNSF Railroad right-of-way to a line about 250 feet south of the Kankakee River. The cooling pond has an average depth of 8 feet at the normal pool elevation of 522.0 ft., and the top of the dike is at El. 527.0 ft (all elevations in this report refers to Mean Sea Level).

The station specific location map can be found in Figure D-1.

2.0 FACILITY OVERVIEW

DNS is a nuclear-fueled steam electric generating facility located at the confluence of the Des Plaines and Kankakee Rivers near Morris, Illinois, at River Mile 272.3. Unit 1 started commercial service on 1 August 1960. Unit 2 started commercial service on 13 April, 1970 and Unit 3 started commercial service on 22 July 1971. Dresden Unit 1 was permanently shut down in 1978 and is in long term safe storage. In 2004, the Nuclear Regulatory Commission granted Dresden Units 2 and 3 a 20-year extension of their operating licenses until 2029 and 2031, respectively. The two boiling water reactors have a combined maximum generating capacity of 1,824 megawatts electric.

Circulating water used to cool and condense steam from the generating process is discharged to a hot canal that flows to a Lift Station were the water is pumped to the cooling pond. The Station discharges wastewater in accordance with a National Pollutant Discharge Elimination System (NPDES) Permit No. IL0002224, which was issued by Illinois EPA on 1 December 2011.

DNS normally operates in a Closed Cycle mode from 1 October through 14 June of each year. In this mode, approximately 1,000,000 gallons per minute (gpm) of cooling water is drawn into the Station's intake structure, passes through the Station's heat exchangers, and discharges to a Hot Canal that routes the water approximately two miles to the Lift Station. The Lift Station is used to transfer the cooling water from the Hot Canal up to the cooling pond. The cooling water flows through the cooling pond and over a spillway into the cold canal. The water continues to flow through the cold canal approximately two miles back to the Station. Flow Regulating Gates are used to direct the majority of the cooling water back to the intake structure for reuse. A small portion of the water is diverted as blowdown flow, approximately 72 million gallons per day (mgd), to the Illinois River via the 2/3 discharge canal (Outfall 002). Makeup water is obtained through the Station's Kankakee River intake.

Dresden's current NPDES permit authorizes the Station to operate in an Indirect Open Cycle mode from 15 June to 30 September of each year. In the Indirect Open Cycle mode, cooling water flow mimics the closed cycle process. However, the Flow Regulating Gates divert all the cooling water from the Cold Canal to the Illinois River via 2/3 Discharge Canal (Outfall 002). The maximum design flow during Indirect Open Cycle operation is 1,548 million gallon per day (mgd). This cooling water flow is withdrawn through the Kankakee River intake. The Illinois Pollution Control Board ("IPCB") approved this operational arrangement and the related alternate thermal limits on 9 July 1981, (IPCB #79-134).

The Lift Station is equipped with six lift pumps, each with a 167,000-gpm capacity. The lift pumps provide motive force that allows the cooling water to flow around the cooling pond, over the spillway, through the Cold Canal to the Flow Regulating Gates. The operation of six lift pumps ensures appropriate lift station capacity to transfer water from the Hot Canal to the cooling pond.

3.0 INTAKE SYSTEM

The Kankakee River is the only surface water intake source for cooling water. Approximately 100 feet from the source, river water enters the intake canal and splits into two canals, one for Unit 1 (that is shutdown) and the other for Units 2 and 3. The Unit 2 and 3 Intake Canal continues for approximately 2400 ft to the Unit 2/3 Crib House.

When both units are at power, cooling water flows through the Unit 2 and 3 condensers and service water systems at a rate that varies from 688,000 gallons per minute (gpm) (1,533 cfs) in the winter to 1,017,000 gpm (2,266 cfs) during the summer.

Cooling water routed through the plant discharges to the Hot Canal. The Hot Canal routes the cooling water approximately 2.5 miles south to the Lift Station which lifts the cooling water approximately 23 feet into the 1,275-acre elevated cooling pond. Cooling water takes between 2.5 to 3.5 days to route around the cooling pond to the Discharge Weir Gates (spillway) located just south of the Lift Station. Cooling water drops approximately 20 feet over the Spillway into the Cold Canal that routes approximately 2.5 miles back to the plant. The returning cooling water can be diverted to the Illinois River or be routed back to the intake canal (depending on which Cycle is in operation).

For 8½ months of the year (1 October to 14 June), the cooling water system is configured in a mode referred to as "closed-cycle with blowdown flow". In this mode, the majority of the cooling water flow is routed back to the intake canal with 50,000 gpm (111 cfs) diverted (blowdown) to the Illinois River. During very cold winters the local emergency management agency operates a siphon system that can divert up to 70,000 gpm (156 cfs) from the cooling pond to the Kankakee River. The siphon lines can be operated twice per year for two-week periods. During these periods, the cooling water system is operated in the closed-cycle mode with no diversion of flow to the Illinois River.

For 3½ months of the year (15 June to 30 September), all the cooling water flows required for Units 2 and 3 are taken directly from the Kankakee River, routed once through the cooling pond, and then, discharged to the Illinois River. This 'once-through' cooling mode is called "indirect open-cycle".

The cooling water system is allowed by the NPDES permit to operate in the "direct open-cycle" mode when both units are shutdown. In this mode the cooling pond is bypassed and all cooling water is routed from the Kankakee River through the plant cooling systems then directly out to the Illinois River.

The intake canal is 2,400 feet long, 56 feet wide and 13 feet deep. The river bottom at the intake canal is at El. 492.0 feet. A floating log boom is installed at the canal entrance to deflect floating debris. The invert of the intake canal for Units 2 and 3, which is separate from the old Unit 1 canal, is at El. 495.0 feet sloping down to El. 482.5 feet at the screen house.

The screen house has six intake bays, each with trash racks that have 0.5-inch x 3.0-inch steel bars spaced 2½ inches apart. A motorized trash rake is used to remove debris that collects on the trash rack. Behind the trash racks, each of the main intake bays is divided in half creating 12 bays to accommodate stop logs and traveling water screens. The stop log slots allow stop logs to be inserted into each bay in order to isolate the bay. The 12 traveling screens are located behind the stop log slots. These vertical traveling screens are located 32 feet downstream of the trash racks. Each screen is 10 feet wide with ⅜-inch mesh. The screens can rotate at either 2.3 or 10 feet per minute. Debris is washed off the screens and into a debris trough by rear spray wash systems. Service water pumps provide 630 gpm of spray wash water at 80 pounds per square inch. The debris troughs lead to a trash collection basket that is emptied periodically. The screens can be rotated manually, but will activate automatically at a pressure differential of 6 inches across the screens.

Downstream of the traveling water screens the intake bays recombine back into 6 bays. Five of the six bays contain a service water pump (15,000 gpm). The service water pumps are located approximately 15 feet behind the traveling screens. Each bay contains a circulating water pump (157,000 gpm) located approximately 25 feet behind the service water pumps. All six circulating water pumps have a 1,750 horsepower motor and are rated to provide 394 cfs at a 36-foot head and 236 revolutions per minute. The pump bellmouth inlets are located at El. 494.5 ft. With all pumps operating under once-through operation, the total flow is 2,364 cfs. Under closed-cycle operation, makeup water to replace evaporative losses amounts to approximately 111 cfs.

4.0 DISCHARGE SYSTEM

4.1 Physical Description

DNS has two separate discharge canals. One discharged cooling water from Unit 1 condenser, which is shutdown, and the other discharges water from the return canal of the cooling pond. To completely understand the discharge from the Units 2 and 3 canal, a brief explanation of the cooling pond and discharge flume follows:

Cooling water, once passed through the cooling condensers, exits the plant through the Units 2 and 3 discharge flume where it becomes the Hot Canal, which is approximately 8,500 feet long and 57 feet wide. A lift station with six 167,000 gpm pumps is located at the end of the Hot

Canal adjacent to the cooling pond. The lift station raises about 1,000,000 gpm of this hot water approximately 22 feet and discharges it into the cooling pond. The water then circulates through the pond in a clockwise direction for 2.5-3.5 days where it meets the Discharge spillway gates (adjacent to the lift station). Discharge is controlled by a adjusting the spillway gates. The pond discharge water then flows through the Cold Canal which runs parallel to the Hot Canal and is returned to a point near the Units 2 and 3 crib house intake. Gate structures in the return canal, intake canal, and river discharge canal are used to regulate the division of flow for recirculation and discharge to the Illinois River.

The cooling system operates closed cycle from the 1 October through the 14 June each year. Discharge to the Illinois River during the closed cycle mode consists essentially of cooling pond blowdown that averages approximately 50,000 gpm. Blowdown discharge is used for controlling dissolved solids in the cooling pond system.

4.2 Supporting Cooling Towers

The Cold Canal and Hot Canal cooling system is used to provide supplemental cooling capacity to the cooling pond prior to water being discharged back to the Illinois River. The canal cooling tower systems are once-through systems and are comprised of two sub-systems: the Hot Canal cooling towers and the Cold Canal cooling tower. The Hot Canal cooling towers take suction from the hot canal, cool the water via a counter flow of air, and discharge back into the hot canal downstream of the suction supply. The Cold Canal system takes suction from the cold canal, cools the water via a counter flow of air, and discharges back to the cold canal downstream of the suction supply.

4.3 Applicable Thermal Plume Limits

Condenser cooling water is withdrawn from the Kankakee River and ultimately discharged to the Illinois River, which is formed by the confluence of the Kankakee River and larger Des Plaines River. Under low river flow conditions, a high percentage of the condenser cooling water is pulled into the Intake Canal from the Des Plaines River. This percentage increases as flow in the Kankakee River decreases.

The following is an overview of Current Temperature Monitoring Methodology/ Standards listed in Dresden NPDES Permit No. IL 0002224:

Thermal limits, that are set forth in Special Condition 3, are based on Illinois environmental regulations and studies and demonstrations performed under §316(a) of the Clean Water Act, that were approved by the Illinois Pollution Control Board (IPCB) Order PBC 79-134 in 1981. In PCB 79-134, the Board approved Alternative Thermal Limits (ATLs) for DNS pursuant to §316(a). In accordance with the Board's Order, the NPDES Permit sets thermal limits for much of the year based on the generally applicable thermal standards of 35 Ill. Admin. Code 302.211(d) and 302.211(e), and sets ATLs for the 15 June through 30 September time period.

The Permit limits, which are based on Section 302.211(d) and (e), restrict the Plant's thermal discharge from causing natural temperatures in the Illinois River to rise above 5ºF, and from causing River temperatures to exceed 60ºF and 90ºF in the winter and summer, respectively, with an allowance of 3ºF above these maximum temperatures for 1% of the hours per calendar year. Compliance with these limits is measured at the edge of a mixing zone. The ATLs in the Permit restrict the temperature of Plant's discharge from 15 June through 30 September to 90ºF, with an allowance to exceed 90ºF up to 3ºF for 10% of the hours available during that time period. Compliance with the ATL is measured end of pipe discharge point from DNS to the River.

The plant's existing thermal limits are summarized in Table 1-1.

Table 1-1. Existing Thermal Limits for Dresden Nuclear Station

Current Temperature Limits				
Month	End of Mixing Zone		End of Pipe	
	Excursion Threshold Temperature (°F)	Current Maximum Excursion Temperature (°F)[2]	Excursion Threshold Temperature (°F)[1]	Current Maximum Excursion Temperature (°F)[2]
January	60	63	-	-
February	60	63	-	-
March	60	63	-	-
April	90	93	-	-
May	90	93	-	-
1-15 June	90	93	-	-
15-30 June	-	-	90	93
July	-	-	90	93
August	-	-	90	93
September	-	-	90	93
October	90	93	-	-
November	90	93	-	-
December	60	63	-	-

5.0 THERMAL PLUME MAPPING AND MODELING STUDY

5.1 Introduction

A thermal plume mapping and modeling study for DNS was conducted in 2013 and 2014. The study included performing two thermal plume surveys in 2013 and one survey in 2014 (Figure D-2). The resulting data were used to develop a 3-dimensional hydrodynamic model that was executed to examine the existing end of discharge canal permit condition and alternative plume configurations during 15 June to 30 September when DNS is operating in indirect open-cycle cooling mode. The DNS cooling water system operates in closed cycle mode throughout the rest of the year. The model output was used as a tool to execute additional scenarios in support of the biothermal assessment in Appendix B.

During indirect open-cycle operation, DNS has two operating units (Units 2 and 3) that draw water from an intake canal on the Kankakee River. The DNS's discharge canal is on the Dresden Pool (i.e., Illinois River), approximately 1,000 meters upstream from the Dresden Island Lock and Dam, and 1,300 meters downstream from the confluence of the Kankakee and Des

Plaines Rivers. Cooling water is pumped via six circulating water pumps each rated at 255 mgd. Thus, the maximum design flow for Units 2 and 3 together is 1,528 mgd (2,364 cfs). The DNS total output is 1,824 MWe with each unit rated at 912 MWe.

5.2 Dresden Nuclear Station and River Conditions

5.2.1 Dresden Nuclear Station

Hourly DNS operating data were obtained for the 2003 to 2014 period. In addition, hourly station discharge temperatures were available from 1998 to 2014. The data sets contained a gap from July 2003 to November 2005. Frequency distributions by month are provided in Table D-1 for intake and discharge temperatures and in Table D-2 for discharge flow and power production. The tables are provided for only the indirect open-cycle operating period, 15 June to 30 September. Identifiable spurious data were removed from the data sets. The highest discharge temperatures were during July with a median (50-percentile) temperature of 30.8°C (87.4°F) and the upper 10-percentile temperatures were above 32.6°C (90.7°F). The upper 10-percentile August discharge temperatures were 32.2°C (89.9°F). In June and September approximately 3.5 percent and less than 1 percent of the temperature were above 32.2°C (90°F), respectively. Discharge flows were almost always at 1,465 mgd and power production was above 1,800 MWe (98 percent capacity) 85 percent of the time during the 15 June to 30 September period (Table D-2).

The number of hours with discharge temperatures greater than 32.2°C (90°F) is summarized in Table D-3. The analysis was performed using a 32.4°C (90.4°F) cutoff. During July, the number of hours with discharge temperatures above 32.2°C (90.7°F) exceeded 200 during the years 1998, 1999 and 2012 and exceeded 100 hours in 2001and 2011. During August, 100 hours was exceeded in 1998, 1999, 2001, and 2011. There were no years during which discharge temperatures were above 32.2°C (90°F) for more than 200 hours during August. The highest number of hours of exceedance of 32.2°C (90.7°F) in June was 81 hours during 2009 and in September 8 hours during 1998.

The average power production as a function of discharge temperature is provided in Table D-4. This analysis was performed to identify power production de-rating as discharge temperatures approach or exceed 32.2°C (90°F). Using the available data for the 15 June to 30 September indirect open-cycle period (2003-2014), the average power production was calculated corresponding to one degree discharge temperature intervals. Typically, a 1,800 MWe power production was maintained up to 31.4-31.9°C (88.5-89.5°F) discharge temperature. A slight decline in power production occurred when grouping all data above 31.9°C (89.5°F). However, when grouping only data above a 32.2°C (90.7°F) discharge temperature, a significant decrease in power production was observed. The average power production when discharge temperatures were greater than 32.2°C (90°F) decreased to 1,356 MWe in July and 1,230 MWe in August. These levels correspond to reductions in power production of 24.7 percent in July and 31.7 percent in August compared to normal power production (1,800 MW).

5.2.2 River Conditions

Kankakee and Des Plaines River flows at the site were calculated from U.S. Geological Survey

(USGS) flows measured at nearby gaging stations and scaled to the site by watershed areas. On the Kankakee River, flows from the USGS gage near Wilmington were available. On the Des Plaines River, the majority of the flow is measured at the USGS gage on Route 53 near Joliet, but flows from two additional tributaries (Du Page River and Hickory Creek) that enter the river before its confluence with the Kankakee were also included to account for additional upstream input. Flow of the Du Page River was increased 15% to account for the additional un-gaged portion of that watershed, and the sum of the Du Page, Hickory, and Joliet USGS flows were increased by 6.5% to account for the un-gaged portion of the Des Plaines River prior to the confluence with the Kankakee River. On the USGS website daily flow data were available at all stations since 2005 and 15 or 30 minute provisional data were also obtained for the 2013 and 2014 survey periods. The drainage areas at these locations are provided in the following table.

Upstream River	Location	Drainage Area (mi^2)
Kankakee	USGS gage on Kankakee at Wilmington	5,150
	Entire Kankakee watershed	5,165
Des Plaines	USGS gage on Des Plaines at Joliet	1,502
	USGS gage on Du Page at Shorewood	324
	Du Page watershed	372
	USGS gage on Hickory Creek at Joliet	107.5
	Entire Des Plaines watershed	2,111

Frequency distributions by month of the daily Kankakee River and Des Plaines River flow data scaled to the DNS site are provided in Tables D-5 and D-6. A frequency distribution of the combined flow for the Illinois River (i.e., Dresden Pool) is provided in Table D-7. During July to September, median (50-percentile) flows are 1,190 to 1,920 cfs on the Kankakee River and 3,879 to 4,801 cfs on the Des Plaines River. The combined Illinois River median flows are a little over twice the 2,265 cfs (1,464 mgd) DNS discharge flow (Table D-2). During July to September, the lower one percentile Illinois River flows of 2,377 to 2,437 cfs are only slightly greater than the 2,265 cfs DNS flow (Table D-7).

Fifteen minute provisional temperature data are available on the USGS web site on the Kankakee River at Wilmington, the Des Plaines River at Channahon, and at the inflow to DNS since the fall of 2012. The monthly average values for June to September during 2013 and 2014 are provided in the following table.

Month	Des Plaines River		Kankakee River		Dresden Intake	
	2013	2014	2013	2014	2013	2014
June (15-30)	26.4 (79.5)[a]	26.0 (78.7)	22.8 (73.0)	22.9 (73.1)	23.3 (73.9)	23.4 (74.1)
July	28.6 (83.5)	26.6 (79.7)	25.1 (77.2)	22.7 (72.9)	28.0 (82.4)	24.0 (75.2)
August	28.3 (82.9)	27.5 (81.5)	24.6 (76.3)	24.6 (76.2)	27.0 (80.6)	26.1 (79.0)
September	27.2 (81.0)	23.7 (74.6)	21.3 (70.3)	19.4 (66.9)	25.3 (77.5)	19.8 (67.7)

[a]Temperatures provided as degrees Celsius and (Fahrenheit)

The above table indicates that the Des Plaines River is several degrees warmer than the Kankakee River. Temperatures were generally cooler in 2014 than 2013, particularly during July and September. Temperatures at the Dresden intake are typically mid-way between those of the Kankakee and Des Plaines Rivers. The 2013 thermal plume surveys indicate that the more buoyant (warmer) Des Plaines River water results in upstream surface intrusion into the Kankakee River.

5.3 Thermal Plume Surveys

Thermal plume surveys were performed on 1 August and 29 August 2013. An additional survey was performed on 18 September 2014. Each thermal survey consisted of mapping the plume by continuously recording near-surface temperatures along a transect grid and by performing a series of vertical temperature profiles. For the duration of each survey day, near surface thermographs were deployed upstream of DNS on the Kankakee and Des Plaines Rivers and downstream of DNS on both the left and right descending banks, just above the Dresden Island Lock and Dam. In 2013, a left bank thermograph was deployed on the Kankakee River, whereas in 2014, both left and right bank thermographs were deployed. During the 2014 survey, replicate left and right bank thermographs were also deployed downstream of the Dresden Island Lock and Dam.

5.3.1 Methodology

The sampling grid for the Dresden survey included transects from 2,400 m upstream on the Des Plaines River and 2,350 m upstream on the Kankakee River to 1,000 m downstream from the DNS discharge canal on the Illinois River (i.e., in Dresden Pool). The sampling transect grid is provided below:

Transect	Downstream Distance (m)	Vertical Stations	Description
DP-2400	-2,400	1	Upstream Des Plaines River background
DP-1700	-1,700	3	
K-2350	-2,350	1	Upstream Kankakee River background
K-1800	-1,800	3	
K-1440	-1,440	3	Adjacent to intake canal
IL-1000	-1,000	4	Upstream Illinois River after confluence
IL-200	-200	3	
IL0	0	4	At discharge canal
IL125	125	4	
IL275	275	3	
IL475	475	3	
IL720	720	3	
IL1000	1,000	3	Downstream near dam

Surface Plume Mapping

Near-surface temperatures were collected along each transect and along a diagonal between transects, producing a zigzag pattern. Three temperature probes were deployed: one at a depth of approximately 1.5 ft, a replicate at 1.5 ft, and one at 3 ft. The primary transects are illustrated in Figure D-3. An example set of ship tracks is provided in Figure D-4 for the 29 August 2013 plume mapping survey.

The temperature monitoring system consisted of a Logan Enterprises temperature probe interfaced with a Deban 500 module and a Trimble GeoXH differential global positioning system (GPS). The Deban module receives the signal from the probe and sends a voltage that responds linearly with temperature to the data logger. According to the manufacturer, the YSI/Deban temperature system has an accuracy of 0.1% full span, which corresponds to 0.05°C (0.09°F). The output from the probe is stored at 1-sec intervals to a Campbell CR10X data logger. The GPS stores the x,y coordinates of the temperature probe position at 1-sec intervals to internal memory. The system clocks on the data logger and the GPS are synchronized in the field at the beginning of each survey. The surface temperature probe and replicate were attached to a fixed strut mounted on the side of the boat at a depth of 1.5 ft. A second probe was deployed on a weighted line and towed at a depth of approximately 3 ft.

Vertical Profiles

Thirty-eight vertical profiling stations were established along the 13 primary transects (Figure D-3). An additional vertical profile was performed at the mouth of the discharge canal. At the majority of transects, 3 vertical profiles were performed at the ¼, ½, and ¾ river width locations, from the left descending bank. Downstream of the confluence of the two rivers at transect IL-1000 and at the near-field transects IL0 and IL125, four vertical profiles were performed incremented by one-fifth of the river width. Vertical temperature profiles were collected 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 is slowly lowered to the bottom (i.e., downcast) and pulled back up to the surface (i.e., upcast). The data collected during the downcast were averaged into 1.0 ft depth intervals. This typically resulted in the collection of four to six data points within every 1.0 ft depth interval. The boat position during each vertical profile was fixed using the GPS.

Thermograph Deployment

During each survey, a HOBO TempPro thermograph was deployed at upstream locations on both the Kankakee and Des Plaines Rivers and at a downstream near-dam location on both the left and right descending banks (Figure D-3). In 2013, the thermographs were deployed on the day prior to the survey and retrieved after the completion of each survey. In 2014, the thermographs were installed 5 to 6 days prior to the survey. In 2013, the Kankakee thermograph was deployed near the left bank and slightly upstream of the K-1800 transect. In 2014, a left and right bank Kankakee thermograph was deployed at the K-2350 transect to provide data directly at the model boundary. The Des Plaines River thermograph was deployed at mid-channel along the DP-2400 transect. The downstream left and right bank thermographs were deployed in the vicinity of the IL1000 transect. In 2014, replicate left and right bank thermographs were also deployed downstream of the Dresden Island Lock and Dam. The left bank thermographs were on the right bank of Dresden Island approximately 450 m downstream of Dresden Island Lock and Dam and the right bank thermographs were approximately 730 m downstream of Dresden Island Lock and Dam. All thermographs were deployed at a depth of 1.5 ft. The thermograph locations above the dam are indicated on Figure D-3. The HOBO TempPro has an accuracy of ±0.2°C (0.4°F) and a resolution of 0.02°C (0.04°F).

Bathymetric Survey

A bathymetric survey of the Des Plaines, Kankakee, and Illinois Rivers in the vicinity of the DNS was performed on 15 and 16 November 2013. The Illinois State Plane South (US survey feet) coordinate system was used for the survey and the horizontal (NAD83) and vertical (NAVD88) position was determined using the National Geodetic Survey (NGS) Online Positioning User Service (OPUS). A Sokkia GRX1 dual frequency base (L1/L2) and receiver utilizing Real Time Kinematic (RTK) GPS survey system was used to obtain survey coordinates. A Carlson Explorer II data logger operating with Carlson SurvCE data collection software was used to record data points. An Odom Hydrotrac echo sounder was used to determine water depth.

The RTK/GPS rover unit was mounted on a fixed staff in the survey boat to maintain satellite and base station connectivity during the survey. The transducer unit for the echo sounder was mounted on the opposite end of the fixed staff, approximately 0.2 feet below the water surface. The echo sounder was calibrated with a survey level rod held on the bottom of the river adjacent to the transducer unit. The depth output on the echo sounder was adjusted to read the same depth (± 0.1 ft) as the level rod. With this equipment, recorded river bottom elevations are not affected by changes in water surface elevations due to lock and dam operations. Points were automatically logged at interval change of 15 ft horizontal and 1 ft vertical.

Survey transects in the three rivers were performed parallel to each bank, centerline of the rivers, and a cross river zigzag pattern going from bank to bank. If areas of abrupt or unusual bottom changes were encountered, the boat returned to the location and additional points were recorded.

Data points collected during the survey were downloaded from the data logger and imported into AutoCAD for surface modeling and contouring. The surface model was used to create contours of equal elevations within the three rivers.

5.3.2 Survey Conditions

The times during which the surface plume mappings and the vertical surveys were performed are summarized below:

Survey	Surface Plume	Vertical Profiles
1 August 2013	1101-1346 hours	1511-1746 hours
29 August 2013	1041-1333 hours	1446-1711 hours
18 September 2014	1100-1402 hours	1444-1633 hours

Flows on the Des Plaines and Kankakee Rivers during the survey period were computed from upstream USGS flow data (Section 2.2). The available 15 and 30 minute data were standardized to a 30-minute data set for each river. The 30-minute flows on the Des Plaines River are highly variable due to upstream conditions, so a 3-point moving average was used to smooth the data. Flow conditions for the Kankakee and Des Plaines Rivers during the three surveys are summarized below:

Survey	Kankakee River flow (cfs)	Des Plaines River flow (cfs)
1 August 2013	1,180-1,230	2,000-2,890
29 August 2013	654-685	1,830-2,280
18 September 2014	5,185-5,315	3,810-4,510

Kankakee River flows were near a median (50-percentile) value during the 1 August survey and at a lower 5-10-percentile value on 29 August (Table D-5). The Des Plaines River flows were below a 20-percentile value during both 2013 surveys (Table D-6). During 18 September 2014, the Kankakee River flow was above an upper 90-percentile and the Des Plaines River flow was between a 45- and a 55-percentile.

The hourly DNS operating conditions for the three survey days are provided in Tables D-8 to D-10. The tables include power production, discharge temperature, and discharge flow. During the 1 August 2013 surface plume survey, the discharge temperature was typically 28.7°C (83.7°F) and during the 29 August surface plume survey the discharge temperature was typically 31.0°C (87.8°F). During the 18 September 2014 surface plume survey the discharge temperature was typically 27.5°C (81.5°F). The DNS discharge flow was 1,465 mgd (2,266 cfs) during all three surveys.

5.3.3 Plume Survey Results

1 August 2013

On 1 August, the surface plume mapping started at 1101 hours and the vertical profile measurements at 1511 hours. The plume mapping was performed from upstream to downstream, followed by the vertical survey in a downstream to upstream direction. Temperature contours developed from the surface plume survey are provided in Figure D-5. During the surface survey, the temperatures upstream on the Des Plaines River at transect DP-2400 were 27.4-27.7°C (81.3-81.9°F). Temperatures upstream on the Kankakee River at transect K-2350 were 24.6-26.0°C (76.3-78.8°F). Downstream of the confluence of the Kankakee and Des Plaines Rivers, but upstream of the discharge canal, Illinois River temperatures at transect IL-200 were 26.6-26.9°C (79.9-80.4°F) and were fairly uniform across the river. Adjacent to the discharge canal, plume temperatures were 28.8°C (83.8°F) and the plume continued across the river with the 27.5°C (81.5°F) contour almost reaching the far (right descending) bank. Slightly downstream, at IL125 transect, the warmest temperatures were in the middle of the river with a range of 27.2-28.0°C (81-82.4°F). Further downstream, at transects IL475, IL720 and IL1000, temperatures ranged from 27.2-27.6°C (81-81.7°F) and were very similar at all three transects with only slightly higher temperatures on the right bank than the left (Figure D-5).

The vertical profile temperature data are provided in Tables D-11a to D-11e. Upstream on the Des Plaines River, the temperature profiles varied little with depth, exhibiting a vertical gradient of 0.4°C (0.7°F) at DP-2400 and less than 0.2°C (0.4°F) at DP-1700. Vertical gradients were more extensive on the Kankakee River. At transect K-1800, the surface temperatures were 26.4-26.8°C (79.5-80.2°F) and the deeper bottom temperature at K-1800-1/4 was 22.5°C (72.5°F) (Table D-11e). Downstream of the confluence, a modest vertical gradient persisted in the deeper water at transects IL-1000 and IL-200. At IL-200, the surface temperatures range from 27.3-27.6°C (81.1-81.7°F) while the bottom temperature on the deeper right descending bank was 24.4°C (75.9°F) (Table D-11c). At the mouth of the discharge canal, the vertical temperature profile was a constant 28.8°C (83.8°F). Along the discharge transect (IL0), there was only a very slight vertical gradient of less than 0.5°C at the first 3 stations, and at IL0-4/5 temperatures decreased surface to bottom from 27.05°C to 26.16°C (80.7°F to 79.1°F). Most temperatures at and near the discharge (transects IL0 and IL125) were between 27.5°C and 28.0°C (81.5°F to 82.4°F) with the temperatures above 28.0°C (82.4°F) recorded only on the surface at IL125-3/5. Downstream at transects IL475 to IL1000 the vertical gradients continue to be very slight, typically less than 0.4°C (0.7°F), or non-existent (Table D-11a).

The upstream and downstream thermograph temperatures are provided in Figure D-6. The thermographs were deployed during the afternoon of 31 July and remained in place until the completion of the vertical survey on 1 August. The upstream thermographs are used as the ambient river temperatures at the upstream model boundaries. The thermographs all displayed a warming trend in the morning of 1 August starting at 0700 hours and had much warmer temperatures in the afternoon on 1 August than on 31 July. Both of these features appear to be driven by warmer air temperatures on 1 August than the previous few days. The relative similarity of the downstream left/right bank temperatures to those on the upstream Des Plaines River is apparent. Upstream temperatures in the Des Plaines River were actually warmer than the downstream temperatures during the day on 1 August. The downstream temperatures are slightly higher on the right bank than the left bank during daytime hours. The sharp temperature increase in the Kankakee River in the morning was not a result of DNS discharge because power production levels were fairly uniform. It was partly due to buoyant (warmer) water from the Des Plaines River intruding upstream into the Kankakee River. In addition, the Kankakee River temperatures reported at Wilmington typically have a 2°C day/night variation resulting from solar warming and shallower water depths.

<u>29 August 2013</u>

On 29 August, the surface plume mapping started at 1041 hours and the vertical profile measurements at 1446 hours. Plume mapping was performed from upstream to downstream, followed by the vertical survey in a downstream to upstream direction. Temperature contours developed from the surface plume survey are provided in Figure D-7. During the surface survey, the temperatures upstream on the Des Plaines River at transect DP-2400 were 29.6-29.9°C (85.3-85.8°F). Temperatures on the upstream Kankakee River at transect K-2350 were 28.5-28.6°C (83.3-83.5°F). Downstream of the confluence of these two rivers, but upstream of the DNS discharge canal, Illinois River temperatures at transect IL-200 were 30.5-30.8°C (86.9-87.4°F) and were fairly uniform across the river. Adjacent to the discharge canal, plume temperatures were 31.3°C (88.3°F) with temperatures greater than 30.5°C (86.9°F) reaching the far bank. At the IL125 and IL275 transects, the maximum temperatures were in the middle of the river with a range at transect IL125 of 30.4-31.1°C (86.7-87.9°F). Further downstream at transects IL475, IL720 and IL1000, temperatures ranged from 30.5-31.2°C (86.9-88.2°F) and were very similar at

all three transects with consistent temperatures across the river.

The vertical profile temperature data are provided in Tables D-12a to D-12e. Upstream on the Des Plaines River, the vertical temperature gradient at DP-2400 was 0.4°C (0.7°F) between the surface and a 4 m depth. At transect DP-1700, which on 1 August had vertical gradients less than 0.2°C (0.4°F), the 29 August gradient ranged from 0.5°C to 0.9°C (0.9°F to 1.6°F). Similar to 1 August, there were greater vertical gradients on the Kankakee River. At transect K-1800-1/4, the surface temperature was 29.6°C (85.3°F) and the bottom temperatures was 27.4°C (81.3°F), a 2.2°C (4.0°F) vertical gradient (Table D-12e). Downstream of the confluence, a vertical gradient persisted through transects IL-1000 and IL-200. At IL-200-3/4, on the deeper right bank, the surface temperature was 31.3°C (88.3°F), whereas the bottom temperature was 29.2°C (84.6°F). At the discharge canal mouth, the surface temperature was 30.8°C (87.5°F) and the vertical gradient from surface to bottom remained within 0.03°C (0.05°F). Along the discharge transect IL0, the vertical gradient was similar to upstream, with the profile at IL0-4/5 ranging from 31.4°C (88.5°F) at the surface to 29.4°C (84.9°F) at the bottom (Table D-12c). Just downstream of the discharge, the highest temperature was 31.5°C (88.7°F) at IL125-3/5 and the 31.0°C (87.8°F) contour extends down to a 2.4 m depth. Farther downstream from IL275 to IL1000, temperatures ranged from 30.0°C to 31.6°C (86-88.9°F) and vertical gradients ranged from 0.2°C to 1.0°C (0.4°F to 1.8°F).

The upstream and downstream thermograph temperatures are provided in Figure D-8. The thermographs were deployed during the afternoon of 28 August and remained in place until the completion of the vertical survey on 29 August. The upstream thermographs are used as the ambient river temperatures at the upstream model boundaries. The thermographs all displayed a warming trend in the morning starting at 0830 hours and, like the 1 August thermographs, showed warmer temperatures in the afternoon on the survey day than the previous day. This, once again, appears to be due to warmer air temperatures on 29 August than on 28 August. During the afternoon, the downstream right bank temperatures were generally 0.5°C (0.9°F) greater than the both the downstream left bank and upstream Des Plaines River temperatures. The sharp temperature increase in the Kankakee River in the morning (similar to the 1 August survey) does not appear to be driven by plant discharge because power production was fairly uniform. This is probably due to buoyant (warmer) water from the Des Plaines River intruding into the Kankakee River and natural day/night temperature variation on the Kankakee River at Wilmington due to its shallower depths.

18 September 2014

On 18 September, the surface plume mapping started at 1100 hours and the vertical profile measurements at 1444 hours. Plume mapping was performed from upstream to downstream, followed by the vertical survey in a downstream to upstream direction. Temperature contours developed from the surface plume survey are provided in Figure D-9. During the surface survey, the temperatures upstream on the Des Plaines River at transect DP-2400 were 19.7-20.0°C (67.5-68°F). Temperatures on the upstream Kankakee River at transect K-2350 were 16.5-17.2°C (61.7-63°F). After the confluence at Il-1000, the temperature increased from approxiamely17.0°C (62.6°F) on the left bank to 20.2°C (68.4°F) on the right bank. At this location, the temperature difference between the Kankakee and Des Plaines Rivers was maintained without significant horizontal mixing. Adjacent to the discharge canal at IL0, plume temperatures were 27.4°C (81.3°F). At transects IL125 and IL275, the plume was primarily on the left half of the river with maximum temperatures near mid-channel of 24-25°C (75.2-77°F) and right bank temperatures of 20.5°C (68.9°F). Further downstream at transects IL475, IL720 and IL1000, temperatures were primarily between 22°C and 23°C (71.6°F and 73.4°F) with slightly lower temperatures along the left bank.

The vertical profile temperature data are provided in Tables D-13a to D-13e. Upstream on the Des Plaines River, the vertical temperature gradient at DP-2400 was 0.4°C (0.7°F) between the surface and a 4 m depth. At transect DP-1700, the vertical gradient was less than 0.2°C, similar to the 1 August 2013 survey. At transect K-1800-1/4, the surface temperature was 17.1°C (62.8°F) and the bottom temperature was 16.8°C (62.2°F), a 0.3°C (0.5°F) vertical gradient (Table D-13e). Downstream of the confluence at IL-1000, surface temperatures increased from 17.2°C (63°F) at IL-1000-1/5 to 20.1°C (68.2°F) at IL-1000-4/5, representative of the two upstream rivers. However the cooler Kankakee waters intruded across the channel along the bottom to the deeper -3/5 and -4/5 stations, providing increased vertical stratification towards the right bank. At IL-200-3/4, on the deeper right bank, the surface temperature was 19.4°C (66.9°F) while the bottom temperature was 17.3°C (63.1°F). At the discharge canal mouth, the surface temperature was 27.7°C (81.9°F) and the vertical gradient was within 0.1°C (0.2°F), from surface to bottom. Along the discharge transect IL0, the vertical gradient was similar to upstream, with the profile at IL0-4/5 ranging from 20.0°C (68°F) at the surface to 17.6°C (63.7°F) at the bottom (Table D-13c). Downstream of the discharge, the highest temperatures were 25.3°C (77.5°F) at IL125-1/5 and 23.8°C (74.8°F) at IL275-1/4. Farther downstream, surface temperatures were lower along the left bank with 19.76°C (67.6°F) at IL475-1/4 and 19.72°C (67.5°F) at IL720-1/4. From IL475 to IL1000, surface temperatures at the -1/2 and -3/4 stations were 22.0°C to 23.2°C (71.6°F to 73.8°F). The lower temperatures at the IL476-1/4 and IL720-1/4 were attributed to the mixing of the water column due to the upstream passage of a barge from the lock just prior to the start of the vertical survey. The vertical stratification decreased from 4.6°C (8.3°F) at IL720-3/4 to 3.3°C (5.9°F) at IL1000-1/2 as a result of slightly decreasing surface temperatures and increasing bottom temperatures.

