EXHIBIT G

FEBRUARY 1, 2011 RAY E. HENRY PRE-FILED TESTIMONY UAA RULEMAKING R08-9(C)

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
WATER QUALITY STANDARDS AND	)	
EFFLUENT LIMITATIONS FOR THE	)	R08-9 Subdocket C
CHICAGO AREA WATERWAY SYSTEM	)	(Rulemaking – Water)
AND THE LOWER DES PLAINES RIVER:	)	
PROPOSED AMENDMENTS TO 35 Ill.	)	
Adm. Code Parts 301, 302, 303 and 304	)	

NOTICE OF FILING

TO: John Therriault, Assistant Clerk
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph Street, Suite 11-500
Chicago, IL 60601

Attached Service List

PLEASE TAKE NOTICE that I have today filed with the Illinois Pollution Control Board Midwest Generation's Pre-Filed Testimony of Ray E. Henry, a copy of which is herewith served upon you.

Dated: February 1, 2011

MIDWEST GENERATION, L.L.C.

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One of Its Attorneys

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CERTIFICATE OF SERVICE

The undersigned, an attorney, certifies that a true copy of the foregoing Notice of Filing and Pre-Filed Testimony of Ray Henry were filed electronically on February 1, 2011 with the following:

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and that true copies were mailed by First Class Mail, postage prepaid, on February 1, 2011 to the parties listed on the foregoing Service List.

/s/ Susan M. Franzetti

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
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WATER QUALITY STANDARDS AND	)	
EFFLUENT LIMITATIONS FOR THE	)	R08-9
CHICAGO AREA WATERWAY SYSTEM	)	Subdocket C
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PROPOSED AMENDMENTS TO 35 Ill.	)	
Adm. Code Parts 301, 302, 303 and 304	)	

PRE-FILED TESTIMONY OF RAY E. HENRY

I. Introduction and Witness Background

My name is Ray E. Henry. I am employed as a Principal Consultant with Sargent & Lundy LLC. I have been employed with Sargent & Lundy since 1971 and have over 39 years of experience in the areas of power plant design, performance, testing and evaluation. I am testifying today on behalf of Midwest Generation EME, LLC ("MWGen").

Sargent & Lundy LLC (S&L) is a full-service architect-engineering firm dedicated to the electric power industry. S&L has been serving electric power clients exclusively since its founding in 1891. S&L is one of the oldest, largest and most experienced engineering companies in the United States. S&L has been authorized to design more than 885 electric generating units representing more than 129,500 megawatts of generating capacity. S&L designed approximately 80% of the large generating units in the State of Illinois, including most of the units currently owned and operated by MWGen, when they were first built. S&L has designed over 60 cooling systems with cooling towers, in several countries over the past 40 years. S&L's experience also includes the preparation of studies and designs for power plant modifications, including the addition of air pollution control equipment, such as flue gas desulfurization systems, mercury removal systems and NOx reduction systems.

I personally have worked on studies and evaluations of cooling towers for new units and the conversion of existing once-through cooling systems to cooling towers. These studies included sizing, performance and cost estimates. S&L has conducted at least 15 studies for the addition of cooling towers at existing plants in the past 30 years. Most of these studies involved the preparation of a conceptual design and accompanying cost estimates to convert an existing power plant's open-cycle cooling system to a closed-cycle cooling system. In all cases, the primary reason that a potential conversion to closed-cycle cooling was under consideration by the power plant operator was to evaluate what options were available for reducing thermal discharges to proposed or actual regulatory thermal standards. Based on both my personal knowledge and information obtained from other S&L personnel, only two of these projects actually were implemented. One project was the Quad Cites, Illinois Nuclear Plant, which was converted to closed-cycle cooling (using a spray canal instead of cooling towers) but was later converted back to once-through cooling. The other project was the Noblesville repowering project in Indiana, where as part of the conversion to a combined cycle plant the cooling system was converted to closed-cycle cooling using mechanical draft cooling towers. The Noblesville plant has two small steam turbines (approximately 50 MW each), which is much smaller than any of the MWGen units in this study. Also, the Noblesville site had more open space available for cooling tower installation than do any of the five MWGen station sites that are the subject of my testimony.

I have a Bachelor of Science in Mechanical Engineering from Purdue University. I am a member of the American Society of Mechanical Engineers (ASME) and a member of the ASME committees for codes and standards and the committee for performance test code for fans. I am a registered Professional Engineer in the states of Illinois and Indiana. A copy of my *curriculum vitae* is attached as Exhibit A.

My testimony will focus on describing and explaining the study performed by Sargent & Lundy (S&L) for MWGen which includes the following: (1) the review of potential options for the subject MWGen electric generating stations to achieve and maintain compliance with the thermal water quality standards proposed in this rule-making proceeding; (2) the design criteria for each of the MWGen stations developed by Sargent & Lundy for use as a basis for estimating the costs of achieving and maintaining such compliance; and (3) the estimated capital and operation and maintenance costs and estimated power loss revenues associated with the additional power demands associated with achieving and maintaining such compliance. A copy of the detailed study report prepared by S&L is attached as Exhibit B.

II. Retention by MWGen and Project Scope

The Illinois Environmental Protection Agency ("IEPA") has proposed a re-designation of the aquatic life use of the areas identified in its rule-making petition as the "Upper Dresden Island Pool" in the Lower Des Plaines River (the "UDIP") and the Chicago Area Waterways ("CAWS"). and the IEPA also has proposed revisions to the current thermal water quality standards to seasonal period average and daily maximum standards for both the UDIP and the CAWS (the "Proposed UAA Thermal Standards"). The Proposed UAA Thermal Standards would apply to receiving waters into which the following five MWGen stations discharge wastewater: Fisk, Crawford, Will County, Joliet 6 (also known as "Joliet Station 9") and Joliet 7&8 (also known as "Joliet Station 29"). MWGen requested that S&L evaluate the technologies that could be installed at these stations to comply with the Proposed UAA Thermal Standards and the estimated costs to do so.

Under the Proposed UAA Rules, the CAWS Aquatic Life Use B ("ALU B") standards would apply to the wastewater discharges from the Fisk, Crawford, and Will County stations, while the Upper Dresden Island Pool ("UDIP") standards would apply to the wastewater discharges from the two Joliet stations. Table 1 below lists the Proposed UAA Thermal Standards for ALU B and the UDIP. Currently, for both the UDIP and the CAWS, the applicable thermal water quality standard is a daily maximum temperature of 93°F which is not to be exceeded more than 5 percent of the time and an absolute maximum of 100°F. (IEPA Statement of Reasons, pps. 11-12). The proposed thermal standards for the UDIP would reduce the daily maximum temperature to 88.7°F which is not to be exceeded more than 2 percent of the time and would establish period averages ranging from 85.1°F during most summer periods down to 53.6°F during the month of February. (IEPA Statement of Reasons, p. 85) The proposed thermal standards for the ALU B waters would reduce the daily maximum to 90.3°F which is not to be exceeded more than 2 percent of the time and would establish period averages ranging from 86.7°F during most summer periods down to 53.6°F period average during the month of February. (IEPA Statement of Reasons, pp. 84-5) The only difference in the proposed period average standards between the UDIP and ALU B waters is during the summer months of July and August when the ALU B waters allowed maximum monthly average is 86.7˚F versus 85.1˚F for the UDIP. For both the UDIP and ALU B waters, the IEPA is proposing to allow excursions up to 3.6°F. (IEPA Statement of Reasons, p. 86) As the IEPA has explained, "[t]he proposed thermal water quality standards are more stringent than the General Use standards for the months April through November, especially when considering the period average" and they "are more stringent than the current Adjusted Water Quality Standards at Interstate-55 for all of the months, especially when considering the period average." (*Id*.)

Table 1
Proposed IEPA Water Temperature Limits

Month	Proposed UAA Period Average CAWs Aquatic Life Use B Thermal WQS	Proposed UAA Maximum CAWs Aquatic Life Use B Thermal WQS	Proposed UAA Period Average Upper Dresden Island Pool Thermal WQS	Proposed UAA Maximum Upper Dresden Island Pool Thermal WQS
Jan 1-31	54.3	90.3	54.3	88.7
Fab 1-29	53.6	90.3	53.6	88.7
Mar 1-15	57.2	90.3	57.2	88.7
Mar 16-31	57.2	90.3	57.2	88.7
Apr 1-15	60.8	90.3	60.8	88.7
Apr 16-30	62.1	90.3	62.1	88.7
May 1-15	69.2	90.3	69.2	88.7
May 16-31	71.4	90.3	71.4	88.7
Jun 1-15	74.2	90.3	74.2	88.7
Jun 16-30	86.7	90.3	85.1	88.7
Jul 1-15	86.7	90.3	85.1	88.7
Jul 16-31	86.7	90.3	85.1	88.7
Aug 1-15	86.7	90.3	85.1	88.7
Aug 16-31	86.7	90.3	85.1	88.7
Sep 1-15	86.7	90.3	85.1	88.7
Sep 16-30	77	90.3	77	88.7
Oct 1-15	73.2	90.3	73.2	88.7
Oct 16-31	69.6	90.3	69.6	88.7
Nov 1-30	66.2	90.3	66.2	88.7
Dec 1-31	59.9	90.3	59.9	88.7

All five MWGen stations are currently subject to an adjusted thermal standard granted by the Illinois Pollution Control Board (Docket AS 96-10, October 3, 1996), referred to as the "I-55 Adjusted Standards," whose limits must be achieved further downstream in the Lower Des Plaines River at the I-55 Bridge. The I-55 Bridge is approximately seven miles downstream of the Joliet Stations. The National Pollution Discharge Elimination System ("NPDES") permits for the five MWGen stations incorporate the I-55 Adjusted Thermal Standards. The S&L Study assumed that the I-55 Adjusted Standards will remain in effect.

III. Description of Sargent & Lundy (S&L) Cost Estimates Study

A. Background Regarding Steam Electric Generating Stations

In most power plants, heat from coal, natural gas, oil, nuclear, biomass or solar energy is used to generate steam that turns a steam turbine and generator to generate electricity. Steam electric generating stations, like the five MWGen stations here, all operate on the same principle: water is boiled to make steam, which drives a turbine, which powers an electric generator. All of the units at the five MWGen stations are "Rankine cycles." A Rankine cycle converts heat into "work", a form of energy. A Rankine cycle is the most common method of generating electricity. . The exhaust steam from the steam turbine must be condensed so that the water can be returned to the steam generator. Condensing the exhaust steam requires a cooling source, which is usually water.

The amount of heat generated from condensing the turbine exhaust steam is greater than the amount of electricity generated. For example, each unit at Joliet 7&8 has a rating of 569 Megawatt (MW) gross electrical output, and the design cooling system heat duty for each unit is greater, at approximately 830 MW (thermal). Thus, large cooling systems are required for these types of units. The five MWGen stations were not designed nor were the station sites selected or arranged to attain thermal water quality standards as strict as those proposed in this rule-making. All of the electrical generating units at all five stations were placed in service in 1966 or earlier.

The amount of cooling water withdrawn from a waterbody by a steam electric generating station depends on several factors, one of which is the type of condenser cooling system. There are two basic types of "wet" condenser cooling systems: open-cycle and closed-cycle. Open-cycle systems pass water through the condenser only once before returning virtually all the water to its source, albeit at a higher temperature. Closed-cycle systems recirculate the heated water from the condenser through an evaporative cooling structure (typically a cooling tower, pond, or lake), Evaporation of some of the water results in the build-up of salts in the water requires the system to "blow down" (*i.e.*, discharge). Closed-cycle cooling systems withdraw much less water than open-cycle systems, but they evaporate (*i.e.*, consume) most of the water withdrawn, returning very little to its source.

Joliet 7&8 is the only station that currently has any cooling towers. These supplemental "helper" cooling towers were not part of the original design of the station. They were installed in 1999, subsequent to the issuance of the I-55 Bridge Adjusted Standards. As previously explained in this proceeding in the testimony of Julia Wozniak of MWGen, the Joliet 7&8 towers are used primarily to maintain compliance with the I-55 Bridge Adjusted Thermal Standards. The towers are also used to meet the existing Secondary Contact thermal water quality standards during critical low flow periods that occur in the Dresden Pool. The use of the towers is necessary during the summer months and also at times of unseasonably warm spring and fall periods to meet the existing thermal water quality standards. The existing cooling towers are wholly insufficient to attain and maintain compliance with the Proposed UAA Thermal Standards for the Upper Dresden Island Pool. They also are not adequate for use as part of a design to convert Joliet 7&8 to a closed-cycle cooling system. The existing cooling towers do not have plume abatement and hence, plumes from these towers would cause fogging and icing if used during cold periods. Also, because the existing cooling towers are not "low drift" towers, they would probably exceed particulate matter emission standards if used in a closed-cycle operation. For all of these reasons, the conceptual design and cost estimate S&L prepared is not based on reusing the existing cooling towers.

B. Description of Technologies Considered by S&L

S&L applied the following criteria to evaluate candidate cooling technologies for the MWGen stations:

- A proven technology for large cooling systems (proven performance and reliability);
- A design that would fit within existing site boundaries;
- A system capable of operating during the range of expected weather conditions;
- A technology that would produce minimal ground level fog or icing;
- A cooling system that would have minimal impact on the efficiency and the net electrical output;
- A design that would minimize construction and station outage time; and
- A technology that would minimize capital and operating cost.

When the above criteria were applied to available cooling technologies, it became apparent that several technologies were not feasible for the MWGen stations due to the lack of sufficient land area at the stations on which to construct the necessary structures or equipment associated with a given technology. For example, two established cooling technologies are man-made cooling lakes and cooling ponds with sprays. However, both of these technologies require a significant amount of land area to construct. These technologies are not technically feasible for the MWGen stations because of their site area limitations.

An open-cycle cooling system with "helper" towers would not be able to meet the proposed temperature limits during all weather conditions. There are times, especially during the months of April, May and June, when the difference between the Proposed UAA Thermal Standards and the wet bulb temperature is too small to allow any practical size of cooling tower to meet these proposed standards. During these periods, the towers sized for closed-cycle operation would not be large enough to cool the effluent discharge to temperatures that comply with the Proposed UAA Thermal Standards if they were operated as "helper" towers. Because open-cycle cooling is more efficient than closed-cycle cooling, the conceptual design for each MWGen station includes provisions to operate open-cycle when the actual river water temperature is low enough to allow open-cycle operation and still meet the Proposed UAA Thermal Standards.

As part of its study, S&L also considered several alternative types of closed loop cooling technologies, including wet and wet/dry mechanical draft cooling towers, radiator type towers (external water required), air cooled condensers (new condenser is located external to the turbine room), and hyperbolic cooling. With the exception of the wet and wet/dry mechanical draft cooling towers, the remaining closed loop cooling technologies considered have either not been proven on such large scale installations as the MWGen stations or are considerably more expensive than the wet and wet/dry mechanical cooling tower technologies. Accordingly, these technologies were eliminated from further consideration.

Mechanical draft cooling towers (either wet or dry) are the most common type of cooling system for use in a closed-cycle system for a large heat load. Mechanical draft cooling towers have the advantages of being a proven design, are usually the lowest cost cooling option and require the smallest land area to construct. A mechanical draft tower is typically 40 to 60 feet tall and anywhere from 40 to several hundred feet long, depending on how much circulating water flow the tower is designed to process.

A cooling tower is actually comprised of several semi-independent modules referred to as “cells”. Each cell consists of: 1) a structural steel, concrete or fiberglass frame; 2) walls (to confine the air and water flow); 3) piping near the top of the framework to distribute the water evenly; 4) a section of “fill” that enhances the contact between the air and water; 5) a large-diameter fan to pull air upward through the tower; and 6) an exhaust stack to help direct warm air upward and away from the sides of the tower. A group of cells is typically linked end-to-end to form a single cooling tower assembly. The group of cells is constructed inside a concrete basin which collects the cool water. The pumps which return the cool water to the condenser are installed on one end of the basin. A more detailed description of mechanical draft cooling towers is provided in Section 2.B of the attached S&L report (Exhibit B).

Wet cooling towers dissipate heat to the atmosphere primarily by evaporating some of the cooling water. The temperature of the cooling water that is not evaporated is reduced. The extent of the reduction in the temperature of the cooling water is limited by what is called the “inlet air wet bulb temperature.” The amount of humidity in the atmosphere air determines the wet bulb temperature, which, in turn influences the effectiveness of a cooling tower in removing heat from the circulating water. The wet bulb temperature changes continually (*i.e.,* hour to hour and day to day) as the weather changes. Higher humidity levels result in higher wet bulb temperatures, and lower humidity levels result in lower wet bulb temperatures. In general, the lower the wet bulb temperature, the lower the cold water temperature – the temperature of the circulating cooling water after it has passed through the cooling tower. Thus cooling towers are more effective on cool, dry days and less effective on warm, humid days. Therefore, tower design for cooling performance and the ability to meet thermal discharge limits involves consideration of meteorology probabilities.

The difference between the cold water temperature leaving the cooling tower and the inlet air wet bulb temperature is called the “approach.” The approach is a measure of the effectiveness of the cooling tower. A lower approach results in a lower water temperature but requires a larger and more expensive cooling tower. A larger tower will provide greater contact time between the circulating water and the airflow, which increases heat removal and lowers the circulating water temperature prior to its discharge. A larger tower is more expensive for a given circulating water flow rate, but it will increase the likelihood that the generating station can remain running at its capacity during hot and humid days, when cooling tower efficiency is reduced.