Upstream thermographs were deployed at mid-channel on the Des Plains River at transect DP-2400 and on the left and right banks of the Kankakee River at transect K-2350. Similar to 2013, left and right bank downstream thermographs were deployed just above the dam at transect IL1000 (Figure D-3). In 2014, thermographs were also deployed on both the left and right banks of the Illinois River downstream of the dam. These thermographs were deployed on 12-13 September, preceding the 18 September survey. The Kankakee River, Des Plaines River, and downstream thermograph temperatures (above the dam) are provided in Figure D-10 for the 18 September survey period. The Kankakee River temperatures in the figure are a composite of the left and right bank thermographs. The Kankakee temperatures decreased from 17.5°C to 15.8°C (63.5°F to 60.4°F) overnight and then displayed a warming trend on the morning of the survey starting at 0800 hours, while the Des Plaines River temperatures were 2-3°C (3.6-5.4°F) higher with less variation. The downstream temperatures (above the dam) were typically 0.5-1.5°C (0.9-2.7°F) higher than the upstream Des Plaines River temperatures. A comparison of the left and right bank thermographs above and below the Dam is provided in Figure D-11 for the six day deployment period. Below the dam, the average difference between the two left bank thermographs was 0.02°C (0.04°F) and between the two right bank thermographs was 0.06°C (0.11°F). Composites of the two left and two right bank thermographs are displayed in Figure D-11. The left and right bank thermographs below the dam were typically within 0.5°C (0.9°F) of each other and were similar to the left bank thermograph above the dam. Above the Dam during 14-15 September, the right bank thermograph was 1.0-1.5°C (1.8-2.7°F) higher than the left bank.

5.4 Model Development

A three-dimensional hydrothermal model was developed to evaluate the thermal discharge plume from DNS to the Illinois River. The modeling task utilized DHI's (Danish Hydraulics Institute) MIKE3 model (DHI 2012, 2014), which provides a state-of-art, three-dimensional modeling framework. The model domain included upstream portions of both the Des Plaines and Kankakee Rivers and extended downstream to the Dam. The model grid is illustrated in Figure D-12. It included 1,530 cells with each cell divided in up to 12 vertical layers depending on depth. The upper three layers were confined to a maximum 1.0 m depth. Below a 1.0 m depth, layer thickness increased from 0.5 m to 1.0 m in the deepest layer. These additional layers were added as necessary to extend to the river bottom. The model domain included entrances to both the DNS intake and discharge canals.

Physical parameters needed for the model including bathymetry, intake/discharge configurations, model boundary conditions, and meteorology are described as follows.

<u>River Bathymetry</u>

The bathymetry of the three rivers in the vicinity of the site was based on a survey performed 15-16 November 2013 (Section 3.1). A bathymetric contour map of the study area is provided in Figure D-13.

<u>Model Boundary Conditions</u>

To execute the model, a river flow was assigned to the upstream Kankakee and Des Plaines River boundaries and an elevation above normal pool (i.e., 504.5 ft) was assigned to the downstream model boundary at the Dresden Island Lock and Dam. River flows on survey days were based on 30-minute USGS data (Section 2.2).

During both the 1 and 29 August 2013 surveys and the 18 September 2014 survey, the upstream Des Plaines River thermograph was applied to the model boundary at the surface and a 0.4°C (0.7°F) temperature gradient was used between the surface and a 4 m depth. The vertical gradient was based on the measured profile at DP-2400 (Tables D-11e and D-11e).

The upstream temperature boundary condition on the Kankakee River was handled differently between the two 2013 and the 2014 surveys. In 2013, the Kankakee River thermograph was located near Transect K-1800 approximately 400 m upstream of the model boundary at transect K-2350. In 2013, it was necessary to adjust the temperature readings to account for the difference between the thermograph location and the model boundary based on the observed gradient from the field survey. In 2014, a left and right bank thermograph was deployed at the K-2350 model boundary.

Examination of the 2013 survey data indicated that the warmer Des Plaines River water was intruding upstream into the Kankakee River. During both surveys, a surface temperature gradient was present between the K-2350 and K-1400 transects (Figures D-5 and D-7). A temperature adjustment was subtracted from the Kankakee River thermograph to account for the gradient between it and transect K-2350 based on the observed field data. In addition, the vertical survey data indicated a significant vertical gradient at K-2350, making it necessary to provide a vertical adjustment. On 1 August an up to 0.5°C temperature was subtracted from the thermograph to provide a surface temperature at the K-2350 model boundary. Up to 2.5°C (4.5°F) was then subtracted from the surface temperature to provide a 4 m depth temperature, bounded by a minimum 22.8°C (73.0°F) value. On 29 August an up to 0.9°C (1.6°F) temperature was subtracted from the thermograph to provide a surface temperature at the K-2350 model boundary and up to 1.5°C (2.7°F) was then subtracted from the surface temperature to provide a 4 m depth temperature, bounded by a minimum 27.8°C (82.0°F) value.

For the 17-18 September 2014 survey period, the left and right bank thermographs were averaged to form a composite surface temperature for application at the K-2350 model boundary. During the afternoon of 18 September, the left bank temperature was up to 2°C (3.6°F) warmer than the right bank, an effect attributed to the direct solar warming near the shallow shoreline and not representative of the cross-section. During this period only the right bank temperature was used in the composite. A 0.5°C (0.9°F) temperature gradient was used between the surface and a 4 m depth.

<u>Meteorology Data</u>

Meteorology parameters used by the MIKE3 model include air temperature, relative humidity, cloud cover, and wind speed and direction. These parameters are used for the calculation of surface heat exchange. Hourly National Oceanic and Atmospheric Administration (NOAA) meteorological data were obtained for the days of the three surveys from Lewis University and Aurora, Illinois weather stations, which are located approximately 16 and 24 miles from the site. The hourly values from the two NOAA locations were averaged together for use in the model. DNS 2013 air temperature and wind speed data were received while the model calibration process was underway. A graphical comparison of the NOAA data to the DNS data indicated that it was sufficiently representative for continued use in the model.

5.5 Model Calibration

Survey conditions were very different between the two 2013 surveys and the 2014 survey. In 2013, the Illinois River flow was less than 4,000 cfs and the temperature difference between the Dresden discharge and the cooler Kankakee River was typically less than 4°C (7.2°F). In 2014, river flow was greater than 9,000 cfs and the temperature difference between the discharge and the Kankakee River was typically 8-10°C (14.4-18.0°F). The higher 2014 river flows also prevented upstream intrusion of the warmer Des Plaines water into the Kankakee River. The model calibration based on the two 2013 surveys did not provide an adequate representation for

2014. This resulted in the development of two model calibrations; the first for lower river flow conditions and the second for higher river flows and lower river temperatures. The daily average Illinois River flow on 18 September 2014 of 9,200 cfs is within the upper 45-percentile of historical flows (Table D-7).

The MIKE3 model was started at 1200 or 1300 hours on the day preceding each survey. This allowed an approximately 24 hour period for the model to reach a dynamic equilibrium prior to the thermal surveys. Hourly DNS discharge flows and temperatures were assigned to the discharge canal and the same flow was withdrawn at the intake canal. USGS 30 minute flow data was assigned to the upstream Des Plaines and Kankakee River boundaries along with the adjusted thermograph data (Section 4). Horizontal and vertical dispersion coefficients were adjusted to achieve a compromise fit between the two 2013 surveys and the 2014 survey. The 2013 field data indicated a gradient of increasing temperatures along the Kankakee between transects K-2350 and K-1400. This was considered to reflect intrusion of the more buoyant (warmer) water from the Des Plaines River upstream into the Kankakee River. The resulting vertical gradients along the Kankakee River were 2-3°C (3.6-5.4°F), whereas the vertical gradients along the Des Plaines River and downstream of the DNS discharge seldom exceeded 0.5°C (0.9°F). Providing for the intrusion of warmer water upstream along the surface of the Kankakee River in 2013 was accomplished by decreasing the vertical dispersion coefficient, thus retarding the mixing of the surface layer into the lower water column. The vertical dispersion coefficient was decreased at the confluence of the two rivers in the vicinity of transect IL-1000 and along the Kankakee River. In 2014, a composite of the left and right bank thermographs at K-2350 were directly used at the Kankakee River model boundary and the model generally contained greater vertical dispersion.

The comparison of the calibrated model to the 1 and 29 August 2013 surveys (low flow model) and the 18 September 2014 (moderate flow model) was performed using the primary surface transects, the vertical profile measurements, and the downstream thermographs. The comparison of the model to field data used the closest 30 minute model output time step to the field survey time. The calibrated models are only capable of reproducing the primary plume features and not transitory events such as effects resulting from the passage of barge tows. Thus, allowances need to be made in comparing the model with instantaneous field data.

<u>1 August 2013 Survey</u>

Comparison of modeled and observed surface temperatures for the 1 August survey are provided in Figures D-14 to D-17 for upstream transects along the Des Plaines and Kankakee Rivers and downstream of the DNS discharge. Figure D-14 provides a comparison at transects K-2350 and K-1440. At K-2350, the use of a single boundary surface temperature is representative of the average observed temperature but is not capable of representing the lateral variation. At K-1440, the model is in excellent agreement along the transect except near the left bank where the lower observed temperature represents vertical mixing from the lower water column at the mouth of the intake canal. On the Des Plaines River at DP-2400, the uniform lateral temperature provides good agreement with the model near the upstream boundary (Figure D-15). At IL-200, after the confluence of the Kankakee and Des Plaines Rivers, the model is in good agreement with the average transect temperature but has a 0.5°C (0.9°F) larger gradient from left to right bank

(Figure D-15). In Figure D-16 at the discharge transect (IL0), the model provides a very good representation of the lateral variation, while at IL125 the model slightly over predicts and is more uniform laterally. Farther downstream at IL475 and IL1000, both the observations and model are very uniform bank to bank (Figure D-17). The slight over-prediction of temperature seen at IL125 continues to IL475, but at IL1000 the differences are less than 0.2°C (0.4°F).

Comparison of modeled to observed temperatures at vertical stations during the 1 August survey are provided in Figures D-18 to D-20. The figures generally show very good agreement between the model and the survey data. Figure D-18 illustrates vertical profiles upstream at DP-1700 and K-1440. At DP-1700, the model reproduces the 0.1°C (0.2°F) vertical gradient over much of the water column. At K-1440, although the modeled temperatures are slightly high, the 4°C (7.2°F) vertical gradient was nicely reproduced. At IL-1000, after the confluence of the two rivers, the model was in very good agreement with surface temperatures along the transect and reproduced the variation in vertical structure from a several degree gradient at IL-1000-2/5 to an almost homogeneous water column towards the right bank at IL-1000-4/5 (Figure D-19). Downstream of the discharge at IL275, the model slightly over-predicted surface temperatures, although bottom temperatures were in good agreement (Figure D-20). At IL720 and IL1000 the model reproduced the nearly homogenous water column and any over-prediction of temperature was less than 0.3°C (0.5°F) (Figure D-20).

A comparison of the model to the left and right bank downstream thermographs at the time of the 1 August survey are provided in Figure D-21. The model was started on 31 July at 1300 hours, several hours before the thermographs were deployed. At 1800 hours on 31 July, Figure D-21 indicates that the last remnant of the lower temperature water from the initial start condition were being flushed from the model at the Dam. During the 1 August survey day, the model accurately represented the left bank temperatures and under predicted the right bank temperatures by typically 0.1-0.2°C (0.2-0.4°F).

<u>29 August 2013 Survey</u>

Comparison of modeled and observed surface temperatures for the 29 August survey are provided in Figures D-22 to D-25 for upstream transects along the Des Plaines and Kankakee Rivers and downstream of the discharge. Figure D-22 provides a comparison at transects K-1800 and K-1440. The model is in excellent agreement along both transects except near the left bank at K-1440. As noted for the 1 August survey, the lower observed temperature represents vertical mixing from the lower water column at the mouth of the intake canal. Upstream at DP-1700 and on the Illinois at IL-1000, lateral temperatures are fairly uniform with excellent agreement between the model and observations (Figure D-23). At the discharge transect and downstream, the agreement between observations and the model continue to be very good at transects IL0 and IL275 (Figure D-24) and transects IL475 and IL1000 (Figure D-25).

Comparison of modeled to observed temperatures at vertical stations during the 29 August survey are provided in Figures D-26 to D-28. The figures generally show very good agreement between the model and the survey data. Figure D-26 illustrates vertical profiles upstream at DP-1700 and K-1440. At DP-1700, the model reproduces the nearly homogeneous deeper water column, while the observed temperatures at the shallower -1/4 and -1/2 locations had greater surface temperature variation. At K-1440, the model provided a good representation of the 2°C (3.6°F) vertical gradient (Figure D-26). At IL-1000, downstream of the confluence of the two rivers, lateral temperatures were very uniform and the model was in excellent agreement with the vertical structure (Figure D-27). Downstream of the discharge at IL125, the model was in good agreement over the water column except for the near bottom temperature at IL125-4/5. At this location the model predicted a homogenous water column, while the IL125-4/5 bottom temperature was more similar to the temperature upstream at IL-1000. Good model representation of the slight vertical temperature structure continued at IL475, IL720 and IL1000 (Figure D-28).

Comparisons of model results to the left and right bank downstream thermographs at the time of the 29 August survey are provided in Figure D-29. The model was started on 28 August at 1200 hrs. At 1800 hours on 28 August, Figure D-29 indicates that the last of the lower temperature waters remnant from the initial start condition were being flushed from the model at the Dam. During the 29 August survey day, the model simulation was a good representation of the left bank thermograph temperatures, but under predicted the right bank temperatures by up to 0.7°C (1.3°F). A 0.5°C (0.9°F) lateral gradient was present during the vertical survey between IL1000-1/2 and IL1000-3/4 (Figure D-28). However, a lateral surface temperature gradient in the vicinity of IL1000 was not evident during the surface plume survey (Figure D-7).

<u>18 September 2014 Survey</u>

Comparison of modeled and observed surface temperatures for the 18 September survey are provided in Figures D-30 to D-33 for upstream transects along the Des Plaines and Kankakee Rivers and downstream of the discharge. Figure D-30 provides a comparison at transects K-1800 and DP-1700. The model is in excellent agreement along both transects and the figure illustrates the 2.5-3.0°C (4.5-5.4°F) difference between the two rivers. At Transect Il-1000, below the confluence of the two rivers, the individual river temperatures are maintained by the model towards the left and right banks with a pronounced horizontal gradient (Figure D-31). Figure D-31 also shows the discharge transect (IL0) with 27°C (80.6°F) water entering at the left bank with Des Plaines River temperatures still present along the right bank. Downstream of the discharge at transects IL275 to IL1000, there is significant temperature variation along each transect, which was not reproducible by a model. At transect IL275, the model matches the maximum temperature at mid-channel and the temperature decrease at the right bank (Figure D-32). At transect IL475, there is a temperature depression at 100-150 m from shore, and a temperature peak at a 200-250 m location. The IL475 model results provide an average fit through this region (Figure D-32). There continues to be a great deal of lateral variation at transect IL720, and at IL1000 the temperature distribution is much smoother with better agreement shown by the model (Figure D-33).

Comparison of modeled to observed temperatures at vertical stations during the 18 September survey are provided in Figures D-34 to D-36, which generally show very good agreement between the model and survey data. Figure D-34 illustrates vertical profiles upstream at K-1800 and DP-1700. At both transects surface temperature and vertical stratification is well represented by the model. Figure D-35 illustrates vertical profiles at transects IL0 and IL275. At IL0-1/5, the model has a higher near discharge surface temperature, a location where the measured temperatures are very sensitive to the positioning of the boat during the plume mapping survey. Temperatures at IL0-2/5 to -4/5 increase following the Kankakee River to Des Plaines River horizontal gradient. Away from the discharge, transect IL0 has only slight vertical stratification that is very well represented by the model. At transect IL275, 4-5°C (7.2-9.0°F) vertical stratification is present at all three stations and the modeled general pattern is in excellent agreement. Figure D-36 illustrates the vertical profiles at transects Il720 and IL1000. Surface temperatures at Il475-1/4 and IL720-1/4 of 19.7°C (67.5°F) during the vertical survey (Table D-13a) were lower than the 21.5-22.5°C (70.7-72.5°F) temperatures observed in this region during the preceding surface plume survey (Figure D-9). At the end of the surface survey, a barge exited the lock and continued upstream along the left bank. The lower -1/4 station temperatures observed during the verticals were considered to have resulted from the barge mixing the water column, a feature not present in the model. At IL720, the model has good agreement with the vertical structure at the -3/4 station and with surface temperatures at the -1/2 station (Figure D-36).

5.6 Mixing Zone Scenarios

The MIKE3 model developed for the DNS was used to examine hypothetical thermal plume configuration for a range of discharge temperature scenarios. Particular attention was given to the 32.2°C (90°F) contour, which becomes more restrictive with decreasing river flow or increasing upstream river temperature. The MIKE3 model was executed with 32.2°C, 33.3°C, and 34.4°C (90°F, 92°F, and 94°F, respectively) discharge temperatures for two river flow/temperature scenarios. The first scenario used the river conditions present during the 29 August 2013 plume survey, the most restrictive of the three surveys, and the second scenario used median (50-percentile) July river flows and average July river temperatures. These scenarios were developed to examine the thermal plume behavior under a variety of hypothetical conditions, and therefore includes some ambient temperature and discharge temperature pairings that are not expected to occur with one another. As such, it should be noted that use of the 34.4°C (94°F) discharge scenario with upstream ambient temperatures <32.2°C (90°F) was modeled solely for demonstration purposes and does not constitute discharge conditions that would be authorized, or expected to occur, under the proposed ATLs.

The daily average Illinois River flow during the 1 August 2013 survey was 3,665 cfs and during 29 August was 2,617 cfs (lower 5-percentile). The more flow restrictive 29 August survey also had higher upstream river temperatures. The daily average temperature at the Des Plaines thermograph was 29.8°C (85.6°F) on 29 August and a lower 27.2°C (81.0°F) on 1 August. The hourly river flow and upstream temperature conditions present during the 29 August survey were used with the MIKE3 model in conjunction with 32.2°C, 33.3°C, and 34.4°C (90°F, 92°F, and 94°F, respectively) discharge temperature scenarios. The average discharge temperature on 29 August was 30.8°C (87.4°F). The resulting thermal plume surface area as a function of temperature is provided in Figure D-37. Surface temperature contours for the 29 August 2013 river condition and a 33.3°C (92°F) discharge temperature are provided in Figure D-38. The 32.2°C (90°F) temperature contour in Figure D-38 has a surface area of 15.2 acres. The percent cross-sectional Illinois River area as a function of temperature at four transects extending downstream towards the dam is provide in Table D-14.

Monthly average 2013 and 2014 temperatures on the Des Plaines River at Channahon and the Kankakee River at Wilmington were presented in Section 2.2. The highest monthly average temperature occurred during July 2013 on both the Des Plaines River (28.6°C [83.5°F]) and Kankakee River (25.1°C [77.2°F]). The median (50-percentile) July flows were 3,870 cfs on the Des Plaines River and 1,920 cfs on the Kankakee River (Tables D-5 and D-6). The combined median site flow of 5,790 cfs is over twice the 2,617 cfs flow that was reported on 29 August 2013. The July median river flows and monthly average river temperatures were used in the MIKE3 model in conjunction with 32.2°C, 33.3°C, and 34.4°C (90°F, 92°F, and 94°F, respectively) discharge temperature scenarios. The resulting thermal plume surface area as a function of temperature is provided in Figure D-39. Surface temperature contours for average July river conditions and a 34.4°C (94°F) discharge temperature are provided in Figure D-40. The 32.2°C (90°F) temperature contour in Figure D-40 has a surface area of 20.3 acres. The percent cross-sectional Illinois River area as a function of temperature at four transects extending downstream towards the Dam is provided in Table D-15.

For the 29 August 2013 river condition scenarios (Figure D-37), the 33.3°C (92°F) discharge temperature had a 26-acre mixing zone temperature of 31.9°C (89.4°F), while the 34.4°C (94°F) discharge temperature had a 26-acre mixing zone temperature of 90.5°F (32.5°C). Thus compliance with a 32.2°C (90°F) 26-acre mixing zone would be met with a discharge temperature slightly below 33.9°C (93°F). At the higher median July river flows, the 34.4°C (94°F) discharge temperature scenario was in compliance with a 32.2°C (90°F)/26-acre mixing zone (Figure D-39).

The cross-sectional areas in Tables D-14 and D-15 provide data at transect IL-200 (upstream of the Dresden discharge), IL0 (the Dresden discharge), and at downstream transects IL475 and IL1000. The tables provide the minimum and maximum temperature at each cross-section and the percent cross-sectional area below the specified temperature. The temperature/cross-sectional area data in Tables D-14 and D-15 are displayed in Figure D-41 at transect IL0 and in Figure D-42 at transect IL475.

For the 29 August 2013 river condition (Table D-14), temperatures below 32.2°C (90°F) at transect IL0 were present in 89.6 percent of the cross-section with a 33.3°C (92°F) discharge temperature and 86.2 percent of the cross-section with a 34.4°C (94°F) discharge temperature (Figure D-41). At transect IL475, only the 34.4°C (94°F) discharge resulted in 32.2°C (90°F) temperatures and 82.6 percent of the cross-section was below this level (Figure D-42). At IL1000, the maximum temperature in the cross-section increased from 31°C (87.8°F) for a 32.2°C (90°F) discharge to 32°C (89.6°F) for a 34.4°C (94°F) discharge.

For the average July river condition (Table D-15), temperatures below 32.2°C (90°F) at transect IL0 were present in 92.2 percent of the cross-section with a 33.3°C (92°F) discharge temperature and 88.3 percent of the cross-section with a 34.4°C (94°F) discharge temperature (Figure D-41). At transect IL475, only the 34.4°C (94°F) discharge resulted in 32.2°C (90°F) temperatures and 99.2 percent of the cross-section was below this level (Figure D-42). At IL1000, the maximum temperature in the cross-section increased from 32°C (89.6°F) for a 32.2°C (90°F) discharge to 31.3°C (88.4°F) for a 34.4°C (94°F) discharge.

Summary

A three-dimensional hydrothermal model was developed for the discharge from the DNS to the Illinois River. The model was executed for 32.2°C, 33.3°C, and 34.4°C (90°F, 92°F and 94°F, respectively) DNS discharge temperatures for two river flow scenarios. The first scenario was for conditions observed during the 29 August 2013, the most restrictive of the three surveys. On 29 August, the daily average Illinois River flow was 2,617 cfs, within the lower 5-percentile of historical flows. The second scenario used median July Kankakee and Des Plaines Rivers flows totaling 5,790 cfs, and average July 2013 river temperatures. For 29 August 2013 survey conditions and a 34.4°C (94°F) discharge temperature, 84.8 percent of the cross section was below 32.2°C (90°F) at transect IL0, 84.3 percent at IL475, and 100 percent of the cross-section at IL1000. For average July river conditions and a 34.4°C (94°F) discharge temperature, 88.3 percent of the cross-section was below 32.2°C (90°F) at IL0, 99.2 percent at IL475, and 100 percent of the cross-section at IL1000. The modeling results indicate that a major portion of the Illinois River cross-section between the DNS discharge and the Dresden Island Lock and Dam maintains temperatures adequate to support biological communities under both typical summer and adverse river conditions. In addition, these conditions are maintained at discharge temperatures above DNS's current 32.2°C (90°F) discharge permit condition.

FIGURES

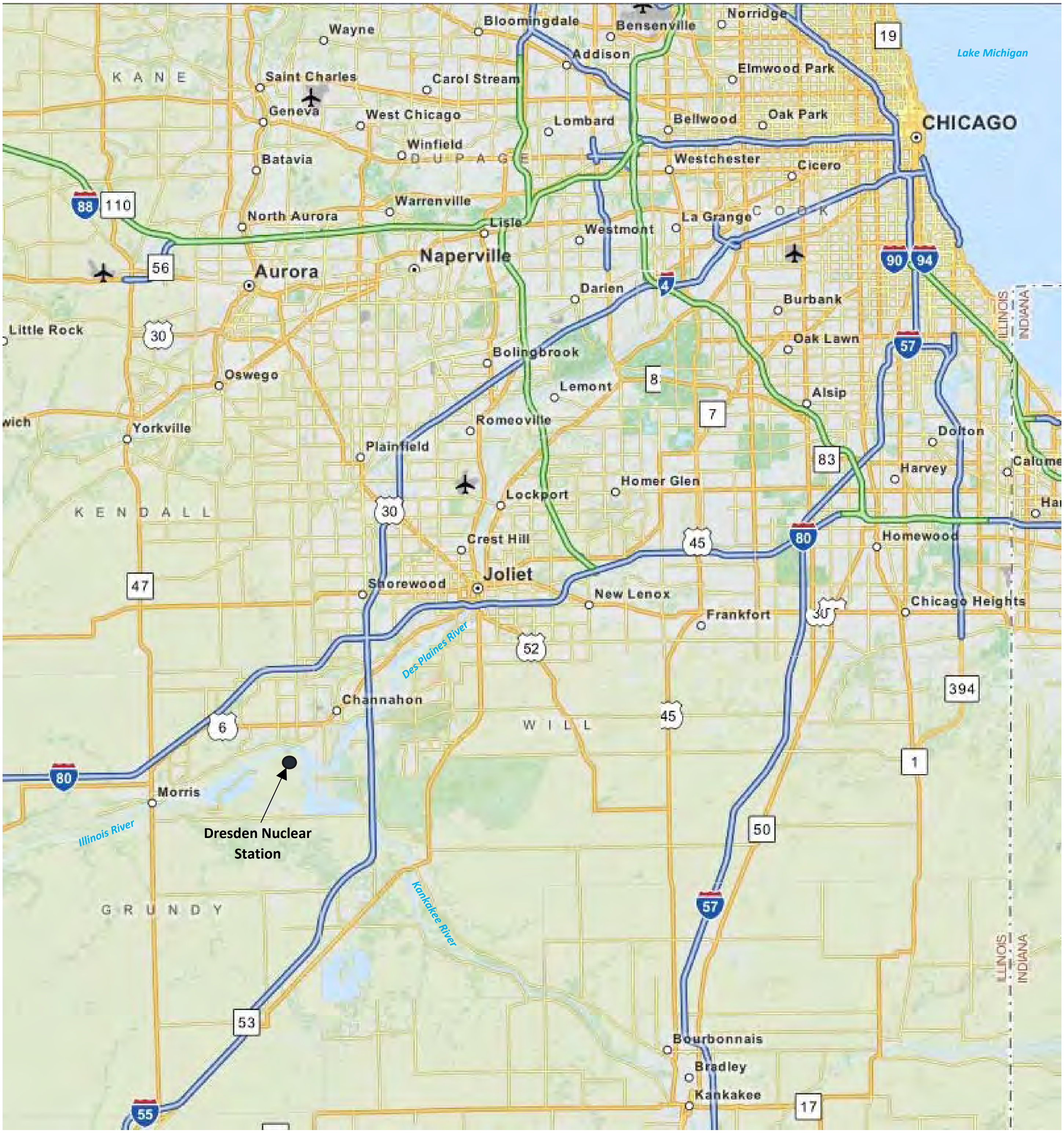
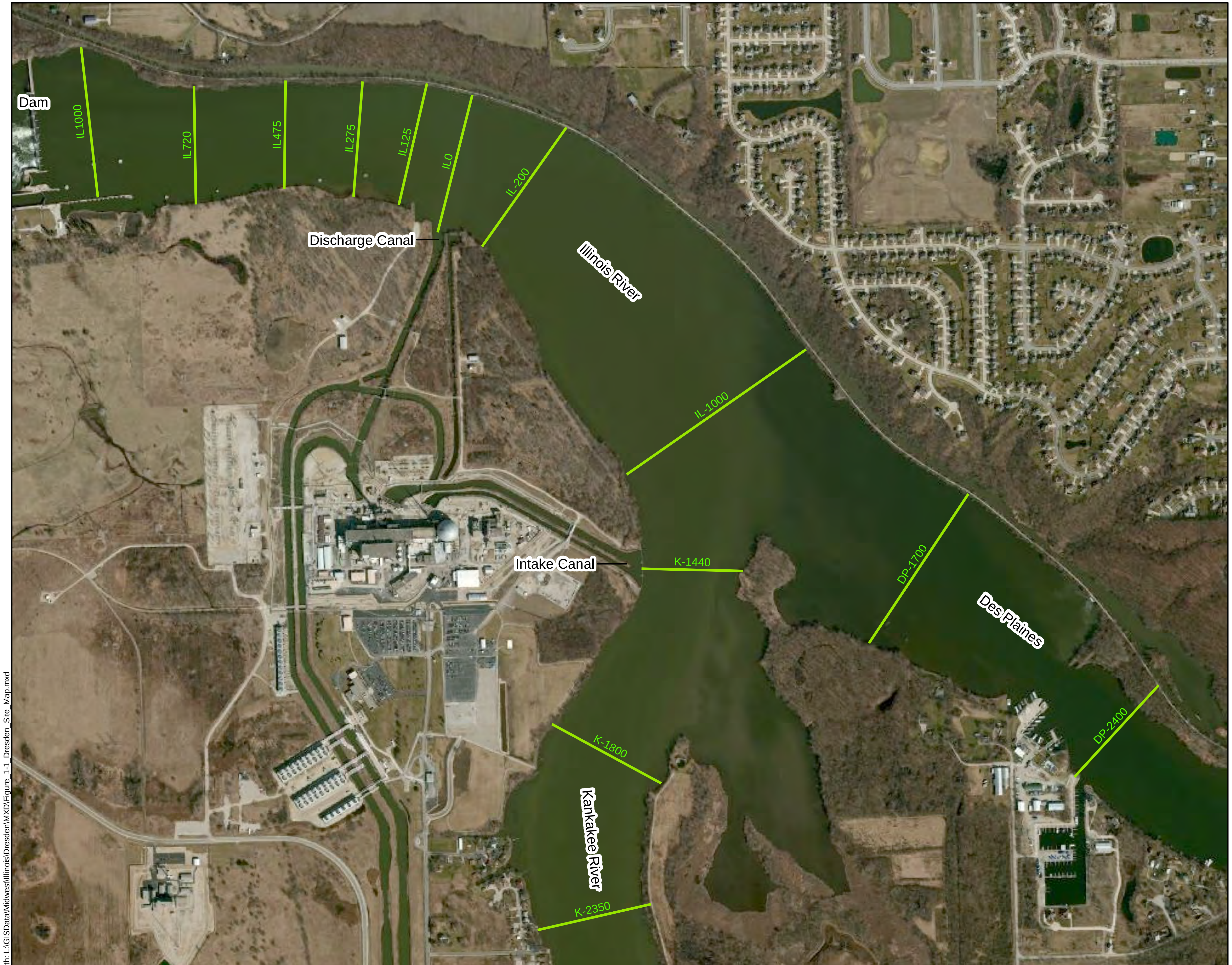
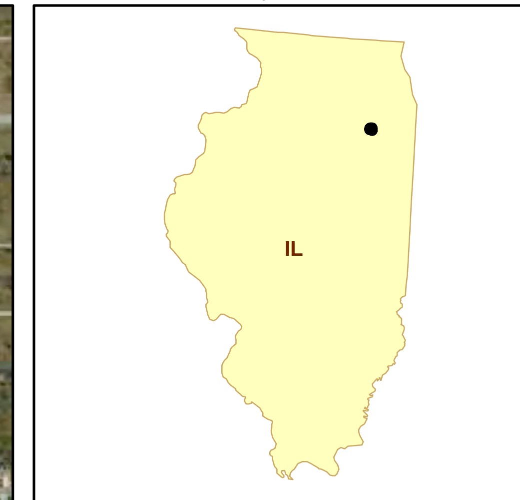


Figure D-1. Location of Dresden Nuclear Station



VICINITY MAP



Legend

Transects

Map Date: December 2013
Data Sources: ArcGIS Map Service 2011

N

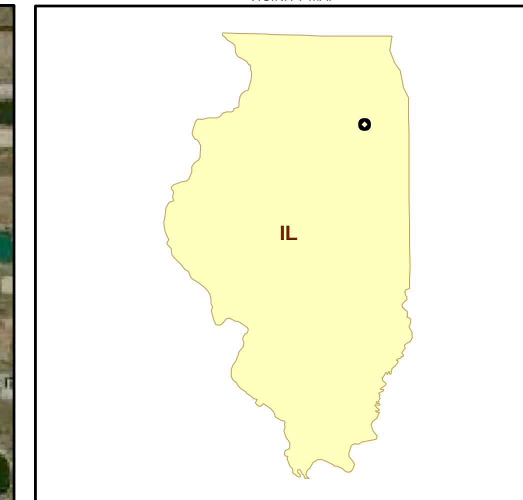
0 200 400
Meters

1 in = 265 meters
(11 x 17 inch figure)

FIGURE **D-2**

Dresden Nuclear Station Site Map Morris, Illinois

Path: L:\GIS\Data\Midwest\Illinois\Dresden\MXD\Figure_1-1_Dresden_Site_Map.mxd



Legend

- Vertical Station
- Transect

Thermograph Locations

- 2013, 2014
- 2014

Map Date: December 2013
Data Sources: ArcGIS Map Service 2011

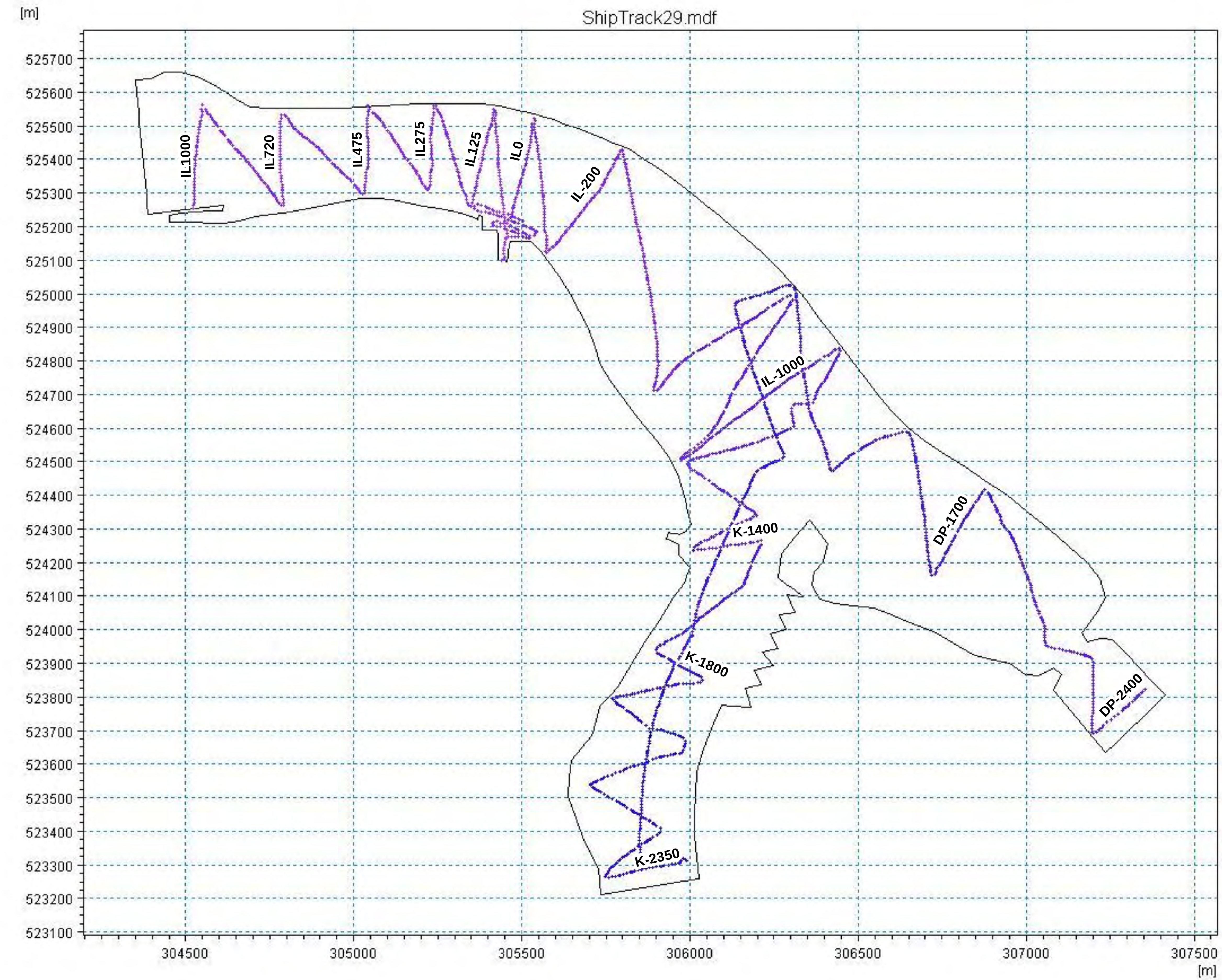
N

0 200 400
Meters

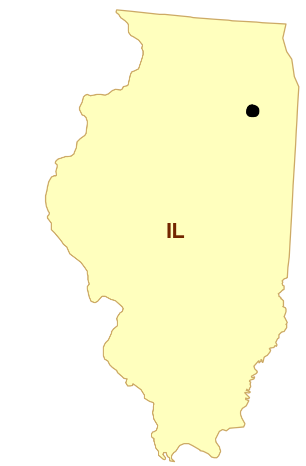
1 centimeter = 100 meters
(11 x 17 inch figure)

FIGURE **D-3**
Survey Transects, Vertical Stations, and Thermograph Locations for Dresden Plume Surveys

Path: L:\GISData\Midwest\Illinois\Dresden\MXD\Figure_3-1.mxd



VICINITY MAP



Map Date: December 2013
Data Sources: ArcGIS Map Service 2011

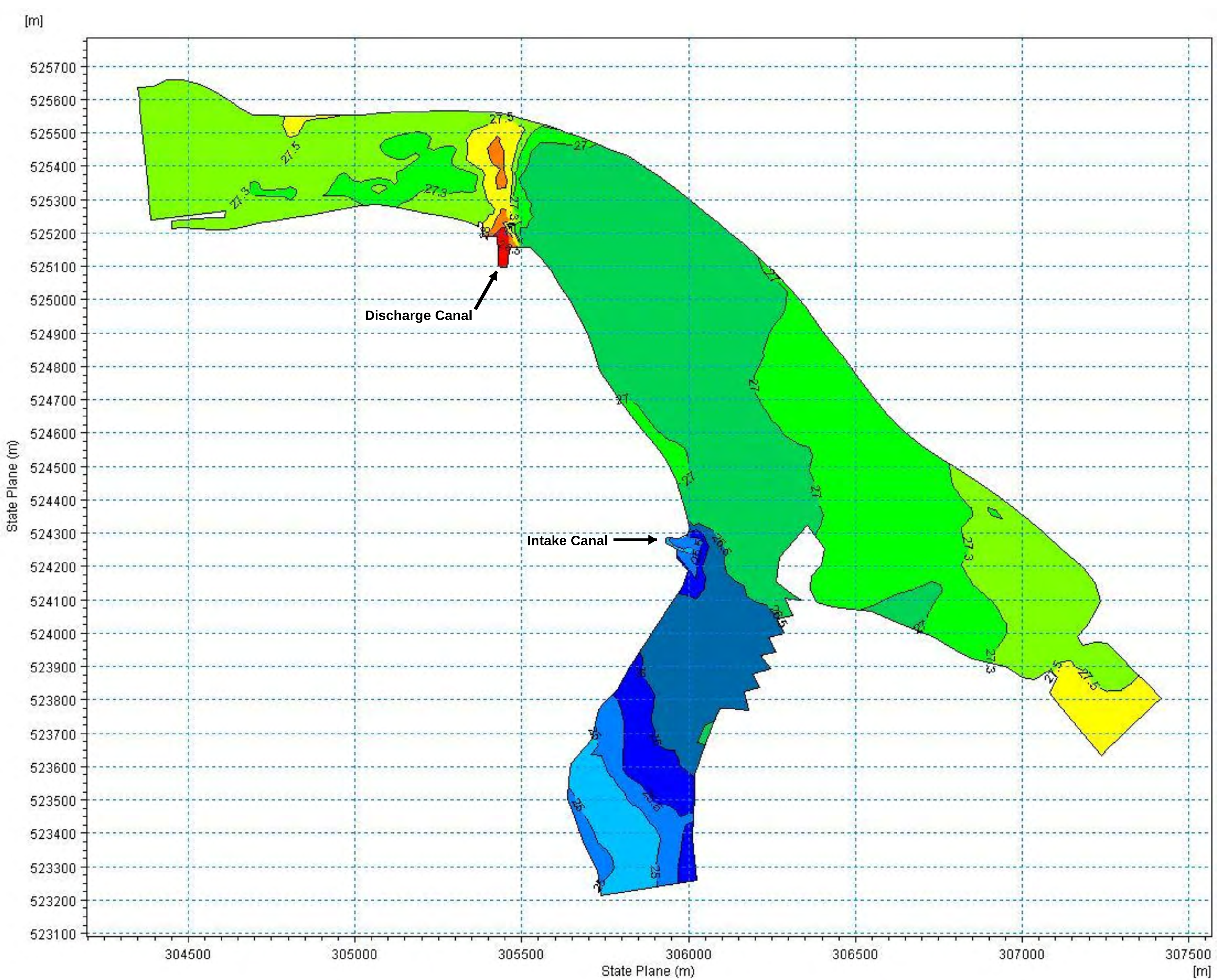
N

0 200 400
Meters

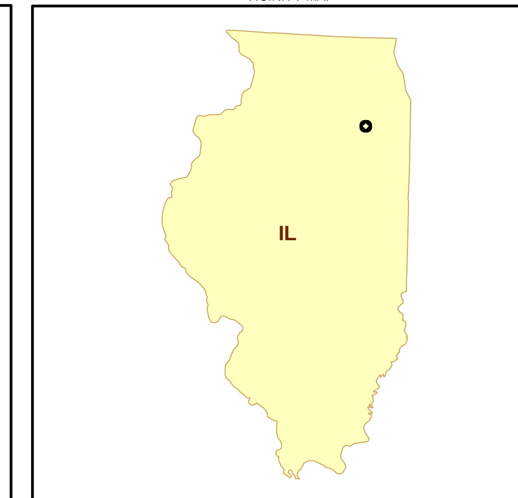
1 in = 235 meters
(11 x 17 inch figure)

FIGURE **D-4**
Ship Track for the 29 August 2013
Dresden Plume Survey

Path: L:\GIS\Data\Midwest\Illinois\Dresden\MXD\Figure_3-2_Ship_Track_29Aug2013.mxd



VICINITY MAP



Map Date: December 2013
Data Sources: ArcGIS Map Service 2011

N

0 200 400
Meters

1 centimeter = 100 meters
(11 x 17 inch figure)

FIGURE **D-5**
Temperature Contours for the 1 August 2013 Dresden Plume Survey

Path: L:\GISDataMidwest\Illinois\Dresden\MXD\Figure_3-3_Surface_Temperature_Contours_1_August2013.mxd

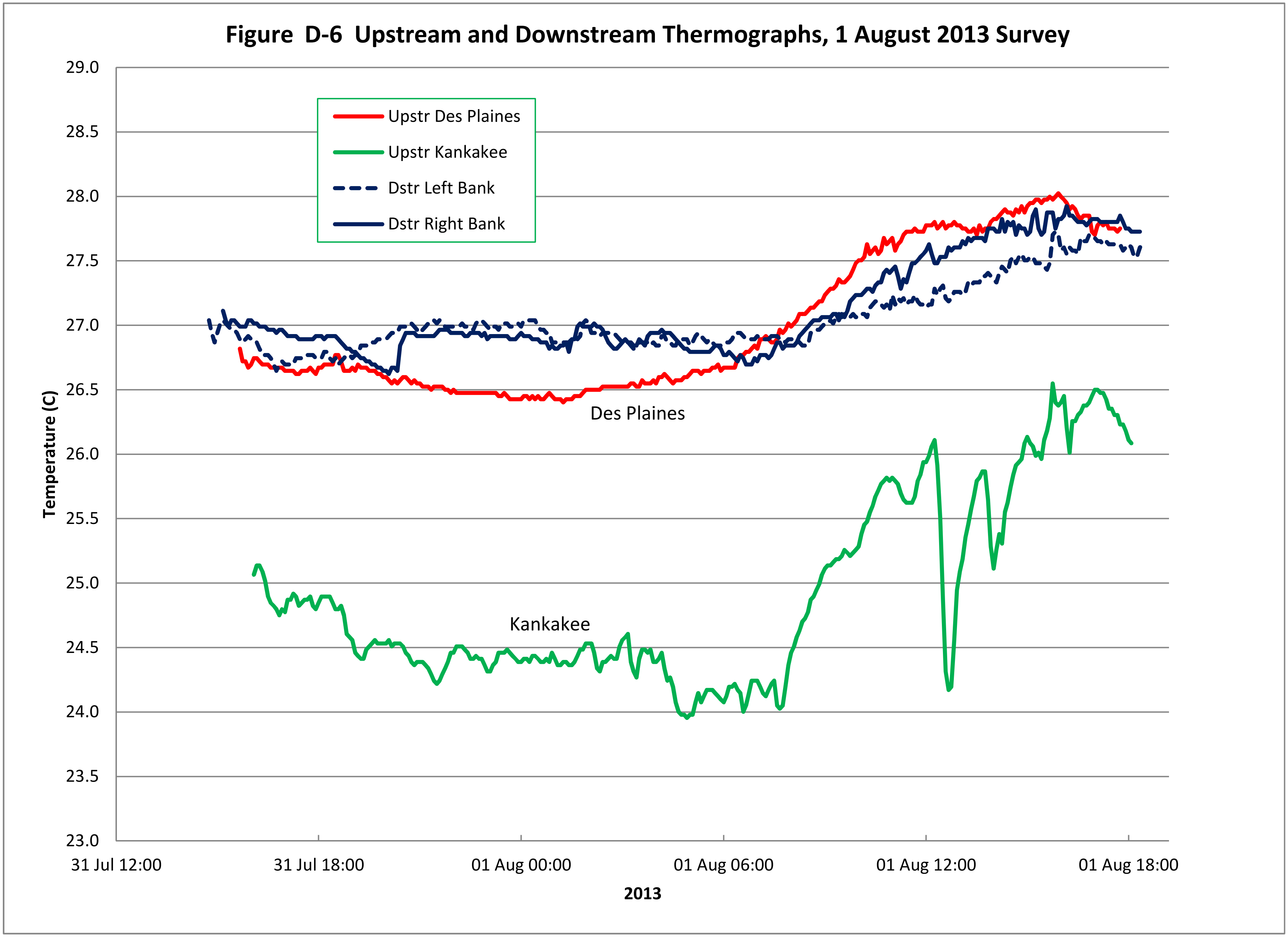
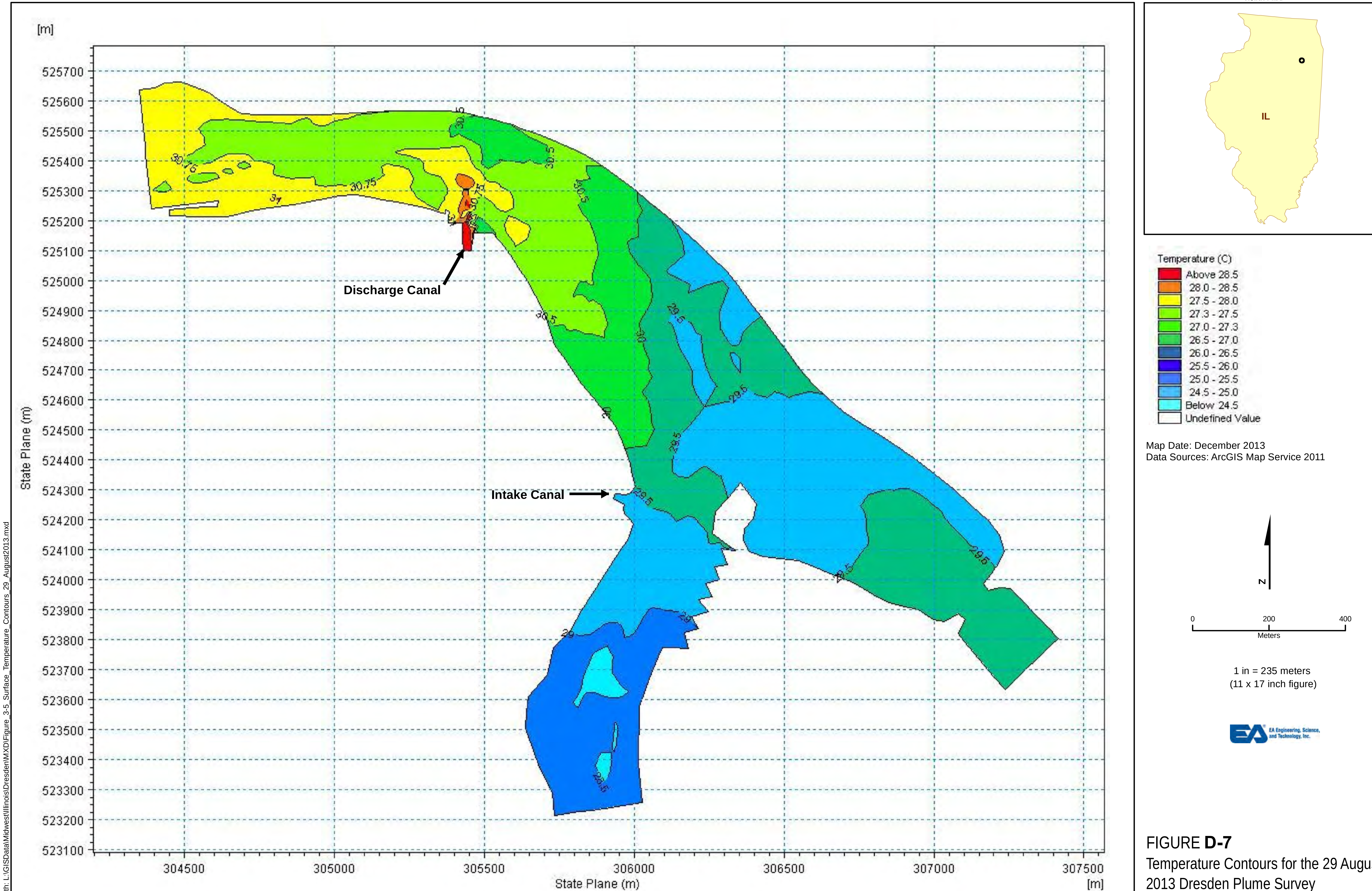


Figure D-6 Upstream and Downstream Thermographs, 1 August 2013 Survey
Upstr Des Plaines
Upstr Kankakee
Dstr Left Bank
Dstr Right Bank
Des Plaines
Kankakee
Temperature (C)
29.0
28.5
28.0
27.5
27.0
26.5
26.0
25.5
25.0
24.5
24.0
23.5
23.0
31 Jul 12:00
31 Jul 18:00
01 Aug 00:00
01 Aug 06:00
01 Aug 12:00
01 Aug 18:00
2013



Map Date: December 2013
Data Sources: ArcGIS Map Service 2011

1 in = 235 meters
(11 x 17 inch figure)

FIGURE **D-7**
Temperature Contours for the 29 August 2013 Dresden Plume Survey

Path: L:\GIS\Data\Midwest\Illinois\Dresden\MXD\Figure_3-5_Surface_Temperature_Contours_29_August2013.mxd

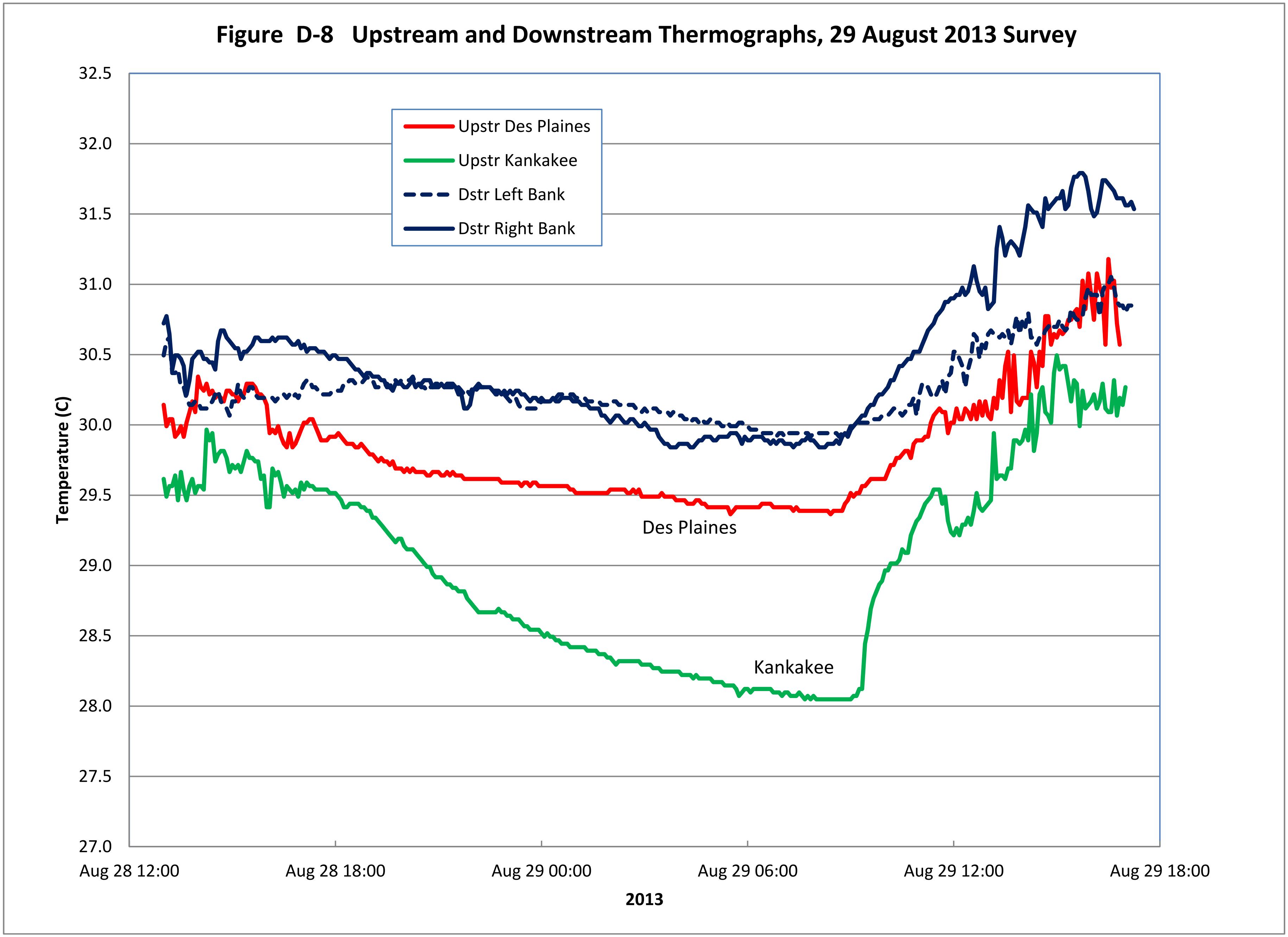


Figure D-8 Upstream and Downstream Thermographs, 29 August 2013 Survey
Upstr Des Plaines
Upstr Kankakee
Dstr Left Bank
Dstr Right Bank
Temperature (C)
32.5
32.0
31.5
31.0
30.5
30.0
29.5
29.0
28.5
28.0
27.5
27.0
Des Plaines
Kankakee
Aug 28 12:00
Aug 28 18:00
Aug 29 00:00
Aug 29 06:00
Aug 29 12:00
Aug 29 18:00
2013

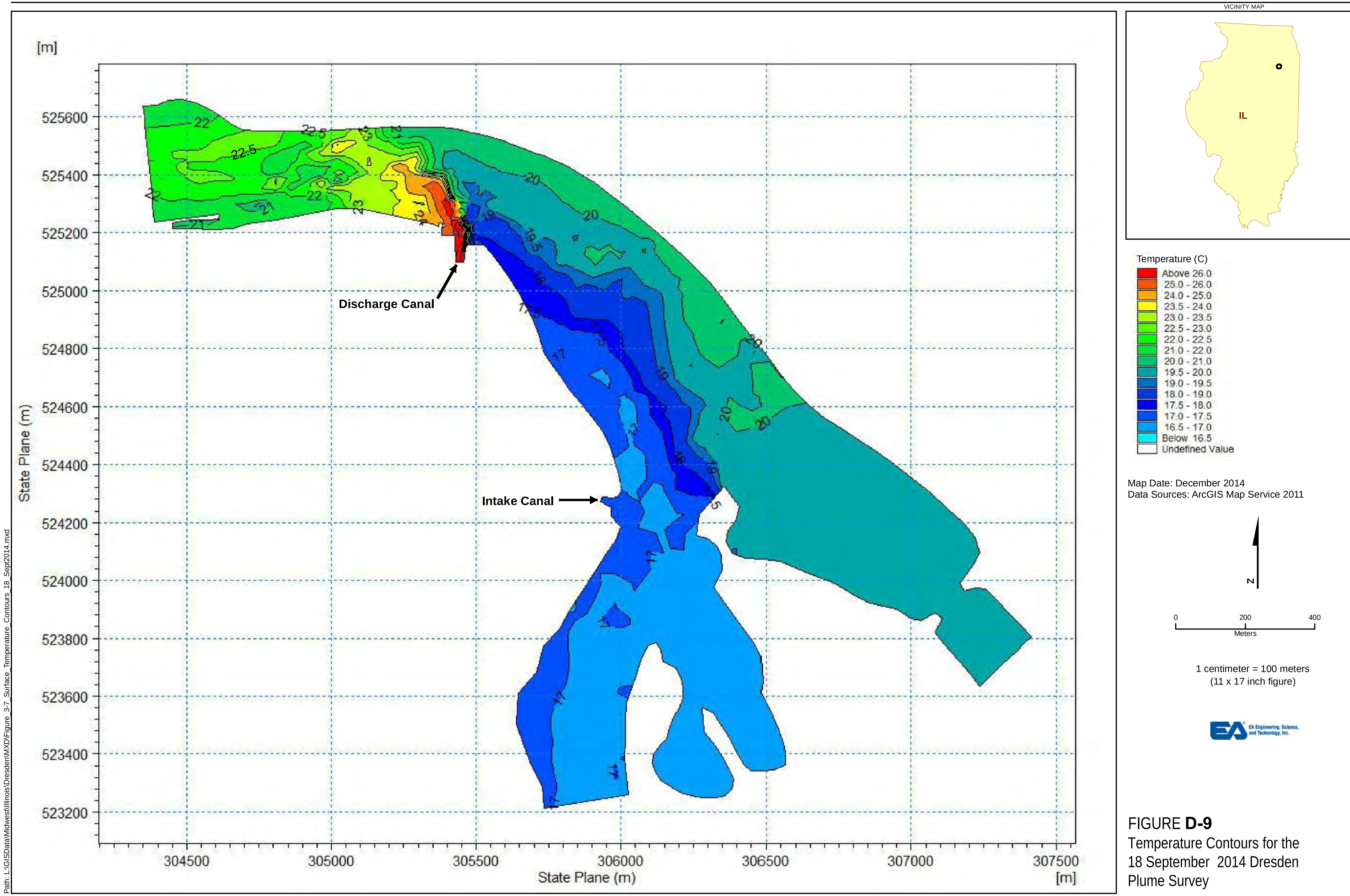


FIGURE **D-9**
Temperature Contours for the 18 September 2014 Dresden Plume Survey

Figure D-10 Upstream and Downstream Thermographs , 18 September 2014 Survey

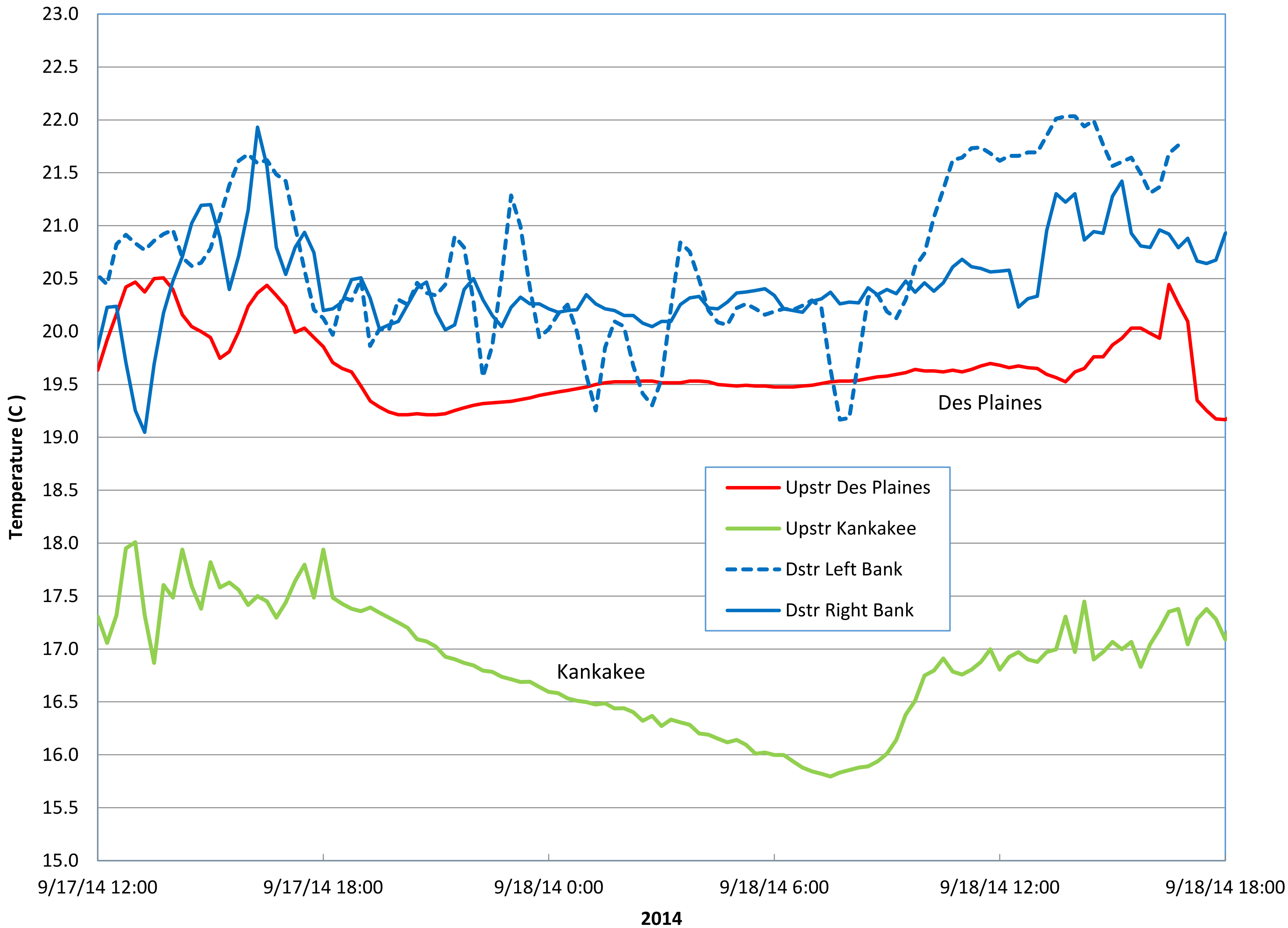
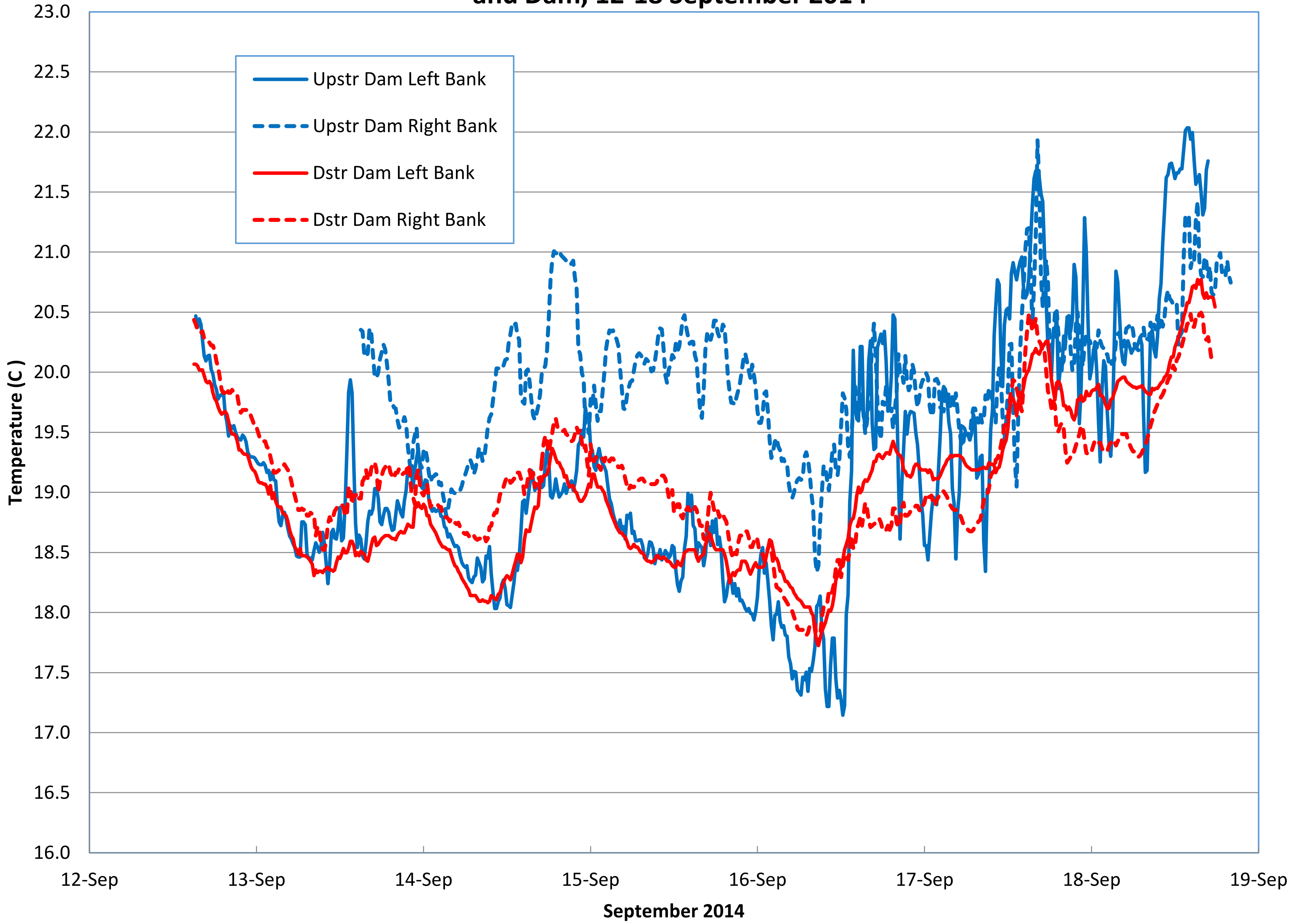
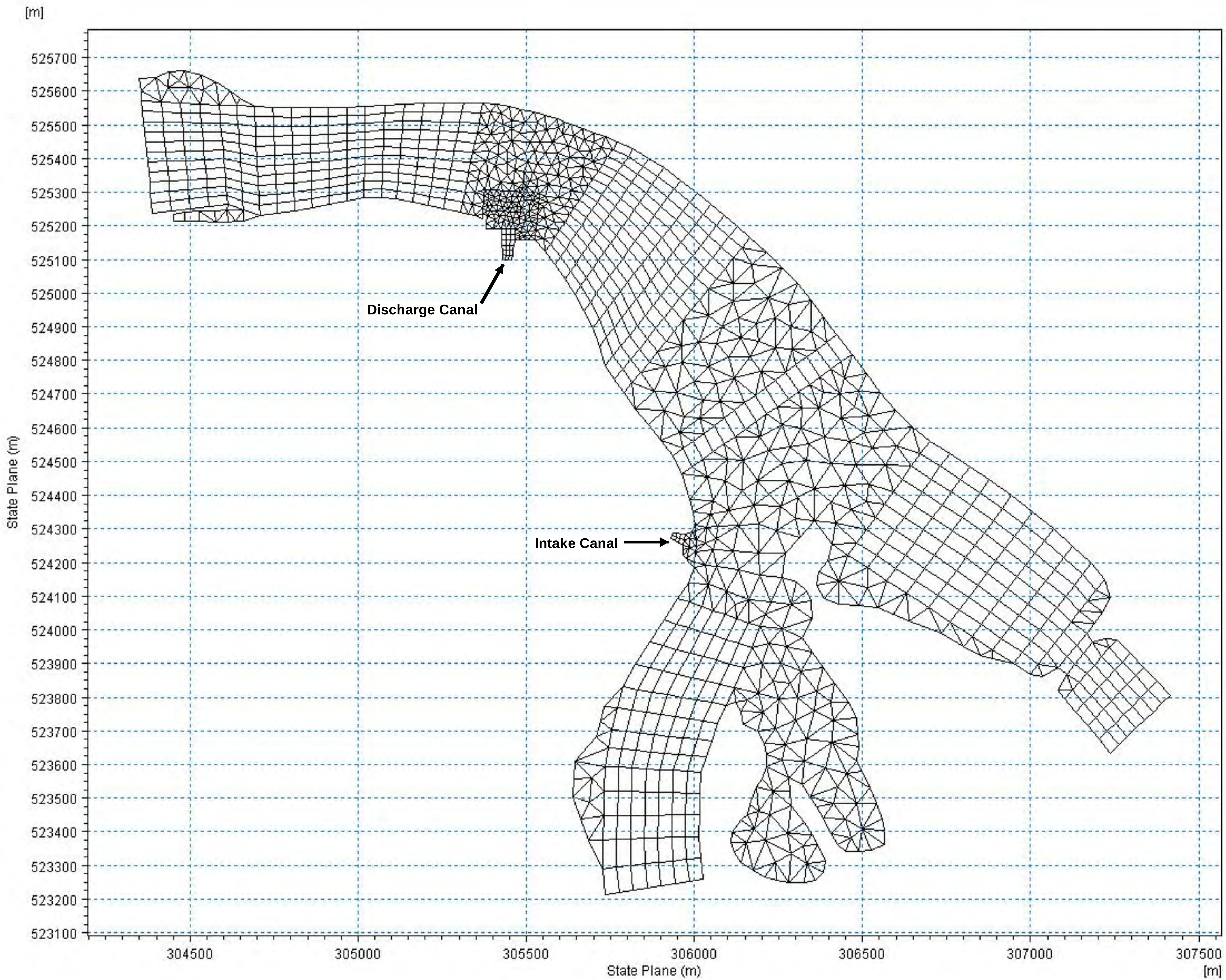
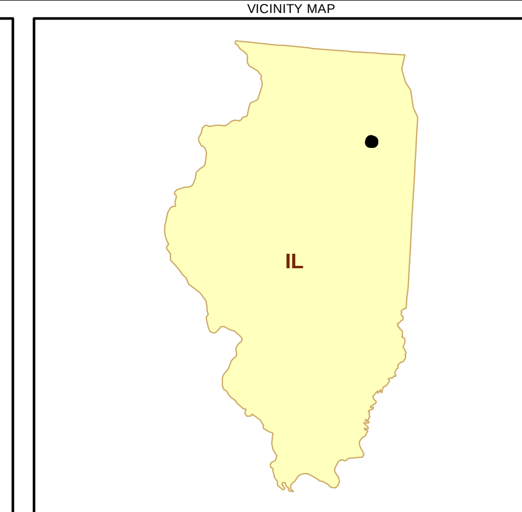


Figure D-11 Thermographs Upstream and Downstream of Dresden Island Lock and Dam, 12-18 September 2014







Map Date: December 2013
Data Sources: ArcGIS Map Service 2011

N

0 200 400
Meters

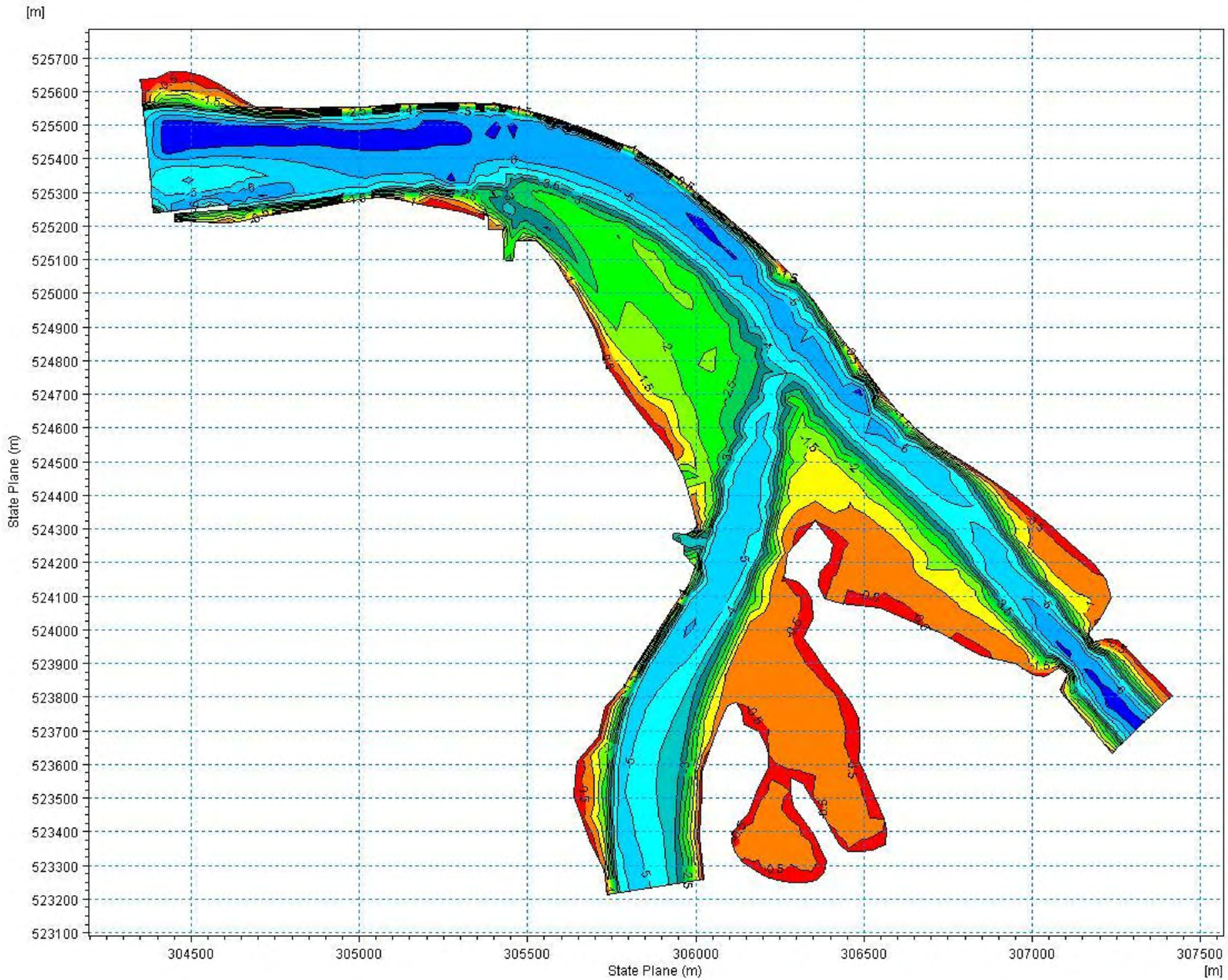
1 in = 235 meters
(11 x 17 inch figure)

EA Engineering, Science, and Technology, Inc.