Although not nearly as widely used as wet cooling towers, another alternative means of cooling the steam generated at power plants is to use "dry cooling" towers. Unlike a wet cooling tower, a dry cooling tower has no direct contact between the circulating water and air and no evaporation. The heat transfer is all "sensible heat" (*i.e.*, the water temperature decreases and the air dry bulb temperature increases). A dry cooling tower uses natural or mechanical air drafts to remove heat and requires little or no water. However, dry cooling is less effective than wet cooling. Also, a dry cooling tower is much larger and results in higher discharge water temperatures than does a wet tower. Dry cooling towers are costly, reduce water intake only minimally compared to closed-cycle wet tower cooling and have other disadvantages. One advantage of a dry tower is that it does not produce a vapor plume (as does a wet tower) because it does not evaporate the cooling water.

A wet/dry tower is, as it sounds, a combination of both wet and dry cooling tower technology. As its name implies, a wet/dry tower has both a wet section and a dry section. The wet section achieves a low cooling water temperature and effective cooling through evaporation. The dry section in turn reheats the air leaving the wet section and thereby reduces the water vapor plume exiting the tower. The S&L study concluded that mechanical draft wet/dry cooling towers were the most cost effective type of cooling for all five MWGen stations.

The use of "helper" cooling towers also was considered for the MWGen stations. "Helper" cooling towers are used to reduce the temperature of the cooling water from the station before it is discharged back to the river. However, applying the Proposed UAA Thermal Standards, under certain reasonably expected weather conditions, such as when the wet bulb temperature is close to the applicable thermal standard, it would not be possible to achieve and maintain compliance, regardless of cooling tower size. For this reason, the cooling towers have to be sized for the full circulating water flow rate and heat load and must be operated in a closed-cycle mode during certain weather conditions.

C. Description of Closed-Cycle Cooling Options for MWGen Stations

The mechanical draft wet/dry cooling towers systems selected for the MWGen stations were sized for closed-cycle operation for the expected range of weather conditions throughout the year. The condition that determines the size of the cooling tower is the maximum wet bulb temperature. The specified design point is a 78°F wet bulb, which corresponds to the 1% occurrence in the summer. (, *Facility Design and Planning Engineering Weather Data*, Departments of the Air Force (USAF), the Army, and the Navy, AFM 88-29, TM 5-785, NAVFAC P-89, Washington D.C., 1978). This ensures that the cold water temperature from the cooling tower to the plant will be equal to or less than the design temperature of 85°F (7°F approach), except for 1% of the time in the summer. The use of the 1% summer wet bulb temperature is the standard industry practice for specifying the cooling tower design point. During periods when the wet bulb temperature is greater than 78°F, the generating units will be able to operate but some load reduction may be required.

Gates, piping and pumps to maintain the flexibility to operate in an open-cycle mode and to operate in a closed-cycle mode were included in the design. This allows the stations both to achieve compliance with the Proposed UAA Thermal Standards and to achieve higher operating efficiency (and hence, lower O&M costs for tower operation) by using once-through cooling when the river and ambient air temperatures are favorable.

Converting a once-through cooling system at a power plant into a closed-cycle system, as would be necessary for each of the five MWGen stations, is a major undertaking for many reasons. First, it is difficult because of the size of the cooling system that is needed. For example, the design cooling water flow rate at Joliet 7&8 is 920,000 gallons per minute. For this cooling water flow rate, three cooling tower sections, two 21-cell, 1008 feet long and one 22-cell, 1056 feet long, 48 feet wide and 58 feet high, would be required. The cooling towers have 64 fans that are 250 horsepower each. The length of these cooling tower sections is approximately the equivalent of slightly over 3.5 football fields laid end to end and reaching approximately 6 stories high across the length of that expanse. The circulating water pipes would be up to 14 feet in diameter, over twice the height of the average person. Also, for a power plant such as the MWGen Joliet 7&8, the cooling system would require at least two new sets of large circulating water pumps in addition to the existing set of pumps in place at the station. Operating the new pumps will require over 18MW of power.

The installation of the closed-cycle cooling system at an existing station requires that a major construction project be completed. The construction of the closed-cycle cooling system requires not only large excavations and foundation work which may need to be conducted in a relatively confined area but also requires work to interface the new cooling system with other existing plant systems, including the auxiliary power system, fire protection system, auxiliary cooling system and controls, in addition to the main cooling system.

As noted above, although there have been several studies of existing plants with once-through cooling systems to evaluate retrofitting them to once-through cooling, few have actually converted to once-through cooling because of the high capital cost, impact on plant performance and the complexity of converting an operating station from once-through to closed-cycle cooling. Plants that have closed-cycle cooling systems were typically designed as closed-cycle stations. When a new plant is designed, the cooling system is a major factor in both the site selection and the overall site arrangement.

D. Key Design Parameters for Estimating Closed-Cycle Cooling System Costs

In order to calculate the estimated costs for installing closed-cycle cooling systems at the five MWGen stations, the key elements of the system conceptual design needed to be identified. For closed-cycle cooling systems, the key design elements include: circulating water design flow rate; design wet bulb temperature and circulating water pump size. However, a complete, detailed design of the cooling system was beyond the scope of the S&L Study. Accordingly, there are likely items that are not included in the S&L design concept that would become necessary to include in an actual design of a closed-cycle cooling system for each of the stations. The costs of such additional items are not included in the cost estimates prepared by S&L for this study.

The closed-cycle cooling system conceptual design includes redundancy that is consistent with normal industry practice. The cooling towers have multiple cells, each with a fan, and the failure of one fan or cell will only slightly reduce cooling that should not require a generating unit shutdown or derating. The cooling system will have multiple pumps, but the design is based on all pumps operating (*i.e.*, there is no spare pump). If a pump fails, the load may need to be reduced through derating at the station, depending on the weather conditions, but it should not require a generating unit to be shut down. Multiple pump losses and/or fan failures can put the affected station at greater risk of having to derate to maintain thermal compliance.

As noted above, the closed-cycle-cooling system for each MWGen station was sized for 100% of the circulating water design flow rate. The cooling tower size is determined by the 1% summer wet bulb temperature.

In addition to cooling towers, a closed-cycle cooling system requires large pumps and piping to supply the circulating water to the cooling towers and to return the water to the existing circulating water pumps. Preliminary sizes were determined for the pumps and piping to use in the S&L cost estimates. The quantities of concrete and steel required for the cooling tower basin and pump and cooling tower supports were estimated along with other commodities, such as a rack system for supporting pipe and conduit.

The preliminary cooling tower design used to estimate costs is based on towers with a low drift design to minimize emissions of particulate matter. Based on a preliminary review of applicable air regulations, the installation of cooling towers at the MWGen stations may trigger New Source Review under the Clean Air Act that would require modeling work to be performed and permitting issues to be addressed. The estimated costs included in the S&L Study did not include the additional costs that would be associated with New Source Review requirements.

Based on a review of receiving waters temperature data for the past several years, and due to the wide variability and uncertainties of flow and temperature in the CSSC and Lower Des Plaines River, a credit for a mixing zone was not utilized in the cooling tower sizing for once-through operation. For each of the MWGen stations, there are many days (over 100 days per year in recent years for some of the stations) where the upstream river temperature exceeds the Proposed UAA Thermal Standards. During these periods, mixing of the stations' respective discharges with the receiving water would not reduce the outlet water temperature to below the proposed standards. However, it was beyond the scope of the S&L Study to try to identify a way to predict the various receiving water conditions and any resulting, available mixing zone based on those conditions, that might allow the stations to operate at limited times during the year in a once-through mode before switching back to closed-cycle operation. Further, even with a closed-cycle cooling system, there is a small (~650 to ~3000 gpm) cooling tower blowdown flow generated. Although this cooling tower blowdown flow will not contribute to any significant water temperature rise within the receiving stream, based on existing receiving stream data, it is expected that there may be times when no mixing is available due to low river flow and/or ambient river temperatures which are higher than the Proposed UAA Thermal Standards. If a small mixing zone is needed but not available, an additional cooling mechanism (likely a chiller at an approximate cost of $3 million per station) may be required to ensure compliance under all operating and receiving water scenarios. However, for purposes of S&L's study, supplemental cooling of the condenser blowdown discharge for the MWGen stations was not included in the study cost estimates.

E. General Description of Design Concept for Each MWGen Station

After identifying the basic design elements common to each of the MWGen stations, S&L then proceeded to evaluate the preliminary design criteria further based on relevant site-specific conditions for each of the stations. During this "station-specific" phase of the preliminary design development for cost estimating purposes, the design criteria were refined as appropriate to address the relevant conditions and issues presented by each of the MWGen stations. To a significant extent, the relevant characteristics of the MWGen stations were similar enough that the preliminary design criteria remained relatively the same for most of the stations. Exhibits A and B in the attached S&L Report include arrangement drawings and flow diagrams that illustrate how the cooling systems would be modified for each station. The results of this phase of the S&L costs study are further explained below.

1. Fisk, Crawford and Joliet 6 Stations

For closed-cycle cooling system design purposes, the Fisk, Crawford and Joliet 6 Stations presented similar conditions. Hence, the preliminary design criteria was substantially the same for these stations. Two cooling tower sections were included in the preliminary design to provide adequate cooling and to fit within the site boundaries. The existing intake and discharge canals would be blocked with diversion walls and gates. The diversion gates could be opened during favorable weather and receiving stream conditions to allow once-through cooling water operation. The existing circulating water pumps would pump water from the intake through the condenser to the discharge, similar to current operation. A new pump house and pumps would be installed in the discharge bay to pump the water to the new cooling towers. Water from the cooling towers would be pumped by new pumps, located in the cooling tower basin, to the existing intake area.

Makeup water for the cooling system will come from the existing intake bay. The existing circulating water inlet channel would be partially left open to the river in closed-cycle operation so that makeup water to the cycle can be drawn in as needed. No separate makeup pumps or piping were included in the design or cost estimate. Blowdown from the system will be taken from the discharge of the pumps located in the cooling tower basin, which will be the coldest water in the cooling system.

2. Will County Units 3 and 4

The design of the closed-cycle cooling system at Will County Station for Units 3 and 4 generally would be similar to the arrangement at Fisk and Crawford. However, due to the larger capacity of the Will County Station as compared to either Fisk or Crawford, the size of the cooling tower would need to be larger to provide the cooling necessary for compliant operations. For Will County, the design criteria include three cooling tower sections instead of the two sections specified for the Fisk and Crawford cooling towers.

3. Joliet 7&8

As is the case for Will County Units 3 and 4, three cooling tower sections would be necessary at Joliet 7&8 to supply adequate cooling. The existing intake and discharge canals would be blocked with diversion gates. The existing circulating water pumps would pump water from the intake through the condenser to the discharge, similar to current operation. A division wall would be installed in the discharge bay to divide the bay into two sections. A new pump house and pumps would be installed in one section of the discharge bay and would be isolated from the other section by a movable gate. Pumps in the new pump house would pump the water to the new cooling towers. Water from the cooling towers would be pumped by new pumps, located in the cooling tower basin, to the existing intake area.

While the preliminary design for all of the MWGen stations includes the ability to operate in two possible modes of operation, closed and open-cycle, Joliet 7&8 would have three possible modes of operation. Joliet 7&8 could operate in closed-cycle or open-cycle mode similar to the other stations but could also operate in open-cycle mode using the new cooling towers as helper towers. This would provide more operating time in open-cycle mode, which would reduce operating costs. Because of the site layout and existing intake and discharge arrangement, this is only practical for Joliet 7&8.

F. Cooling System Design Challenges and Constraints

The new cooling system at all five MWGen stations requires installing large equipment in relatively small areas. The space constraints presented by each of the MWGen station properties affected the design of the cooling tower arrangements, making it less than an optimal design if space were not limited. More specifically, the cooling tower arrangements included in the preliminary design are less than ideal with respect to preventing recirculation of air between cooling towers. Recirculation of air between cooling towers is typically something that is prevented or minimized in designing cooling towers because any such recirculation will reduce tower performance. Reduced tower performance results in higher operating costs.

In addition to space limitations at the MWGen stations, additional design issues arise from existing structures and equipment at the stations that interfere with retrofitting them to closed-cycle operations. At Fisk, Crawford and Will County Stations, the available area for locating the cooling towers is also the location of existing high voltage transmission lines owned by Commonwealth Edison ("ComEd"). Therefore, the preliminary design for each of these stations includes having to move and relocate these high voltage transmission lines. However, S&L does not know whether an evaluation by ComEd would determine that the relocation of its transmission lines is feasible or, if feasible, what conditions or costs ComEd would require in return for its agreement to move and relocate these lines.

Another design consideration was the noise that is generated from the operation of cooling towers. S&L's review concluded that noise emissions from the cooling towers are expected to be below the regulatory limits for all of the units except for Joliet 7&8 due to the proximity of an existing office building west of the proposed Joliet 7&8 cooling tower location. However, because of the preliminary scope of the design work completed for this study, the cost of noise abatement was not included in the Joliet 7&8 capital cost estimates prepared by S&L.

Due to the nature of the preliminary design concept work conducted by S&L, certain assumptions needed to be made to complete the cost estimates. This was primarily the case in the area of permitting. The design concept and cost estimates are based on the assumption that state and federal permitting authorities, *e.g.*, Illinois EPA and the U.S. Army Corps of Engineers, will grant all of the necessary permits for the construction and operation of the cooling tower system at each of the MWGen stations. Such permits would include the required construction permit(s) for the towers and the modifications to intake and discharge canals as included in the design concept, as well as any related environmental operating permits, such as for particulate matter emissions from the towers. Due to the relatively high level of uncertainty associated with the extent of the effort necessary to complete the permitting process for each of the stations, S&L did not include a cost estimate line item for permitting in the capital and O&M estimated costs presented in its study. S&L also assumed that the permits could be obtained within the estimated project schedule it prepared as part of its report.

IV. Estimated Economic Costs of Compliance with Proposed UAA Thermal Standards

Based on the preliminary design criteria S&L identified for each of the five MWGen stations, S&L then developed estimates for the costs that are involved in implementing the retrofitting of each of the five MWGen stations to closed-cycle cooling. These estimated costs included capital and O&M cost estimates and estimated power loss revenues associated with the additional power required to operate the cooling towers. The cost estimates for each of the MWGen stations, and how they were prepared for each of the cost categories, is explained further below.

A. Capital Cost Estimates

The estimated capital costs for each MWGen station to convert to closed-cycle cooling systems are listed in Table 2 below, and are explained in more detail in Section 5 of the S&L report (Exhibit B). The estimated capital costs range from $115 million for Joliet 6 to $300 million for Joliet 7&8, for a total capital cost of nearly $1 billion for all five of the MWGen stations.

Table 2

Capital Cost Estimates for Conversion of MWGen Stations to Closed-Cycle Cooling

UNIT	STATION TOTAL GROSS MW	CAPITAL COST WET/DRY TOWER ($)	WET/DRY CAPITAL COST ($) PER KW
FISK 19	348	$137,100,000	$394
CRAWFORD 7&8	585	$165,200,000	$282
WILL COUNTY 3&4	832	$257,100,000	$309
JOLIET 6	341	$115,700,000	$339
JOLIET 7&8	1,138	$300,900,000	$264
TOTALS	3,244	$976,000,000	$301 (AVERAGE)

S&L generated the capital cost estimates based on a combination of budgetary equipment quotes, engineering material quantity estimates and the use of S&L's cost estimating database. The largest cost component is the physical cooling tower itself, which is approximately 15% to 25% of the total capital cost, depending on the station. Budgetary quotes were obtained from SPX/Marley, a major cooling tower supplier. The cost for pumps, piping, electrical equipment and labor were obtained both from S&L's estimating database, which includes data from budget quotes and contracts from past S&L projects, and from published rates for labor and productivity.

The cost estimates provided are "order of magnitude" – meaning that the accuracy is limited to -30%/+50%. These are reasonable cost estimates in the context that they are based on conceptual designs, physical layouts and contain a fair level of detail in all the major account categories.

However, detailed engineering and detailed design have not been performed. During the detailed design and engineering phase of installing a new system into an existing plant, it is common to encounter unforeseen problems that increase the cost. Thus, the +50% is more likely than the -30%. The design parameters used for the cost estimates are based on assumption of the scope and design basis. There are several unknowns that could, and likely will, lead to changes in the cost estimates. Generally, these unknowns are items that would increase the estimated costs, as further explained below.

B. Closed-Cycle Cooling Systems Estimated O&M Costs for MWGen Stations

In addition to the capital costs, the closed-cycle cooling systems will also require annual expenditures to operate and maintain the system (the "O&M costs"). The principal elements of O&M costs for closed-cycle cooling systems are a) cooling tower fan and circulating water system pump power costs, b) preventative maintenance and repair of cooling tower fan and circulating water pump systems, and 3) chemicals for control of corrosion and biological growth. The estimated annual O&M costs, including the costs for the auxiliary power consumptions are listed in Table 3.

Table 3

Estimated Annual Operating and Maintenance Costs for Conversion of MWGen Stations to Closed-Cycle Cooling

Unit	Station Total Gross MW	Wet/Dry Towers
Fisk 19	348	$2,127,000
Crawford 7&8	585	$3,960,000
Will County 3&4	832	$5,750,000
Joliet 6	341	$2,660,000
Joliet 7&8	1,138	$9,080,000
Totals	**3,244**	**$23,577,000**

In addition to the auxiliary power consumption (as discussed further below) and the O&M costs associated with closed-cycle cooling, the cooling water temperature to the condensers will be higher than with once-through cooling. This will result in a loss in gross electrical output and plant efficiency. The loss will vary with ambient temperature, but is expected to be approximately 1%.