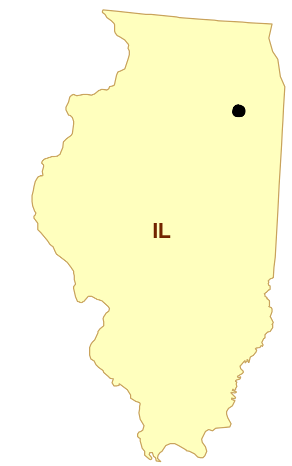
FIGURE **D-12**

Mike3 Model Grid

Path: L:\GISData\Midwest\Illinois\Dresden\MXD\Figure_4-1_Mike3_Model_Grid.mxd



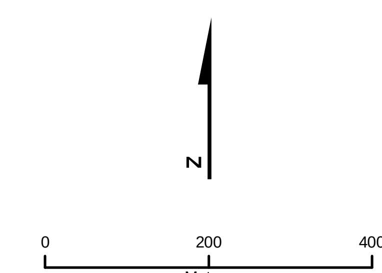
VICINITY MAP



Bathymetry [m]

	Above -0.5
	-1.0 - -0.5
	-1.5 - -1.0
	-2.0 - -1.5
	-2.5 - -2.0
	-3.0 - -2.5
	-3.5 - -3.0
	-4.0 - -3.5
	-5.0 - -4.0
	-6.0 - -5.0
	-7.0 - -6.0
	Below -7.0
	Undefined Value

Map Date: December 2013
Data Sources: ArcGIS Map Service 2011



1 in = 235 meters
(11 x 17 inch figure)

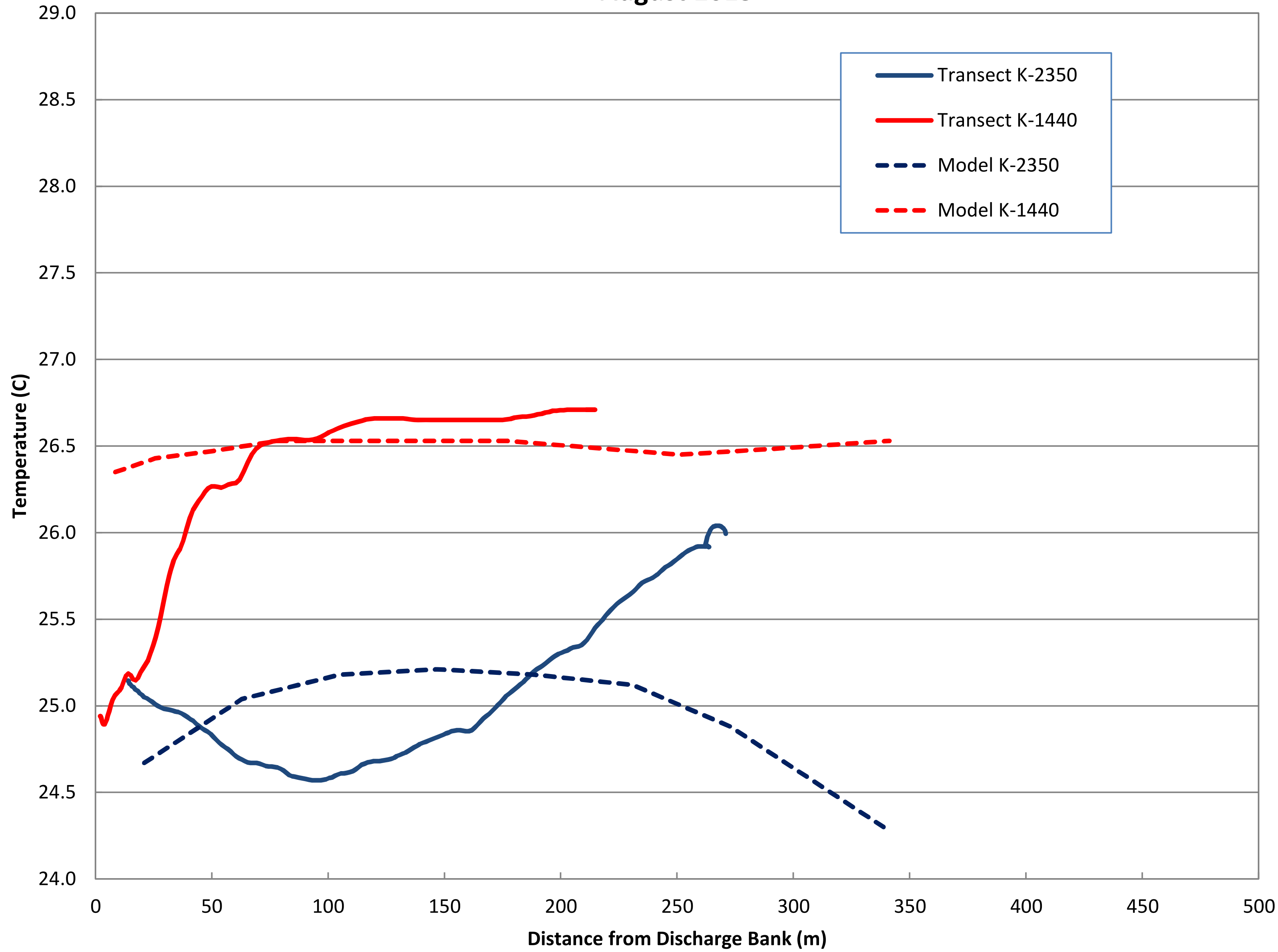
EA Engineering, Science, and Technology, Inc.

FIGURE **D-13**

Bathymetric Contours, 15-16 November 2013

Path: L:\GISData\Midwest\Illinois\Dresden\MXD\Figure_4-2_Bathymetric_Contours_6_Nov2013.mxd

Figure D-14 Observed and Modeled Temperature at Transects K-2350 and K-1440, 1 August 2013



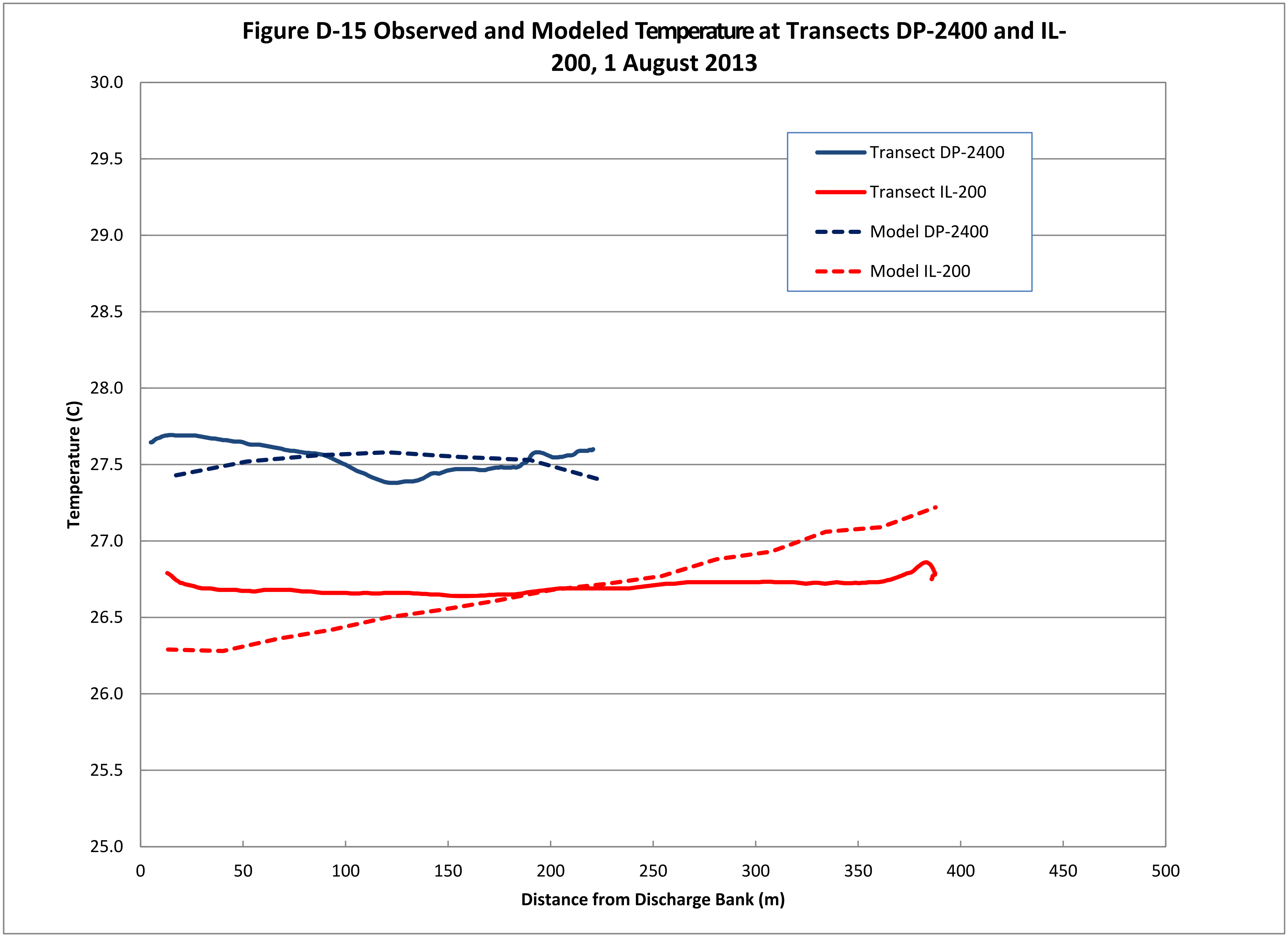


Figure D-15 Observed and Modeled Temperature at Transects DP-2400 and IL-200, 1 August 2013
Temperature (C)
30.0
29.5
29.0
28.5
28.0
27.5
27.0
26.5
26.0
25.5
25.0
0
50
100
150
200
250
300
350
400
450
500
Distance from Discharge Bank (m)
Transect DP-2400
Transect IL-200
Model DP-2400
Model IL-200

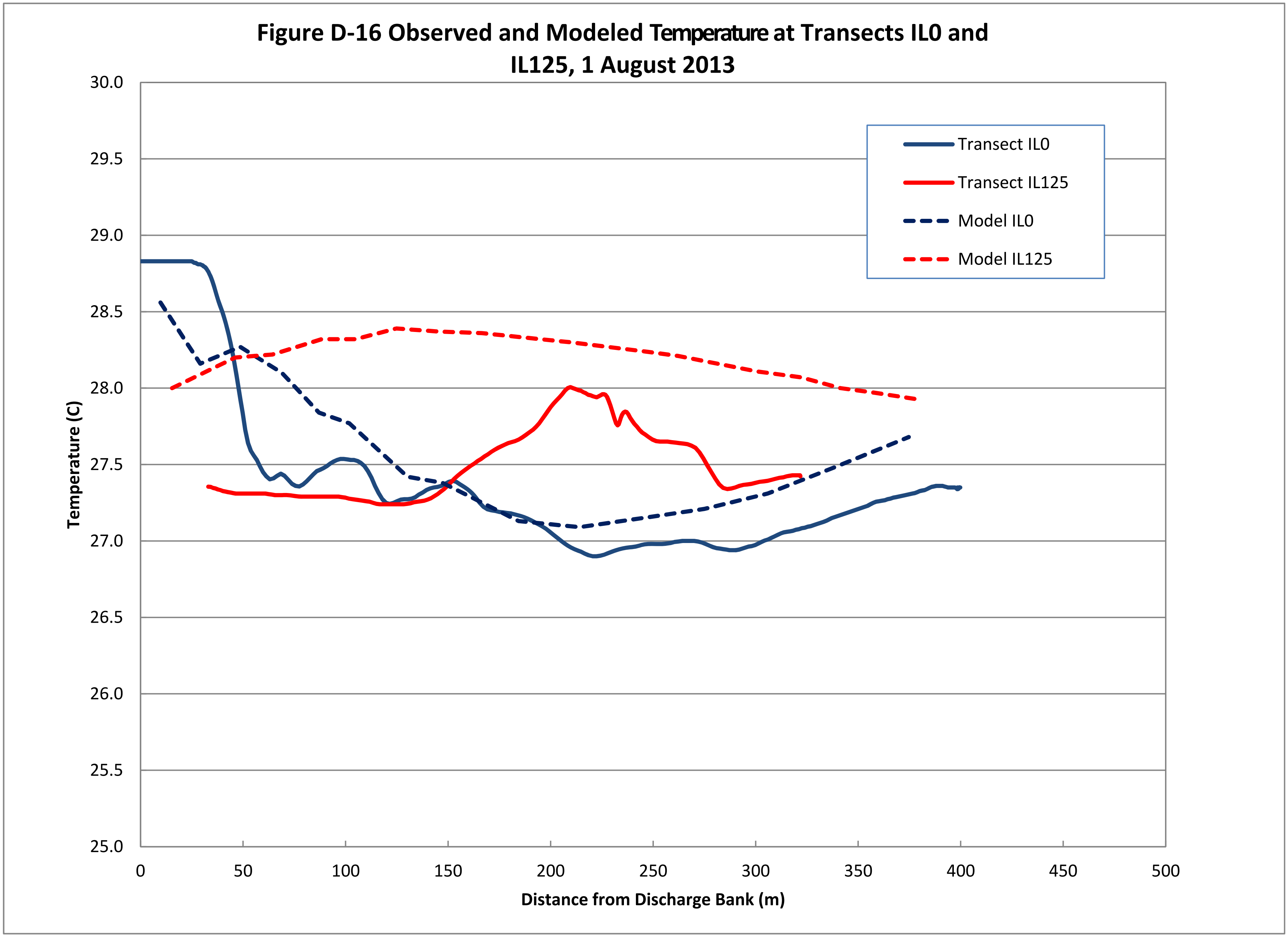


Figure D-16 Observed and Modeled Temperature at Transects IL0 and IL125, 1 August 2013
30.0
29.5
29.0
28.5
28.0
27.5
27.0
26.5
26.0
25.5
25.0
Temperature (C)
0
50
100
150
200
250
300
350
400
450
500
Distance from Discharge Bank (m)
Transect IL0
Transect IL125
Model IL0
Model IL125

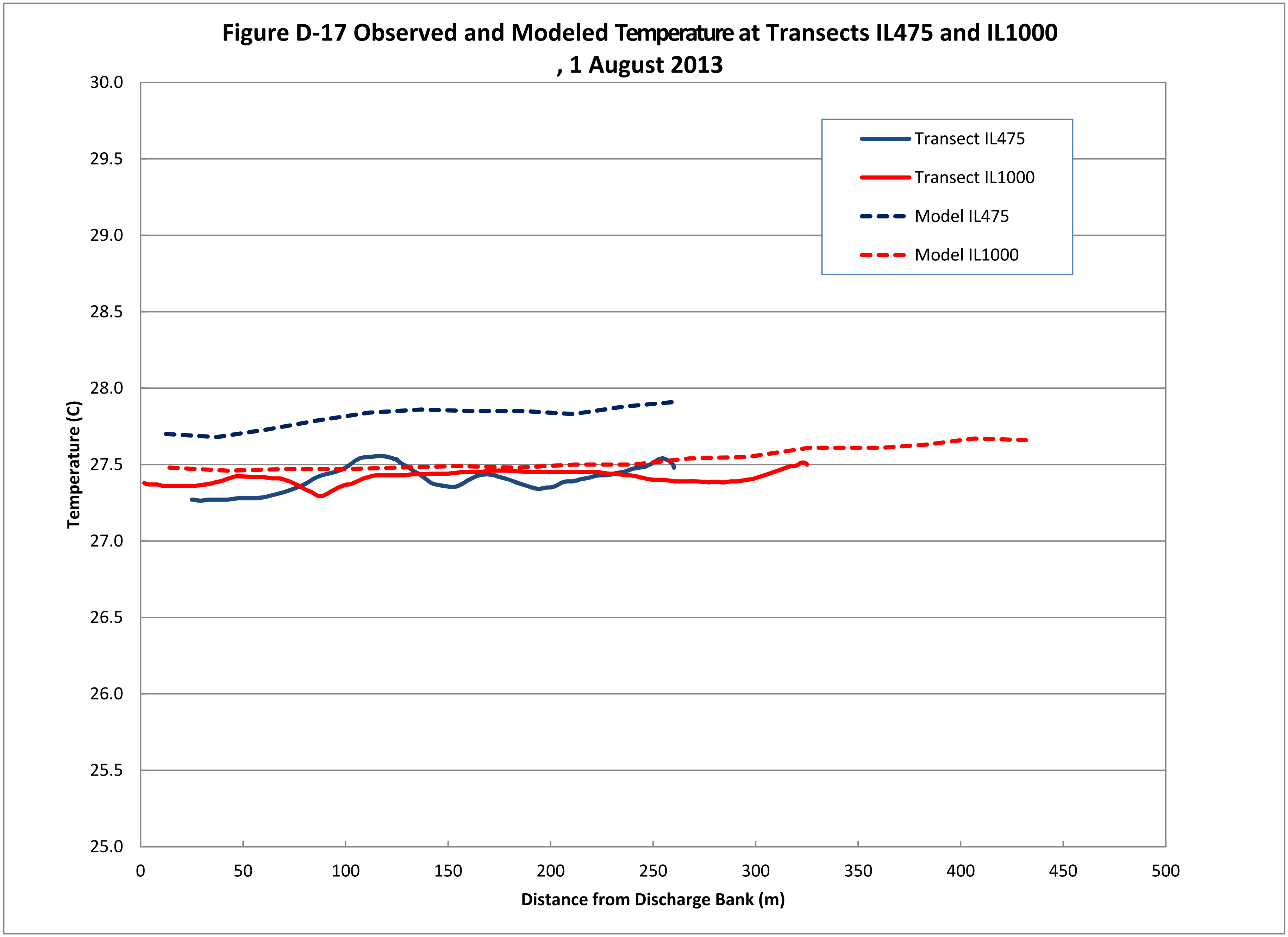
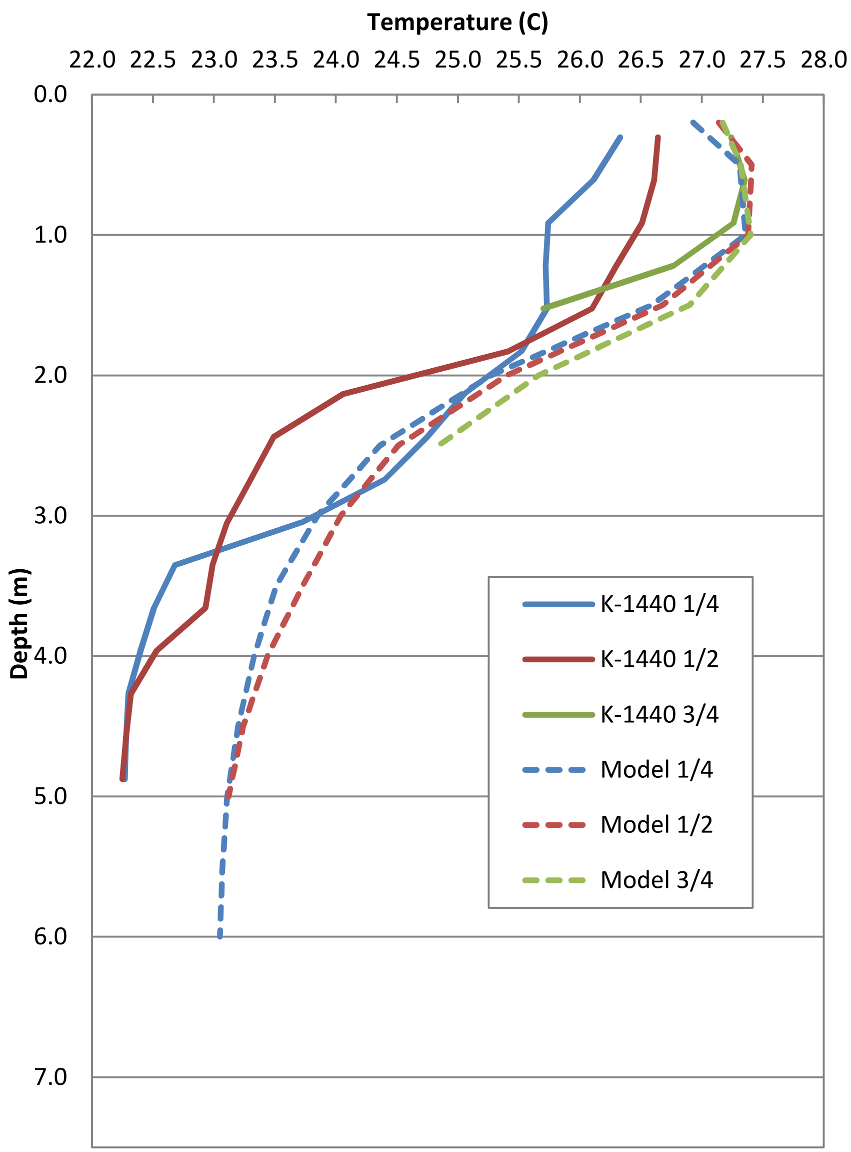


Figure D-17 Observed and Modeled Temperature at Transects IL475 and IL1000
, 1 August 2013
Temperature (C)
30.0
29.5
29.0
28.5
28.0
27.5
27.0
26.5
26.0
25.5
25.0
0
50
100
150
200
250
300
350
400
450
500
Distance from Discharge Bank (m)
Transect IL475
Transect IL1000
Model IL475
Model IL1000

Figure D-18 Observed and Modeled Vertical Temperatures at Transect K-1440 and DP-1700, 1 August 2013



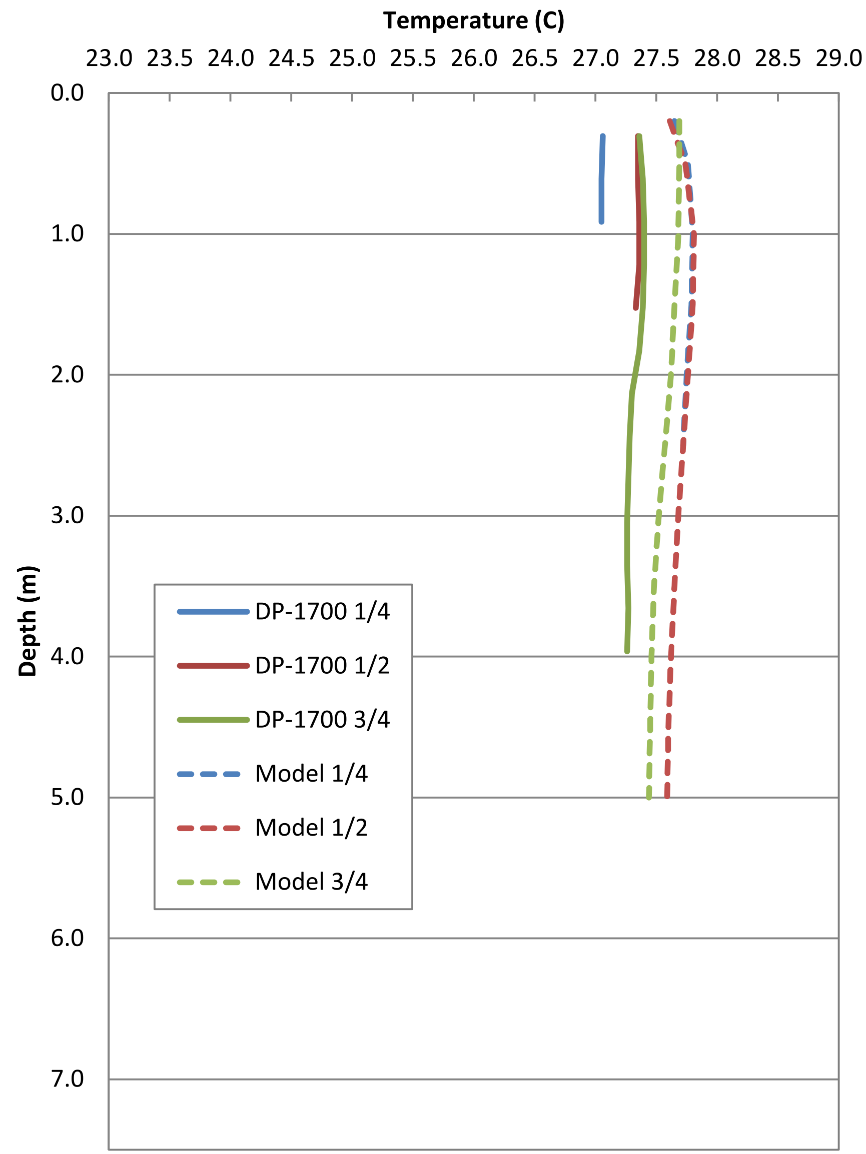


Figure D-19 Observed and Modeled Vertical Temperatures at Transects IL-1000 and IL0, 1 August 2013

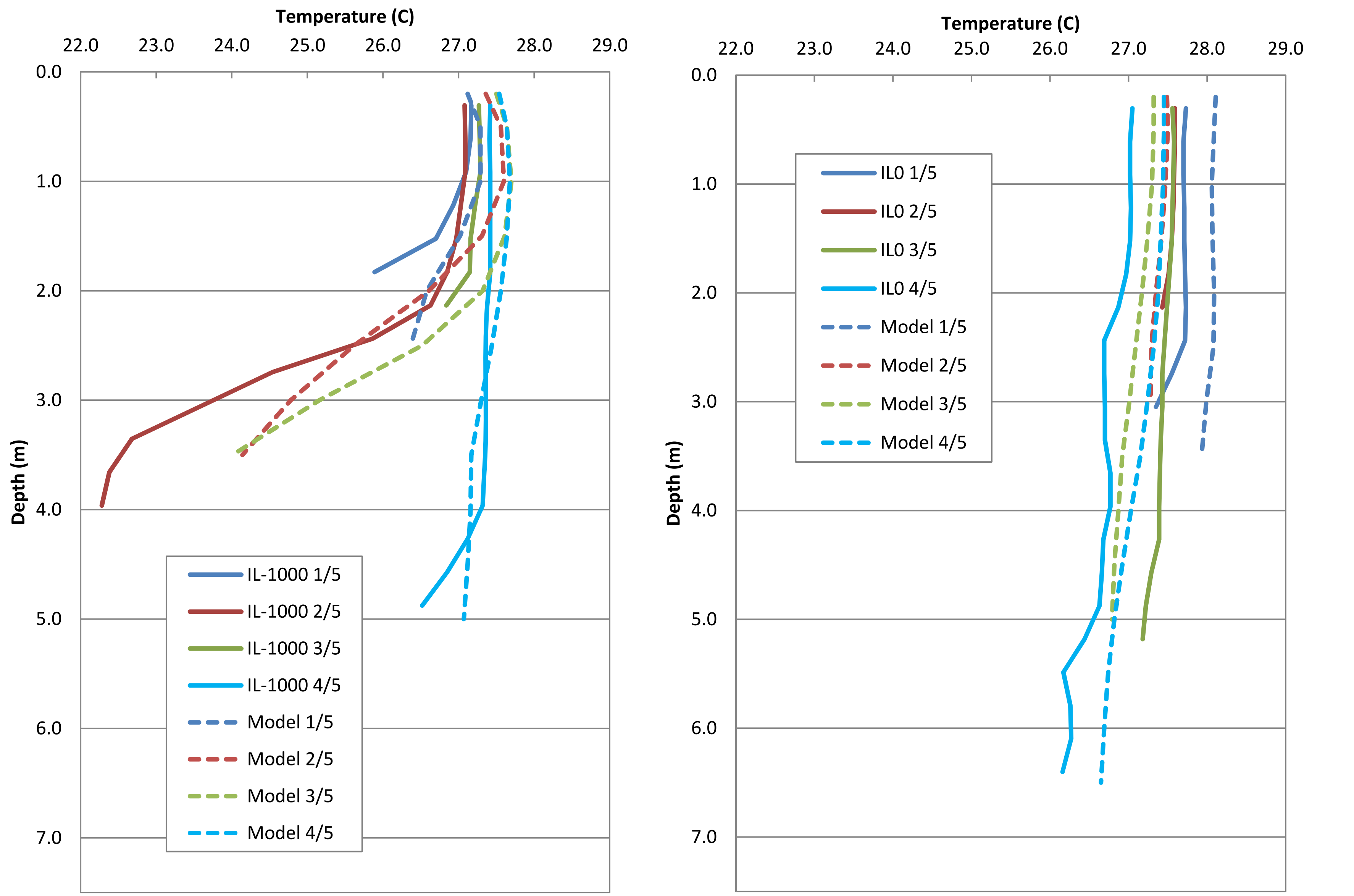


Figure D-20 Observed and Modeled Vertical Temperatures at Transects IL275, IL720 and IL1000, 1 August 2013

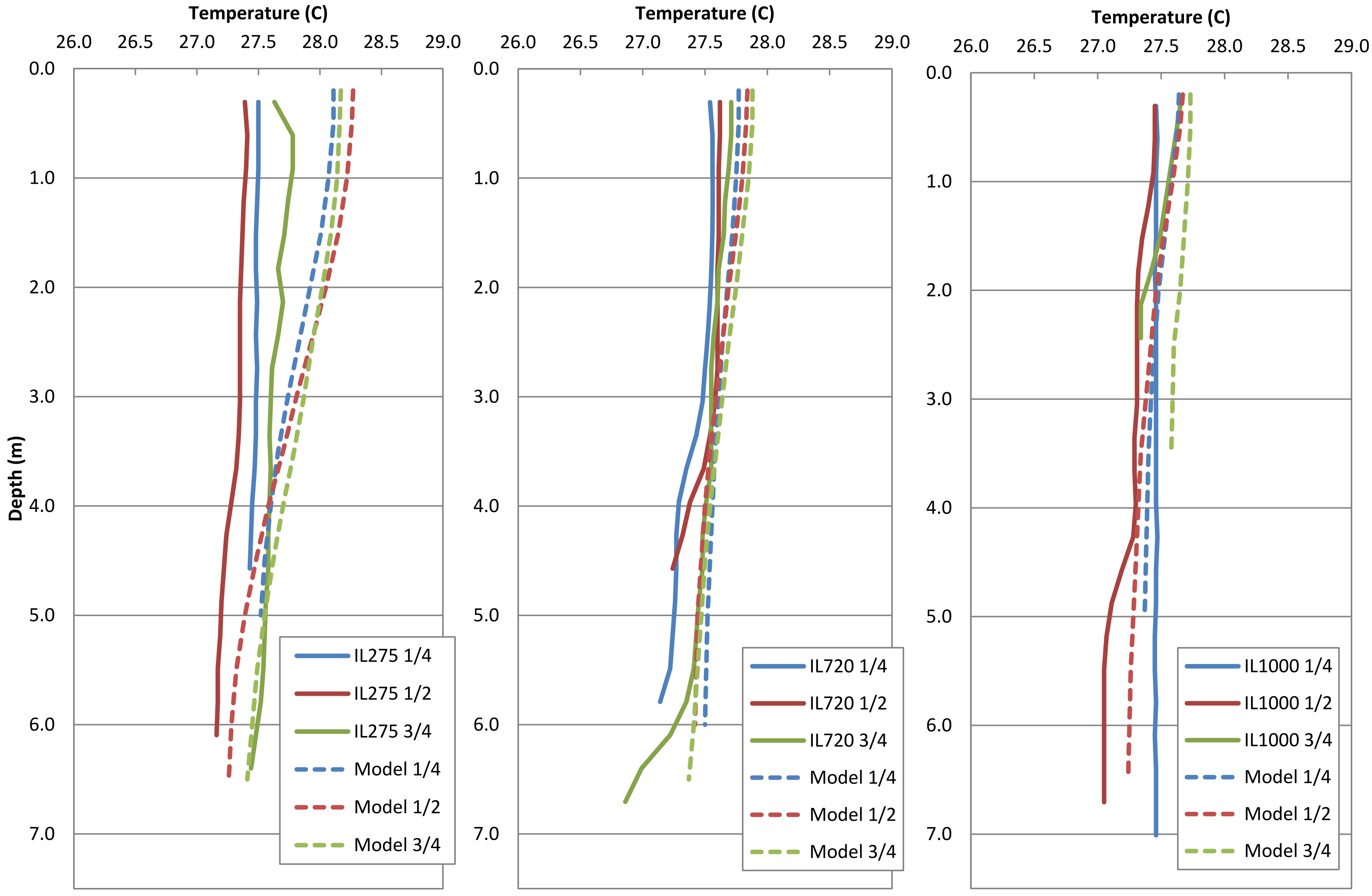
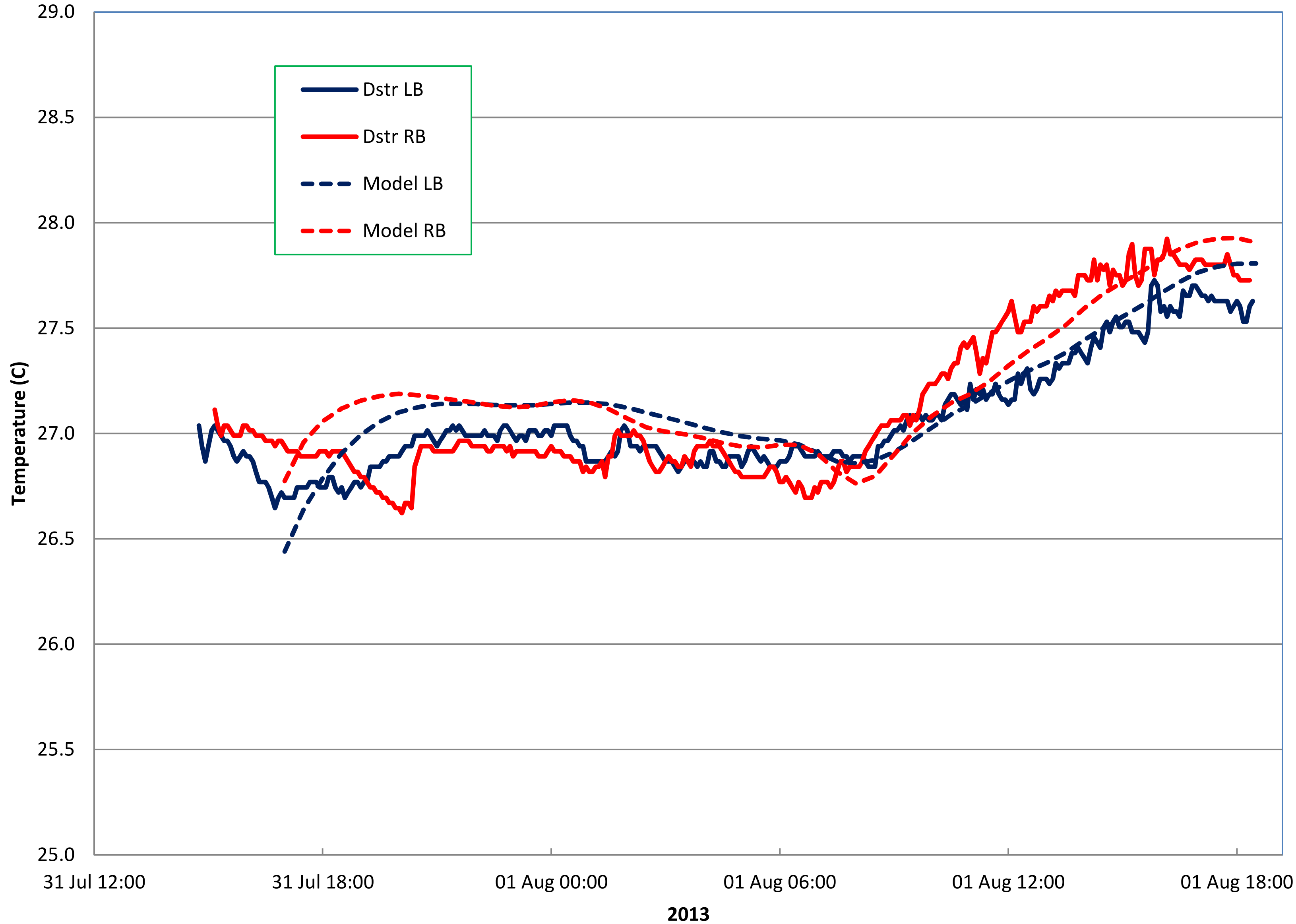