C. Auxiliary Power Use Associated with Conversion to Closed-Cycle Cooling

The operation of cooling towers requires a power supply. The power demand of the cooling towers results in additional power that would have to be supplied by each MWGen station on an ongoing basis. This additional power would be supplied by the electricity generated by each of the stations. This additional power demand, referred to here as the "auxiliary power use," results in a loss of revenue to MWGen because it can no longer be sold on the open market. It instead must be used to operate the new cooling towers. It also means that other electrical generating station units must produce more power to supply to the electric grid to make up for the power consumed by the cooling towers. The cooling tower fans and new pumps will consume 2 to 3% of the gross electrical output of the stations. For Joliet 7&8, the cooling system will require over 35MW of power. The auxiliary power consumption for the closed-cycle cooling system for each MWGen station is listed below in Table 4.

Table 4

Cooling Tower Annual Auxiliary Power Use (MW) for MWGen Stations

	Fisk 348 MW	**Crawford 585 MW**	**Will County 3&4 832 MW**	**Joliet 6 341 MW**	**Joliet 7&8 1,138 MW**
Cooling Tower Fan Power	3.24	6.08	9.32	4.28	16.20
Supply Pump Power	3.89	6.48	9.72	4.78	17.01
Discharge Pump Power	0.65	0.97	0.81	.0.81	1.94
Average Aux Power Use	**7.78**	**13.53**	**19.85**	**9.87**	**35.15**
Percentage of MW Output	**2.2**	**2.3**	**2.4**	**2.9**	**3.1**

D. Loss of Plant Generating Capacity

The circulating water inlet temperature to the condenser is higher in closed-cycle mode than in open-cycle mode, because it is not possible to reduce (with cooling towers) the cold-water temperature of the circulating water system to the temperature of the body of water previously used for open-cycle cooling. This higher condenser inlet temperature reduces turbine-generator efficiency and results in a loss of plant generating capacity, and a corresponding loss of revenue from electricity sales. The estimated annual loss in revenue for all five stations is approximately $3,800,000.

E. Potential Additional Costs

Although the work required in preparing the above cost estimates involved an extensive effort, there are still several unknowns in the design basis that could lead to changes in the cost estimates, primarily changes which would increase the cost estimates provided here. These items including the following:

- Noise abatement for the cooling towers is not included in the cost estimates. Noise abatement could cost up to $12.6 million at Joliet 7&8. Although noise abatement is not expected to be required at the other stations, if it does become an issue during permitting, it would increase the S&L estimated costs.

- Blowdown from the cooling towers will be higher than the allowable discharge temperature during some weather conditions. Since the blowdown flow rate will be small compared to the total flow rate, S&L assumed additional cooling of the blowdown will not be required based on the assumption that a mixing zone may be available to allow for compliance at the edge of the mixing zone and not at the end-of-pipe outfall. If however sufficient mixing is not available for one or more of the stations' discharges of cooling tower blowdown, then additional cooling of the blowdown will be required. The capital cost per station for this additional cooling, through the add-on installation and operation of a chiller, will be approximately an additional $3 million per station.

- Changes in the cooling tower location due to transmission line issues would increase the cost. S&L assumed that any interference with the siting of the cooling towers caused by third-party owned, existing transmission lines could be addressed through relocating of the transmission lines. It is not known whether this is a correct assumption.

- A change in cooling tower type, such as dry cooling, would increase cost.

- Additional work resulting from requirements imposed by the Illinois EPA, U.S. EPA Army Corp of Engineers or city or county governments during permitting reviews could increase costs. As an example, if the cooling towers are required to be relocated, the cost would increase.

- Interference from underground utilities could require design changes and impact cost. All of these generating units are on old sites and there may be abandoned, below-ground utilities discovered during the construction phase of the work that have to be removed. No costs for such unknown conditions were included in the S&L cost estimates.

- A constructability review by a general contractor could either identify cost savings or extra costs not included in the estimates. For example, a construction contractor may find that the lack of on-site construction storage area may increase the construction costs.

V. Conclusion

S&L's study of the applicable technology and estimated compliance costs relating to the Proposed UAA Thermal Standards involved an extensive amount of effort by several of its experienced and qualified personnel, as well as cost information generated by an outside cooling tower manufacturer. Based on the significant level of effort devoted to this study, it is clear that the IEPA's proposed re-designation of the aquatic life use of the Upper Dresden Island Pool and the CAWS and the accompanying Proposed UAA Thermal Standards would require new closed-cycle cooling systems for all five MWGen stations that have used these waterways for once-through cooling since they began operating. When the MWGen stations were designed several decades ago, they were not designed nor were their respective sites selected or arranged to attain thermal water quality standards as strict as those proposed in this rule-making. Due to the lack of sufficient land area at the MWGen stations on which to construct the necessary structures or equipment associated with cooling lakes and cooling ponds with sprays, these technologies are not technically feasible for the MWGen stations. Further, there are reasonably expected weather conditions in the vicinity of the MWGen stations which make the use of "helper" towers another option which is not technically feasible for these stations to employ to achieve compliance with the Proposed UAA Thermal Standards. Thus, the new cooling system required for each of the MWGen stations must be designed for closed-cycle operation.

Based on the results of S&L's study, plume abated (wet/dry) mechanical draft cooling towers are the lowest cost alternative for closed-cycle cooling that will achieve and maintain compliance with the Proposed UAA Thermal Standards. For all five MWGen stations, converting them to closed-cycle cooling systems would require an estimated total capital investment of nearly $1 billion, and would result in over $23,000,000 per year in operating and maintenance costs. In addition, the net electrical output and efficiency of all five stations would be reduced. However, as discussed above, because certain assumptions were made in the course of the S&L Study that may not be achieved in an actual implementation of the conceptual design, such as the relocation of high voltage transmission lines, as well as the existence of very few actual cases of converting open-cycle generating stations to closed-cycle operation with which to compare these estimated costs, the implementation of the conceptual design on which these cost estimates are based at each of the MWGen stations is not a technical certainty and is likely to result in actual costs that exceed these estimates.

Respectfully submitted,

Ray E. Henry

Ray E. Henry

EXHIBIT A

TO THE WRITTEN TESTIMONY OF RAY E. HENRY

Curriculum Vitae of Ray E. Henry

RAY E. HENRY
Principal Consultant
Sargent & Lundy Consulting

Sargent & Lundy LLC

EDUCATION

Purdue University - B.S. Mechanical Engineering - 1971

REGISTRATIONS

Professional Engineer – Illinois, Indiana

PROFICIENCIES

Mechanical engineering

Project Management

Power plant design

Steam turbine design review

Boiler design review

Cycle optimization

Fan specialist

Plant betterment

Condition assessment and rehabilitation studies

Reliability and availability

Plant performance

Cooling Systems

Cycling conversion

Training and technology transfer

RESPONSIBILITIES

Mr. Henry is a principal consultant.

As a technical consultant, Mr. Henry provides technical support to the various project teams within Sargent & Lundy. His specialties include, system design, plant condition assessment, performance testing, heat balance studies, plant optimization studies, plant configuration, alternate technology assessment, cycling conversion, fuel switching, cooling system optimization, etc.

Mr. Henry also serves as a project manager for owner's engineer/consultant projects. The scope of these projects usually consists of conceptual design studies, feasibility studies and economic evaluations, preparation of engineering, procurement, and construction (EPC) specifications, evaluation of EPC bids, design review and construction technical support.

Mr. Henry is also Sargent & Lundy's specialist for power plant fans, condensers, and cooling towers.

EXPERIENCE

Mr. Henry has more than 35 years of experience in the mechanical engineering, design, and analysis of major steam-electric generating stations. Mr. Henry has participated in construction overviews, serving as the project lender's engineer.

Mr. Henry serves as a technical consultant on many of the combined cycle plants designed by S&L.

Mr. Henry is a member of the American Society of Mechanical Engineers (ASME) Performance Test Code Committee for fans, PTC II. He has participated in field tests and has provided performance evaluations of boilers, turbines, condensers, pumps, fans, steam generators, and feedwater heaters. He has participated in performance test for conventional and combined cycle plants, including preparation of test procedures, field testing, evaluation of test results and due diligence review of tests and test reports.

Mr. Henry is a member of the American Society of Mechanical Engineers (ASME) Performance Test Codes Standards Committee.

Mr. Henry currently serves as Sargent & Lundy's and fan specialist and one of several boiler and turbine specialists. He has been involved in fan evaluations and the development of specifications for replacement of fans.

Mr. Henry has also been involved in the preparation of and review of EPC and equipment specifications for unit sizes of 12 MW to 1000 MW. He has participated in EPC and equipment bid evaluations, design reviews, performance tests, unit assessments, and performance improvements.

Mr. Henry recently served as a technical consultant to the International Finance Corporation unit of the World Bank regarding its update, published in December 2008, of Environmental, Health, and Safety Guidelines for Thermal Power Plants. That is a key reference document for environmental evaluations of thermal power facilities worldwide.

Mr. Henry developed Sargent & Lundy's HTBAL program to model various steam turbine cycles.

Before assuming his position as consultant and project manger, Mr. Henry was the manager of Sargent & Lundy's Power System Engineering Division, consisting of consultants, technical specialists, senior engineers, and engineers who analyze units in design as well as units that are operating.

Prior to his position as a division manager, Mr. Henry was a senior mechanical project engineer. He performed preliminary design studies to determine general plant layout; sized and specified equipment; analyzed economic factors; prepared flow diagrams; and sized piping, which included analyzing flexibility and support systems. He maintained client contact and incorporated operating philosophies within design parameters. He also interfaced with suppliers in selecting equipment, materials, and labor packages; evaluated proposals; and recommended purchases.

Mr. Henry's specific experience includes the following:

INDEPENDENT ENGINEER / OWNER'S ENGINEER / CONSULTANT

- **Banco Itaú BBA S.A. MPX Energia (Brazil)**
  - Pecém II, 1x365 MW coal-fired. (2009 to present)

- **Fujian Electric Power Survey & Design Institute/Hebei Electric Power Design & Research Institute/Inner-Mongolia Power Exploration & Design Institute (China)**
  - Consulting services for design of 1000MW supercritical coal units (2008 to present)

- **Office National de l'Électricité (Morocco)**
  - Safi 2x660 MW coal fired plant (2008 to present)

- **Phu My 3 BOT Company (Vietnam)**
  - Phu My 3 2x2x1 natural gas combined cycle, 700 MW (2007-2008)

- **AES (Chile)**
  - Nueva Ventanas, 260 MW coal-fired.
    (2006 to 2007)
  - Guacolda, 150 MW coal-fired.
    (2006 to 2007)

- **Inter-American Development Bank/MPX Energia/Energias do Brasil (Brazil)**
  - Pecém I, 2x360 MW coal-fired. (2008 to present)
  - Itaqui, 1x360 MW coal-fired (2008 to 2009)

- **P.T. Tanjung Jati Power Company (Indonesia)**
  - Tanjung Jati "A", 2x600 MW coal-fired.
    (2005 to 2007)

- **Singapore Power International (Korea)**
  - Anyang and Buchon CHP, 2x475 MW LNG. (2000)
  - Bugok CC, 1x538 MW LNG-fired. (2000)

- **TotalFina/Tractebel (Abu Dhabi)**
  - 800 MW gas fired combined cycle
    Project Manager (1999-2000)

- **Shanghai Municipal Electric Power Company (China)**
  - Waigaoqiao Phase II, supercritical coal, 900 MW to 1000 MW.
    Project Manager. (1996-2002)

- **Wing Group (China)**
  - Dengfeng, 2x300 MW coal-fired.
    (1995 to 1998)

- **Sithe China Limited (China)**
  - Puqi, 2 x300 MW coal fired, IPP.
    (1997 to 1998)

- **Yellow Sea Company (China)**
  - Jinhua, 2x30 MW coal-fired cogeneration.
    (1995 to 1998)

- **Illinova (China)**
  - Zhuzhou, 2x12 MW coal-fired cogeneration.
    (1996 to 1997)

- **Electric Power of Henan (China)**
  - Qinbei, 2x600 MW coal-fired.
    (1995 to 1997)

CONCEPTUAL DESIGN STUDIES

- **Office National de l'Électricité (Morocco)**
  - Jorf Lasfer, Conceptual study for new coal fired generation, including site layout, evaluation of unit size and design, performance estimates and capital and O&M cost estimates. (2005 to 2007)

- **Shanghai Municipal Electric Power Company (China)**
  - Waigaoqiao, supercritical coal, 900 MW to 1000 MW.
    Project Manager. Phase II site evaluation for the potential addition of four supercritical coal-fired units. Stage 1 of the project, consists of conceptual design and bid document review and Stage 2 consists of interface. (1996 to 2002)

    Site study for extension units. (1993)

- **Central & South West Services, Inc.**
  - Technology assessment of new generation. (1993 to 1994)

PLANT DESIGN

- **Huaneng International Power Development Corporation**
  - Shidongkou 1 and 2, coal, 600 MW, supercritical.
    Performed pipe sizing and prepared heat balances. (1988)

- **PSI Energy**
  - Gibson 5, coal, 618 MW, supercritical.
    Performed preliminary design studies for plant layout; optimized cycle configuration; sized and specified equipment, including auxiliary boiler; analyzed economic factors; prepared flow diagrams; procured equipment and materials; and prepared labor packages, provided technical support for construction. (1979 to 1983)

For the following projects, Mr. Henry supervised equipment sizing, optimization of systems and components, performance evaluation of equipment from various manufacturers, and feasibility studies.

- **Central Power & Light Company**
  - Coleto Creek 1, coal, 570 MW.
    (1974 to 1977)

- **Commonwealth Edison Company**
  - Byron 1 and 2/Braidwood 1 and 2, nuclear, 1175 MW each.
    (1974 to 1977)

- **Northern Indiana Public Service Company**
  - Schahfer 14 and 15, coal, 550 MW each.
    (1971 to 1973, 1974 to 1977)

- **Illinois Power**
  - Clinton 1, nuclear, 985 MW;
  - Havana 6, coal, 439 MW.
    (1973 to 1977)

- **American Electric Power Service Corporation/Buckeye Power, Inc.**
  - Cardinal 3, coal, 615 MW, supercritical.
    (1973 to 1974)

BOILERS

- **Mitsui**
  - Point Aconi, 185 MW CFB.
    Boiler efficiency and plant heat rate tests. (1994 to 1995)

- **National Power**
  - Jiaxing 660 MW coal.
    Design review of boiler proposal. (1995)

- **PSI Energy**
  - Gibson 3, 668 MW, coal.
    Technical support for test burn of PRB coal. (1993 to 1995)

- **Carolina Power & Light Company**
  - Asheville Unit 2, coal 200 MW.
    Boiler capacity and HUT tests. (1995)

- **Carolina Power & Light Company**
  - Roxboro Unit 2, 600 MW coal.
    Retrofit of new pulverizers and coal pipe. (1995)

COOLING SYSTEM

- **PSI Energy**
  - Cayuga 1 and 2, coal, 531 MW each.
    Study to convert to closed cycle cooling. (1993)

- **PSEG Nuclear**
  - Salem 1 and 2, nuclear
    Evaluation of cooling tower retrofit (1994)

- **Genesis Energy**
  - Huntly Power Station Units 1 to 4
    Specification and evaluation of helper cooling tower (2004)
    Evaluation of alternative cooling systems (2010)

- **Enviro Power**
  - Various sites
    Cooling tower evaporation rates (2001)

- **Vattenfall**
  - Moorburg Units 1 and 2, coal, 840 MW each.
    Study of cooling system (2009)

PRECIPITATOR UPGRADES

- **Indianapolis Power & Light Company**

- Pritchard 6, coal, 69 MW.
  Fan testing, model flow testing, and precipitator procurement. (1992 to 1993)

CONDITION ASSESSMENT

- **ATCO Power**
  - Battle River Units 3 and 4
    Evaluated condition of steam turbine, boiler and other major equipment. (2006)
- **AES**
  - Ekibastuz units 1-5
    Review of steam turbine, boiler and other major equipment (2007)
- **The Cincinnati Gas & Electric Company**
  - Miami Fort 5, coal, 80 MW.
    Evaluated condition of fans, fluid drives, and condenser. (1987)
- **PSI Energy**
  - Gallagher 4, coal, 150 MW.
    Evaluated condition of fans, condenser, and feedwater heater. (1986)
- **Northern Indiana Public Service Company**
  - Mitchell 4, coal, 138 MW.
    Evaluated condition of fans, condenser boiler feed pumps, fluid drives, and feedwater heaters. (1985)
- **Boston Edison Company/Electric Power Research Institute**
  - Mystic, oil, 565 MW.
    Developed guidelines for fans and heat rate. (1984)

MISCELLANEOUS

- **Arizona Public Service Company**
  - Various stations.
    Developed turbine cycle and heat rate seminar for presentation to client's personnel. (1987)
- **Northern Indiana Public Service Company**
  - Provided engineering services to increase unit capacity. (1984)

- **Mitsui/Toshiba**
  - Performed survey of moisture separator reheaters. (1983 to 1984)

- **University of Wisconsin**
  - Performed balance-of-plant conceptual design for a fusion reactor. (1973 to 1974)

PLANT PERFORMANCE

- **TU Electric**
  - Mechanical Project Engineer. Subcontractor on EPRI heat rate improvement guideline project (RP2181). (1987 to 1989)

- **SEGS VIII and IX**
  - Plant performance improvement study. (1994)

- **Wisconsin Electric**
  - Pleasant Prairie, coal, 570 MW.
    Determined sources from plant to supply energy to industrial park. Identified sources and determined heat rate and power generation degradation caused by source. Also evaluated advantages and disadvantages and balance-of-plant impact. (1987)

- **Wisconsin Power & Light Company**
  - Rock River 2, coal, 75 MW.
    Conducted unit performance evaluation and developed a performance evaluation manual. (1987)

- **Boston Edison Company**
  - Mystic 4-7, oil, 1086 MW total;
  - New Boston 1 and 2, oil, 738 MW total.
    Performed unit availability study. (1985)

- **Interstate Power Company**
  - Lansing 4, coal, 252 MW.
    Performed unit performance evaluation. (1984)

- **Central Illinois Public Service Company**
  - Grand Tower 4, coal, 100 MW;
  - Newton 2, coal, 567 MW.
    Performed unit performance evaluation. (1983)

CYCLING CONVERSION

- **Houston Lighting & Power Company**
  - Sam Bertron 1 and 2/Deepwater 7/W. A. Parish 1 and 2; gas; 156 MW each.
    Development of system design for cycling modifications and determination of startup times for warm starts. (1986)

CLEAN AIR ACT AMENDMENT

- **PSI Energy**
  - All stations.
    Program Manager. Design, procurement, and installation design of continuous emission monitors. (1991 to 1992)

    Program Manager. Phase I Clean Air Act Amendment compliance study. (1991)

TRAINING AND TECHNOLOGY TRANSFER

- **Korea Electric Power Corporation/Korea Power Engineering Company**
  - Yonggwang 3 and 4, nuclear, 950 MW each.
    Conducted six-month transfer of technology course on heat exchangers. (1987 to 1988)

- **Arizona Public Service Company**
  - Conducted two-day course on heat balances. (1986)

- **Sargent & Lundy**
  - Instructor of a course in fans for Sargent & Lundy's Power Plant Fundamentals program.