Figure D-21 Observed and Modeled Temperatures at Downstream Left and Right Bank Thermographs, 1 August 2013 Survey



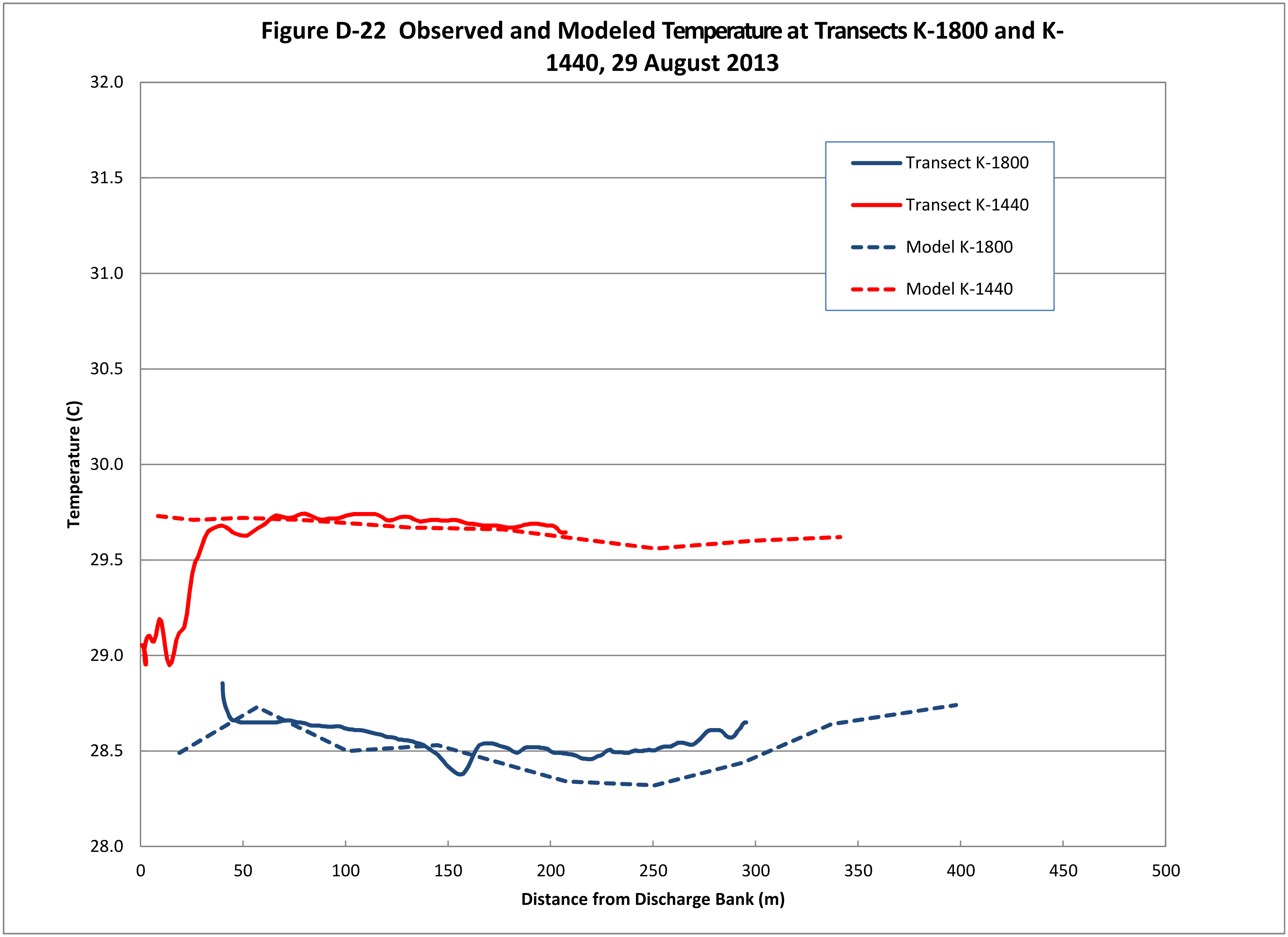


Figure D-22 Observed and Modeled Temperature at Transects K-1800 and K-1440, 29 August 2013
Temperature (C)
32.0
31.5
31.0
30.5
30.0
29.5
29.0
28.5
28.0
0
50
100
150
200
250
300
350
400
450
500
Distance from Discharge Bank (m)
Transect K-1800
Transect K-1440
Model K-1800
Model K-1440

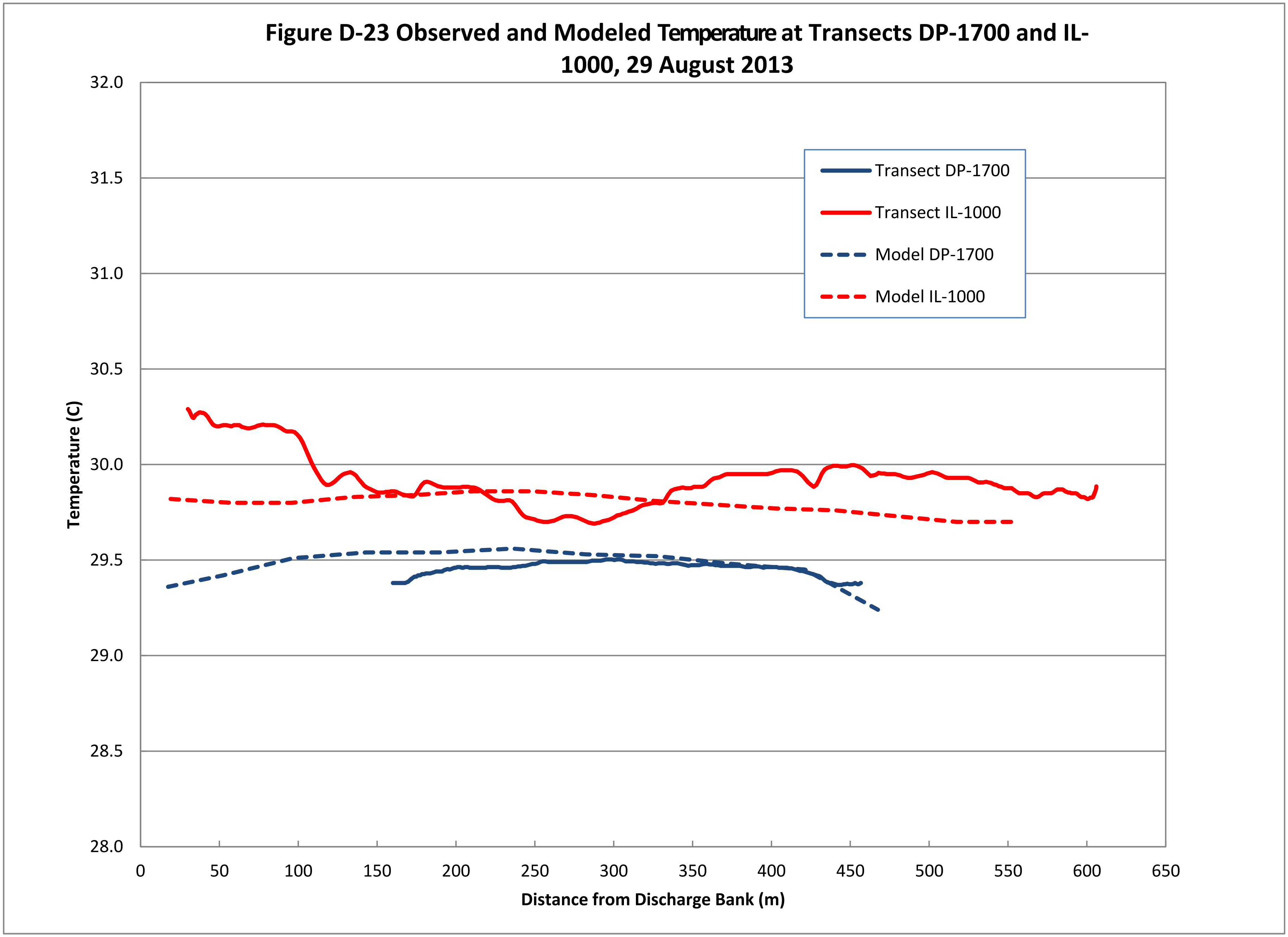


Figure D-23 Observed and Modeled Temperature at Transects DP-1700 and IL-1000, 29 August 2013
Transect DP-1700
Transect IL-1000
Model DP-1700
Model IL-1000
Temperature (C)
32.0
31.5
31.0
30.5
30.0
29.5
29.0
28.5
28.0
0
50
100
150
200
250
300
350
400
450
500
550
600
650
Distance from Discharge Bank (m)

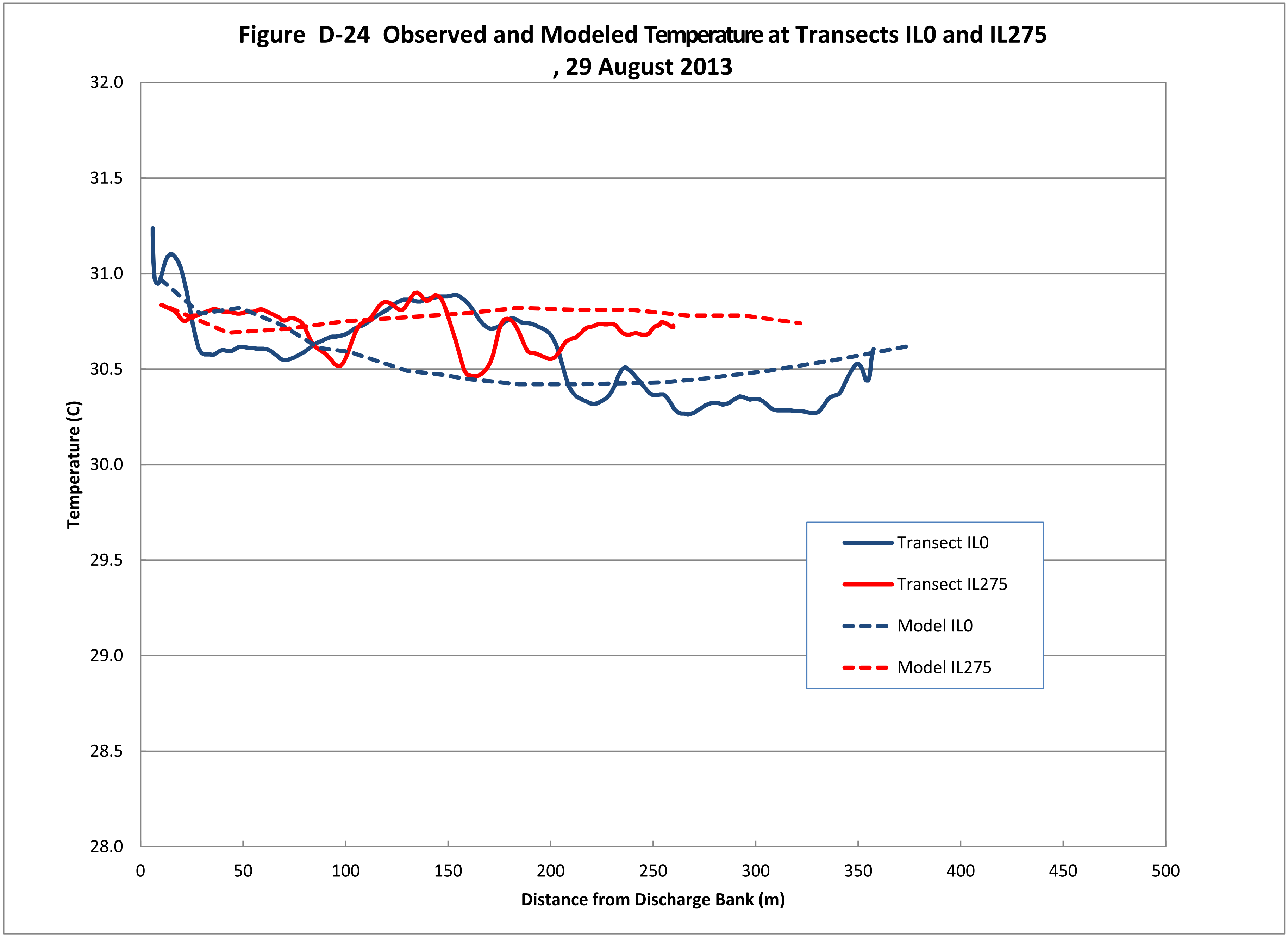


Figure D-24 Observed and Modeled Temperature at Transects IL0 and IL275
, 29 August 2013
Temperature (C)
32.0
31.5
31.0
30.5
30.0
29.5
29.0
28.5
28.0
0
50
100
150
200
250
300
350
400
450
500
Distance from Discharge Bank (m)
Transect IL0
Transect IL275
Model IL0
Model IL275

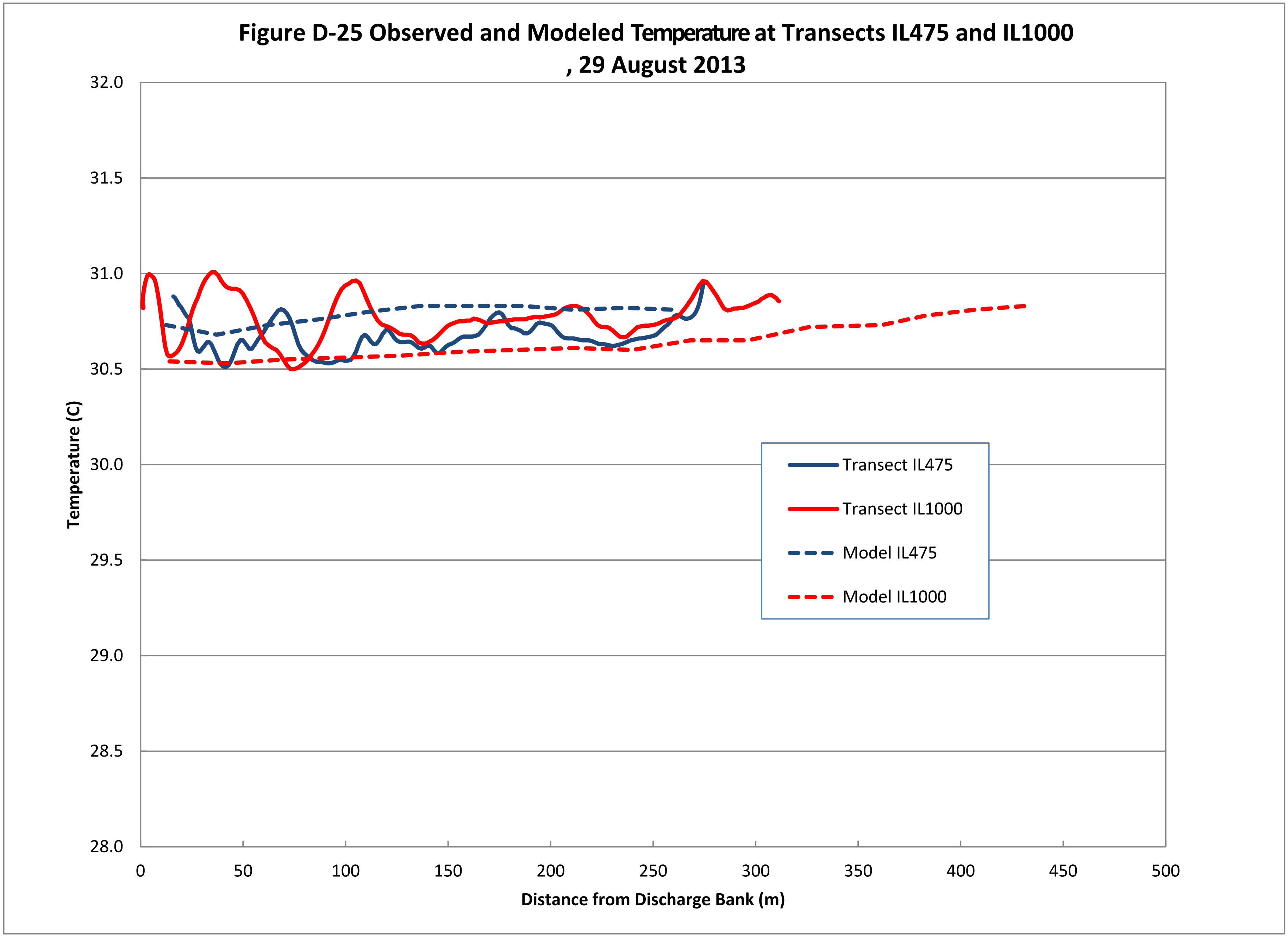
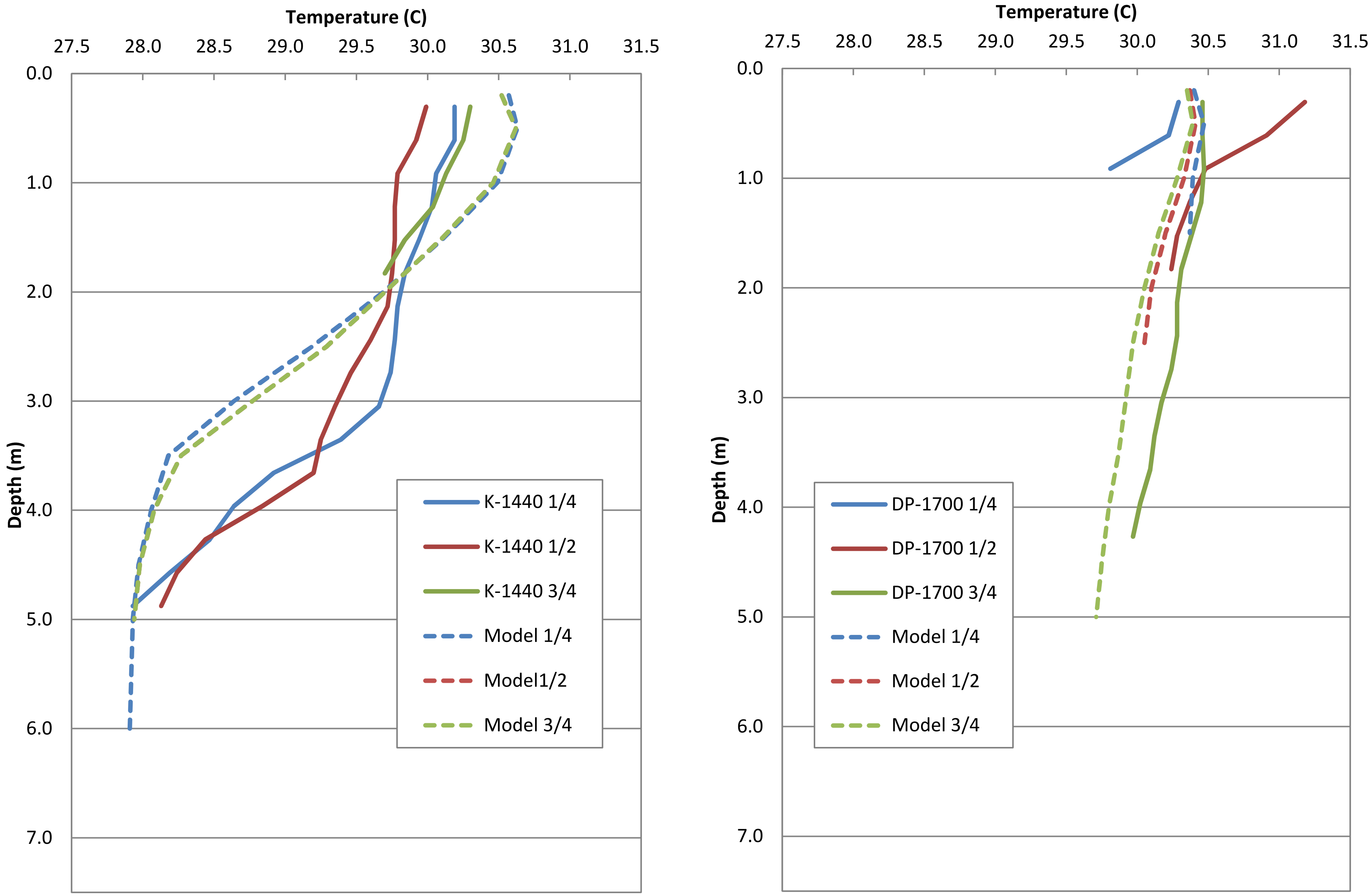


Figure D-25 Observed and Modeled Temperature at Transects IL475 and IL1000
, 29 August 2013
Temperature (C)
32.0
31.5
31.0
30.5
30.0
29.5
29.0
28.5
28.0
0
50
100
150
200
250
300
350
400
450
500
Distance from Discharge Bank (m)
Transect IL475
Transect IL1000
Model IL475
Model IL1000

Figure D-26 Observed and Modeled Vertical Temperatures at Transect K-1440 and DP-1700, 29 August 2013



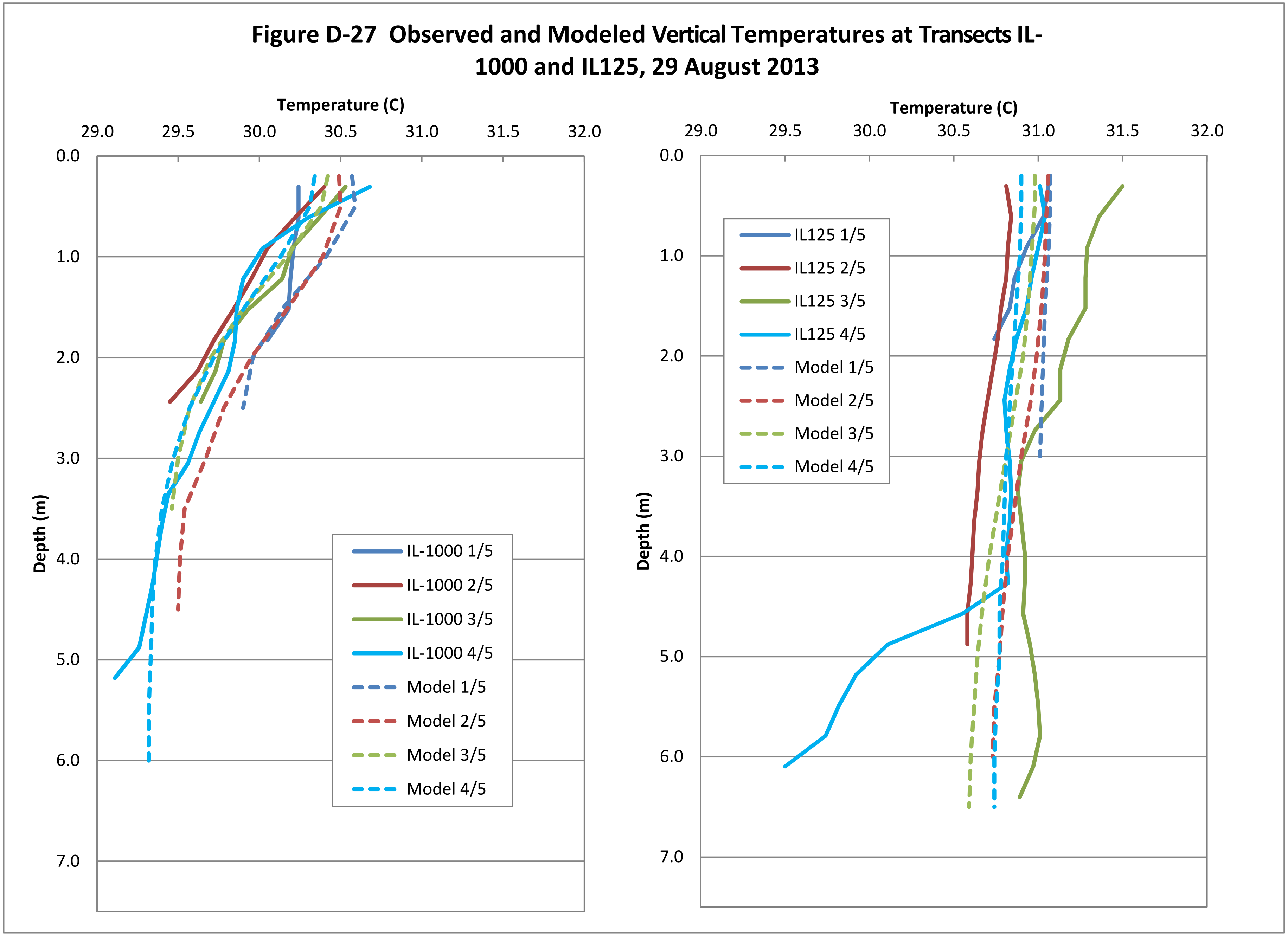


Figure D-27 Observed and Modeled Vertical Temperatures at Transects IL-1000 and IL125, 29 August 2013
Temperature (C)
29.0
29.5
30.0
30.5
31.0
31.5
32.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Depth (m)
IL-1000 1/5
IL-1000 2/5
IL-1000 3/5
IL-1000 4/5
Model 1/5
Model 2/5
Model 3/5
Model 4/5
Temperature (C)
29.0
29.5
30.0
30.5
31.0
31.5
32.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Depth (m)
IL125 1/5
IL125 2/5
IL125 3/5
IL125 4/5
Model 1/5
Model 2/5
Model 3/5
Model 4/5

Figure D-28 Observed and Modeled Vertical Temperatures at Transects IL475, IL720 and IL1000, 29 August 2013

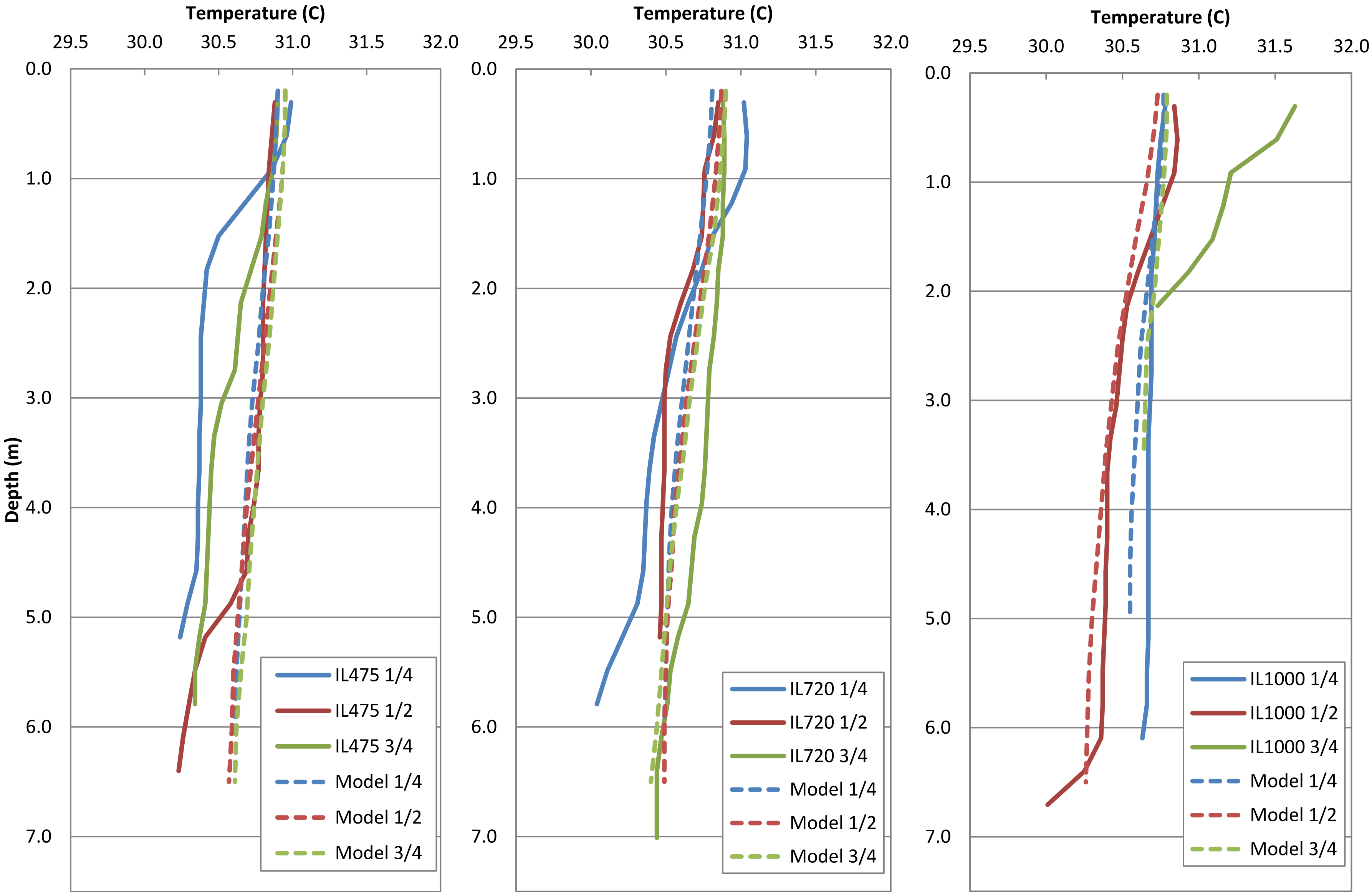
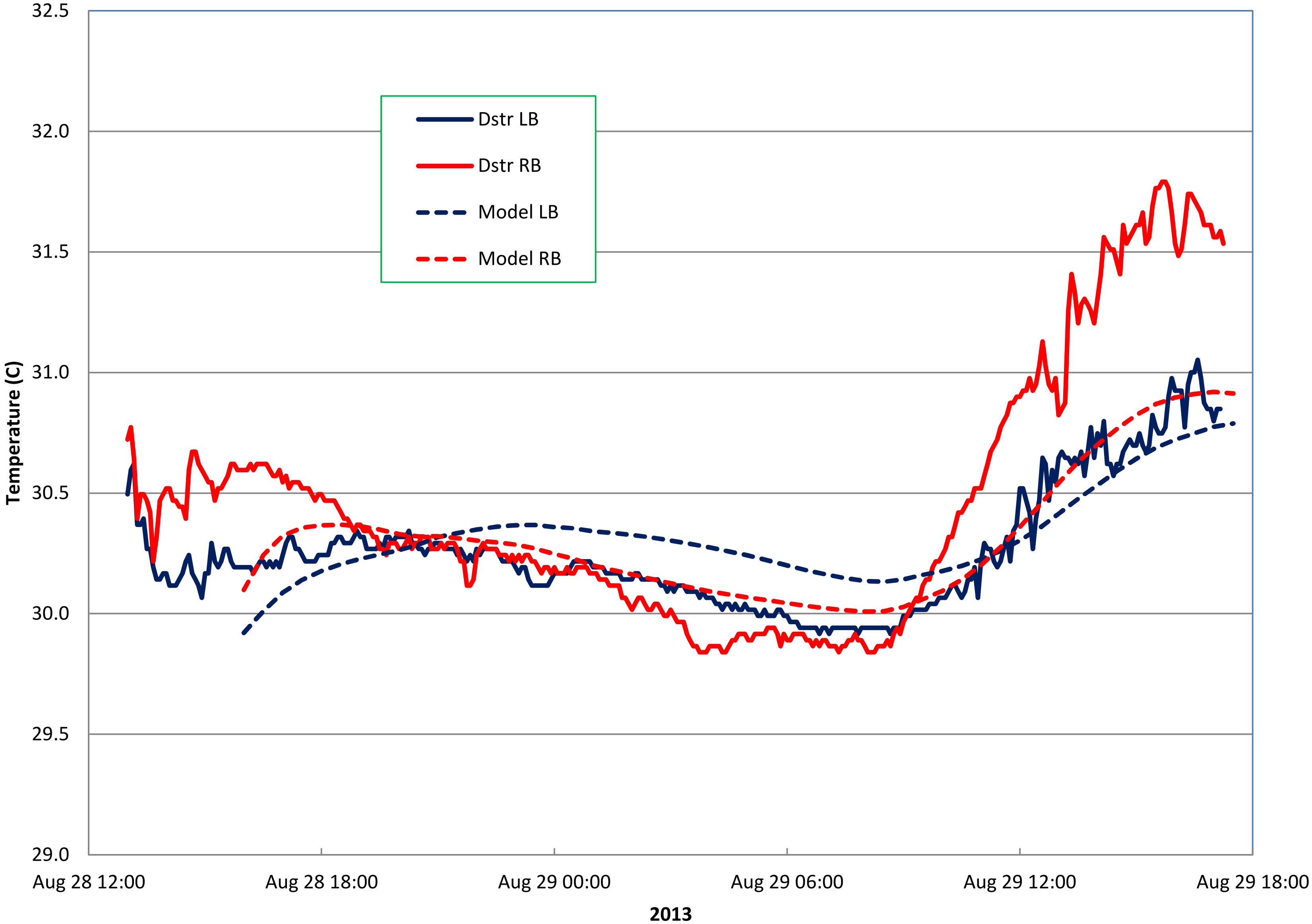


Figure D-29 Observed amd Modeled Temperatures at Downstream Left and Right Bank Thermographs, 29 August 2013 Survey



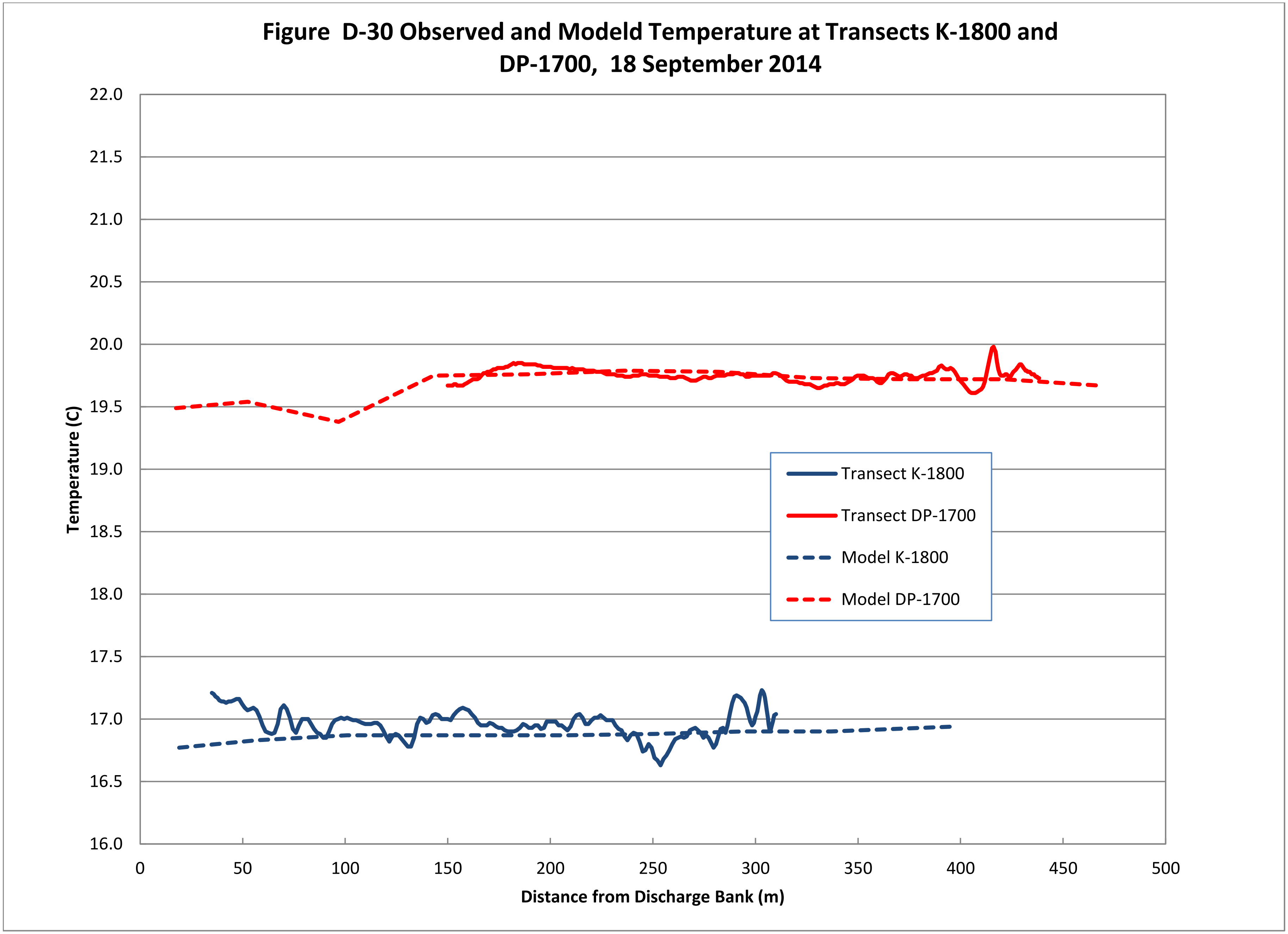


Figure D-30 Observed and Modeld Temperature at Transects K-1800 and DP-1700, 18 September 2014
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
Temperature (C)
0
50
100
150
200
250
300
350
400
450
500
Distance from Discharge Bank (m)
Transect K-1800
Transect DP-1700
Model K-1800
Model DP-1700