FANS

- **Commonwealth Edison Company**
  - Kincaid 1 and 2, coal, 1160 MW total.
    Study for upgrading induced draft (ID) fans for the addition of an FGD system. (1991 to 1992)

    Provided engineering services for replacement of gas recirculation fan wheels. (1988)

  - Waukegan 8, coal and gas, 355 MW.
    Provided engineering services for replacement of ID fan wheel. (1988)

  - Joliet 7 and 8, coal and gas, 580 MW each.
    Performed engineering services in connection with ID fan wheel and fan rotor replacement. (1987)

- Powerton 5 and 6, coal, 828 MW each.
  Provided engineering services for replacement of forced draft (FD) fan wheel. (1987)

- Will County 1 and 2, coal, 280 MW total.
  Provided engineering services for ID fan hub replacement and prepared specifications for replacement of FD fan wheel. (1987)

- **Electric Power Research Institute**
  - Study manager for developing operating and maintenance guidelines (RP2504-7) for draft fans. (1988 to 1992)

- **PSI Energy**
  - Gibson 4, coal, 668 MW.
    Study for upgrading ID fans for the addition of a flue gas desulfurization system. (1991)
  - Cayuga 1 and 2, coal, 1062 MW total.
    Provided engineering service for replacement of FD and ID fan wheels. (1988)
  - Wabash River 6, coal, 365 MW.
    Provided engineering services for replacement of ID fan wheels. (1988)

- **Florida Power & Light Company**
  - Various stations.
    Prepared generic FD fan specifications for several 400 MW units. (1987)

MEMBERSHIPS

American Society of Mechanical Engineers
- Performance Test Codes Standards Committee
- Committee PTC-11, Fans

PUBLICATIONS

“Emission Limits and Controls for Coal Fired Plants in the United States” (coauthor), Presented at the International Seminar on Energy Savings and Environmental Protection in Large Scale Thermal Power Companies, Shanghai, 2007

“Uncertainty Analysis in Fan Testing” (coauthor), ASME POWER2007, San Antonio, Texas, July 2007.

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EXHIBIT H

2011 SARGENT & LUNDY REPORT

MIDWEST GENERATION EME, LLC
CHICAGO AREA WATERWAYS AND LOWER DES PLAINES RIVER GENERATING UNITS

COOLING TOWER COST STUDY

REPORT NO. SL-009359

Date: February 1, 2011

S&L Project No. 10683-130

Sargent & Lundy LLC

55 East Monroe Street
Chicago, IL 60603-5780 USA

MIDWEST GENERATION EME, LLC
CHICAGO AREA WATERWAYS AND LOWER DES PLAINES RIVER GENERATING UNITS

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REPORT NO. SL-009359

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MIDWEST GENERATION EME, LLC
CHICAGO AREA WATERWAYS AND LOWER DES PLAINES RIVER GENERATING UNITS

COOLING TOWER COST STUDY

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1. EXECUTIVE SUMMARY

Proposed rules by the Illinois Environmental Protection Agency ("Illinois EPA" or "Agency") seek to change the use designation for the Upper Illinois Waterway ("UIW") from the existing "secondary contact and indigenous aquatic life" use (the "Proposed UAA Rules"). The Proposed UAA Rules include more stringent thermal water quality standards ("Proposed UAA Thermal Standards") for the UIW. Five electrical generating stations owned and operated by Midwest Generation EME, LLC ("MWGen") are located along and discharge to those portions of the UIW known as the South Branch of the Chicago River, Chicago Sanitary and Ship Canal ("CSSC") and the Upper Dresden Island Pool ("UDIP") of the Lower Des Plaines River. These stations are Fisk, Crawford, Will County and Joliet (2 stations) generating stations. Joliet 6 is located on the south side of the Des Plaines River, while Joliet 7&8 is located on the north side of the Des Plaines River. Will County Units 1&2 were retired effective December 31, 2010. Therefore, these two units were not included in this study. The MWGen generating stations operate based on a once-through, open-cycle circulating water system design. None of the MWGen generating stations are capable of achieving and consistently maintaining compliance with the proposed thermal standards at existing operating levels.

MWGen requested that Sargent & Lundy (S&L) evaluate the various technologies that are available for cooling the Fisk, Crawford, Will County and Joliet units. S&L has been designing power plants since its beginning in 1891. The original Fisk unit was designed by S&L in the early 1900's. Since that time, S&L has designed many power plants that incorporate different types of cooling tower designs.

This report addresses the potential cost and operational impacts associated with revised limits on thermal discharges from the subject MWGen generating stations. This particular study expands and updates earlier work prepared in 2005, that presented proposed cost estimates and other information developed by S&L for the installation of thermal control technology at the MWGen stations. In 2008, after this rule-making was initiated, S&L began work to review and update its prior 2005 study. The proposed thermal control technology evaluated consisted of multi-cell cooling towers designed for closed-cycle operation, with provisions to permit operation in open-cycle mode when conditions allow. The incremental capital costs for the provisions to permit open-cycle mode constitute a small percentage of the overall project cost. Those incremental costs are discussed further in Section 5.

At the time of the 2005 S&L study, it was not known what new thermal standards the Illinois EPA would propose for the UIW. Accordingly, in the absence of any suggested thermal standards on which to base the study, the 2005 S&L study used the existing Illinois General Use thermal standards as the design basis for evaluating the control options and associated costs for achieving compliance. In the 2005 study, the estimated capital costs for wet towers ranged from about \$59,500,000 for Joliet 6 to about \$170,000,000 for Joliet 7/8, and the costs for wet/dry (plume abated) towers ranged from about \$84,500,000 for Joliet 6 to about \$257,000,000 for Joliet 7/8. Annual Operation and Maintenance (O&M) costs were also estimated in the 2005 study. O&M costs are, to a great extent, proportional to a plant's electrical output, so it is to be expected that O&M costs for the largest plant, Joliet 7/8 at 1,138 MW, would be considerably higher than O&M costs for Fisk at 348 MW. The 2005 estimated O&M costs for wet/dry towers ranged from about \$1,400,000 for Fisk to about \$7,000,000 for Joliet 7/8.

In this study, the Proposed UAA Thermal Standards are used as the design basis for determining the feasibility of add-on thermal control technology and the associated costs of compliance for each of the MWGen stations. As part of the design basis, the proposed cooling systems were designed with the goal of allowing the stations to run at full capacity under the most demanding conditions. Under the Proposed UAA Thermal Standards, it is generally expected that the most demanding thermal conditions will occur during the hot summer months. However, because the Proposed UAA Thermal Standards include stringent seasonal thermal criteria throughout the year, the design also needed to address the need to operate without capacity restrictions during the cooler times of the year. The following information was developed in this study for cooling towers at Fisk, Crawford, Joliet and Will County:

- Evaluation of capability for meeting the proposed thermal standards;
- Review of regulatory and permitting issues and risks;
- Order-of-magnitude (-30%/+50%) capital and O&M cost estimates; and
- Review of schedule requirements and layout feasibility.

Several alternative types of closed loop cooling technologies were evaluated as part of this study, including radiator type towers (external water required), air cooled condensers (new condenser is located external to the turbine room), and hyperbolic natural draft cooling towers. These options have either not been proven on such large scale installations or are considerably more expensive than the conventional wet cooling tower design.

The advantage of the closed-cycle wet cooling tower approach is that it virtually eliminates thermal discharges to the adjacent river. There is still a small discharge that is required to control the water chemistry of the tower (referred to as "cooling tower blowdown"), but this is a fraction of a percent of the total open loop cooling compared to the current open-cycle operation of these stations. If a mixing zone is granted for discharging cooling tower blowdown, it is assumed that the cooling tower blowdown will meet the Proposed UAA Thermal Standards at the edge of the mixing zone. However, S&L recognizes that, if the ambient temperature of the river is above the Proposed UAA Thermal Standards, an allowed mixing zone may not be applicable under the existing mixing zone regulation in 35 IAC § 302.102. Accordingly, it is currently not known whether and to what extent each of the MWGen stations would be granted an allowed mixing zone. In any event, the estimated costs of the proposed cooling towers and associated circulating water system modifications discussed in this report are not significantly affected. If the stations' cooling tower blowdown discharge is not subject to an allowed mixing zone, the temperature of the cooling tower blowdown discharge must comply with the Proposed UAA Thermal Standards at the point of discharge to the river. In the absence of an allowed mixing zone, an additional cooling mechanism (likely a chiller totaling approximately $3 million per station) may be required to guarantee compliance at each of the MWGen stations under all operating and receiving water scenarios. However, for purposes of this report, we have not included any supplemental cooling of the cooling tower blowdown discharge for any of the stations in the study cost estimates.

Three different design scenarios were evaluated for the Joliet and Will County Stations. These are wet towers (which yield a visible, fog-like discharge plume), wet/dry towers (plume-abated towers), and wet towers with provisions to convert to wet/dry operation. The cooling tower design for Fisk and Crawford was based solely on the wet/dry (plume-abated) design, in order to prevent icing on the nearby interstate highway, high voltage power lines, and in nearby commercial and residential areas. The estimated compliance capital costs for all of the stations covered by this study range from $93,400,000 at Joliet 6 to $223,800,000 at Joliet 7/8 for wet towers to between $115,700,000 at Joliet 6 and $300,900,000 at Joliet 7/8 for the wet/dry options. Annual Operation and Maintenance (O&M) costs for wet/dry towers ranged from $2,127,000 at Fisk to $9,080,000 at Joliet 7/8.

The estimated capital costs for the various designs considered are summarized in Table ES-1. Table ES-1 also provides the capital cost per kilowatt for the wet/dry tower designs for each of the five MWGen stations, which ranges from $264/kW to $394/kW, with an average cost across all five stations of $301/kW. Annual O&M costs, based on 75 percent capacity factors, are summarized in Table ES-2. Table ES-3 summarizes the portion of each station's gross capacity which is lost due to the cooling tower systems' auxiliary power demand.

Table ES-1

Cost Summary of All Wet/Dry, Wet/Dry Convertible, and Wet Non-Convertible Towers

Unit	Station Total Gross MW	Capital Cost Wet/Dry Tower ($)	Capital Cost Wet Convertible to Wet/Dry ($)	Capital Cost Wet Only ($)	Wet/Dry Capital Cost ($ per kW)
Fisk 19	348	$137,100,000	N/A	N/A	$394
Crawford 7&8	585	$165,200,000	N/A	N/A	$282
Will County 3&4	832	$257,100,000	$230,200,000	$210,700,000	$309
Joliet 6	341	$115,700,000	$103,600,000	$93,400,000	$339
Joliet 7&8	1,138	$300,900,000	$257,900,000	$223,800,000	$264
Totals	**3,244**	**$976,000,000**	-	-	**$301 (average)**

Table ES-2
Estimated Annual Operating and Maintenance Costs

Unit	Station Total Gross MW	Wet/Dry Towers	Wet or Wet Convertible Towers
Fisk 19	348	$2,127,000	N/A
Crawford 7&8	585	$3,960,000	N/A
Will County 3&4	832	$5,750,000	$5,710,000
Joliet 6	341	$2,660,000	$2,350,000
Joliet 7&8	1,138	$9,080,000	$8,280,000
Totals	**3,244**	**$23,577,000**	N/A

Auxiliary power use increases for the cooling tower operation. Each cooling tower cell is provided with a fan, and additional pumps are required to move cooling water through the closed cooling loop. The power demands of the fans and additional pumps contribute to the additional auxiliary power requirements. The auxiliary power requirements for the MWGen plants are shown in Table ES-3.

Table ES-3
Cooling Tower Auxiliary Power Use (Annual-Average MW)

	Fisk 348 MW	Crawford 585 MW	Will County 3&4 832 MW	Joliet 6 341 MW	Joliet 7&8 1,138 MW
Cooling Tower Fan Power	3.24	6.08	9.32	4.28	16.20
Supply Pump Power	3.89	6.48	9.72	4.78	17.01
Discharge Pump Power	0.65	0.97	0.81	0.81	1.94
Average Aux Power Use	**7.78**	**13.53**	**19.85**	**9.87**	**35.15**
Percentage of MW Output	**2.2**	**2.3**	**2.4**	**2.9**	**3.1**

From the data in Table ES-3, it can be seen that the cooling tower systems consume between 2.2 percent and 3.1 percent of the stations' gross output, which represents lost generating capacity for each affected station. The economic effects of station generating capacity loss are discussed in Section 5.

The costs presented above are based on the preliminary design criteria prepared by S&L for this report. For each of the MWGen stations, cooling tower design is based on a 7°F approach temperature and a 1% wet bulb occurrence. These numbers drive the performance and cost of the tower. Smaller approach temperatures require larger and more expensive towers to accommodate a given cooling water flow requirement. But, smaller (or lower) approach temperatures also increase the likelihood that the unit can remain running at its full rated load under all operating conditions. Conversely, higher approach temperatures would reduce the size of the tower required but would increase the risk that the unit would need to be operated at much less than its rated load on hot days when the demand for power is typically at its greatest. A higher approach temperature would also increase the temperature of the cooling tower blowdown, increasing the risk of not meeting the applicable temperature limits, especially if these apply at the end-of-pipe. The potential capital cost savings realized for designing to a 12°F approach temperature, instead of the 7°F approach temperature selected for this study, would be approximately 20 percent. Even with this potential cost savings, the overall cost of the cooling tower installation still represents a substantial capital expense. The use of a 7°F approach temperature yields the lowest practical cooling tower blowdown temperature, and thus minimizes the overall thermal impact on the river. Please refer to Section 2.C.2 for a more detailed discussion of cooling tower design and function.

There are several concerns associated with the proposed cooling tower installations. The feasibility of siting cooling towers poses significant constructability difficulties at many of the MWGen stations. "Constructability" is an industry term used to indicate both the economic feasibility and the ease with which equipment can actually be installed. Installation of cooling towers at Fisk, Crawford, and Will County stations will require relocation of ComEd high voltage lines to prevent ice buildup caused by the cooling towers' operation and potentially catastrophic snapping of these power lines during the winter months. Based on S&L's past professional experience, the estimated capital costs include an allowance for transmission line relocation where applicable, but there was no study performed to define the scope of this necessary modification. This study also assumes that if requested, ComEd would agree to and allow the relocation of the high voltage lines. If relocation of the ComEd high voltage lines is not possible, the towers would pose a safety concern at Fisk, Crawford, and Will County which may prevent their installation unless another alternative approach to their installation can be identified.

Many of the MWGen stations have very limited available space for locating new cooling towers. The limited availability of space can affect the towers' performance. These tight arrangements promote interference (when the hot air discharge of one tower enters the intake of a nearby tower, leading to poor performance). Another negative impact of the tight tower arrangement is recirculation (when the hot air discharge of a tower enters its own intake, leading to poor performance) when winds are blowing in an unfavorable direction.

Noise emissions from the cooling towers are expected to be below the regulatory limits for all of the units except for Joliet 7&8 due to the proximity of an existing office building west of the proposed Joliet 7&8 cooling tower location. The cost of noise abatement was not included in the Joliet 7&8 capital cost estimates.

Particulate emissions from the cooling tower are estimated to be greater than the 25 ton/year threshold for New Source Review (NSR) for overall particulate matter for the Joliet 7&8 and Will County 3&4 cooling towers. These emission levels would trigger requirements for Best Available Control Technology (BACT); however, drift eliminators (included in the design) meet the BACT standards.

Particulate emissions with an aerodynamic diameter less than 10 microns (PM_{10}) are estimated to fall below the NSR PM_{10} threshold of 15 tons/year at all stations except Joliet 7&8, based on use of published ratios of PM_{10}:PM emissions that have been accepted by the Illinois EPA in the past. Using this method, Joliet 7&8 have predicted combined PM_{10} emissions of approximately 15.06 tons/year, which is slightly above the threshold. Will County 3&4 have predicted combined emissions of approximately 10 tons/year, based on a conservative 100% capacity factor and 100% closed-cycle operation. If a methodology different from the ratio method is used to calculate PM_{10} emissions, the 15 tons/year threshold possibly could be exceeded at Will County, depending on the final calculation methods and assumptions. Fisk, Crawford and Joliet 6 should not have issues related to PM_{10} emissions.

Lastly, S&L estimates that a single tower installation will require a minimum of 29 months to complete after additional studies are completed and critical design criteria are finalized. This schedule is based on a single tower installation; the overall duration for a multiple station cooling tower installation will be longer. From a design standpoint, much of the required effort will be largely repetitive. For example, once a cooling tower specification is prepared for one station, it will take considerably less time to prepare a comparable specification for another station. However, it is likely that MWGen's ability to pursue multiple cooling tower projects in parallel will be limited by the time required to fabricate and deliver the cooling tower material and equipment and/or by the time required to construct the tower and other structures.

At present, there are few utility-size cooling tower projects underway nationally, and the construction labor market is favorable. With such conditions, assuming funding can be acquired when needed, one might be able to execute projects at Fisk and Crawford in parallel, and to start projects at the next stations in sequence with a 12- to 15-month lag. Assuming such "best case" scenario circumstances, after the time required to complete the final design criteria, the time required to implement closed-cycle cooling at the five MWGen stations is estimated to be a minimum of 60 months. However, as the economy improves, lead times will lengthen and construction labor will become less available. Therefore, it is not possible to predict accurately the overall time required to design, fabricate and install cooling towers at five power stations. Again, assuming that funding can be obtained when needed, for planning purposes, S&L recommends that at least 72 months should be allowed for that process.

The extent of transmission line relocation was not examined in any detail during this study. The time required to obtain permission for line relocation and to actually relocate the lines has not been considered in the schedule discussion above.

2. APPROACH AND SCOPE OF COOLING TOWER STUDY

This section addresses:

- The Proposed UAA Thermal Standards which will force installation of closed-cycle cooling at Crawford, Fisk, Joliet 6, Joliet 7/8 and Will County 3/4;
- A discussion of cooling tower design and performance considerations; and
- A description of the scope of this cooling tower cost study report.

A. PROPOSED UAA THERMAL WATER QUALITY STANDARDS

In October 2007, the Agency filed the Proposed UAA Rules with the Illinois Pollution Control Board. If adopted, the Proposed UAA Rules would reclassify the subject waters into which each of the MwGen stations discharge from their current "secondary contact" use designation and impose more stringent thermal standards for the associated waterways. The Proposed UAA Rules include thermal standards that are stricter than the existing General Use standards.

Table 2-1 below lists the Proposed UAA Thermal Standards, which would apply on a period average basis with a daily maximum limit. Under the Proposed UAA Rules, the CAWS Aquatic Life Use B ("ALU B") standards would apply to Fisk, Crawford, and Will County, while the Upper Dresden Island Pool ("UDIP") standards would apply to Joliet. The Proposed UAA Thermal Standards may be applied at the edge of an approved mixing zone pursuant to the requirements of 35 Ill. Adm. Code §302.102. However, a final determination of whether any mixing zone will be allowed, and, if so, how large, is not currently known because it would be determined by the Agency in future NPDES permitting if any revised thermal water quality standards are ultimately adopted. For the purpose of this study, it is assumed that the small (~650 to ~3000 gpm) cooling tower blowdown flows generated by a closed-cycle cooling system either will comply with the Proposed UAA Thermal Standards or will not contribute to any significant water temperature rise within the receiving stream, thus making any need for a mixing zone limited to a very small area of the receiving stream. However, based on existing receiving stream data, it is expected that there may be times when no mixing is available due to low river flow and/or ambient river temperatures which are higher than the Proposed UAA Thermal Standards. In the absence of an allowed mixing zone, an additional cooling mechanism (likely a chiller at a total approximate cost of $3 million per station) may be required to ensure compliance at each of the MWGen stations under all operating and receiving water scenarios. However, for purposes of this report, we have not included any supplemental cooling of the blowdown discharge for any of the stations in the study cost estimates.

Table 2-1
Proposed IEPA Water Temperature Limits

Month	October 2007 Final IEPA Average CAW Aquatic Life Use B Temp Limit	October 2007 Final IEPA Maximum CAW Aquatic Life Use B Temp Limit	October 2007 Final IEPA Average Upper Dresden Island Pool Temp Limit	October 2007 Final IEPA Maximum Upper Dresden Island Pool Temp Limit
Jan 1-31	54.3	90.3	54.3	88.7
Feb 1-29	53.6	90.3	53.6	88.7
Mar 1-15	57.2	90.3	57.2	88.7
Mar 16-31	57.2	90.3	57.2	88.7
Apr 1-15	60.8	90.3	60.8	88.7
Apr 16-30	62.1	90.3	62.1	88.7
May 1-15	69.2	90.3	69.2	88.7
May 16-31	71.4	90.3	71.4	88.7
Jun 1-15	74.2	90.3	74.2	88.7
Jun 16-30	86.7	90.3	85.1	88.7
Jul 1-15	86.7	90.3	85.1	88.7
Jul 16-31	86.7	90.3	85.1	88.7
Aug 1-15	86.7	90.3	85.1	88.7
Aug 16-31	86.7	90.3	85.1	88.7
Sep 1-15	86.7	90.3	85.1	88.7
Sep 16-30	77	90.3	77	88.7
Oct 1-15	73.2	90.3	73.2	88.7
Oct 16-31	69.6	90.3	69.6	88.7
Nov 1-30	66.2	90.3	66.2	88.7
Dec 1-31	59.9	90.3	59.9	88.7

The MWGen stations that are impacted by the Proposed UAA Rules are Fisk, Crawford, Will County and the two Joliet stations. Thermal discharges from the MWGen stations in their current once-through, open-cycle design do not meet the Proposed UAA Thermal Standards either for the CAWS Aquatic Life Use B or the UDIP. Based on the Proposed UAA Thermal Standards, as summarized in Table 2-1 above, it was determined that closed-cycle cooling tower control technology would be the most effective means of complying with the Proposed UAA Thermal Standards while maintaining the capability to operate at the design electrical output of each unit.

B. COOLING TOWER DESIGN AND PERFORMANCE

1) Cooling Tower Function and Physical Characteristics

Cooling towers are used to transfer the heat from the power plant circulating water into the atmosphere. Steam from the turbine-generator exhaust is cooled and condensed to water in one side of a large heat exchanger, called the condenser, and is pumped back (recycled) to the boiler. The other side of the condenser is cooled by the circulating water system, and the circulating water gains heat as it passes through the condenser. The circulating water is sprayed into the top of the cooling tower, where it comes into contact with air from the atmosphere which flows upward through the tower. Some of the warm circulating water is evaporated and absorbed by the cooler air. This evaporation of a portion of the circulating water is the primary mechanism for heat transfer between the water and the air. The air cools the circulating water so it can be pumped back to the condenser and the cycle is repeated. "Fill" is used to break up falling water droplets in the tower and promote interaction between the water and the ambient air.

Cooling towers of a type called "mechanical draft" were evaluated for installation at the MWGen stations. A mechanical-draft tower is typically 40 to 60 feet tall and anywhere from 40 to several hundred feet long, depending on the volume of circulating water flow the tower is designed to process. A cooling tower is actually comprised of several semi-independent modules referred to as "cells". Each cell consists of 1) a structural steel or fiberglass frame, 2) walls (to confine the air and water flow), 3) piping near the top of the framework to distribute the water evenly, 4) material called "fill" (installed within the tower framework) to improve heat transfer between the water flowing down and the air flowing up, 5) a large-diameter fan to pull air upward through the tower, and 6) an exhaust stack to help direct warm air upward and away from the sides of the tower. A group of cells is typically linked end-to-end to form a single cooling tower assembly. The group of cells is constructed inside a concrete basin which collects the cool water. The pumps which return the cool water to the condenser are installed on one end of the basin.

The number of individual cells in the cooling towers evaluated for this study ranged from a low of 16 at Fisk Station to a high of 64 at Joliet 7/8. The cooling tower equipment arrangement drawings presented in Exhibit A show that it was necessary to break the total number of cells required into two or more groups owing to space limitations at the stations.

2) Cooling Tower Performance Considerations

Sizing of wet and plume-abated (wet/dry) cooling towers depends primarily on two key parameters: wet bulb temperature, which is determined by weather conditions, and approach temperature, a value which is selected by the cooling system designer.

The amount of humidity in the atmosphere air determines the wet bulb temperature, which, in turn influences the effectiveness of cooling tower in removing heat from the circulating water. Higher humidity levels result in higher wet bulb temperatures, and lower humidity levels result in lower wet bulb temperatures. In general, the lower the wet bulb temperature, the lower the cold water temperature – the temperature of the circulating cooling water after it has passed through the cooling tower. Thus cooling towers are more effective on cool, dry days and less effective on warm, humid days.

Wet bulb temperature changes continually (hour to hour and day to day) as weather changes. Therefore, tower design for cooling performance and the ability to meet thermal discharge limits involves consideration of meteorology probabilities. A conservative approach that accounts for reasonably expected weather conditions was used in this study to ensure that the tower design will remove the heat from the generating station even during the most hot and humid days. The cooling towers were designed based on the "Summer

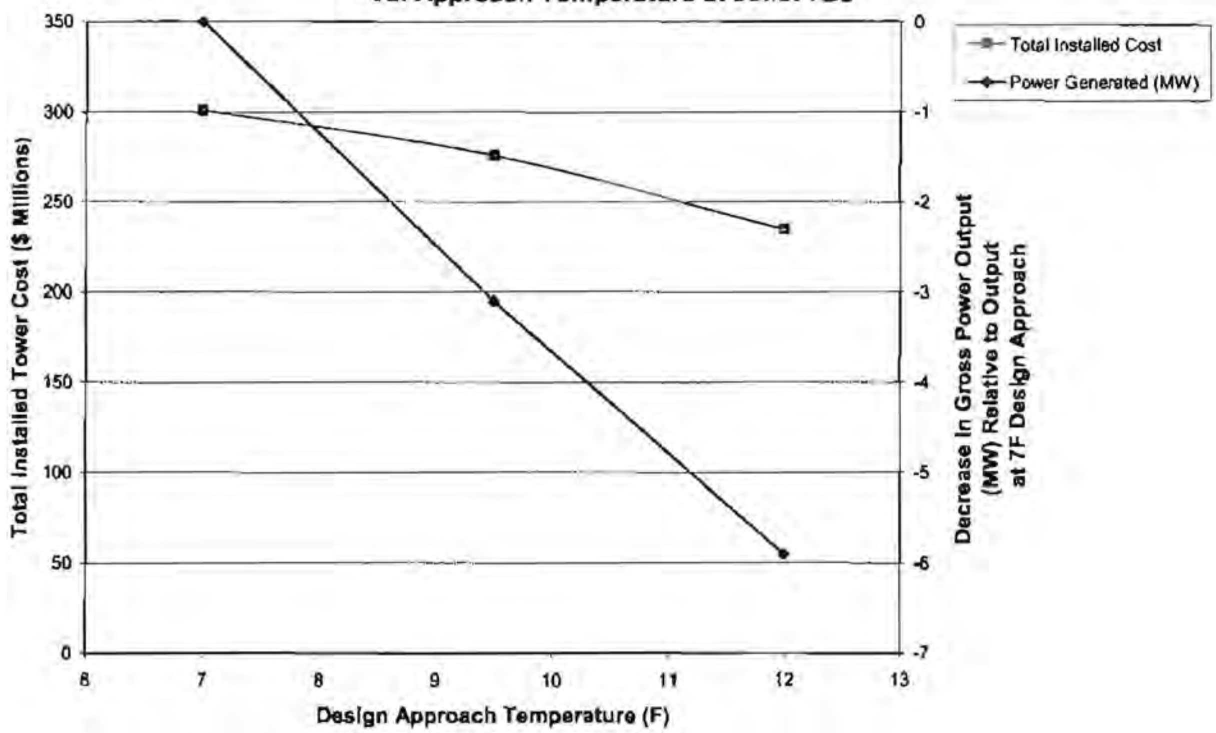
1%" wet bulb temperature which means that the historical wet bulb temperatures exceed this value only 1% of the time during the hottest months. Historical wet bulb data was obtained from a U.S. Air Force publication. (See paragraph 3.a.6 below for a complete reference to this publication.)

A second important parameter that defines the design of a cooling tower is "approach temperature." The approach temperature is defined as how close the water being cooled approaches the wet bulb temperature. Design for a lower approach temperature results in a larger tower, which is usually effected by increasing the number of cells in the tower. A larger tower will provide greater contact time between the circulating water and the airflow, which increases heat removal and lowers cold water temperature. A larger tower is more expensive for a given circulating water flow rate, but it will increase the likelihood that the generating station can remain running at full load during the most hot and humid days.

Figure 2-1 illustrates the capital costs for the Joliet 7&8 towers as a function of approach temperature. This same general relationship among cooling tower approach temperature, cooling tower cost, and auxiliary power demand is typical of the towers evaluated for the other generating stations considered in this study. Cooling tower cost decreases with higher approach temperatures although the cost is still in the order of hundreds of millions of dollars. With this decrease in cost, however, comes an increased risk that the unit will generate less electrical power during a time when demand is high and the cost for purchased power also is almost always relatively high. To minimize the risk that the cooling towers chosen would necessitate unit deratings to maintain compliance at the MWGen stations at times when demand for electricity is high, an approach temperature of 7°F was used as the basis for this study.

An additional benefit of designing the towers with a 7°F approach is that it minimizes the temperature of the cooling tower blowdown flow to the relevant waterway. Decreasing the tower size and cost by selecting a larger approach temperature such as 9°F or 12°F would increase the temperature of the cooling tower blowdown flow. An approach temperature increase of even 2-3 degrees would likely lead to an end-of-pipe cooling tower blowdown flow temperature that is warmer than the Proposed UAA Thermal Standards maximum value during the summer months.

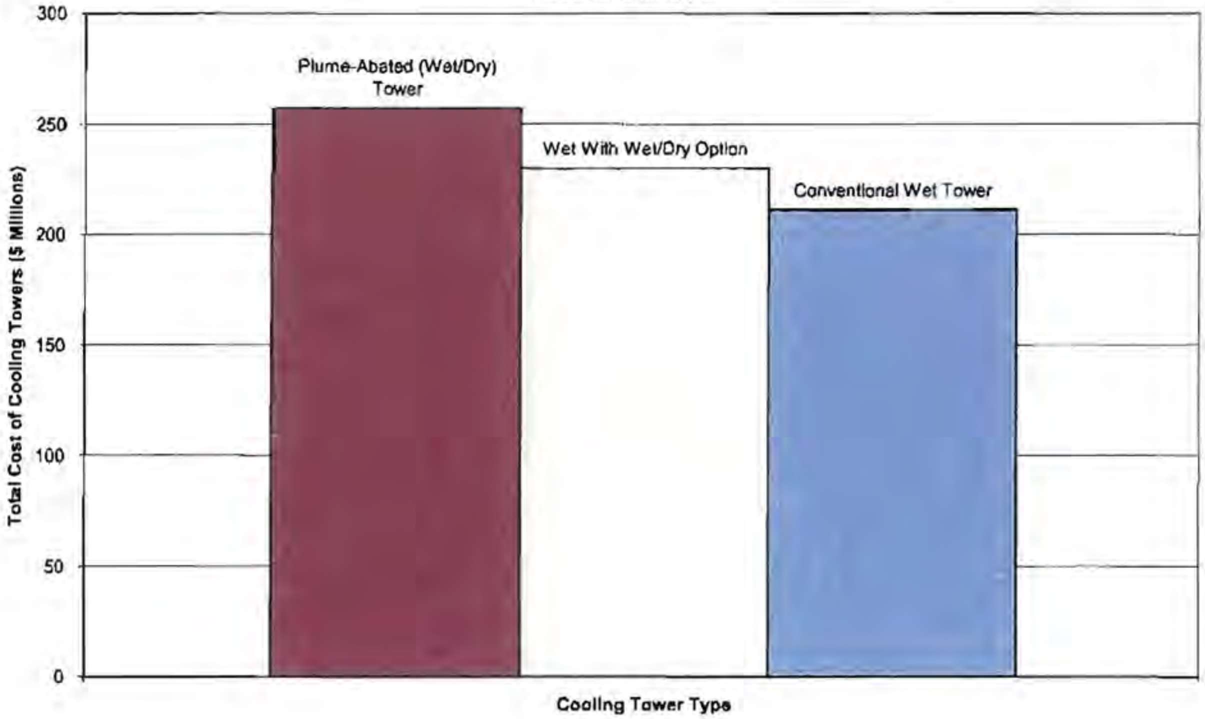
Figure 2-1
Total Installed Cost of Wet/Dry Cooling Towers and Power Generation Impact Vs. Approach Temperature at Joliet 7&8



A final design consideration is the treatment of the fog-like plume that normally rises from cooling towers. Towers with visible water vapor plumes are available at lower cost but can cause potential visibility problems and icing problems in freezing weather. Visibility and icing problems can create safety hazards on nearby streets and highways and for those who use them. Icing problems are particularly hazardous to power lines located in the vicinity of an electrical generating station because the icing can cause power lines to fail and interrupt power service to customers. Wet/dry or "plume-abated" towers minimize the risk of visibility and icing problems. Wet/dry towers have a dry reheating section above the wet section, which further warms the warm, moist air leaving the wet section of the tower. Such wet/dry towers make the plume essentially invisible and decreases the potential for visibility and icing problems. Hence, the reason they are called "plume-abated" towers. Plume-abated towers are designed so that the visible plume extends no farther than one tower height. It should be noted that there is still some icing concern with wet/dry towers, though the icing risk is lower than that associated with pure wet towers.