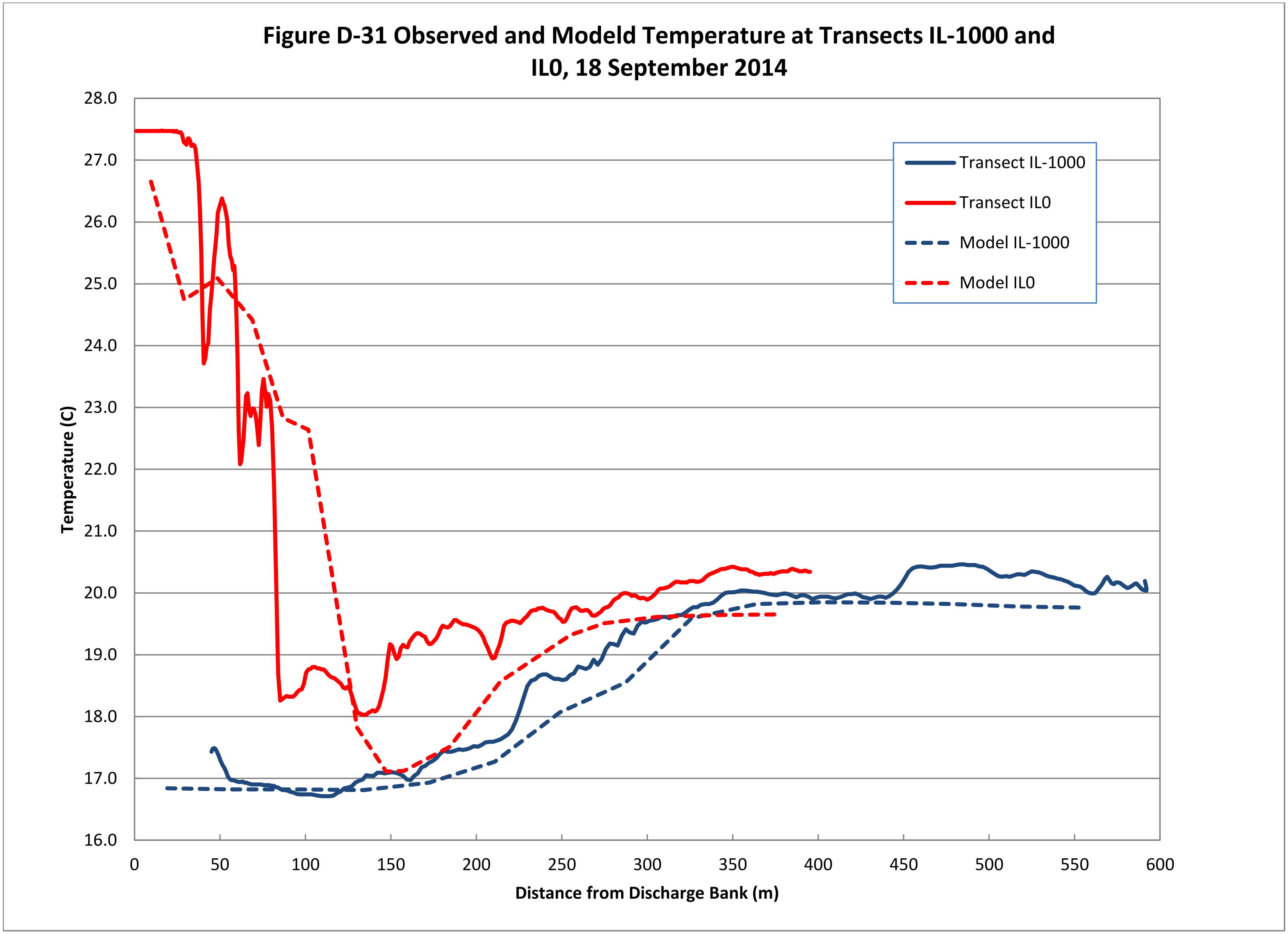


Figure D-31 Observed and Modeld Temperature at Transects IL-1000 and IL0, 18 September 2014
Temperature (C)
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance from Discharge Bank (m)
Transect IL-1000
Transect IL0
Model IL-1000
Model IL0

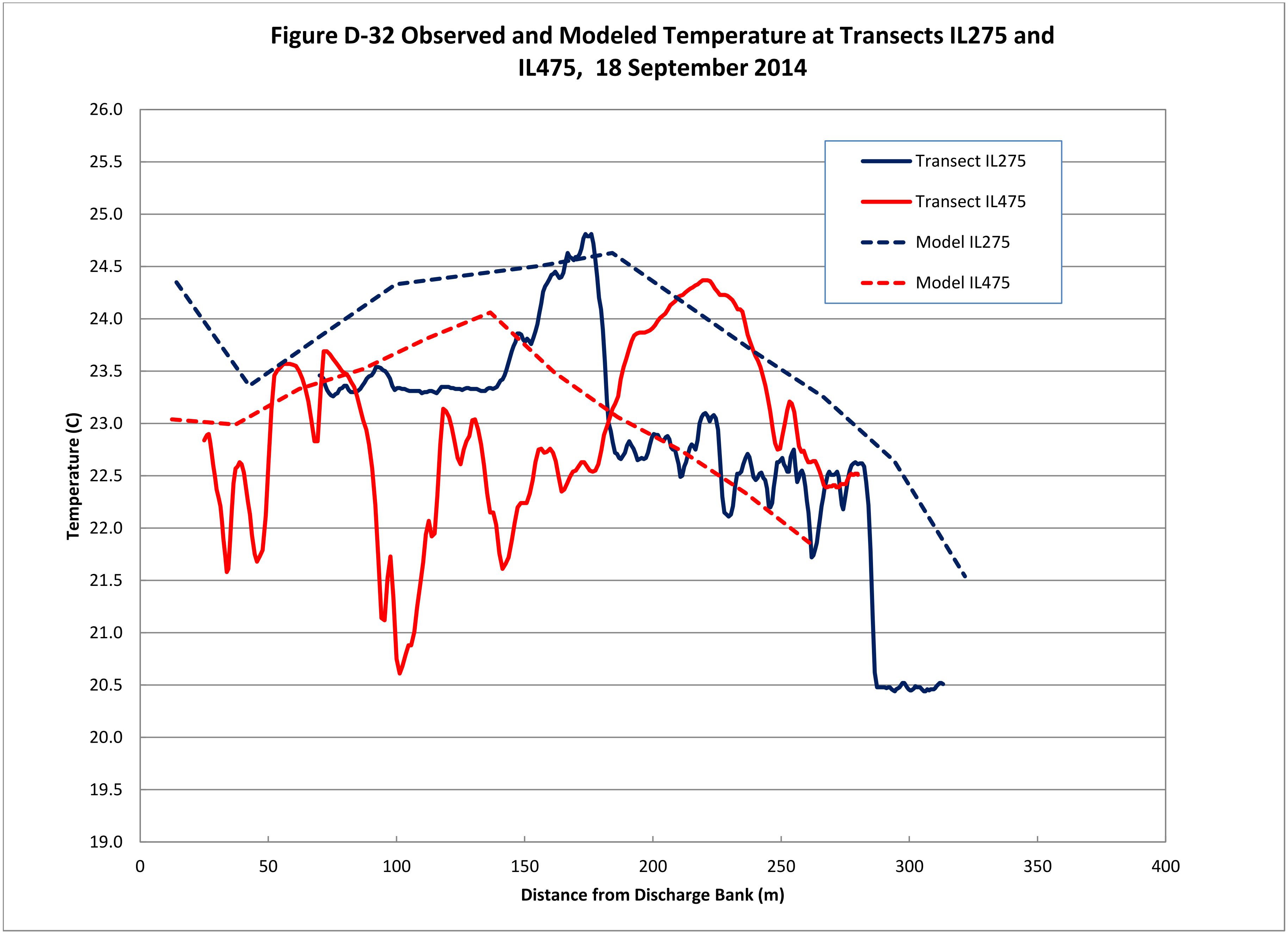


Figure D-32 Observed and Modeled Temperature at Transects IL275 and IL475, 18 September 2014
26.0
25.5
25.0
24.5
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
Temperature (C)
0
50
100
150
200
250
300
350
400
Distance from Discharge Bank (m)
Transect IL275
Transect IL475
Model IL275
Model IL475

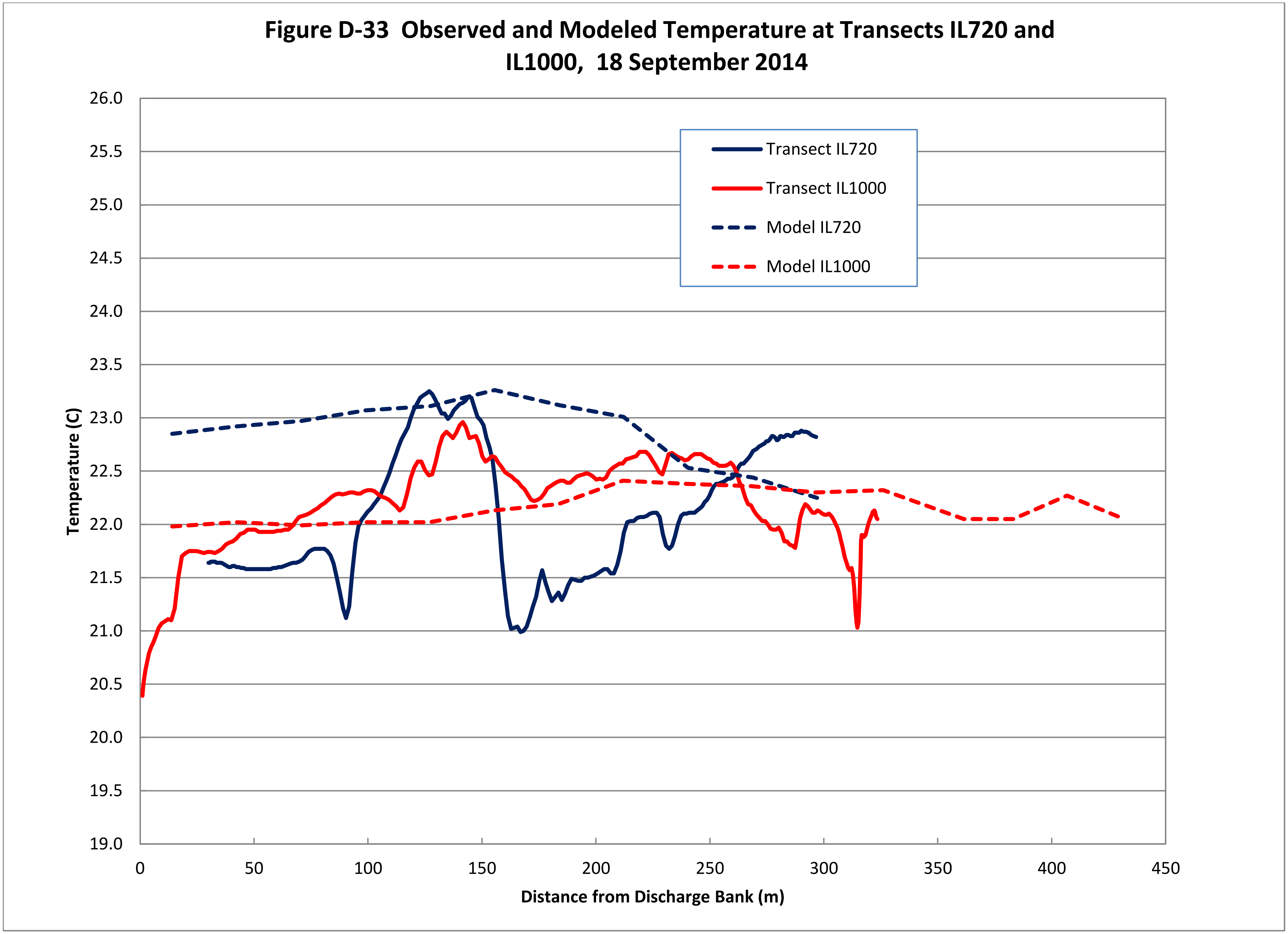
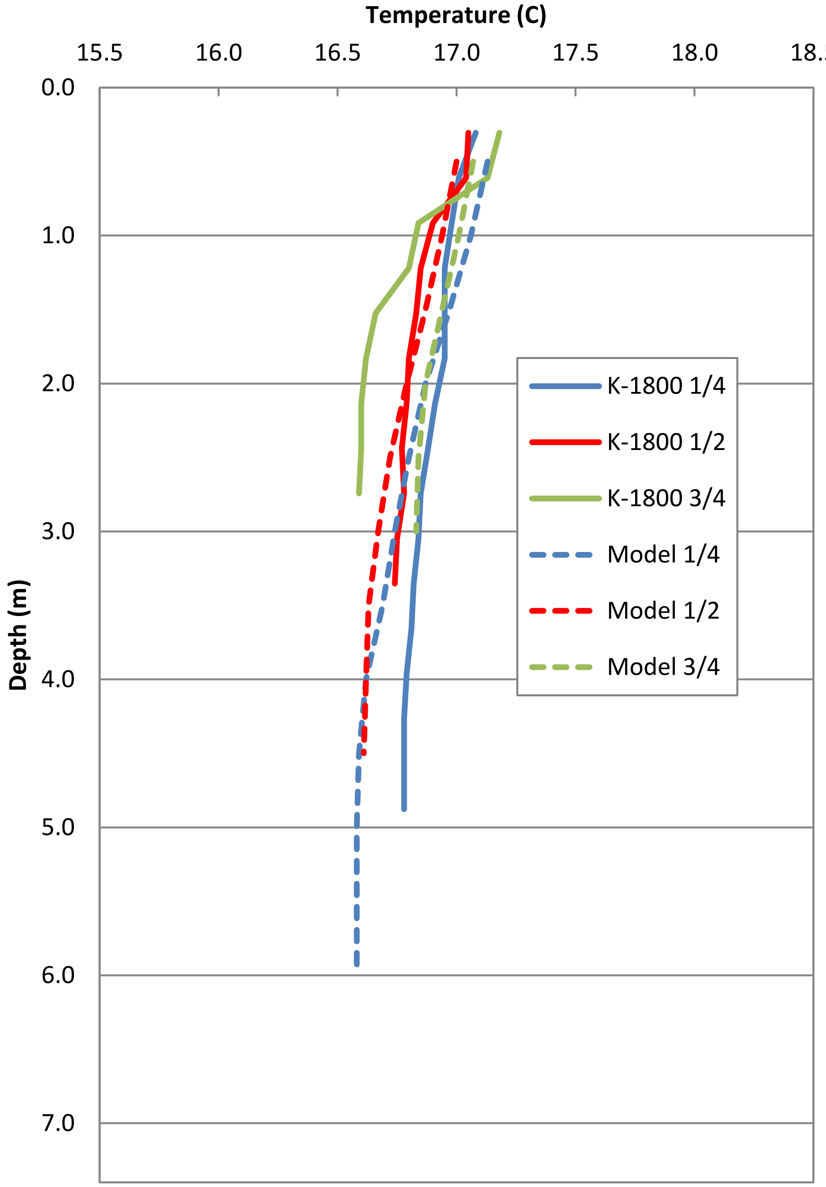


Figure D-33 Observed and Modeled Temperature at Transects IL720 and IL1000, 18 September 2014
26.0
25.5
25.0
24.5
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
Temperature (C)
0
50
100
150
200
250
300
350
400
450
Distance from Discharge Bank (m)
Transect IL720
Transect IL1000
Model IL720
Model IL1000

Figure D-34 Observed and Modeled Vertical Temperatures at Transect K-1800 and DP-1700, 18 September 2014



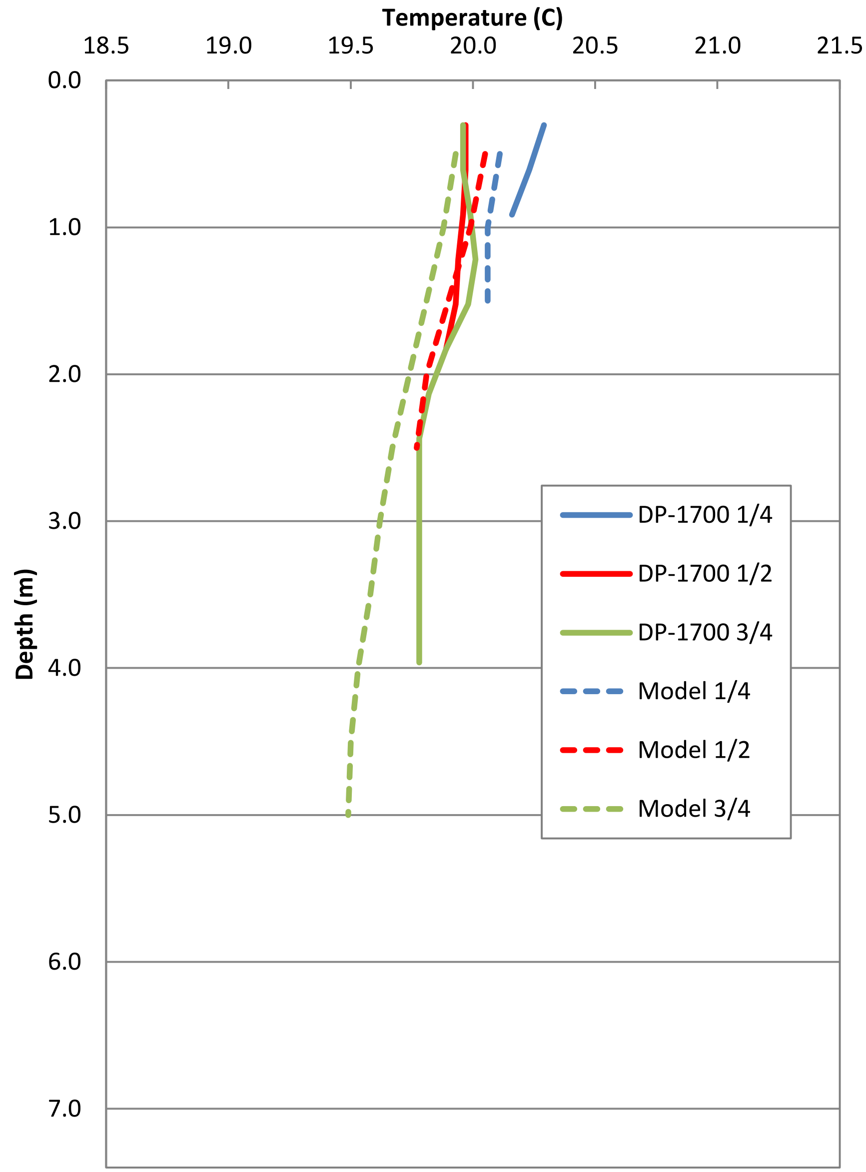


Figure D-35 Observed and Modeled Vertical Temperatures at Transect IL0 and IL275, 18 September 2014

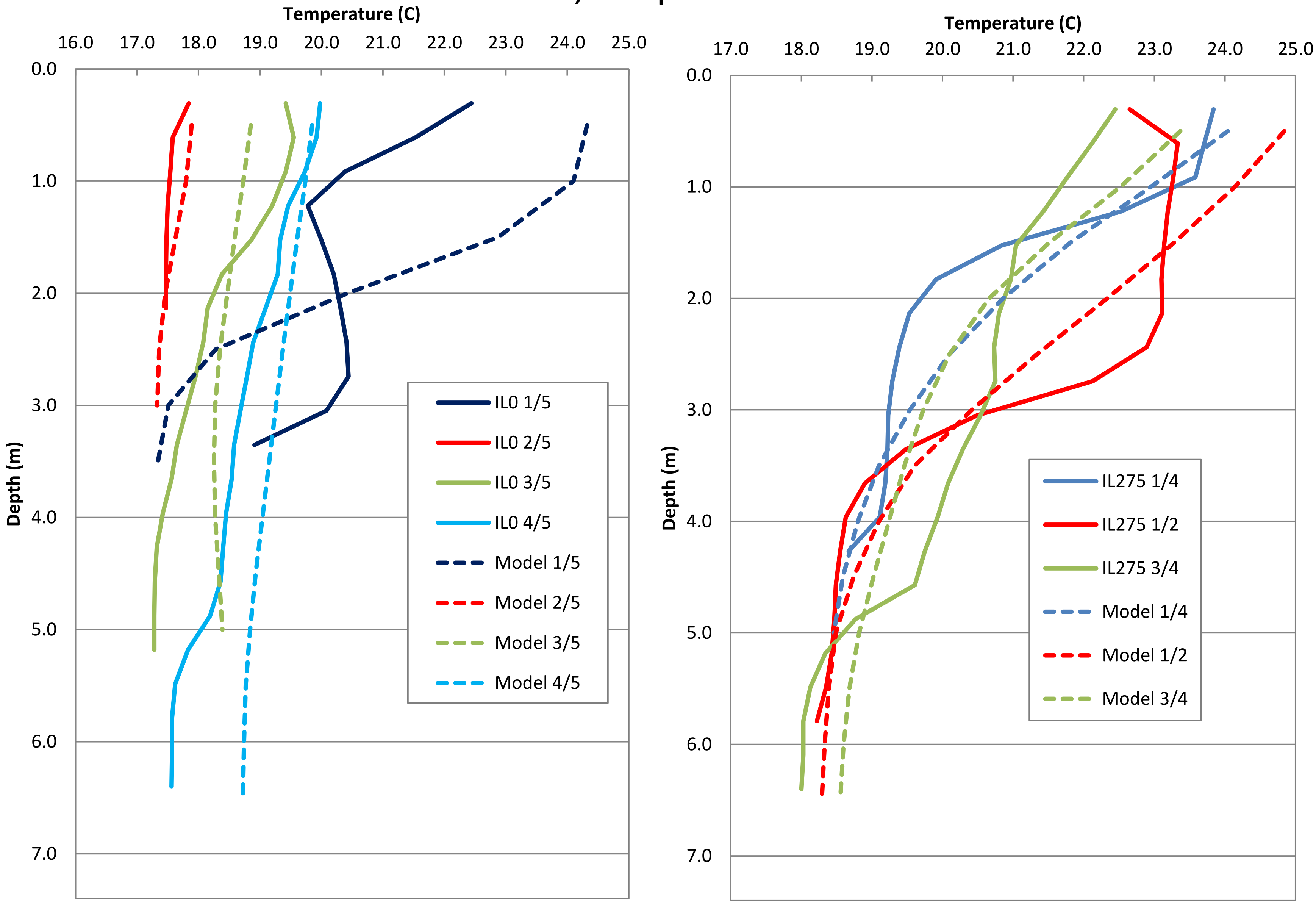
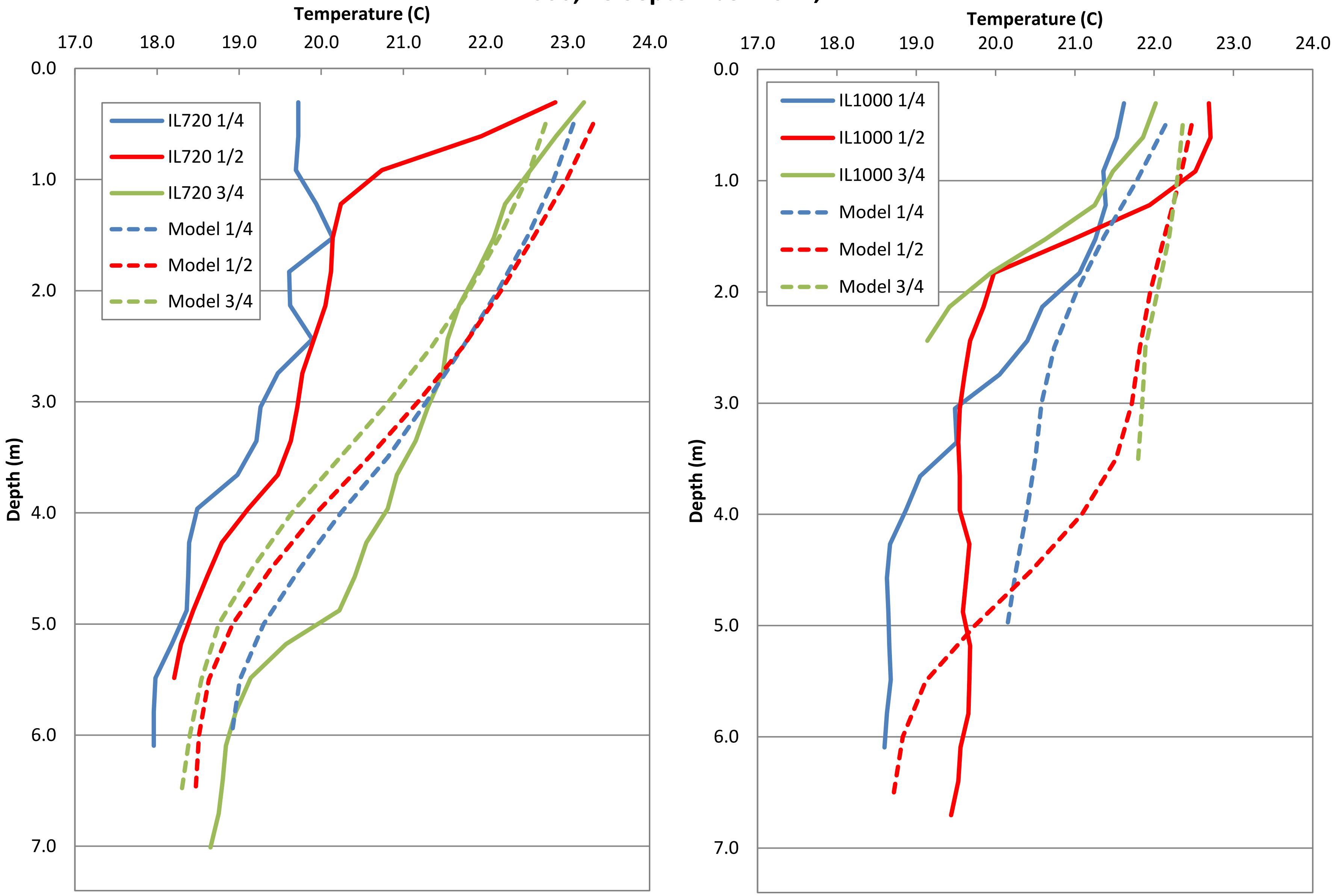


Figure D-36 Observed and Modeled Vertical Temperatures at Transect IL720 and IL1000, 18 September 2014,



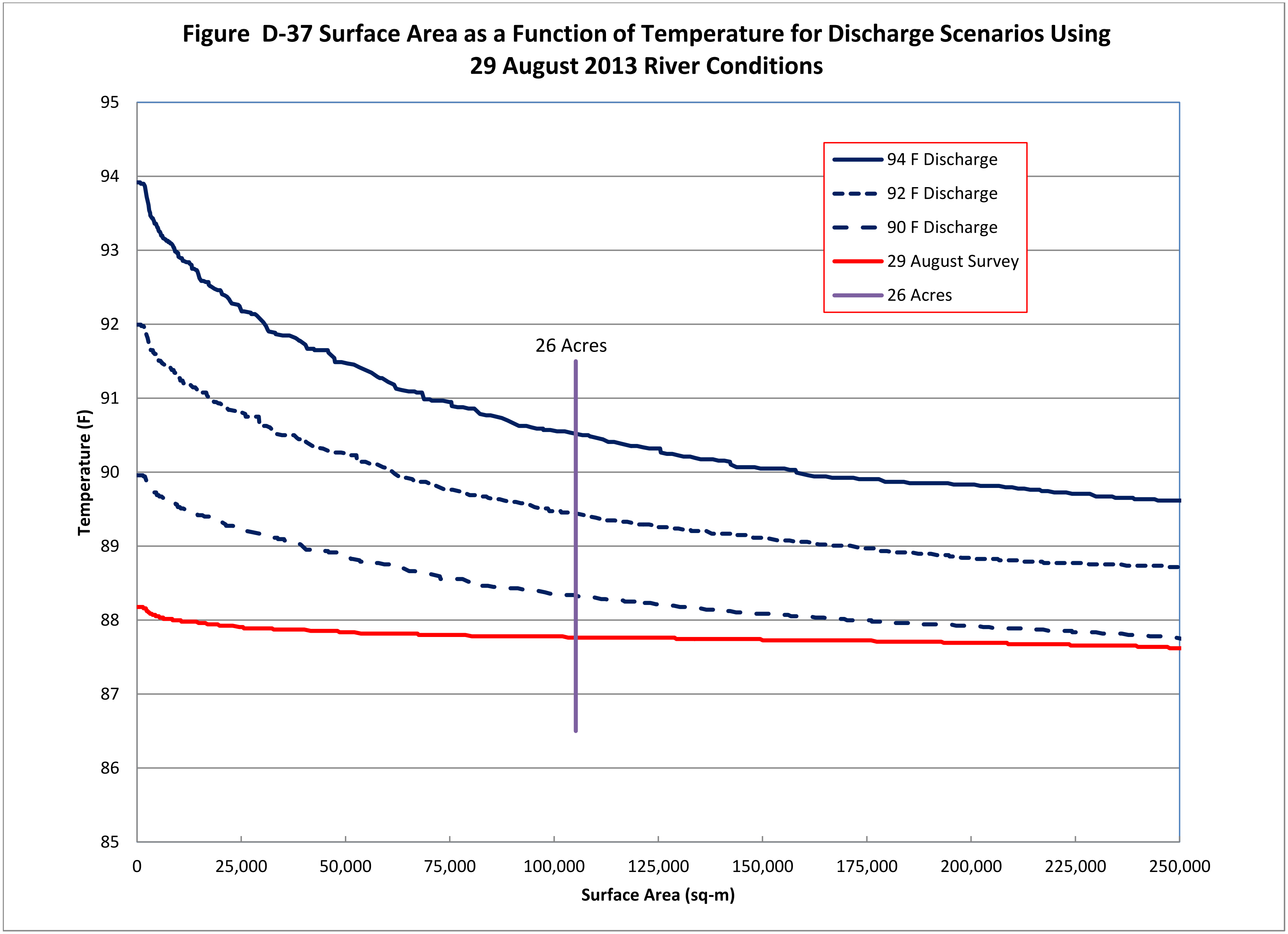
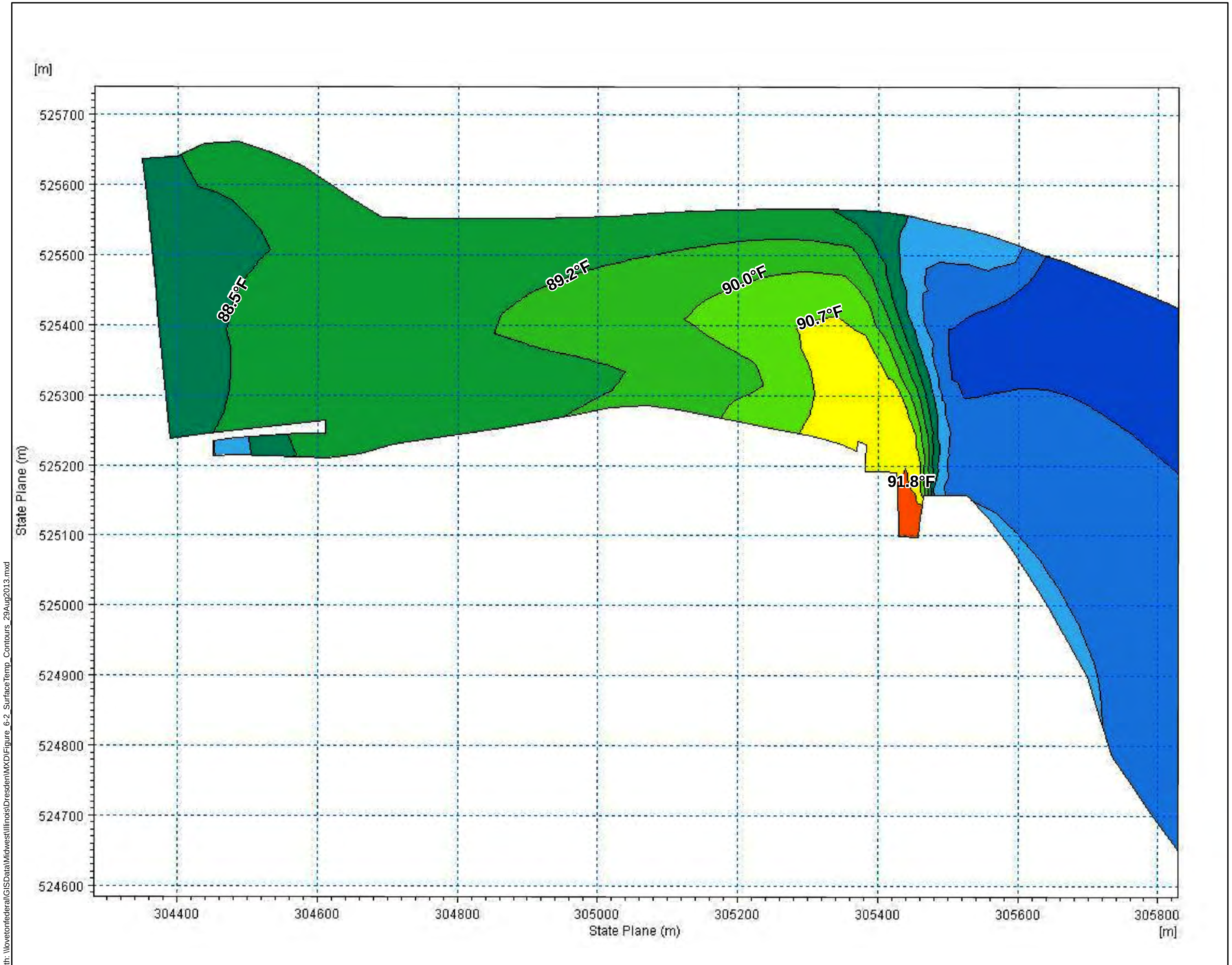
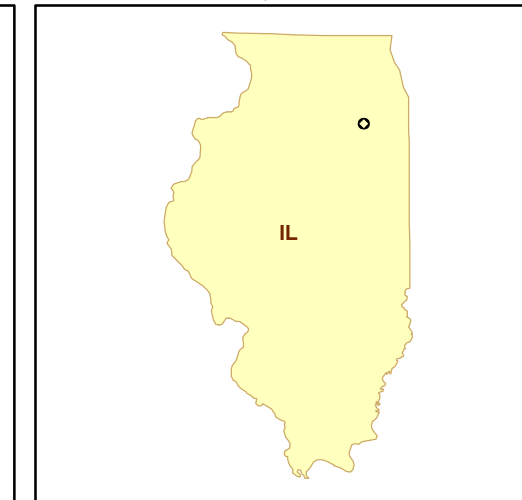


Figure D-37 Surface Area as a Function of Temperature for Discharge Scenarios Using 29 August 2013 River Conditions
95
94
93
92
91
90
89
88
87
86
85
Temperature (F)
0
25,000
50,000
75,000
100,000
125,000
150,000
175,000
200,000
225,000
250,000
Surface Area (sq-m)
26 Acres
94 F Discharge
92 F Discharge
90 F Discharge
29 August Survey
26 Acres



VICINITY MAP



Temperature [deg C]

- Above 33.60
- 33.20 - 33.60
- 32.60 - 33.20
- 32.22 - 32.60
- 31.80 - 32.22
- 31.40 - 31.80
- 31.00 - 31.40
- 30.60 - 31.00
- 30.20 - 30.60
- 29.80 - 30.20
- Below 29.80
- Undefined Value

Map Date: January 2014

N

0 100 200
Meters

1 in = 140 meters
(11 x 17 inch figure)

FIGURE **D-38**
Surface Temperature Contours for a 92°F Discharge Temperature under 29 August River Conditions

Path: \\lovetonfederal\GIS\Data\Midwest\Illinois\Dresden\MXD\Figure_6-2_SurfaceTemp_Contours_29Aug2013.mxd