If it is uncertain whether plume abatement will ultimately be required for a given generating station, a wet-type tower can be designed with features which allow later conversion to plume-abated or wet/dry operation. The principal features required are design of the cooling tower basin and structural supports for the higher weight of the plume-abatement heat exchangers that are added to convert the tower to wet/dry operation. Although a wet-type tower that is not originally designed for conversion to plume abatement could subsequently be converted, the costs of doing so would be much higher than if provision for subsequent conversion were made in the original design. Figure 2-2 illustrates the relative costs of all three tower types based on the costs for Will County Station Units 3/4. As shown in more detail in Section 5, the cost relationship among the three types of towers at Will County is also typical for Joliet 6 and Joliet 7/8.

Figure 2-2
Installed Capital Cost of Will County Cooling Towers for Three Different Types



Wet/dry towers were selected as the base design for Crawford and Fisk, owing to those stations' proximity to a nearby interstate highway, electric transmission lines, and commercial and residential areas. Wet-type towers are believed to be acceptable for Joliet 6, Joliet 7/8 and Will County 3/4, but installed costs for all three types are provided in Section 5.

All of the MWGen stations were designed for and operate as open-cycle cooling stations. Cooling tower costs for retrofit applications to convert from open-cycle to closed-cycle cooling, such as is the case here for the MWGen stations, are generally higher than those for a tower provided at a generating unit initially designed for closed-cycle operation – estimated to be approximately 10 to 20 percent higher. Units designed for once-through (open-cycle) cooling typically have a smaller condenser than units originally designed for closed-cycle operation. A retrofit tower will typically be made larger to compensate for the smaller condenser. Increasing the size of the condenser during retrofit is a potential design option, but the costs of condenser modifications are higher than the incremental costs of larger cooling towers.

The cost estimates provided here for all wet/dry cooling tower options are based on cooling tower quotes obtained from SPX/Marley, a cooling tower supplier, in response to a brief specification and sizing table provided by S&L. Low-clog film fill was selected by SPX/Marley as suitable for the MWGen applications, based on the Total Suspended Solids levels in the make-up water. Make-up water quality data is presented in Exhibit F.

Exhibit C contains preliminary design specifications for the cooling tower designs. This design basis information was provided to SPX/Marley by S&L to use as the basis for its estimates of cooling tower costs.

3) Alternative Cooling Tower Technologies

The following alternative cooling technologies were also considered at the start of the study, but were eliminated from further consideration for the reasons stated below:

- Radiator-type towers (with no water cooling): Eliminated because these towers have never been applied to units of the size or approach temperature applicable here and they would require a prohibitive amount of land that is not available at the MWGen stations.
- Air-cooled condensers: Eliminated because existing unit condensers at the MWGen stations would have to be replaced and low-pressure steam would need to be ducted to the new air-cooled condenser (ACC). This option would not likely be technically feasible due to large amount of land area required for such installations, and the difficulty routing the very large duct required from the turbine exhaust to the ACC inlet. An ACC would increase turbine backpressure, which would further reduce the station's generating capacity, and it also would be prohibitively expensive.
- Hyperbolic natural draft cooling towers: Eliminated due to the extremely high cost (4 to 8 times the cost of a conventional wet tower), concerns about a) interference with the glide paths for nearby airports, b) the land area required, and c) overall permitting owing to negative public perception of the aesthetics of such tall structures.

C. COOLING TOWER COST STUDY SCOPE

The scope of this study is as follows:

- Obtain capital and O&M costs in current dollars for cooling towers sized for closed-cycle operation under summer conditions. The cooling tower equipment arrangement drawings and closed-cooling cycle diagrams that form the basis of the cost estimating criteria are provided in Exhibits A and B, respectively. Major equipment was sized based on maximum boiler heat input, maximum exhaust flows, and original condenser and circulating water design conditions.

- Develop "order-of-magnitude" (-30%/+50%) cost estimates for the following scenarios in this study:
  - ➢ Wet cooling tower with plume abatement (wet/dry tower) for all five stations.
  - ➢ Wet cooling towers for Joliet (both stations) and Will County Stations without the option to add plume abatement.
  - ➢ Wet cooling towers for Joliet (both stations) and Will County Stations without plume abatement but designed with additional structure to allow addition of plume abatement at a later date.

  Budgetary cost estimates from SPX/Marley, a prominent power plant cooling tower supplier, were solicited to obtain current costs for all cooling tower options. S&L calculated balance-of-plant costs using previous plant designs and our in-house cost database.
- Estimate O&M costs, including auxiliary power for tower fans and additional circulating water pump head requirements, plus chemical costs and tower maintenance.
- Compare estimated cooling tower blowdown temperatures and volumes to proposed thermal standards to determine whether further temperature dispersion study is required.
- Estimate particulate emissions due to cooling tower "drift", and determine whether these emissions could trigger additional air permit or compliance requirements.
- Perform a qualitative assessment of possible tower noise emissions and any regulatory or ordinance requirements that may require measures for noise mitigation.
- Evaluate the impact of cooling tower addition on plant thermal cycle. The ability of a cooling tower to produce cold water is limited by the outdoor wet bulb temperature. Generally, the cooler the return water to the condenser, the higher the efficiency of the turbine generator, and the more electricity which is generated. In addition, lower return water temperatures result in lower condenser discharge temperatures.
- Determine preliminary permitting requirements for installation of cooling towers.
- Prepare a preliminary construction schedule based on typical cooling tower installation duration.

3. CONCEPTUAL DESIGN BASIS FOR CLOSED LOOP COOLING TOWER STUDY

In order to design the cooling towers required at each of the MWGen stations, the current unit rating (in gross MW), which represents the current generating capacity of each station, was used. Major equipment was sized based on maximum boiler heat input, maximum exhaust flows, and original condenser and circulating water design conditions. Preliminary design specifications were developed for the towers needed at each station.

The following paragraphs describe the parameters common to all units at the MWGen stations which set the design of the cooling towers for this study. Design bases for individual units at each of the stations are provided in Exhibit D.

A. DESIGN ELEMENTS COMMON TO ALL UNITS

The following design bases were applied to cooling tower cost estimates and layouts for all of the electrical generating units located at each of the MWGen stations:

1) Cost estimates are "order-of-magnitude" accuracy, -30%/+50%.

2) The cooling systems for all stations were sized for closed-cycle operation at summer conditions. Cost estimates include towers sized to handle 100% of heat rejection duty. To maintain the flexibility to operate in open-cycle mode, when river temperature and meteorological conditions permit, gates were included in the estimates. As discussed in Section 5 below, the incremental increase in capital cost for these open-cycle provisions of the design are a small percentage of overall project cost. As noted above, when this study was originally prepared in 2005, the design considerations were based on General Use thermal standards. Under the General Use thermal water quality standards, the probability of being able to operate in open-cycle mode during parts of the year is greater than under the stricter Proposed UAA Rules. Hence, the design basis of the 2005 study included the capability to switch between open-cycle and closed-cycle cooling operation. Given the incremental increase in capital cost associated with including open-cycle capability in the design is a small percentage of overall estimated costs, for the purposes of updating the study, it was decided to retain this open-cycle capability in the design basis.

3) Estimates of O&M costs, particulate emissions, and cooling tower blowdown discharge are based on continuous closed-cycle operation, for conservatism and because it is not known to what extent open-cycle operation will be compliant with applicable thermal standards.

4) Cost estimates for plume-abated (wet/dry) towers were developed for all stations. Consideration of wet only and wet/convertible to plume-abated was given to Joliet 6, Joliet 7/8 and Will County 3/4.

The following is a comparison of plume-abated (wet/dry) tower characteristics compared to conventional wet towers:

- Wet/dry towers use 7-13% less total makeup water than wet towers
- Extent of drift/level of particulate matter emissions will be the same for wet/dry and wet towers operations
- Icing still occurs with wet/dry towers, but will be less than with wet towers, due to the increased saturation temperature of the air. Moisture will still condense on cold surfaces, however.
- Visible plume will be negligible for wet/dry towers at the design point. A small amount of visible plume occurs at lower temperatures and/or at high relative humidity conditions.
- The wet/dry tower uses approximately 10-25% more electrical power than a wet tower.
- Noise emissions are similar for both types of towers.

5) The cooling tower site arrangement drawings (provided in Exhibit A) are based on the wet/dry tower layouts. SPX/Marley was consulted to determine the cooling tower arrangements that are technically feasible based on the type of cooling tower to be installed. SPX/Marley advised that back-to-back cooling towers are not available for wet/dry cooling tower types due to the need for the dry section to receive air from both sides. Therefore, the design for all of the wet/dry cooling towers consists of a single row of cells. Pure wet towers were not considered as the base design due to all of the previously mentioned reasons, including creation of poor visibility near the stations, icing of roads, and icing of overhead power lines. Cost estimates for both wet-only and wet/convertible to plume-abated were developed, however, and are provided in Section 5.

6) The cooling towers at all of the stations were designed for a summer season wet bulb temperature of 78°F. This is the 1% summer season wet bulb temperature for all of the stations.[1] This is a conservative approach used to avoid derating the units during the summer months when the demand for power is highest.

7) The cooling towers at all of the stations were designed for an 85°F cold water temperature, which is a reasonable choice based on the 1% summer wet bulb temperature in the Chicago area, and the choice of a 7°F approach temperature. This is a conservative approach selected to minimize the potential for unit derating (reduction in generating capacity) on hot, humid days.

[1] Departments of the Air Force (USAF), the Army, and the Navy, "Facility Design and Planning Engineering Weather Data", AFM 88-29, TM 5-785, NAVFAC P-89, Washington D.C., 1978.

8) All of the cooling towers were designed for a minimum achievable drift rate of 0.0005% (*i.e.*, with drift eliminators). This minimizes the water particulate emissions of the towers. Exhibit E contains the results of the particulate calculations. Exhibit F contains the water quality data input used.

9) Under closed-cycle operation, each station was assumed to operate at five cycles of concentration. The phrase "five cycles of concentration" means the cooling water is recirculated until the total dissolved solids (TDS) level reaches a value five times the TDS concentration in the make-up water. Further build-up is limited by cooling tower blowdown. A value of five cycles is most often chosen for design purposes because it minimizes the need for make-up water and limits TDS concentrations to levels which do not create corrosion problems for cooling system materials.

10) All of the towers are priced with fiberglass construction. Fire protection costs have not been incorporated into the cooling tower estimates but could increase the cost of the towers substantially dependent upon the requirements of the agency having jurisdiction and the extent to which they require installation of fire protection equipment.

11) Single speed non-reversing motors were assumed for all of the cooling towers.

12) Chlorination, sulfuric acid addition, and dechlorination equipment were included in the system design and cost estimates for closed-cycle operation at all of the stations.

13) From its professional experience, S&L estimates the annual water treatment chemical cost to be $1,000/MW for a station with closed-cycle cooling towers. This cost is based on the gross load of the station unit(s) in all cases, and is based on Sargent & Lundy's 120 years of power plant design experience.

14) Cooling tower blowdown from the closed-cycle mode of operation was assumed to be by a bleed stream from the cooling tower water supply pumps. No separate cooling tower blowdown pumps were included in the design or cost estimate, though a small (up to 12" diameter) pipe was included. The cooling tower blowdown, evaporation, and makeup water data are contained in Exhibit G.

15) The following methodology was used to estimate the potential impact on turbine MW output (*i.e.*, capacity loss) resulting from operation in a closed cooling configuration:

- The cold water temperatures of the towers corresponding to the 1% wet bulb during each month of the year were used as condenser circulating water input values. These cold water temperatures, which are identical to the cooling tower blowdown temperatures, are based on cooling tower industry (*i.e.*, Cooling Tower Institute) data.
- Condenser backpressures at 70% assumed cleanliness were estimated, and the percent heat rate adjustment was read from the original heat rate adjustment vs. backpressure curves at valves wide open flow.

- The variations in generator output between the design output value and the output during closed loop cooling operation at the maximum wet bulb temperature were calculated ("closed-cycle gain/loss"). Then the variations in generator output between the design output value and the output during open-cycle cooling operation with the Proposed UAA Thermal Standards Period Average temperature as the condenser circulating water inlet temperature were calculated ("open-cycle gain/loss"). The difference between the closed-cycle gain/loss and the open-cycle gain/loss is the MW output gain or loss for each time period during the year. Note that the Period Average values are tabulated on a partial month basis where so specified in the Proposed UAA Thermal Standards, while the closed-cycle 1% wet bulb values derive from the monthly ASHRAE[2] values. A separate partial month wet bulb distribution was not developed for this current study.

16) Isolating the stations' intake and discharge channels from the river typically involves a combination of fixed walls and moveable gates. Where the term "gate" alone is used in this report, the installation may also involve some fixed walls at that location. The actual configurations used in the design are documented in the capital cost estimates for each station that are presented in Exhibit I. It was assumed that the existing circulating water inlet channel would be partially left open to the river in closed-cycle operation so that makeup water to the cycle can be drawn in as needed. No separate makeup pumps or piping were included in the design or cost estimate.

17) No special noise abatement equipment was included in the base cost estimates. SPX/Marley indicates that the predicted noise level is about 90 dBA at 3 meters from the tower. Rough noise abatement options and costs were provided by SPX/Marley, but the predicted noise reduction is not guaranteed without a full noise study. A simple comparison of noise levels (inverse square method) was performed (see Section 4 of this report) by locating approximate distances of nearest residential and industrial/ commercial sites, using satellite photographs and the survey drawing for each site.

18) All electrical power costs are based on a price of electricity of $36.71/MWh, which is based on the weighted average price of peak and off-peak pricing over a five-year period beginning in 2011 as calculated by MWGen.

B. STATION OR UNIT-SPECIFIC ASSUMPTIONS

The design and layout of the cooling tower system must be customized at each station due to differences in plant size and layouts. The unit specific design inputs for cooling tower design provided to SPX/Marley are presented in Exhibit C. Exhibit D contains the detailed balance-of-project design inputs used for each station.

[2] American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), "The Handbook 2005 of Fundamentals", published by ASHRAE, Atlanta, Georgia, 2005.

4. REGULATORY AND PERMITTING ISSUES

The construction and operation of cooling towers at the five MWGen stations will be subject to a number of environmental and local construction permitting requirements. The S&L study included determining the expected permit requirements for the proposed closed-cycle cooling systems, which are presented in the discussion below, but further detailed review is recommended if any of the projects are slated to proceed. Regulatory and permitting standards potentially applicable to a cooling tower installation project include: (1) air permitting for particulate matter emissions; (2) modifications to the facility's National Pollutant Discharge Elimination System (NPDES) permit for changes associated with cooling water intake and wastewater treatment and discharge characteristics; (3) U.S. Army Corps of Engineer permits to allow construction activities within a waterway or activities that impact wetlands; (4) local building permit requirements; and (5) noise emission regulations. Due to the conceptual nature of the design basis included in this study, a cost estimate for preparing and obtaining the necessary permits for construction and operation of the closed-cycle cooling systems for each of the MWGen stations was beyond the scope of this study. Accordingly, costs associated with obtaining permits have not been included in the capital cost estimates presented in this report.

A. AIR PERMITTING

Particulate matter emissions occur from cooling towers as a result of cooling water being entrained in the air stream. Particulate matter in the drift water sent into the air by the tower is primarily composed of the same impurities as in the tower cooling water.[3] The magnitude of the drift loss is influenced by the number and size of droplets produced within the tower, which are a function of tower design, air and water flow patterns, and design of the drift eliminators. The most effective way to reduce drift from cooling towers is by installing drift eliminators. Drift eliminators, included in the design basis for all towers in this study, are designed to remove entrained droplets before the droplets leave the tower.

Particulate emissions from a new cooling tower can trigger the need for New Source Review (NSR) air quality review and permitting. NSR is a federal regulatory program (implemented in Illinois by the Illinois EPA) that applies to major new sources of air pollution and major modifications of existing major sources of air pollution. An existing major source of emissions (such as the Crawford, Fisk, Joliet, and Will County Generating Stations) can become subject to NSR if modifications are made to the existing source, and the modification results in a significant increase in the annual emissions of a regulated NSR pollutant.

Regulated NSR pollutants include total particulate matter (PM), PM with an aerodynamic diameter less than 10 microns (μm) or less (PM_{10}), and PM with an aerodynamic diameter of 2.5 μm or less ($PM_{2.5}$). With respect to particulate matter emissions, a significant emissions increase is defined as being above 25 tons per year (tpy) PM, 15 tpy PM_{10}, or 10 tpy PM2.5. (See 35 IAC §203.209).

[3] Cooling Tower Drift, it Measurement, Control and Environmental Effect. Cooling Tower Institute Paper No: TP73-01

Emission calculations were prepared for each MWGen cooling tower configuration to quantify potential particulate emissions. Total PM emissions were estimated based on: (1) the circulating water flow rate at full load; (2) projected drift eliminator efficiency; (3) total dissolved solids (TDS) in the circulating water; and (4) the assumption that 100% of the TDS in the drift would be emitted as PM, using the following equation:[4]

$$E_{PM} = Q * \rho_w * (60 \text{ min/hr}) * \%DL * (TDS/10^6)$$

Where:

E_{PM} = PM emission rate (lb/hr)
Q = circulating water flow rate (gpm)
ρ_w = density of water (8.34 lb/gal)
%DL = Drift Loss Efficiency (0.0005%)
TDS = Total Dissolved Solids in the liquid drift (ppmw)

The methodology given in EPA's AP-42 Chapter 13.4 calculates total PM emissions, but does not account for particle size distribution. Therefore, to determine PM10 and PM2.5 emissions, S&L used the methodology described by Reisman and Frisbie to calculate the particle size distribution of solids emitted after evaporation of the liquid drift.[5] Particle size is determined based on representative drift droplet size distribution data, TDS in the drift droplets, and the assumption that the total mass of dissolved solids in the drift condenses into a spherical particle after all the water evaporates. The percentage of drift droplets containing particles small enough to produce PM10 or PM2.5 emissions can be calculated using the following equation:

$$D_p = D_d \, [(TDS)(\rho_w / \rho_{TDS})]^{1/3}$$

Where:

D_p = diameter of the solid particle (μm)
D_d = diameter of the drift droplet (μm)
ρ_w = density of water (1.0 g/cm^3)
ρ_{TDS} = density of the solid particles (assumed to be equal to sodium chloride, 2.2 g/cm^3)
TDS = Total Dissolved Solids in the liquid drift (ppmw)

Using this approach, drift from cooling towers with higher TDS values tend to form larger solid particles as the liquid drift evaporates. In other words, PM10-to-PM and PM2.5-to-PM ratios are inversely related to circulating water TDS, as shown in Figure 4-1.

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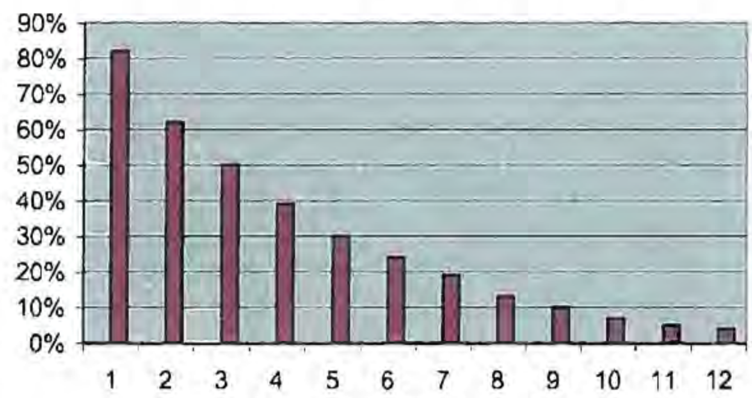
[4] The methodology described herein for calculating cooling tower particulate emissions is taken from EPA's *Compilation of Air Pollutant Emission Factors*, AP-42 Fifth Edition, Volume I: Stationary Point and Area Sources, Chapter 13.4 Wet Cooling Towers, available at: http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s04.pdf.

[5] Reisman, J., and Frisbie, G., *Calculating Realistic PM10 Emissions from Cooling Towers*, Greystone Environmental Consultants, Inc., Sacramento, CA. See also, Hennon, D., *Cooling Tower Emissions Quantification Using the Cooling Technology Institute Test Code ATC-140*, Cooling Tower Institute, Paper No. TP03-08.

FIGURE 4-1
Percentage of Drift PM That Evaporates to PM10



Taken from: Reisman, J., and Frisbie, G., "Calculating Realistic PM10 Emissions from Cooling Towers," Greystone Environmental Consultants, Inc., Sacramento, CA.

Particle size distribution was calculated for each MWGen generating station using the methodology described above and the circulating water TDS values summarized in Table 4-1. Cooling water TDS values were obtained from water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC).[6] Results of the particle size distribution calculations for three different maximum TDS concentrations (*i.e.*, 3,680 ppmw, 4,220 ppmw and 2,935 ppmw) are shown in Tables 4-2 through 4-4, respectively.

[6] Cooling water TDS values were obtained from the 2007 Annual Summary Report Water Quality within the Waterways System of the Metropolitan Water Reclamation District of Greater Chicago, September 2008.

Table 4-1
Generating Station TDS Values

CASE	Makeup Water TDS	Cycles of Concentration	Maximum TDS
	(ppm)	#	(ppm)
Fisk 19	736	5	3,680
Crawford 7&8	736	5	3,680
Will County 3&4	844	5	4,220
Joliet 6	587	5	2,935
Joliet 7&8	587	5	2,935

Table 4-2
Solid Particle Size Distribution (TDS = 3,680 ppmw)

TDS	3,680					
Liquid Droplet Diameter	Liquid Droplet Volume	EPRI Droplet Size Distribution	Liquid Droplet Mass	Solid Particle Mass	Solid Particle Volume	Particle Size Diameter
um	um^3	% smaller	ug	ug	um^3	um
10	524	0.000	5.24E-04	1.93E-06	0.9	1.187
20	4,189	0.196	4.19E-03	1.54E-05	7.0	2.374
30	14,137	0.226	1.41E-02	5.20E-05	23.7	3.561
40	33,510	0.514	3.35E-02	1.23E-04	56.1	4.748
50	65,450	1.816	6.55E-02	2.41E-04	109.5	5.935
60	113,097	5.702	1.13E-01	4.16E-04	189.2	7.122
70	179,594	21.348	1.80E-01	6.61E-04	300.4	8.309
90	381,704	49.812	3.82E-01	1.40E-03	638.5	10.684
110	696,910	70.509	6.97E-01	2.56E-03	1,165.7	13.058
130	1,150,347	82.023	1.15E+00	4.23E-03	1,924.2	15.432
150	1,767,146	88.012	1.77E+00	6.50E-03	2,956.0	17.806
180	3,053,628	91.032	3.05E+00	1.12E-02	5,107.9	21.367
210	4,849,048	92.468	4.85E+00	1.78E-02	8,111.1	24.928
240	7,238,229	94.091	7.24E+00	2.66E-02	12,107.6	28.490
270	10,305,995	94.689	1.03E+01	3.79E-02	17,239.1	32.051
300	14,137,167	96.288	1.41E+01	5.20E-02	23,647.6	35.612
350	22,449,298	97.011	2.24E+01	8.26E-02	37,551.6	41.547
400	33,510,322	98.340	3.35E+01	1.23E-01	56,053.6	47.483
450	47,712,938	99.071	4.77E+01	1.76E-01	79,810.7	53.418
500	65,449,847	99.071	6.54E+01	2.41E-01	109,479.7	59.353
600	113,097,336	100.0	1.13E+02	4.16E-01	189,181.0	71.224

Table 4-3
Solid Particle Size Distribution (TDS = 4,220 ppmw)

TDS	4,220					
Liquid Droplet Diameter	**Liquid Droplet Volume**	**EPRI Droplet Size Distribution**	**Liquid Droplet Mass**	**Solid Particle Mass**	**Solid Particle Volume**	**Particle Size Diameter**
um	**um^3**	**% smaller**	**ug**	**ug**	**um^3**	**um**
10	524	0.000	5.24E-04	2.21E-06	1.0	1.243
20	4,189	0.196	4.19E-03	1.77E-05	8.0	2.485
30	14,137	0.226	1.41E-02	5.97E-05	27.1	3.728
40	33,510	0.514	3.35E-02	1.41E-04	64.3	4.970
50	65,450	1.816	6.55E-02	2.76E-04	125.6	6.213
60	113,097	5.702	1.13E-01	4.77E-04	216.9	7.455
70	179,594	21.348	1.80E-01	7.58E-04	344.5	8.698
90	381,704	49.812	3.82E-01	1.61E-03	732.2	11.183
110	696,910	70.509	6.97E-01	2.94E-03	1,336.8	13.668
130	1,150,347	82.023	1.15E+00	4.85E-03	2,206.6	16.153
150	1,767,146	88.012	1.77E+00	7.46E-03	3,389.7	18.638
180	3,053,628	91.032	3.05E+00	1.29E-02	5,857.4	22.365
210	4,849,048	92.468	4.85E+00	2.05E-02	9,301.4	26.093
240	7,238,229	94.091	7.24E+00	3.05E-02	13,884.2	29.820
270	10,305,995	94.689	1.03E+01	4.35E-02	19,768.8	33.548
300	14,137,167	96.288	1.41E+01	5.97E-02	27,117.7	37.275
350	22,449,298	97.011	2.24E+01	9.47E-02	43,061.8	43.488
400	33,510,322	98.340	3.35E+01	1.41E-01	64,278.9	49.700
450	47,712,938	99.071	4.77E+01	2.01E-01	91,522.1	55.913
500	65,449,847	99.071	6.54E+01	2.76E-01	125,544.7	62.125
600	113,097,336	100.0	1.13E+02	4.77E-01	216,941.3	74.550

Table 4-4
Solid Particle Size Distribution (TDS = 2,935 ppmw)

TDS	2,935					
Liquid Droplet Diameter	**Liquid Droplet Volume**	**EPRI Droplet Size Distribution**	**Liquid Droplet Mass**	**Solid Particle Mass**	**Solid Particle Volume**	**Particle Size Diameter**
um	**um³**	**% smaller**	**ug**	**ug**	**um³**	**um**
10	524	0.000	5.24E-04	1.54E-06	0.7	1.101
20	4,189	0.196	4.19E-03	1.23E-05	5.6	2.202
30	14,137	0.226	1.41E-02	4.15E-05	18.9	3.303
40	33,510	0.514	3.35E-02	9.84E-05	44.7	4.403
50	65,450	1.816	6.55E-02	1.92E-04	87.3	5.504
60	113,097	5.702	1.13E-01	3.32E-04	150.9	6.605
70	179,594	21.348	1.80E-01	5.27E-04	239.6	7.706
90	381,704	49.812	3.82E-01	1.12E-03	509.2	9.908
110	696,910	70.509	6.97E-01	2.05E-03	929.7	12.109
130	1,150,347	82.023	1.15E+00	3.38E-03	1,534.7	14.311
150	1,767,146	88.012	1.77E+00	5.19E-03	2,357.5	16.513
180	3,053,628	91.032	3.05E+00	8.96E-03	4,073.8	19.815
210	4,849,048	92.468	4.85E+00	1.42E-02	6,469.1	23.118
240	7,238,229	94.091	7.24E+00	2.12E-02	9,656.5	26.420
270	10,305,995	94.689	1.03E+01	3.02E-02	13,749.1	29.723
300	14,137,167	96.288	1.41E+01	4.15E-02	18,860.3	33.026
350	22,449,298	97.011	2.24E+01	6.59E-02	29,949.4	38.530
400	33,510,322	98.340	3.35E+01	9.84E-02	44,705.8	44.034
450	47,712,938	99.071	4.77E+01	1.40E-01	63,653.4	49.538
500	65,449,847	99.071	6.54E+01	1.92E-01	87,316.1	55.043
600	113,097,336	100.0	1.13E+02	3.32E-01	150,882.1	66.051

Using straight-line interpolation for solid particle sizes of 2.5 and 10 μm diameter, the PM_{10}-to-PM and $PM_{2.5}$-to-PM ratios for each station are summarized in Table 4-5. Potential PM_{10} and $PM_{2.5}$ emissions for each cooling tower configuration are summarized in Table 4-6.

Table 4-5
PM_{10}-to-PM and $PM_{2.5}$-to-PM Ratios for Each Station

CASE	Maximum TDS	% of PM that Evaporates to PM10	% of PM that Evaporates to PM2.5
	(ppm)	(%)	(%)
Fisk 19	3,680	41.6	0.20
Crawford 7&8	3,680	41.6	0.20
Will County 3&4	4,220	36.3	0.20
Joliet 6	2,935	50.7	0.20
Joliet 7&8	2,935	50.7	0.20

Table 4-6
Potential $PM/PM_{2.5}$ Emission Calculation Summary

Station	Total Number of Cells	Circulating Water Flow per Cell	Calculated Total Drift Loss	Estimated Maximum TDS	Calculated Potential Total PM Emissions	Calculated Potential PM10 Emissions	Calculated Potential PM2.5 Emissions
	(#)	(gpm)	(gpm)	(ppm)	(tpy)	(tpy)	(tpy)
Fisk 19	16	13,125	1.0	3,680	8.5	3.53	0.017
Crawford 7&8	30	12,747	1.9	3,680	15.4	6.40	0.031
W/C 3&4	40	15,000	3.0	4,220	27.7	10.0	0.055
Joliet 6	18	14,500	1.3	2,935	8.5	4.29	0.017
Joliet 7&8	64	14,375	4.6	2,935	29.7	15.06	0.059

The following should be noted regarding interpretation of this calculation:

- Circulating water flows are the original station design values.
- Total Dissolved Solids (TDS) concentrations in the cooling water were obtained from water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC): 2007 Annual Summary Report, "Water Quality Within the Waterways System of the Metropolitan Water Reclamation District of Greater Chicago", September 2008. The 2007 data are given in Exhibit F. The 2009 Annual Summary Report No. 10-36, July 2010, was reviewed and the 2007 report data were found to be representative. Estimated maximum TDS values in Table 4-1 were based on the 90th percentile TDS values of water quality given in Exhibit F and on the assumption of 5 cycles of concentration. (See discussion in Section 3.A.9, above.)

- The calculations above are based on 100% capacity factor and operation in closed-cycle 100% of the time, which are both conservative assumptions.
- The NSR threshold for overall PM emissions is 25 tpy. Calculated total PM emissions from the Will County and Joliet 7&8 cooling towers exceed these thresholds, triggering NSR review for the control of PM emissions. Potential NSR considerations are discussed in more detail below.
- The NSR threshold for PM_{10} emissions is 15 tpy. Calculated PM_{10} emissions from cooling towers at Joliet 7&8 are slightly above this threshold, and could trigger NSR review for the control of PM_{10}. PM_{10} emissions from cooling towers at the other MWGen stations fall below this threshold and should not trigger NSR permitting. Annual PM_{10} emissions were calculated using the PM_{10}-to-PM ratios calculated in Tables 4-2 thru 4-4, and the conservative assumption regarding capacity factors. The methodology used to calculate the PM_{10}-to-PM ratio has been accepted by Illinois EPA in the past for permitting of new units, but acceptance is not guaranteed for all future cases. If this calculated ratio method is not accepted and a higher PM_{10}:PM ratio is required. Joliet 7&8, Will County 3&4 and Crawford 7&8 could be at some risk of exceeding the PM_{10} NSR threshold, triggering NSR review and permitting.
- The NSR threshold for $PM_{2.5}$ emissions is 10 tpy. Calculated $PM_{2.5}$ emissions from cooling towers at all MWGen stations fall below this threshold and should not trigger NSR permitting. Annual $PM_{2.5}$ emissions were calculated using the $PM_{2.5}$-to-PM ratios calculated in Tables 4-2 thru 4-4, and the conservative assumption regarding capacity factors. The methodology used to calculate the $PM_{2.5}$-to-PM ratio results in very low $PM_{2.5}$ emissions because of the diameter of the drift droplets and the cooling water TDS. Using the methodology described above, a large majority of PM emitted from the cooling towers will have an aerodynamic diameter greater than 2.5 μm. If this methodology is not accepted by Illinois EPA, $PM_{2.5}$ emissions would need to be calculated using an alternative methodology, and, depending on the $PM_{2.5}$-to-PM ratio used, could result in higher annual $PM_{2.5}$ emissions. However, a significant change in the ratio would be needed to result in $PM_{2.5}$ emissions above the NSR significance level.

More detail on potential NSR considerations is provided below to give an idea of the upper bounds of this risk for Joliet and Will County Stations.

Project specific NSR permitting requirements depend upon the location of the emission source. Sources located in an area meeting the National Ambient Air Quality Standards (NAAQS) are subject to the Prevention of Significant Deterioration (PSD) regulations, while sources located in areas that do not meet the NAAQS are subject to the nonattainment area (NAA) regulations in 35 IAC Part 203. A summary of the current PM NAAQS is provided in Table 4-7.

Table 4-7
Current Particulate Matter National Ambient Air Quality Standards

Pollutant	Primary Standards		Secondary Standards	
	Level	Averaging Time	Level	Averaging Time
PM_{10}	150 $\mu g/m^3$	24-hour	Same as Primary	
$PM_{2.5}$	15.0 $\mu g/m^3$	Annual (Arithmetic Average)	Same as Primary	
	35 $\mu g/m^3$	24-hour	Same as Primary	

All areas in Illinois are currently designated as attainment/unclassifiable with respect to the PM_{10} NAAQS. Thus, cooling tower projects that result in a significant net increase in annual emissions of PM or PM_{10} would be subject to the PSD preconstruction permitting and review regulations. Among other things, the PSD regulations require air pollutants to be controlled using best available control technology (BACT).

BACT is defined as an emission limitation based on the maximum degree of reduction which, on a case-by-case basis, is determined to be achievable taking into account energy, environmental, and economic impacts and other costs. U.S. EPA maintains a database of recently issued NSR permits, including a description of the control technology required to meet the LAER or BACT (the "RBLC Database"). The RBLC Database lists several BACT determinations for industrial process cooling towers (process code 99.009). All recently permitted industrial process cooling towers have been permitted with "drift eliminators" as BACT for PM_{10} control. For example an NSR permit recently issued to the City Utilities of Springfield – Southwest Power Station in Missouri identified "high efficiency drift eliminator – 0.001% drift" as BACT to control particulate emissions from the facility's cooling tower.