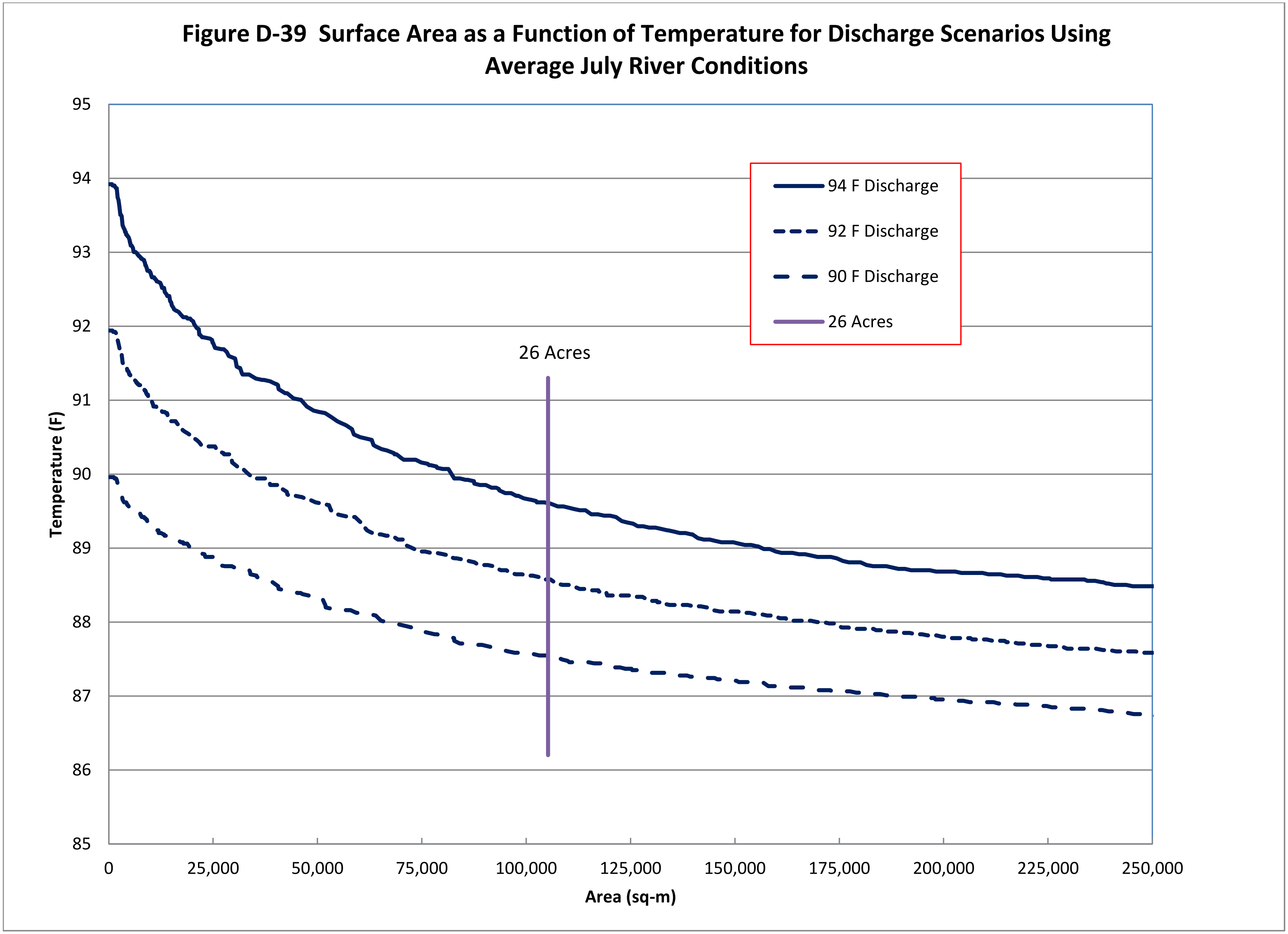
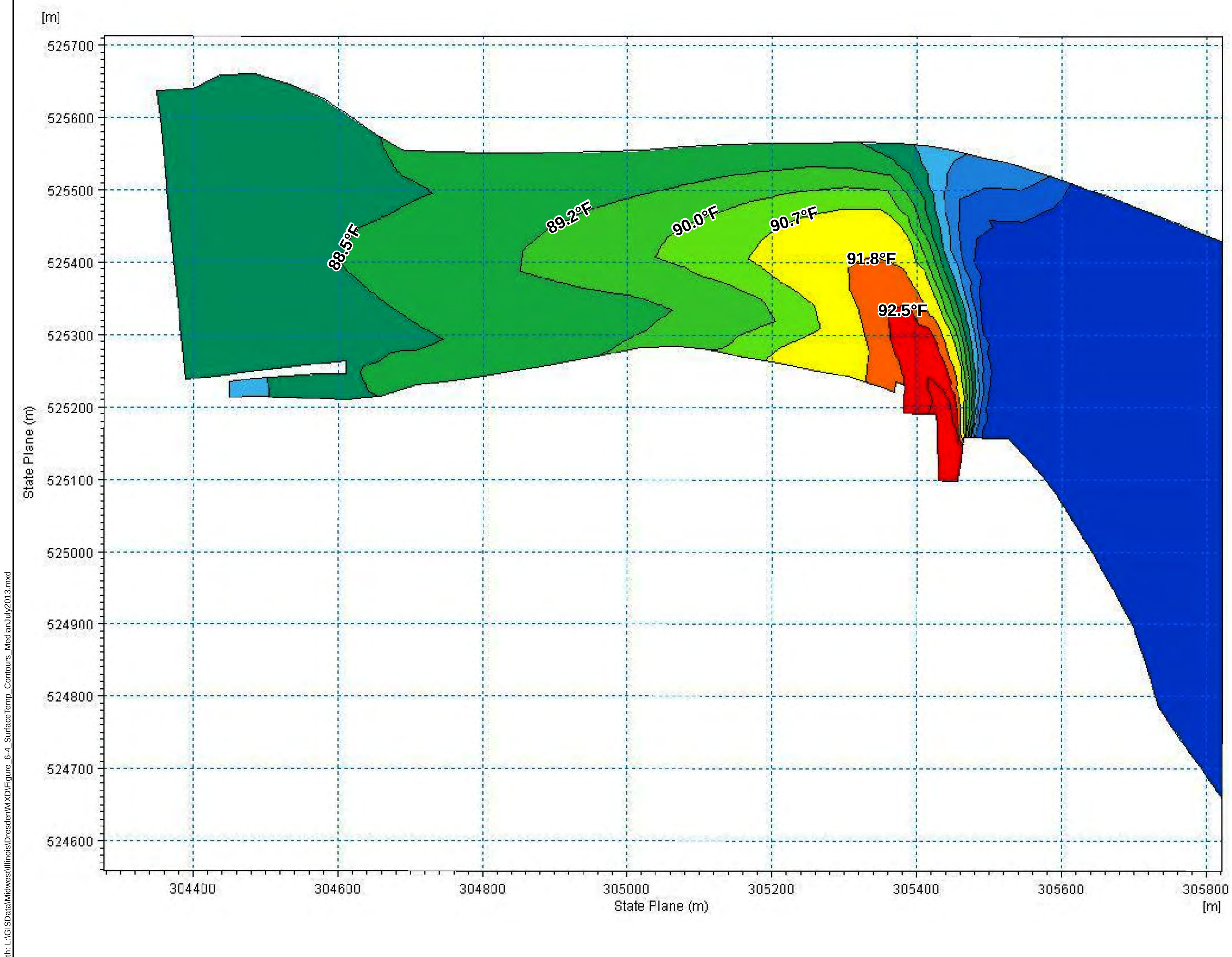
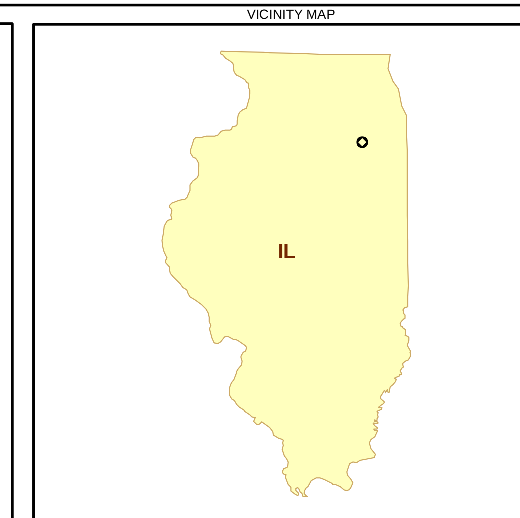


Figure D-39 Surface Area as a Function of Temperature for Discharge Scenarios Using Average July River Conditions
94 F Discharge
92 F Discharge
90 F Discharge
26 Acres
26 Acres
Temperature (F)
95
94
93
92
91
90
89
88
87
86
85
Area (sq-m)
0
25,000
50,000
75,000
100,000
125,000
150,000
175,000
200,000
225,000
250,000





Temperature [deg C]
Above 33.60
33.20 - 33.60
32.60 - 33.20
32.22 - 32.60
31.80 - 32.22
31.40 - 31.80
31.00 - 31.40
30.60 - 31.00
30.20 - 30.60
29.80 - 30.20
Below 29.80
Undefined Value

Map Date: January 2014

N

0 100 200
Meters

1 in = 140 meters
(11 x 17 inch figure)

FIGURE **D-40**

Surface Temperature Contours for a 94°F Discharge Temperature under Median July River Conditions

Figure D-41 Cross-Sectional Area at Transect IL0 for a Range of Dresden Discharge Temperatures, 29 August 2013 and Average July River Conditions

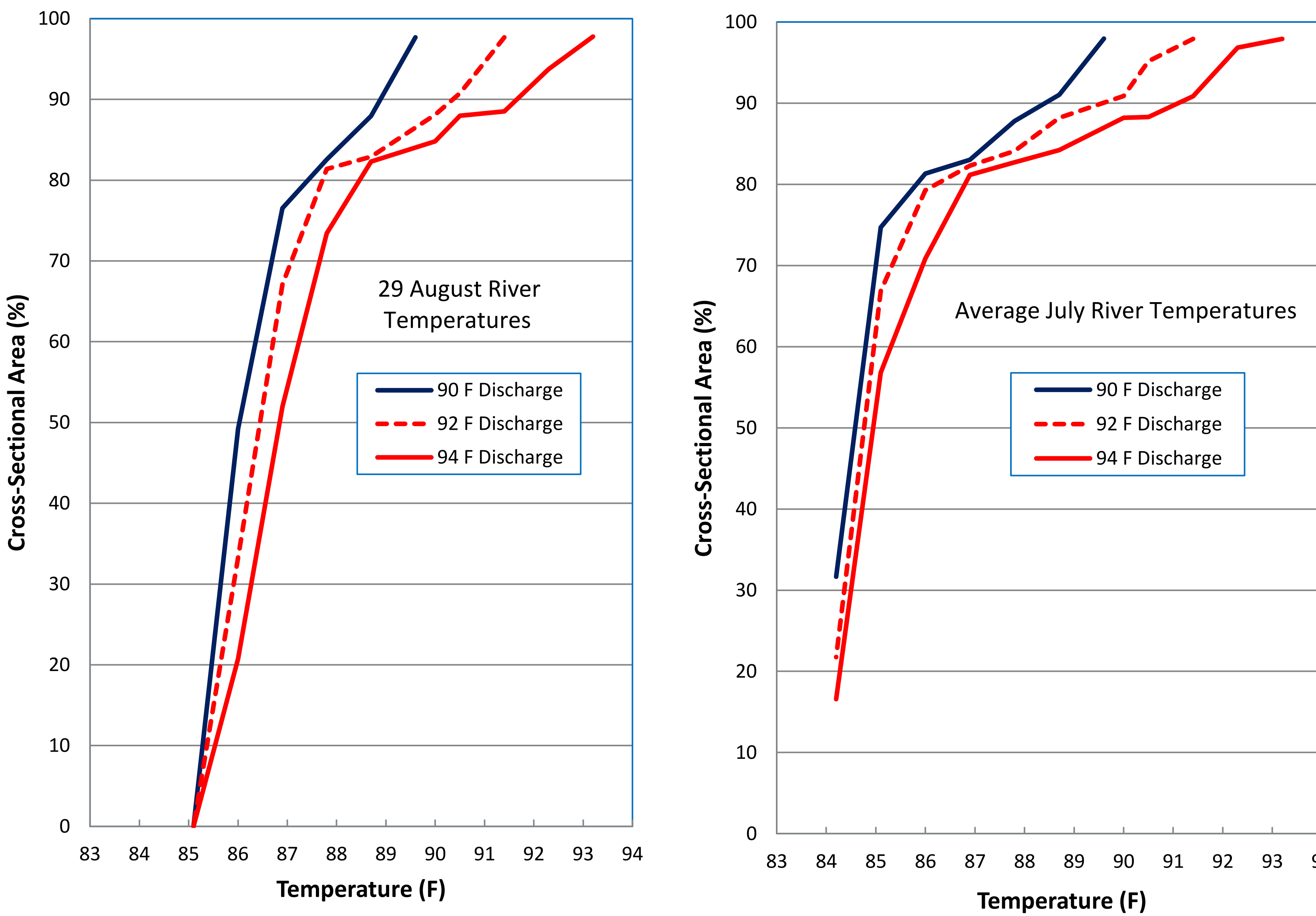
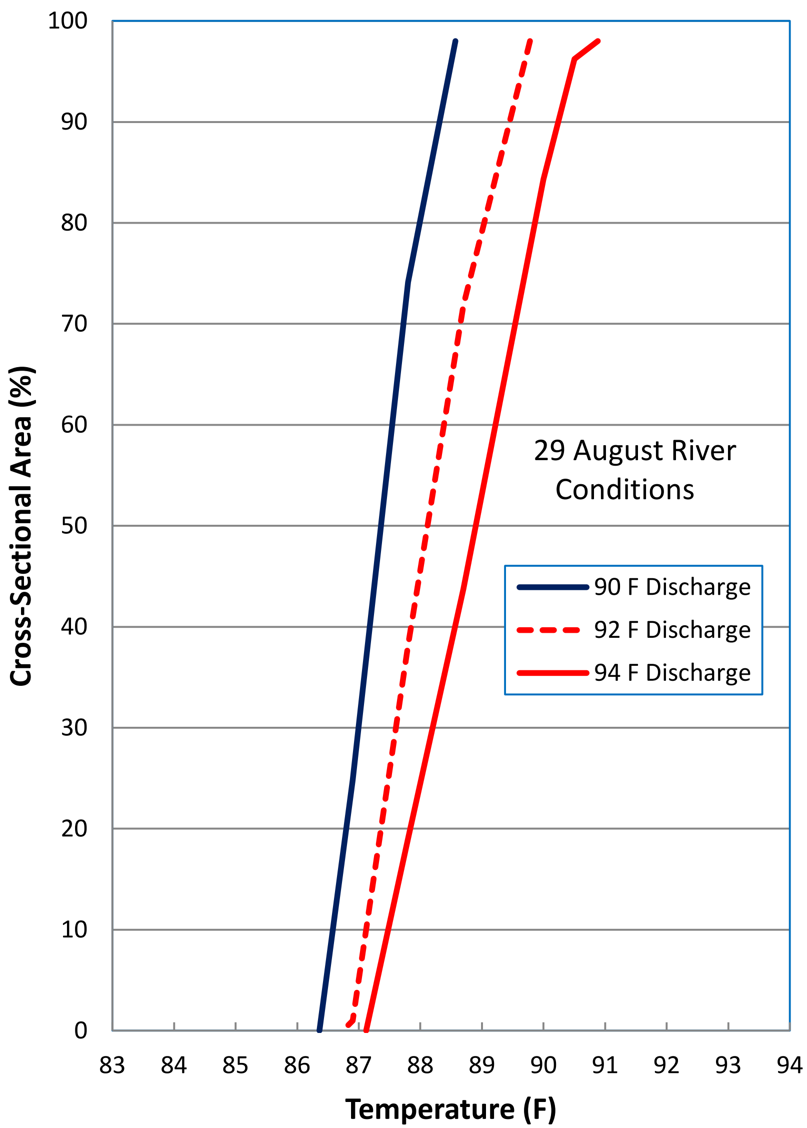
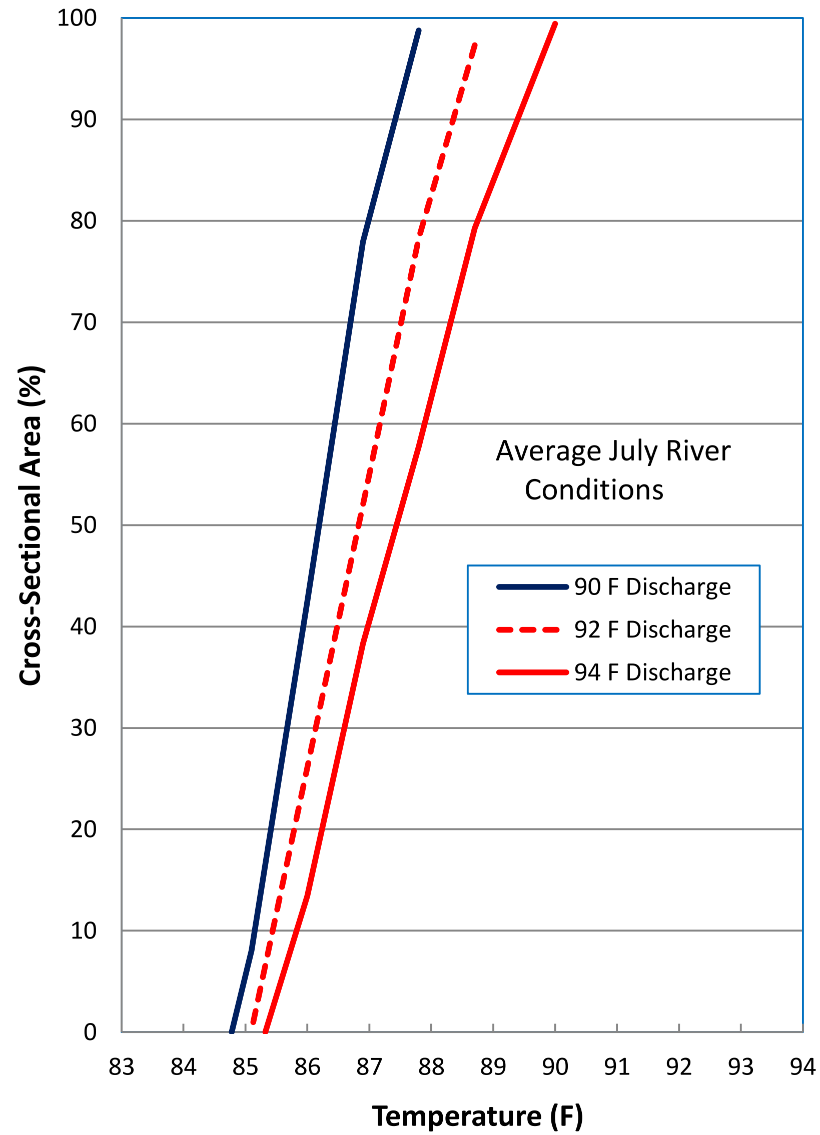


Figure D-42 Cross-Sectional Area at Transect IL475 for a Range of Dresden Discharge Temperatures, 29 August 2013 and Average July River Conditions





TABLES

Table D-1 Frequency Distribution of Hourly Intake (2003-2014) and Discharge (1998-2014) Temperature

Percentile	Intake Temperature (F)			
(%)	Jun	Jul	Aug	Sep
1	68.2	67.1	68.7	57.3
5	69.6	70.8	72.6	61.5
10	70.8	72.8	74.3	63.6
15	71.8	74.4	75.8	65.0
20	72.5	75.7	76.6	66.2
25	73.1	76.8	77.3	67.3
30	73.9	77.9	78.0	68.0
35	74.4	78.6	78.4	68.8
40	74.9	79.4	79.0	69.4
45	75.3	80.0	79.5	70.2
50	75.8	80.5	79.9	71.3
55	76.4	81.0	80.4	72.4
60	76.8	81.5	80.7	73.1
65	77.5	82.4	81.3	73.8
70	78.1	83.5	81.9	74.5
75	78.9	84.4	82.5	75.5
80	79.7	85.1	83.4	76.5
85	80.3	85.8	84.4	77.8
90	81.7	87.2	85.3	79.8
95	83.5	89.4	87.2	82.2
99	86.4	93.7	91.3	96.0
Mean	76.1	80.4	79.9	71.6
Max	93.0	99.9	97.3	99.9
Obs	2111	4440	4407	3666

Note: 15-30 June

Data gap: July 2003 to November 2005

Percentile	Discharge Temperature (F)			
(%)	Jun	Jul	Aug	Sep
1	78.7	80.2	81.4	70.2
5	81.3	82.1	83.1	75.1
10	82.5	83.5	84.1	77.4
15	83.3	84.4	84.7	79.0
20	83.9	84.9	85.2	79.9
25	84.2	85.4	85.6	80.8
30	84.5	85.7	85.9	81.5
35	84.9	86.2	86.2	81.9
40	85.1	86.6	86.5	82.5
45	85.4	87.0	86.8	83.0
50	85.7	87.4	87.0	83.5
55	86.0	87.8	87.3	84.0
60	86.3	88.1	87.6	84.3
65	86.6	88.4	87.9	84.8
70	86.9	88.7	88.2	85.4
75	87.2	89.0	88.5	86.0
80	87.6	89.4	88.9	86.5
85	88.1	89.9	89.3	87.3
90	88.5	90.7	89.9	88.2
95	89.2	91.8	90.7	88.8
99	91.2	93.7	91.6	89.6
Mean	85.6	87.2	87.0	83.0
Max	96.4	99.6	92.6	91.2
Obs	5312	10354	10298	9146

Note: 15-30 June

Data gap: July 2003 to November 2005

Table D-2 Frequency Distribution of Hourly Discharge Flow and Power Production, 2003 - 2014

Percentile	Discharge Flow (mgd)			
(%)	Jun	Jul	Aug	Sep
1	1,464	1,012	1,012	108
5	1,464	1,464	1,012	1,012
10	1,464	1,464	1,464	1,012
15	1,464	1,464	1,464	1,012
20	1,464	1,464	1,464	1,464
25	1,464	1,464	1,464	1,464
30	1,464	1,464	1,464	1,464
35	1,464	1,464	1,464	1,464
40	1,464	1,464	1,464	1,464
45	1,464	1,464	1,464	1,464
50	1,464	1,464	1,464	1,464
55	1,464	1,464	1,464	1,464
60	1,464	1,464	1,464	1,464
65	1,464	1,464	1,464	1,464
70	1,464	1,464	1,464	1,464
75	1,464	1,464	1,464	1,464
80	1,464	1,464	1,464	1,464
85	1,464	1,464	1,464	1,464
90	1,464	1,464	1,464	1,464
95	1,464	1,464	1,464	1,464
99	1,464	1,464	1,464	1,464
Mean	1,462	1,454	1,436	1,372
Max	1,464	1,464	1,464	1,464
Obs	3575	6696	6672	5760

Note: 15-30 June

Data gap: July 2003 to November 2005

Percentile	Power Production (MW)			
(%)	Jun	Jul	Aug	Sep
1	912	1,339	1,687	871
5	1,816	1,718	1,787	914
10	1,821	1,794	1,802	1,662
15	1,822	1,805	1,808	1,812
20	1,824	1,811	1,811	1,820
25	1,825	1,815	1,814	1,822
30	1,826	1,818	1,816	1,823
35	1,826	1,820	1,818	1,824
40	1,827	1,821	1,820	1,825
45	1,828	1,822	1,821	1,826
50	1,830	1,823	1,823	1,826
55	1,832	1,824	1,824	1,827
60	1,835	1,825	1,825	1,829
65	1,839	1,826	1,827	1,832
70	1,845	1,828	1,829	1,836
75	1,850	1,830	1,842	1,839
80	1,912	1,874	1,888	1,843
85	1,918	1,910	1,900	1,850
90	1,923	1,918	1,906	1,889
95	1,928	1,925	1,912	1,907
99	1,936	1,934	1,919	1,924
Mean	1,823	1,821	1,828	1,771
Max	1,944	1,940	1,926	1,933
Obs	3574	6695	6586	5760

Note: 15-30 June

Data gap: July 2003 to November 2005

Table D-3 Number of Hours With Discharge Temperature Greater Than 90 F, 15 June to 30 September, 1998-2014

Year	Discharge > 90 F (Hours)			
	June	July	August	Sept
1998	51	215	183	8
1999	22	274	111	0
2000	0	0	0	2
2001	0	171	168	0
2002	0	46	8	0
2003	0	n/a	n/a	n/a
2004	n/a	n/a	n/a	n/a
2005	n/a	n/a	n/a	n/a
2006	0	29	20	1
2007	0	0	19	0
2008	0	0	1	0
2009	81	0	0	1
2010	0	8	31	0
2011	0	122	106	0
2012	0	268	2	0
2013	0	59	0	0
2014	0	0	0	0

Table D-4 Monthly Average Power Production for Range of Temperature Intervals, 2003 - 2014

Temperature (F)	Average Power Production (MW)			
	June	July	August	Sept
>90.0	1,730	1,356	1,230	1,457
>89.5	1,824	1,755	1,790	1,822
88.5 -89.5	1,825	1,809	1,787	1,803
87.5 -88.5	1,784	1,819	1,760	1,794
86.5 -87.5	1,798	1,837	1,762	1,712
85.5 -86.5	1,827	1,798	1,826	1,752
% Reduction > 90 F	5.2	25.1	31.1	19.2

% Reduction relative to power production at 88.5-89.5 F

Table D-5 Frequency Distribution of Daily Average Flow on the Kankakee River at Wilmington, 2005-2013

Percentile	River Flow (cfs)												
(%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	1,270	1,030	1,920	1,900	2,200	845	507	539	527	601	846	840	586
5	1,730	1,310	3,820	2,150	2,790	1,340	570	663	599	733	882	1,000	789
10	2,010	2,590	4,100	2,850	3,080	1,680	668	738	657	808	984	1,200	988
15	2,600	3,230	4,370	3,470	3,290	1,880	752	811	711	900	1,060	1,360	1,140
20	3,160	3,360	4,610	3,790	3,600	2,200	1,010	862	802	960	1,250	1,520	1,350
25	3,560	3,750	4,950	4,450	3,900	2,510	1,200	932	907	1,040	1,500	1,810	1,630
30	3,840	4,020	5,390	4,790	4,000	2,860	1,300	994	990	1,110	1,670	2,180	1,920
35	4,080	4,190	5,790	5,030	4,530	3,270	1,470	1,030	1,020	1,180	1,950	2,780	2,260
40	4,270	4,400	6,380	5,320	4,780	3,680	1,600	1,120	1,060	1,240	2,050	3,420	2,680
45	4,430	4,700	6,910	5,690	5,110	4,430	1,770	1,180	1,090	1,360	2,210	3,740	3,200
50	4,750	5,150	7,270	6,140	5,540	5,370	1,920	1,260	1,190	1,490	2,440	4,010	3,680
55	5,090	5,580	7,770	6,490	6,030	6,090	2,160	1,360	1,320	1,590	2,600	4,270	4,090
60	5,610	6,190	8,250	7,180	6,860	6,710	2,390	1,470	1,410	1,700	2,780	4,780	4,480
65	6,100	6,890	8,870	7,870	7,480	7,440	2,580	1,610	1,650	1,840	3,120	5,190	5,030
70	6,910	7,980	9,580	9,600	8,270	8,610	2,750	1,750	1,930	2,260	3,740	7,000	5,710
75	8,670	8,920	10,400	10,800	9,360	9,360	3,050	1,870	2,170	2,680	4,000	7,870	6,620
80	9,830	9,970	11,500	12,200	10,400	10,400	3,270	2,220	2,440	4,100	4,220	9,420	7,830
85	11,700	10,900	13,000	13,600	12,700	12,000	3,620	2,580	2,790	4,430	4,450	11,000	9,570
90	15,500	13,100	15,800	17,200	14,600	15,700	4,250	3,100	4,390	5,310	5,530	13,900	11,800
95	20,800	18,300	21,500	22,300	19,300	18,300	5,180	5,300	9,510	6,400	6,730	17,000	16,700
99	41,000	34,800	33,900	29,600	25,700	22,500	6,330	16,200	32,500	12,000	13,000	28,700	28,700
Mean	7,308	7,098	8,880	8,382	7,485	6,769	2,240	1,899	2,724	2,394	2,973	5,901	5,299
Max	45,200	35,800	40,400	38,200	31,400	25,700	8,050	23,100	47,000	23,400	18,500	33,900	47,000
Obs	248	247	279	270	279	270	279	279	270	279	270	256	3226

Table D-6 Frequency Distribution of Daily Average Flow on the Des Plaines River Scaled to the Site, 2005-2013

Percentile	River Flow (cfs)												
(%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	1,365	1,397	2,378	1,734	1,750	1,598	1,803	1,786	1,721	1,443	1,055	1,375	1,375
5	1,659	1,837	2,656	2,103	2,088	1,943	2,214	2,243	2,119	1,762	1,267	1,646	1,771
10	1,877	1,976	2,918	2,611	2,564	2,540	2,584	2,489	2,249	1,883	1,423	1,840	2,037
15	2,088	2,211	3,133	3,145	2,839	2,827	2,819	2,827	2,454	1,977	1,546	2,058	2,262
20	2,194	2,385	3,348	3,378	2,961	2,949	2,973	3,124	2,620	2,050	1,638	2,206	2,462
25	2,292	2,490	3,533	3,595	3,147	3,075	3,136	3,393	2,874	2,173	1,728	2,317	2,688
30	2,457	2,602	3,688	3,760	3,293	3,255	3,338	3,610	3,055	2,292	1,824	2,385	2,888
35	2,566	2,802	3,885	4,020	3,534	3,415	3,434	3,764	3,161	2,436	1,932	2,492	3,087
40	2,756	2,940	4,350	4,324	3,706	3,545	3,558	4,040	3,420	2,556	2,018	2,692	3,293
45	2,849	3,245	4,692	4,657	3,952	3,811	3,723	4,360	3,810	2,677	2,171	2,807	3,512
50	3,038	3,352	5,080	4,930	4,208	4,119	3,870	4,801	4,026	2,757	2,256	2,970	3,755
55	3,217	3,540	5,451	5,374	4,562	4,473	4,031	4,834	4,306	2,951	2,362	3,259	4,067
60	3,392	3,927	5,865	5,693	4,787	4,957	4,194	4,835	4,615	3,085	2,530	3,524	4,446
65	3,632	4,347	6,519	6,377	5,051	5,418	4,569	5,052	4,837	3,304	2,767	3,926	4,829
70	4,107	4,824	6,980	7,148	5,337	6,124	4,827	5,426	4,844	3,751	3,191	4,419	4,900
75	4,581	5,810	7,577	7,767	5,802	6,859	4,829	5,954	4,969	4,568	3,942	4,877	5,451
80	4,932	6,564	8,367	8,911	6,761	7,701	4,943	6,405	5,832	4,849	4,673	5,523	6,174
85	5,839	7,821	9,110	10,396	7,277	8,614	5,371	7,515	6,521	4,854	4,867	6,163	7,138
90	7,399	9,000	11,038	11,792	9,354	9,891	6,786	8,594	7,409	4,860	4,873	7,104	8,569
95	10,363	12,020	12,856	15,720	12,953	11,974	11,656	12,431	9,292	7,056	5,947	12,259	11,749
99	18,146	18,311	30,697	30,932	16,933	17,699	19,817	23,980	35,120	18,451	10,237	29,390	19,817
Mean	3,973	4,635	6,263	6,472	5,200	5,397	4,653	5,462	4,969	3,577	2,945	4,377	4,839
Max	20,606	21,569	35,598	41,676	23,301	27,714	30,174	34,585	44,166	22,662	14,509	39,437	44,166
Obs	248	247	279	270	279	270	279	279	270	279	270	256	3226

Table D-7 Frequency Distribution of Daily Average Flow on the Illinois River (Kankakee and Des Plaines Rivers) Scaled to the Site, 2005-2013

Percentile	River Flow (cfs)												
(%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	3,277	3,252	4,660	3,812	4,823	3,137	2,437	2,565	2,377	2,227	2,369	2,484	2,523
5	3,726	3,949	6,469	4,367	5,602	4,134	3,063	3,051	3,032	2,651	2,591	2,855	3,137
10	4,375	5,021	7,318	6,079	5,930	4,437	3,728	3,476	3,307	2,979	2,824	3,308	3,659
15	5,105	5,564	7,799	6,980	6,310	5,066	4,071	3,896	3,727	3,256	3,027	3,584	4,107
20	5,518	6,096	8,135	7,810	6,673	5,430	4,278	4,096	3,902	3,385	3,312	4,141	4,570
25	5,848	6,306	8,791	8,268	6,934	5,802	4,591	4,441	4,107	3,511	3,515	4,595	5,116
30	6,209	6,675	9,426	8,667	7,764	6,335	4,905	4,717	4,239	3,677	3,766	5,241	5,593
35	6,652	6,952	9,963	9,254	8,391	7,003	5,236	5,159	4,413	3,916	4,116	5,557	6,111
40	7,006	7,364	10,556	9,990	9,102	7,789	5,503	5,468	4,742	4,036	4,522	6,209	6,652
45	7,507	7,992	11,607	10,411	9,789	8,794	5,812	5,906	5,079	4,236	4,982	7,001	7,187
50	7,940	8,723	12,575	10,923	10,476	9,720	6,243	6,350	5,366	4,598	5,421	7,567	7,912
55	8,639	9,222	13,006	11,561	11,077	10,582	6,613	6,727	5,836	4,889	5,745	8,133	8,572
60	9,303	10,180	14,035	13,594	11,582	11,779	6,970	7,250	6,522	5,455	5,994	9,452	9,453
65	9,681	11,487	15,793	15,440	12,331	13,422	7,712	8,031	7,054	6,557	6,605	10,406	10,268
70	11,789	13,296	16,787	17,049	13,539	14,922	8,177	8,864	8,316	7,498	7,336	11,117	10,452
75	13,354	15,108	17,853	18,354	15,344	16,849	9,129	9,960	9,858	8,786	8,224	12,358	11,799
80	15,376	16,269	19,677	20,035	17,252	19,131	9,991	10,268	10,273	10,019	9,872	14,670	13,979
85	17,111	18,706	22,738	23,414	20,271	20,747	10,260	10,270	10,284	10,307	10,345	16,969	16,643
90	21,688	23,553	25,691	29,001	24,053	23,690	10,291	10,825	11,943	10,328	10,373	20,697	20,156
95	30,255	29,761	33,568	34,926	29,833	27,344	13,386	18,469	18,813	14,587	10,876	28,026	26,285
99	52,292	44,177	67,777	60,432	39,681	38,014	23,818	36,158	69,842	24,882	20,886	51,390	43,818
Mean	11,281	11,733	15,144	14,855	12,686	12,160	7,145	7,834	8,200	6,436	6,251	10,381	10,319
Max	63,346	45,010	69,761	79,876	43,771	44,989	32,844	53,385	91,166	41,818	33,009	73,337	91,166
Obs	248	247	279	270	279	270	279	279	270	279	270	256	3226

Table D-8 Hourly Dresden Nuclear Station Operating Data, 1 August 2013

Time	Temperature (F)		Temperature (C)		Discharge Flow (mgd)	Power Production (Mwe)
	Intake	Discharge	Intake	Discharge		
7/31/13 12:00	74.5	82.8	23.6	28.2	1,464.5	1,919
7/31/13 13:00	74.7	82.9	23.7	28.3	1,464.5	1,919
7/31/13 14:00	75.3	82.9	24.1	28.3	1,464.5	1,923
7/31/13 15:00	75.9	82.9	24.4	28.3	1,464.5	1,923
7/31/13 16:00	74.9	83.0	23.8	28.3	1,464.5	1,922
7/31/13 17:00	74.4	83.0	23.6	28.3	1,464.5	1,922
7/31/13 18:00	74.1	83.0	23.4	28.3	1,464.5	1,923
7/31/13 19:00	73.3	83.0	22.9	28.3	1,464.5	1,924
7/31/13 20:00	75.6	83.0	24.2	28.3	1,464.5	1,919
7/31/13 21:00	72.1	83.0	22.3	28.3	1,464.5	1,919
7/31/13 22:00	72.1	83.0	22.3	28.3	1,464.5	1,921
7/31/13 23:00	71.7	82.9	22.1	28.3	1,464.5	1,918
8/1/13 0:00	70.8	82.9	21.6	28.3	1,464.5	1,920
8/1/13 1:00	70.0	82.9	21.1	28.3	1,464.5	1,921
8/1/13 2:00	69.5	82.8	20.8	28.2	1,464.5	1,923
8/1/13 3:00	68.9	82.8	20.5	28.2	1,464.5	1,919
8/1/13 4:00	68.8	82.7	20.5	28.2	1,464.5	1,921
8/1/13 5:00	68.8	80.6	20.5	27.0	1,464.5	1,922
8/1/13 6:00	69.6	82.6	20.9	28.1	1,464.5	1,923
8/1/13 7:00	79.2	82.8	26.2	28.2	1,464.5	1,923
8/1/13 8:00	85.1	82.9	29.5	28.3	1,464.5	1,922
8/1/13 9:00	87.5	83.1	30.8	28.4	1,464.5	1,920
8/1/13 10:00	87.8	83.2	31.0	28.4	1,464.5	1,920
8/1/13 11:00	87.1	83.4	30.6	28.5	1,464.5	1,922
8/1/13 12:00	85.8	83.5	29.9	28.6	1,464.5	1,921
8/1/13 13:00	83.0	83.6	28.4	28.7	1,464.5	1,920
8/1/13 14:00	82.4	83.6	28.0	28.7	1,464.5	1,918
8/1/13 15:00	81.7	83.7	27.6	28.7	1,464.5	1,918
8/1/13 16:00	81.0	83.7	27.2	28.7	1,464.5	1,914
8/1/13 17:00	80.0	83.7	26.7	28.7	1,464.5	1,918
8/1/13 18:00	79.5	83.7	26.4	28.7	1,464.5	1,917
8/1/13 19:00	78.2	83.7	25.7	28.7	1,464.5	1,914
8/1/13 20:00	76.1	83.8	24.5	28.8	1,464.5	1,917
8/1/13 21:00	74.5	83.7	23.6	28.7	1,464.5	1,913
8/1/13 22:00	73.6	83.7	23.1	28.7	1,464.5	1,913
8/1/13 23:00	73.0	83.7	22.8	28.7	1,464.5	1,912

Table D-9 Hourly Dresden Nuclear Station Operating Data, 29 August 2013

Time	Temperature (F)		Temperature (C)		Discharge Flow (mgd)	Power Production (Mwe)
	Intake	Discharge	Intake	Discharge		
8/28/13 12:00	93.8	87.4	34.3	30.8	1,464.5	n/a
8/28/13 13:00	91.7	87.5	33.2	30.8	1,464.5	n/a
8/28/13 14:00	90.0	87.7	32.2	30.9	1,464.5	n/a
8/28/13 15:00	88.6	87.8	31.4	31.0	1,464.5	n/a
8/28/13 16:00	88.3	87.8	31.3	31.0	1,464.5	n/a
8/28/13 17:00	86.4	87.7	30.2	30.9	1,464.5	n/a
8/28/13 18:00	84.5	87.5	29.2	30.9	1,464.5	n/a
8/28/13 19:00	83.1	87.4	28.4	30.8	1,464.5	n/a
8/28/13 20:00	81.9	87.3	27.7	30.7	1,464.5	n/a
8/28/13 21:00	81.1	87.2	27.3	30.6	1,464.5	n/a
8/28/13 22:00	80.3	87.0	26.8	30.6	1,464.5	n/a
8/28/13 23:00	79.6	86.9	26.4	30.5	1,464.5	n/a
8/29/13 0:00	76.3	86.8	24.6	30.5	1,464.5	n/a
8/29/13 1:00	78.5	86.7	25.9	30.4	1,464.5	n/a
8/29/13 2:00	78.4	86.7	25.8	30.4	1,464.5	n/a
8/29/13 3:00	78.3	86.6	25.7	30.3	1,464.5	n/a
8/29/13 4:00	78.2	86.5	25.7	30.3	1,464.5	n/a
8/29/13 5:00	78.1	86.4	25.6	30.2	1,464.5	n/a
8/29/13 6:00	78.1	86.4	25.6	30.2	1,464.5	n/a
8/29/13 7:00	78.5	86.3	25.8	30.2	1,464.5	n/a
8/29/13 8:00	79.1	86.5	26.2	30.3	1,464.5	n/a
8/29/13 9:00	84.5	86.8	29.2	30.4	1,464.5	n/a
8/29/13 10:00	88.4	87.1	31.3	30.6	1,464.5	n/a
8/29/13 11:00	89.1	87.4	31.7	30.8	1,464.5	n/a
8/29/13 12:00	89.2	87.6	31.8	30.9	1,464.5	n/a
8/29/13 13:00	88.1	87.8	31.2	31.0	1,464.5	n/a
8/29/13 14:00	88.0	87.9	31.1	31.1	1,464.5	n/a
8/29/13 15:00	87.8	88.0	31.0	31.1	1,464.5	n/a
8/29/13 16:00	87.7	88.1	30.9	31.2	1,464.5	n/a
8/29/13 17:00	87.4	88.2	30.8	31.2	1,464.5	n/a
8/29/13 18:00	86.9	88.2	30.5	31.2	1,464.5	n/a
8/29/13 19:00	85.8	88.3	29.9	31.3	1,464.5	n/a
8/29/13 20:00	84.2	88.3	29.0	31.3	1,464.5	n/a
8/29/13 21:00	83.2	88.1	28.5	31.2	1,464.5	n/a
8/29/13 22:00	82.3	88.0	27.9	31.1	1,464.5	n/a
8/29/13 23:00	81.4	87.9	27.5	31.0	1,464.5	n/a

Table D-10 Hourly Dresden Nuclear Station Operating Data, 18 September 2014

Time	Temperature (F)		Temperature (C)		Discharge Flow (mgd)	Power Production (Mwe)
	Intake	Discharge	Intake	Discharge		
9/17/14 12:00	71.7	80.0	22.1	26.7	1,464.5	1,915
9/17/14 13:00	69.8	80.3	21.0	26.8	1,464.5	1,916
9/17/14 14:00	68.9	80.6	20.5	27.0	1,464.5	1,915
9/17/14 15:00	68.3	80.9	20.2	27.2	1,464.5	1,914
9/17/14 16:00	67.9	81.2	19.9	27.3	1,464.5	1,914
9/17/14 17:00	67.1	81.5	19.5	27.5	1,464.5	1,919
9/17/14 18:00	65.7	81.4	18.7	27.5	1,464.5	1,914
9/17/14 19:00	63.5	81.3	17.5	27.4	1,464.5	1,913
9/17/14 20:00	62.5	81.1	16.9	27.3	1,464.5	1,912
9/17/14 21:00	62.0	81.0	16.7	27.2	1,464.5	1,913
9/17/14 22:00	61.4	80.8	16.3	27.1	1,464.5	1,914
9/17/14 23:00	60.8	80.7	16.0	27.0	1,464.5	1,914
9/18/14 0:00	60.1	80.5	15.6	26.9	1,464.5	1,912
9/18/14 1:00	59.5	80.4	15.3	26.9	1,464.5	1,913
9/18/14 2:00	59.2	80.3	15.1	26.8	1,464.5	1,915
9/18/14 3:00	58.4	80.2	14.6	26.8	1,464.5	1,915
9/18/14 4:00	57.8	80.2	14.3	26.8	1,464.5	1,910
9/18/14 5:00	57.4	80.1	14.1	26.7	1,464.5	1,914
9/18/14 6:00	57.1	80.1	13.9	26.7	1,464.5	1,915
9/18/14 7:00	61.8	80.0	16.5	26.7	1,464.5	1,914
9/18/14 8:00	68.5	80.0	20.3	26.7	1,464.5	1,912
9/18/14 9:00	70.8	80.0	21.5	26.7	1,464.5	1,910
9/18/14 10:00	71.5	80.2	21.9	26.8	1,464.5	1,912
9/18/14 11:00	71.6	80.5	22.0	27.0	1,464.5	1,910
9/18/14 12:00	71.5	80.8	21.9	27.1	1,464.5	1,912
9/18/14 13:00	69.1	81.1	20.6	27.3	1,464.5	1,913
9/18/14 14:00	68.5	81.3	20.3	27.4	1,464.5	1,911
9/18/14 15:00	68.0	81.5	20.0	27.5	1,464.5	1,911
9/18/14 16:00	67.6	81.7	19.8	27.6	1,464.5	1,913
9/18/14 17:00	66.4	81.9	19.1	27.7	1,464.5	1,910
9/18/14 18:00	65.6	81.7	18.6	27.6	1,464.5	1,913
9/18/14 19:00	64.3	81.5	17.9	27.5	1,464.5	1,911
9/18/14 20:00	63.2	81.3	17.3	27.4	1,464.5	1,909
9/18/14 21:00	62.5	76.0	17.0	24.4	1,464.5	1,909
9/18/14 22:00	62.0	80.9	16.7	27.2	1,464.5	1,912
9/18/14 23:00	61.6	80.7	16.4	27.1	1,464.5	1,911

Table D-11a Vertical Temperature Profiles at the Dresden Nuclear Station During the 1 August 2013 Survey

Depth (m)	Depth (ft)	Temperature (C)								
		IL 1000-1/4 1511 hr	IL 1000-1/2 1515 hr	IL 1000-3/4 1519 hr	IL 720-1/4 1533 hr	IL 720-1/2 1531 hr	IL 720-3/4 1528 hr	IL 475-1/4 1537 hr	IL 475-1/2 1540 hr	IL 475-3/4 1531 hr
0.30	1	27.46	27.45	27.65	27.54	27.62	27.71	27.37	27.65	27.62
0.61	2	27.47	27.45	27.61	27.56	27.62	27.71	27.45	27.64	27.62
0.91	3	27.46	27.44	27.57	27.56	27.61	27.69	27.46	27.63	27.61
1.22	4	27.46	27.40	27.53	27.56	27.61	27.66	27.46	27.53	27.61
1.52	5	27.46	27.35	27.49	27.56	27.61	27.65	27.46	27.40	27.61
1.83	6	27.45	27.32	27.42	27.55	27.60	27.61	27.46	27.34	27.60
2.13	7	27.46	27.31	27.34	27.54	27.60	27.60	27.46	27.27	27.60
2.44	8	27.46	27.31	27.34	27.52	27.60	27.57	27.46	27.22	27.60
2.74	9	27.46	27.31		27.50	27.60	27.55	27.47	27.17	27.60
3.05	10	27.46	27.31		27.48	27.58	27.55	27.47	27.17	27.58
3.35	11	27.46	27.29		27.43	27.54	27.55	27.47	27.19	27.54
3.66	12	27.46	27.29		27.35	27.49	27.55	27.47	27.20	27.49
3.96	13	27.46	27.30		27.29	27.38	27.51	27.48	27.19	27.38
4.27	14	27.47	27.28		27.27	27.32	27.48	27.47	27.18	27.32
4.57	15	27.46	27.19		27.27	27.24	27.48	27.44	27.20	27.24
4.88	16	27.46	27.11		27.26		27.45	27.41	27.21	
5.18	17	27.45	27.07		27.24		27.43		27.21	
5.49	18	27.45	27.05		27.22		27.41		27.22	
5.79	19	27.46	27.05		27.14		27.35		27.23	
6.10	20	27.45	27.05				27.22			
6.40	21	27.46	27.05				26.99			
6.71	22	27.46	27.05				26.86			
7.01	23	27.46								

Table D-11b Vertical Temperature Profiles at the Dresden Nuclear Station During the 1 August 2013 Survey

Depth (m)	Depth (ft)	Temperature (C)						
		IL 275-1/4 1553 hr	IL 275-1/2 1550 hr	IL 275-3/4 1547 hr	IL 125-1/5 1556 hr	IL 125-2/5 1559 hr	IL 125-3/5 1601 hr	IL 125-4/5 1610 hr
0.30	1	27.50	27.39	27.63	27.57	27.70	28.02	27.75
0.61	2	27.50	27.41	27.78	27.58	27.70	28.01	27.73
0.91	3	27.50	27.40	27.78	27.58	27.70	27.99	27.72
1.22	4	27.49	27.38	27.74	27.58	27.71	27.98	27.73
1.52	5	27.48	27.37	27.71	27.58	27.71	27.98	27.72
1.83	6	27.48	27.36	27.66	27.58	27.70	27.97	27.73
2.13	7	27.49	27.35	27.70	27.58	27.70	27.95	27.74
2.44	8	27.48	27.35	27.66	27.57	27.68	27.92	27.76
2.74	9	27.49	27.35	27.61		27.63	27.79	27.78
3.05	10	27.48	27.35	27.60		27.60	27.70	27.76
3.35	11	27.48	27.34	27.59		27.61	27.60	27.75
3.66	12	27.47	27.32	27.60		27.65	27.56	27.76
3.96	13	27.45	27.28	27.59		27.61	27.53	27.79
4.27	14	27.44	27.24	27.58		27.59	27.53	27.79
4.57	15	27.43	27.22	27.58		27.57	27.54	27.78
4.88	16		27.20	27.56		27.54	27.53	27.80
5.18	17		27.19	27.55			27.53	27.80
5.49	18		27.17	27.54			27.56	27.80
5.79	19		27.17	27.52			27.57	27.80
6.10	20		27.16	27.48			27.57	27.79
6.40	21			27.44				

Table D-11c Vertical Temperature Profiles at the Dresden Nuclear Station During the 1 August 2013 Survey

Depth (m)	Depth (ft)	Temperature (C)							
		DISCHARGE 1630 hr	IL 0-1/5 1627 hr	IL 0-2/5 1621 hr	IL 0-3/5 1617 hr	IL 0-4/5 1614 hr	IL -200-1/4 1634 hr	IL -200-1/2 1637 hr	IL -200-3/4 1640 hr
0.30	1	28.82	27.73	27.59	27.56	27.05	27.45	27.55	27.32
0.61	2	28.83	27.70	27.59	27.58	27.02	27.52	27.58	27.31
0.91	3	28.83	27.70	27.58	27.57	27.02	27.51	27.58	27.31
1.22	4	28.83	27.71	27.57	27.56	27.03	27.48	27.58	27.32
1.52	5	28.83	27.71	27.55	27.55	27.02	27.45	27.58	27.34
1.83	6	28.83	27.72	27.51	27.52	26.97	27.40	27.58	27.35
2.13	7		27.73	27.43	27.49	26.87		27.54	27.33
2.44	8		27.72		27.46	26.69		27.42	27.31
2.74	9		27.55		27.43	26.69			27.36
3.05	10		27.35		27.43	26.70			27.39
3.35	11				27.41	26.70			27.35
3.66	12				27.40	26.77			27.33
3.96	13				27.39	26.77			27.28
4.27	14				27.39	26.68			27.23
4.57	15				27.29	26.66			27.18
4.88	16				27.22	26.63			27.05
5.18	17				27.18	26.44			26.54
5.49	18					26.17			25.89
5.79	19					26.26			25.10
6.10	20					26.27			24.38
6.40	21					26.16			

Table D-11d Vertical Temperature Profiles at the Dresden Nuclear Station During the 1 August 2013 Survey

Depth (m)	Depth (ft)	Temperature (C)						
		IL -1000-1/5 1721 hr	IL -1000-2/5 1724 hr	IL -1000-3/5 1727 hr	IL -1000-4/5 1729 hr	K -1440-1/4 1657 hr	K -1440-1/2 1654 hr	K -1440-3/4 1651 hr
0.30	1	27.17	27.08	27.27	27.42	26.33	26.64	27.24
0.61	2	27.16	27.09	27.28	27.41	26.11	26.61	27.35
0.91	3	27.10	27.09	27.29	27.42	25.74	26.51	27.26
1.22	4	26.93	27.03	27.22	27.42	25.72	26.30	26.77
1.52	5	26.70	26.97	27.16	27.42	25.73	26.10	25.70
1.83	6	25.89	26.85	27.15	27.42	25.52	25.41	
2.13	7		26.63	26.84	27.38	25.05	24.06	
2.44	8		25.86		27.36	24.75	23.49	
2.74	9		24.54		27.36	24.40	23.30	
3.05	10		23.61		27.36	23.72	23.11	
3.35	11		22.68		27.36	22.68	22.99	
3.66	12		22.38		27.34	22.51	22.93	
3.96	13		22.28		27.32	22.40	22.53	
4.27	14				27.12	22.30	22.32	
4.57	15				26.85	22.28	22.28	
4.88	16				26.52	22.27	22.25	

Table D-11e Vertical Temperature Profiles at the Dresden Nuclear Station During the 1 August 2013 Survey

Depth (m)	Depth (ft)	Temperature (C) K -1800-1/4 1701 hr	K -1800-1/2 1704 hr	K -1800-3/4 1706 hr	K -2350-1/2 1711 hr	DP -1700-1/4 1740 hr	DP -1700-1/2 1737 hr	DP -1700-3/4 1735 hr	DP -2400-1/2 1746 hr
0.30	1	26.48	26.42	26.82	24.98	27.06	27.35	27.36	27.66
0.61	2	26.47	26.21	26.81	24.99	27.05	27.35	27.39	27.67
0.91	3	26.46	25.89	26.75	24.83	27.05	27.36	27.40	27.66
1.22	4	26.40	25.51	26.35	24.75		27.36	27.40	27.56
1.52	5	26.32	25.27	25.33	24.73		27.33	27.39	27.49
1.83	6	26.26	25.06	24.61	24.76			27.36	27.45
2.13	7	26.17	24.90	24.34	24.67			27.30	27.44
2.44	8	25.78	24.61	24.11	24.56			27.28	27.45
2.74	9	24.56	24.11		24.48			27.27	27.45
3.05	10	23.45	23.78		24.37			27.26	27.39
3.35	11	22.92	23.00		24.15			27.26	27.38
3.66	12	22.78			23.55			27.27	27.37
3.96	13	22.72			23.03			27.26	27.35
4.27	14	22.61							27.31
4.57	15	22.45							27.25

Table D-12a Vertical Temperature Profiles at the Dresden Nuclear Station During the 29 August 2013 Survey

Depth (m)	Depth (ft)	Temperature (C)								
		IL 1000-1/4 1711 hr	IL 1000-1/2 1446 hr	IL 1000-3/4 1449 hr	IL 720-1/4 1458 hr	IL 720-1/2 1456 hr	IL 720-3/4 1453 hr	IL 475-1/4 1504 hr	IL 475-1/2 1506 hr	IL 475-3/4 1508 hr
0.30	1	30.78	30.84	31.63	31.02	30.85	30.88	30.99	30.88	30.90
0.61	2	30.75	30.86	31.51	31.04	30.82	30.89	30.96	30.86	30.89
0.91	3	30.73	30.84	31.21	31.03	30.76	30.89	30.86	30.84	30.87
1.22	4	30.72	30.76	31.16	30.94	30.75	30.88	30.68	30.83	30.82
1.52	5	30.71	30.68	31.09	30.81	30.74	30.88	30.50	30.82	30.79
1.83	6	30.69	30.60	30.93	30.74	30.68	30.85	30.42	30.81	30.72
2.13	7	30.69	30.53	30.73	30.65	30.60	30.84	30.40	30.80	30.65
2.44	8	30.69	30.50		30.57	30.53	30.82	30.38	30.80	30.63
2.74	9	30.69	30.48		30.52	30.50	30.79	30.38	30.80	30.61
3.05	10	30.68	30.46		30.47	30.49	30.78	30.38	30.78	30.52
3.35	11	30.67	30.42		30.42	30.49	30.77	30.37	30.77	30.47
3.66	12	30.67	30.40		30.39	30.49	30.76	30.37	30.77	30.45
3.96	13	30.67	30.40		30.37	30.48	30.74	30.36	30.74	30.44
4.27	14	30.67	30.40		30.36	30.47	30.69	30.36	30.70	30.43
4.57	15	30.67	30.39		30.35	30.47	30.67	30.35	30.69	30.42
4.88	16	30.67	30.39		30.31	30.47	30.65	30.29	30.58	30.41
5.18	17	30.67	30.38		30.21	30.46	30.58	30.24	30.41	30.37
5.49	18	30.66	30.37		30.11		30.53		30.34	30.34
5.79	19	30.66	30.37		30.04		30.51		30.30	30.34
6.10	20	30.63	30.36				30.47		30.26	
6.40	21		30.25				30.44		30.23	
6.71	22		30.01				30.44			
7.01	23						30.44			

Table D-12b Vertical Temperature Profiles at the Dresden Nuclear Station During the 29 August 2013 Survey

Depth (m)	Depth (ft)	Temperature (C)						
		IL 275-1/4 1516 hr	IL 275-1/2 1513 hr	IL 275-3/4 1511 hr	IL 125-1/5 1518 hr	IL 125-2/5 1521 hr	IL 125-3/5 1522 hr	IL 125-4/5 1524 hr
0.30	1	30.83	30.97	30.92	31.06	30.81	31.50	31.01
0.61	2	30.83	30.96	30.90	31.03	30.84	31.36	31.04
0.91	3	30.78	30.94	30.83	30.93	30.82	31.29	31.00
1.22	4	30.76	30.84	30.82	30.86	30.81	31.28	30.96
1.52	5	30.75	30.81	30.83	30.83	30.78	31.28	30.93
1.83	6	30.75	30.77	30.82	30.74	30.76	31.18	30.87
2.13	7	30.74	30.71	30.78		30.73	31.13	30.83
2.44	8	30.74	30.69	30.77		30.70	31.13	30.80
2.74	9	30.74	30.64	30.75		30.67	30.98	30.81
3.05	10	30.74	30.56	30.75		30.65	30.90	30.83
3.35	11	30.73	30.45	30.75		30.64	30.88	30.84
3.66	12	30.70	30.39	30.74		30.62	30.90	30.83
3.96	13	30.68	30.38	30.73		30.61	30.92	30.81
4.27	14	30.63	30.39	30.73		30.60	30.92	30.82
4.57	15		30.37	30.74		30.58	30.91	30.55
4.88	16		30.34	30.73		30.58	30.95	30.11
5.18	17		30.35	30.74			30.98	29.92
5.49	18		30.32	30.74			31.00	29.82
5.79	19		30.33	30.74			31.01	29.74
6.10	20			30.74			30.97	29.50
6.40	21			30.74			30.89	

Table D-12c Vertical Temperature Profiles at the Dresden Nuclear Station During the 29 August 2013 Survey

Depth (m)	Depth (ft)	Temperature (C)							
		DISCHARGE 1536 hr	IL 0-1/5 1534 hr	IL 0-2/5 1531 hr	IL 0-3/5 1529 hr	IL 0-4/5 1527 hr	IL -200-1/4 1540 hr	IL -200-1/2 1542 hr	IL -200-3/4 1544 hr
0.30	1	31.86	31.39	31.26	31.17	31.41	31.02	31.23	31.33
0.61	2	31.86	31.14	31.20	31.10	31.38	31.03	31.23	31.30
0.91	3	31.86	31.11	31.13	31.04	31.29	31.02	31.24	31.24
1.22	4	31.86	31.03	31.10	30.98	31.23	31.01	31.24	31.17
1.52	5	31.86	31.01	30.94	30.89	30.96	30.93	31.18	31.01
1.83	6	31.86	31.05	30.65	30.80	30.76	30.38	30.78	30.83
2.13	7	31.87	31.06	30.24	30.73	30.64		30.26	30.58
2.44	8	31.84	31.04		30.60	30.57		30.08	30.40
2.74	9		30.15		30.42	30.52		30.02	30.30
3.05	10				30.31	30.47		29.90	30.24
3.35	11				30.17	30.37			30.13
3.66	12				30.06	30.26			30.00
3.96	13				30.00	30.16			29.79
4.27	14				29.93	30.08			29.69
4.57	15				29.90	30.04			29.64
4.88	16				29.82	29.94			29.61
5.18	17					29.83			29.56
5.49	18					29.66			29.45
5.79	19					29.45			29.30
6.10	20					29.40			29.22
6.40	21					29.38			

Table D-12d Vertical Temperature Profiles at the Dresden Nuclear Station During the 29 August 2013 Survey

Depth (m)	Depth (ft)	Temperature (C)						
		IL -1000-1/5 1600 hr	IL -1000-2/5 1556 hr	IL -1000-3/5 1554 hr	IL -1000-4/5 1551 hr	K -1440-1/4 1629 hr	K -1440-1/2 1627 hr	K -1440-3/4 1621 hr
0.30	1	30.24	30.40	30.53	30.68	30.19	29.99	30.30
0.61	2	30.24	30.22	30.37	30.30	30.19	29.92	30.25
0.91	3	30.21	30.05	30.20	30.02	30.06	29.79	30.13
1.22	4	30.19	29.95	30.14	29.90	30.03	29.77	30.04
1.52	5	30.18	29.84	29.93	29.86	29.94	29.77	29.84
1.83	6	30.05	29.72	29.78	29.85	29.84	29.75	29.70
2.13	7		29.62	29.73	29.81	29.79	29.72	
2.44	8		29.45	29.64	29.72	29.77	29.60	
2.74	9				29.63	29.74	29.46	
3.05	10				29.56	29.66	29.35	
3.35	11				29.44	29.39	29.25	
3.66	12				29.40	28.92	29.20	
3.96	13				29.37	28.64	28.84	
4.27	14				29.34	28.47	28.44	
4.57	15				29.30	28.19	28.24	
4.88	16				29.26	27.93	28.13	
5.18	17				29.11			

Table D-12e Vertical Temperature Profiles at the Dresden Nuclear Station During the 29 August 2013 Survey

Depth (m)	Depth (ft)	Temperature (C)							
		K -1800-1/4 1610 hr	K -1800-1/2 1613 hr	K -1800-3/4 1616 hr	K -2350-1/2 1605 hr	DP -1700-1/4 1639 hr	DP -1700-1/2 1636 hr	DP -1700-3/4 1633 hr	DP -2400-1/2 1646 hr
0.30	1	29.64	29.58	29.79	29.13	30.29	31.18	30.46	30.67
0.61	2	29.64	29.58	29.81	29.16	30.22	30.91	30.46	30.64
0.91	3	29.63	29.55	29.74	29.09	29.81	30.48	30.47	30.61
1.22	4	29.61	29.53	29.55	29.03		30.37	30.45	30.59
1.52	5	29.58	29.49	29.34	28.86		30.28	30.38	30.58
1.83	6	29.51	29.43	29.16	28.71		30.24	30.31	30.55
2.13	7	29.43	29.38	29.06	28.50			30.28	30.54
2.44	8	29.31	29.31	29.02	28.14			30.28	30.51
2.74	9	29.23	29.19	28.99	27.96			30.24	30.43
3.05	10	29.09	29.08		27.89			30.17	30.37
3.35	11	28.79	28.83		27.82			30.12	30.31
3.66	12	28.35			27.76			30.09	30.26
3.96	13	28.02			27.54			30.02	30.23
4.27	14	27.89						29.97	30.22
4.57	15	27.43							30.16
4.88	16								30.17
5.18	17								30.15
5.49	18								30.10

Table D-13a Vertical Temperature Profiles at the Dresden Nuclear Station During the 18 September 2014 Survey

Depth	Depth	Temperature (C)								
		IL 1000-1/4	IL 1000-1/2	IL 1000-3/4	IL 720-1/4	IL 720-1/2	IL 720-3/4	IL 475-1/4	IL 475-1/2	IL 475-3/4
(m)	(ft)	1444 hr	1446 hr	1449 hr	1505 hr	1503 hr	1455 hr	1510 hr	1512 hr	1515 hr
0.30	1	21.62	22.69	22.02	19.72	22.85	23.20	19.76	22.24	23.01
0.61	2	21.53	22.71	21.86	19.72	21.95	22.86	19.58	21.31	22.56
0.91	3	21.36	22.52	21.48	19.69	20.74	22.55	18.94	20.87	22.01
1.22	4	21.39	21.94	21.25	19.94	20.24	22.24	18.66	20.64	21.33
1.52	5	21.26	20.98	20.63	20.14	20.14	22.10	18.64	19.80	21.31
1.83	6	21.06	19.98	19.94	19.61	20.12	21.90	18.48	19.49	21.27
2.13	7	20.59	19.85	19.42	19.62	20.05	21.68	18.34	19.40	21.28
2.44	8	20.40	19.68	19.14	19.89	19.91	21.54	18.29	19.15	21.23
2.74	9	20.05	19.61		19.47	19.77	21.48	18.28	18.78	21.24
3.05	10	19.49	19.55		19.26	19.71	21.30	18.28	18.48	21.25
3.35	11	19.51	19.53		19.21	19.63	21.15	18.26	18.39	21.12
3.66	12	19.05	19.55		18.98	19.47	20.92	18.24	18.31	20.85
3.96	13	18.87	19.55		18.49	19.11	20.81	18.23	18.25	20.66
4.27	14	18.67	19.67		18.39	18.79	20.55	18.23	18.23	20.52
4.57	15	18.63	19.63		18.38	18.61	20.41	18.21	18.21	20.42
4.88	16	18.65	19.59		18.36	18.44	20.22	18.21	18.18	20.27
5.18	17	18.66	19.68		18.18	18.29	19.57	18.20	18.16	20.24
5.49	18	18.68	19.67		17.98	18.21	19.14	18.18	18.15	20.23
5.79	19	18.63	19.66		17.96		18.96		18.12	20.19
6.10	20	18.60	19.56		17.96		18.84		18.10	
6.40	21		19.53				18.80		18.11	
6.71	22		19.44				18.75			
7.01	23						18.65			

Table D-13b Vertical Temperature Profiles at the Dresden Nuclear Station During the 18 September 2014 Survey

Depth (m)	Depth (ft)	Temperature (C)						
		IL 275-1/4	IL 275-1/2	IL 275-3/4	IL 125-1/5	IL 125-2/5	IL 125-3/5	IL 125-4/5
		1521 hr	1519 hr	1517 hr	1523 hr	1524 hr	1526 hr	1527 hr
0.30	1	23.84	22.65	22.45	25.26	24.46	20.88	19.32
0.61	2	23.71	23.33	22.12	25.23	24.42	19.90	19.38
0.91	3	23.58	23.27	21.77	24.69	24.56	19.77	19.28
1.22	4	22.53	23.19	21.43	21.27	24.75	19.68	19.21
1.52	5	20.84	23.14	21.04		24.23	19.58	19.19
1.83	6	19.91	23.10	20.97		23.32	19.50	19.20
2.13	7	19.53	23.11	20.80		22.51	19.39	19.23
2.44	8	19.39	22.89	20.73		22.06	19.23	19.19
2.74	9	19.29	22.13	20.75		21.45	19.07	18.94
3.05	10	19.23	20.49	20.54		21.08	18.89	18.54
3.35	11	19.22	19.48	20.29		20.83	18.62	18.32
3.66	12	19.19	18.90	20.08		20.79	18.36	18.23
3.96	13	19.11	18.63	19.93		21.09	18.20	18.14
4.27	14	18.67	18.55	19.75		20.23	18.03	18.11
4.57	15		18.49	19.61		20.10	17.87	18.09
4.88	16		18.47	18.77		19.76	17.74	18.08
5.18	17		18.43	18.34		19.28	17.56	18.02
5.49	18		18.35	18.13			17.45	17.99
5.79	19		18.22	18.03			17.38	17.93
6.10	20			18.03			17.29	17.92
6.40	21			18.00				

Table D-13c Vertical Temperature Profiles at the Dresden Nuclear Station During the 18 September 2014 Survey

Depth (m)	Depth (ft)	Temperature (C)							
		DISCHARGE 1540 hr	IL 0-1/5 1535 hr	IL 0-2/5 1533 hr	IL 0-3/5 1531 hr	IL 0-4/5 1530 hr	IL -200-1/4 1540 hr	IL -200-1/2 1542 hr	IL -200-3/4 1543 hr
0.30	1	27.66	22.44	17.84	19.42	19.98	18.20	19.90	19.39
0.61	2	27.73	21.53	17.58	19.55	19.92	17.55	19.90	19.87
0.91	3	27.74	20.38	17.54	19.42	19.73	17.35	19.75	19.88
1.22	4	27.75	19.78	17.50	19.20	19.46	17.31	19.17	19.89
1.52	5	27.76	20.00	17.48	18.86	19.33	17.26	18.96	19.68
1.83	6	27.76	20.20	17.47	18.38	19.29	17.24	18.41	19.49
2.13	7	27.68	20.31	17.47	18.15	19.09		18.22	19.38
2.44	8		20.41		18.08	18.89		18.16	19.20
2.74	9		20.44		17.95	18.79		18.09	18.98
3.05	10		20.08		17.80	18.68		18.02	18.87
3.35	11		18.91		17.65	18.58			18.73
3.66	12				17.56	18.54			18.64
3.96	13				17.42	18.45			18.55
4.27	14				17.32	18.40			18.38
4.57	15				17.29	18.36			18.23
4.88	16				17.28	18.19			18.01
5.18	17				17.28	17.83			17.70
5.49	18					17.62			17.52
5.79	19					17.57			17.42
6.10	20					17.57			17.33
6.40	21					17.56			17.28

Table D-13d Vertical Temperature Profiles at the Dresden Nuclear Station During the 18 September 2014 Survey

Depth (m)	Depth (ft)	Temperature (C)						
		IL -1000-1/5 1553 hr	IL -1000-2/5 1551 hr	IL -1000-3/5 1550 hr	IL -1000-4/5 1548 hr	K -1440-1/4 1600 hr	K -1440-1/2 1558 hr	K -1440-3/4 1557 hr
0.30	1	17.20	18.34	20.04	20.12	17.04	17.07	18.73
0.61	2	17.02	18.31	19.78	19.89	17.04	17.06	17.29
0.91	3	16.86	18.00	18.54	19.90	16.99	17.04	16.75
1.22	4	16.82	17.83	17.79	19.89	16.92	16.96	16.54
1.52	5	16.78	17.57	17.09	19.88	16.84	16.88	
1.83	6	16.76	17.15	16.57	19.87	16.81	16.84	
2.13	7		16.93	16.50	19.83	16.78	16.81	
2.44	8		16.83	16.48	19.77	16.72	16.80	
2.74	9			16.46	19.76	16.70	16.75	
3.05	10			16.46	19.76	16.70	16.66	
3.35	11			16.46	19.76	16.71	16.63	
3.66	12			16.46	19.75	16.68	16.59	
3.96	13				19.75	16.66	16.59	
4.27	14				19.55	16.63	16.55	
4.57	15				19.23	16.61	16.51	
4.88	16				18.91	16.59	16.48	
5.19	17				17.97	16.58		

Table D-13e Vertical Temperature Profiles at the Dresden Nuclear Station During the 18 September 2014 Survey

Depth (m)	Depth (ft)	Temperature (C)							
		K -1800-1/4	K -1800-1/2	K -1800-3/4	K -2350-1/2	DP -1700-1/4	DP -1700-1/2	DP -1700-3/4	DP -2400-1/2
		1605 hr	1606 hr	1608 hr	1614 hr	1624 hr	1622 hr	1620 hr	1633 hr
0.30	1	17.08	17.05	17.18	17.10	20.29	19.97	19.96	20.19
0.61	2	17.01	17.04	17.13	17.05	20.23	19.97	19.96	20.05
0.91	3	16.98	16.90	16.84	17.03	20.16	19.96	19.99	20.05
1.22	4	16.95	16.85	16.80	16.98		19.94	20.01	20.03
1.52	5	16.95	16.83	16.66	16.90		19.93	19.98	20.00
1.83	6	16.95	16.80	16.62	16.88		19.89	19.89	19.98
2.13	7	16.91	16.79	16.60	16.86			19.82	19.96
2.44	8	16.88	16.77	16.60	16.84			19.78	19.95
2.74	9	16.85	16.78	16.59	16.83			19.78	19.95
3.05	10	16.84	16.75		16.83			19.78	19.89
3.35	11	16.82	16.74		16.82			19.78	19.85
3.66	12	16.81			16.82			19.78	19.83
3.96	13	16.79			16.82			19.78	19.83
4.27	14	16.78							19.81
4.57	15	16.78							19.70
4.88	16	16.78							19.62
5.19	17								19.62

Table D-14 Cross-Sectional Area as a Function of Temperature for 90 F, 92 F, and 94 F Discharge Scenarios, 29 August Survey Conditions

90 F Discharge Temperature

Temperature		Cross-Sectional Area (%)			
(C)	(F)	IL-200	IL0	IL475	IL1000
	Max (F)	87.15	89.87	88.57	87.84
	Min (F)	85.48	85.53	86.36	86.79
32.0	89.6		97.7		
31.5	88.7		88.0		
31.0	87.8		82.6	74.1	99.5
30.5	86.9	94.0	76.5	24.8	7.9
30.0	86.0	62.8	49.2	0.0	0.0
29.5	85.1	0.0	0.0	0.0	0.0

92 F Discharge Temperature

Temperature		Cross-Sectional Area (%)			
(C)	(F)	IL-200	IL0	IL475	IL1000
	Max (F)	87.15	91.85	89.78	88.70
	Min (F)	85.50	85.59	86.74	87.49
33.0	91.4		97.7		
32.5	90.5		90.8		
32.2	90.0		88.1		
31.5	88.7		82.9	71.9	99.8
31.0	87.8		81.4	38.2	23.2
30.5	86.9	94.0	67.1	1.0	0.0
30.0	86.0	62.8	33.3	0.0	0.0
29.5	85.1	0.0	0.0	0.0	0.0

94 F Discharge Temperature

Temperature		Cross-Sectional Area (%)			
(C)	(F)	IL-200	IL0	IL475	IL1000
	Max (F)	87.15	93.72	90.88	89.58
	Min (F)	85.50	85.64	87.12	88.14
34.0	93.2		97.8		
33.5	92.3		93.8		
33.0	91.4		88.5		
32.5	90.5		88.0	96.2	
32.2	90.0		84.8	84.3	
31.5	88.7		82.3	43.8	42.2
31.0	87.8		73.4	19.0	0.0
30.5	86.9	94.0	52.0	0.0	0.0
30.0	86.0	62.9	20.8	0.0	0.0
29.5	85.1	0.0	0.0	0.0	0.0

Table D-15 Cross-Sectional Area as a Function of Temperature for 90 F, 92F, and 94 F Discharge Scenarios, Average July Conditions

90 F Discharge Temperature

Temperature		Cross-Sectional Area (%)			
(C)	(F)	IL-200	IL0	IL475	IL1000
	Max (F)	85.53	89.82	87.89	86.85
	Min (F)	83.88	83.97	84.78	85.42
32.0	89.6		98.0		
31.5	88.7		91.0		
31.0	87.8		87.8	98.8	
30.5	86.9		83.0	78.0	
30.0	86.0		81.3	42.4	43.8
29.5	85.1	93.9	74.7	8.1	0.0
29.0	84.2	51.4	31.7	0.0	0.0

92 F Discharge Temperature

Temperature		Cross-Sectional Area (%)			
(C)	(F)	IL-200	IL0	IL475	IL1000
	Max (F)	85.53	91.74	89.01	87.60
	Min (F)	83.88	83.98	85.05	85.98
33.0	91.4		97.9		
32.5	90.5		95.2		
32.2	90.0		90.9		
31.5	88.7		88.2	97.3	
31.0	87.8		84.1	78.3	
30.5	86.9		82.3	52.0	71.7
30.0	86.0		79.3	26.1	0.2
29.5	85.1	93.9	66.8	0.2	0.0
29.0	84.2	51.4	21.8	0.0	0.0

94 F Discharge Temperature

Temperature		Cross-Sectional Area (%)			
(C)	(F)	IL-200	IL0	IL475	IL1000
	Max (F)	85.53	93.67	90.10	88.39
	Min (F)	83.88	84.02	85.32	86.54
34.0	93.2		97.9		
33.5	92.3		96.8		
33.0	91.4		90.9		
32.5	90.5		88.3		
32.2	90.0		88.2	99.4	
31.5	88.7		84.2	79.3	
31.0	87.8		82.7	57.7	83.0
30.5	86.9		81.2	38.3	18.9
30.0	86.0		70.9	13.4	0.0
29.5	85.1	93.9	56.8	0.0	0.0
29.0	84.2	50.7	16.6	0.0	0.0