Based on a review of BACT determinations listed in the RBLC Database, high efficiency drift eliminators should represent BACT for large industrial process cooling towers, and would likely represent LAER. Based on information from Marley, drift eliminators can be designed to reduce drift to 0.0005% of the circulating water flow. There are no other technically feasible drift control technologies available for wet cooling towers. Emission calculations in Table 4-6 are based on a drift eliminator efficiency of 0.0005%, and all of the cooling tower capital costs in this study include drift eliminators.

Crawford, Fisk, Will County, and Joliet generating stations are located in Cook and Will Counties, respectively. U.S.EPA has designated both Cook and Will Counties as nonattainment areas with respect to annual $PM_{2.5}$ NAAQS. Because all of the generating stations are located within areas designated as nonattainment for $PM_{2.5}$, the cooling tower projects will be subject to the NAA permitting regulations in 35 IAC Part 203 if their emissions exceed the NSR significant emissions threshold. Under the Part 203 air regulations, a construction permit is required prior to actual construction of a major new source or major modification (35 IAC 203.203). In addition, the owner or operator of a major modification must demonstrate that the control equipment and process measures applied to the modification will produce the lowest achievable emission rate (LAER). This requirement applies to each emissions unit at which a net increase in emissions of the pollutant will occur as a result of the modification (e.g., the cooling towers). LAER is defined as the more stringent rate of emissions based on the following:

a. The most stringent emission limitation which is contained in the implementation plan of any state for such class or category of stationary source, unless it is demonstrated that such limitation is not achievable; or

b. The most stringent emission limitation which is achieved in practice by such a class or category of stationary sources.

As discussed above, EPA's RBLC Database lists several BACT determinations for industrial process cooling towers (process code 99.009), but does not include any recent projects that required LAER. Based on a review of the RBLC Database, and a review of cooling tower particulate control technologies, high efficiency drift eliminators should represent BACT for large industrial process cooling towers, and would likely represent LAER.

High efficiency drift eliminators would likely represent LAER for large industrial process cooling towers. However, because LAER does not include an evaluation of economic impacts, and because the Illinois NAA regulations require an evaluation of alternative environmental control techniques, it is possible that Illinois EPA would require MWGen to evaluate the feasibility of dry cooling tower configurations (*e.g.*, air cooled condensers) to minimize particulate matter emissions in the $PM_{2.5}$ nonattainment areas. As noted previously, dry cooling towers were not investigated in the study since this technology is generally more expensive and requires significantly more land than the equivalent wet cooling tower. If dry cooling towers were required to be installed in order to meet LAER requirements, the estimated costs of compliance presented in this study would significantly increase, and overall feasibility issues would need to be considered.

In addition to the requirement to achieve LAER, 35 IAC Section 203.302 requires the owner or operator of a new major modification to provide emission offsets equal to or greater than the net increase in emissions from the modification. Offsets must be sufficient to allow Illinois EPA to determine that the modification will not interfere with reasonable further progress toward meeting the applicable NAAQS. Owners/operators of a new major modification are also required to demonstrate that benefits of the modification significantly outweigh the environmental and social costs based upon an analysis of alternative sites, sizes, production processes, and environmental control techniques for such proposed source. (35 IAC Section 203.306).

Because LAER may require an evaluation of dry cooling, and because Illinois NAA regulations require emissions off-sets, MWGen may need to investigate options to reduce further particulate emissions to provide internal emission offsets and "net-out" of NSR review. NSR significant thresholds are based on the "net" emissions increase at an existing source. Net emissions increase is defined as the amount by which the sum of any increase in actual emissions from a particular modification and any other increases or decreases in actual emissions at the source that are contemporaneous with the particular change and are otherwise creditable, exceeds zero.

(See, 35 IAC 203.208: Net Emission Determination). In other words, if a generating station can reduce existing actual particulate matter emissions by a quantity equal to or greater than the increase from the cooling tower project, the station should net-out of NSR review and eliminate the need for a LAER evaluation and emission offsets.

B. NPDES PERMITTING

Modifications to the cooling water systems that alter the characteristics of the cooling water discharge or the location of the cooling water discharge are subject to NPDES permitting requirements. NPDES permitting procedures require any person proposing modifications to an existing discharge to submit an application to the appropriate agency at least 180 days before the date on which the discharge is to begin.

1. Wastewater Discharges

All facilities that discharge pollutants from any point source into waters of the United States are required to obtain a NPDES permit. The term "pollutant" is defined very broadly by the NPDES regulations and includes any type of industrial waste discharged into water, including cooling tower blowdown. Depending on the design of the cooling tower, including any water recycling/reuse systems, operating a cooling tower could result in a new wastewater stream requiring treatment and discharge. MWGen would be required to modify its existing NPDES permits to allow treatment and discharge of any wastewater streams associated with the cooling towers investigated in this study.

The cooling tower blowdown flows to the river in closed-cycle operation were calculated using the evaporation flow rates provided by Marley and the assumed five cycles of concentration. The temperature of cooling tower blowdown was assumed to be the same as the cold water temperature of the tower. The 1% wet bulb temperature at O'Hare, according to the ASHRAE 2005 handbook, was used as the wet bulb temperature during each month of the year.

The maximum temperatures of the cooling tower blowdown from each station were calculated month-by-month, and the results were compared with the Proposed UAA Thermal Standards. The results are presented in Exhibit H. Average monthly blowdown temperatures are much more difficult to predict, as those estimates require a detailed study of the meteorological data as a function of time of day for each day of the month. Such a detailed evaluation was beyond the scope of this study.

In general, the maximum monthly end-of-pipe cooling tower blowdown temperatures exceed the corresponding Proposed UAA Thermal Standards' monthly allowable discharge temperature. However, in closed-cycle operation, the cooling tower blowdown would be routed to the existing station discharge canal at a point just beyond the barrier walls/gates which would isolate the circulating water systems from the river. (Refer to Exhibits A and B.) Some mixing will occur in the discharge canal, and, as mentioned previously, the cooling tower blowdown flow rates are negligible compared to the overall volumetric flow of the waterways, therefore any temperature rise in the receiving water would be expected to be negligible.

If compliance is to be determined based on end-of-pipe temperature and the Proposed UAA Thermal Standards would be exceeded at times, the cooling tower blowdown can be routed through a chiller package to cool it prior to discharge. The installed cost of a chiller package is estimated to be about $3,000,000 for Joliet 7/8, the station which has the highest cooling tower blowdown flow rate and therefore, the highest likelihood and frequency of exceeding the Proposed UAA Thermal Standards if a mixing zone is not allowed for the cooling tower blowdown discharge. The costs of chiller packages for the other stations are expected to be proportionally lower.

2. Wastewater Treatment Facility Construction Permits

In Illinois, a water pollution control construction permit is required for industrial activities with the potential to cause water pollution. This construction permit is required prior to constructing or modifying any wastewater treatment facility as specified in the Illinois water pollution regulations.

A construction permit is required prior to commencing construction of a regulated wastewater management system. The treatment of cooling tower blowdown prior to discharge from any MWGen generating station would require a construction permit. The construction permit application can be submitted concurrently with the NPDES permit modification, if required. Cost estimates for obtaining permits were not included in this analysis.

C. U.S. ARMY CORPS OF ENGINEERS PERMITTING

Section 404 of the CWA requires a permit before discharging or placing any dredged or fill material into navigable waters of the United States. The CWA delegates dredged or fill material discharge permit approval authority to the U.S. Army Corps of Engineers. The definition of "navigable water" for a section 404 permit is very broad, and includes waters that are, or could be, used for interstate commerce, as well as lakes, impoundments, and wetlands. The subject CSSC and UDIP surface waters meet the definition of a "navigable water" under CWA Section 404.

Activities, including modifications to the cooling water intake/discharge structures and construction activities impacting existing wetlands, will require a permit from the U.S. Army Corps of Engineers. In general, if a wetland is located on a site proposed for development, the developer must apply for a Corp of Engineers permit to place fill into the wetland. For projects that impact over 0.25 acre of wetlands, the applicant will be required to provide compensatory wetland mitigation. It is important to note that the Corp of Engineers will require the applicant to avoid and/or minimize wetland destruction before compensatory wetland mitigation will be considered.[7]

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[7] None of the cooling tower arrangements studies here for the MWGen generating stations are believed to impact existing wetland areas.

The construction of the cooling towers at each of the MWGen stations may require the issuance of a CWA section 404 permit due to excavation and fill activities adjacent to or in the waterway necessary to complete their construction. In order to expedite the permitting and review process, the Corps of Engineers has developed a limited number of nationwide permits (NWPs) for activities the Corps has identified as being substantially similar in nature and causing only minimal environmental impacts. Construction activities within a waterway that are not covered by a NWP require the Corps to issue an individual permit for the activity. Issuance of an individual construction permit may also trigger the need for a formal Environmental Impact Statement (EIS).

The Corps of Engineers cannot issue a permit for any activity that may result in a discharge into navigable waters unless the State of Illinois, through the Illinois EPA, first provides a CWA Section 401 Certification. The Section 401 Certification includes a statement that the State has reasonable assurance that the activity will be conducted in a manner which will not violate applicable water quality standards. For purposes of this study, it was assumed that both the CWA section 401 Certification and a section 404 permit would be issued for the proposed cooling towers construction projects necessary to attain compliance with the Proposed UAA Thermal Standards. Cost estimates for obtaining permits were not included in this analysis.

D. NOISE REGULATIONS

Generally speaking, the falling water within a cooling tower results in locally high noise levels. To meet county noise regulations, the sound levels must be reduced approximately to that of a normal conversation at nearby site boundaries. Under current regulations, only Joliet 7&8 appears to have the potential to violate noise limits.

Table 4-8 below shows approximate costs and abatement reduction options for Joliet Units 7 and 8 that were proposed by SPX/Marley. The most expensive option, on the order of $12.5 million, would most likely be necessary to achieve the required sound level reduction.

Table 4-8
Joliet 7&8 Noise Abatement Cost Options

Attenuation Method	dBA Reduction	Approximate Cost For 80 Cells
SA	-2.4	$3,000,000
GBW	-3.7	$4,450,000
SA + GBW	-4.8	$7,450,000
FDBW	-0.7	$5,110,000
SA + FDBW	-3.6	$8,110,000
GBW+FDBW	-5.4	$9,560,000
SA+GBW+FDBW	-7.1	$12,560,000
SA = Splash Attenuation		
GBW = Grade Barrier Wall		
FDBW = Fan Deck Barrier Wall		

Splash attenuation (SA) consists of installing a thin layer of film at the bottom of the air inlet to the tower to help break up the noise generated by the falling water.

A grade barrier wall (GBW) is a wall installed at the ground elevation along the side of the tower which is more noise-sensitive to further attenuate the noise of falling water. It is as high as the tower air inlet, and is three air inlet heights away from the tower structure.

A fan deck barrier wall (FDBW) is a wall installed along the tower fan deck along the more noise-sensitive side to screen the noise from the fans, motors and gearboxes. The barrier wall extends to a height about one foot above the tops of the fan stacks.

5. STUDY RESULTS

There are three primary elements of cost associated with conversion of an existing electrical generating station from open-cycle operation to closed-cycle operation. These are:

- The engineering, material and equipment purchase, and construction of modifications to the plant's circulating water system, including
    - Cooling towers,
    - Pumps and piping,
    - Electrical and control equipment,
    - Barrier walls and/or gates (to isolate the open-cycle intake and discharge).
- Operating and maintenance costs, including
    - Electricity to run the new pumps and cooling tower fans,
    - Costs of chemicals needed to control water quality in closed-cycle operation, and
    - Mechanical and electrical maintenance of the new equipment.
- Loss of plant generating capacity. As discussed in Section 2, the circulating water inlet temperature to the condenser is higher in closed-cycle mode than in open-cycle mode, because it is not possible to reduce (with cooling towers) the cold-water temperature of the circulating water system to the temperature of the body of water previously used for open-cycle cooling. This higher condenser inlet temperature reduces turbine-generator efficiency and results in a loss of plant generating capacity, and a corresponding loss of revenue from electricity sales.

All three elements of the costs of closed-cycle conversion and operation are discussed individually for each station in the paragraphs below. The methodologies that were used to develop the costs in this section were discussed in Section 3 above. All O&M and lost capacity costs are based on a 75 percent capacity factor.

A. FISK STATION TECHNOLOGY OPTIONS AND COST ESTIMATE RESULTS

A1. FISK COOLING TOWER ARRANGEMENT

Exhibit A1 shows the arrangement of the cooling tower proposed for Fisk. The "tower" actually consists of two physically separate sections – two groups of cells – as there is not enough room at the station property for one long tower section. Installation of the northern tower would require the demolition of existing old Switch House No. 1 to make room for the cooling tower. The cost estimate includes this demolition and replacement of active electrical equipment in this switch house in the electrical costs. The demolition costs do not include asbestos removal or lead paint abatement which may be necessary given the age of the Switch House.

The northern tower is not ideally oriented to the prevailing winds and may be subject to increased recirculation which would lower the cooling ability of the towers, leading to increased risk of violating the thermal discharge limits, as well as requiring derates to the unit. The adjacent building to the east may interfere with air flow into that side of the tower which could also decrease tower cooling ability. A ComEd switchyard is located immediately to the west of the tower and would be subject to icing risk, although it is generally upwind of the tower. Wet/dry (plume-abated) cooling towers reduce the potential for icing downwind of the tower but do not eliminate it. Any such buildup of ice would lead to extra weight loading the live power lines, potentially resulting in line collapse. The consequences of this would be power outages and the risk of injury to persons in the immediate area. The southern tower section is more suitably oriented but would require demolition of the existing metal cleaning tank and demolition/ replacement of the plant makeup water treatment facility. The existing boiler building to the north of this tower may interfere with air flow into that side of the tower, adversely impacting tower performance.

Exhibit B1 shows the closed loop cooling tower flow diagram for the Fisk Station. A gate would be installed in the existing discharge flume in order to allow for the option of switching between open and closed-cycle cooling modes. Under closed-cycle operation, this gate would be closed and two 50% cooling tower supply pumps would pump the water from the flume upstream of the gate to the cooling towers. The cooled water would be pumped by four 25% cooling tower discharge pumps (two per tower) through above ground steel-lined concrete piping to the existing circulating water (CW) intake, and discharged there between the existing trash rakes and traveling screens to re-enter the existing CW pumps and condenser.

A2. FISK COOLING TOWER CAPITAL COST ESTIMATES

The capital costs (including the quoted pricing from Marley) for the wet/dry tower are shown in Exhibit I1. Below in Table 5-1, the cost for the 100% closed loop tower is broken into the key components. For the wet/dry tower option, the total estimated capital cost is approximately $137 million, which translates to a normalized capital cost of $394 per kilowatt of generating capacity. This value is derived by dividing the total installed cost of closed-cycle conversion in dollars by the plant's gross electrical capacity in kilowatts. Normalizing capital costs on a "per kW" basis is common practice in the power industry, similar to comparing costs on a "per square foot" basis in the construction industry.

Table 5-1
Fisk Capital Costs

Unit	Marley Wet/Dry CT Cost ($)	BOP Equipment and Material Cost ($)	Installation Cost ($)	Indirect Costs ($)	Contingency ($)	Total Cost ($)	Total Cost ($/kW)
Fisk 19	$13,300,000	$23,600,000	$60,500,000	$18,500,000	$21,400,000	$137,100,000	$394

A3. FISK COOLING TOWER O&M COST ESTIMATES

The operation and maintenance cost for a wet/dry (plume-abated) cooling tower at Fisk includes cooling tower fan and pump power (46,831 MWh at $36.71/MWh), tower maintenance costs such as gear oil replacement, and chemical costs for chlorination and anti-scaling additives. The total annual O&M cost is approximately $2,127,000. A detailed breakdown of these O&M costs is shown in Exhibit J. The breakdown of the costs is shown in Table 5-2.

Table 5-2
Fisk O&M Costs

Unit	Annual CT Fan Power Cost ($)	Annual Pump Power Cost ($)	Annual Maintenance Cost ($)	Annual Chemical Cost ($)	Total Annual O&M Cost ($)
Fisk 19	$781,000	$938,000	$60,000	$348,000	$2,127,000

A4. FISK DERATING IMPACTS WITH CLOSED-CYCLE COOLING TOWER

Table 5-3 below summarizes the month-by-month loss of plant capacity in closed-cycle operation compared to open-cycle operation weather and water temperature conditions.

Table 5-3
Fisk 19 Megawatt Loss Due to Closed v. Open-Cycle Operation

Period	Closed-Cycle MW Loss	Open-Cycle MW Gain/Loss	Total MW Gain/Loss Running Closed vs. Open-Cycle
January	-1.37	0.26	-1.63
February	-1.75	0.35	-2.11
March 1-15	-3.70	-0.15	-3.55
March 16-31	-3.70	-0.15	-3.55
April 1-15	-4.98	-0.75	-4.23
April 16-30	-4.98	-1.00	-3.98
May 1-15	-7.18	-2.68	-4.50
May 16-31	-7.18	-3.34	-3.84
June 1-15	-8.75	-4.29	-4.46
June 16-30	-8.75	-10.56	1.81
July 1-15	-10.10	-10.56	0.46
July 16-31	-10.10	-10.56	0.46
August 1-15	-9.78	-10.56	0.78
August 16-31	-9.78	-10.56	0.78
Sep. 1-15	-8.02	-10.56	2.54
Sep. 16-30	-8.02	-5.39	-2.64
October 1-15	-5.18	-3.94	-1.24
Oct. 16-31	-5.18	-2.80	-2.38

Period	Closed-Cycle MW Loss	Open-Cycle MW Gain/Loss	Total MW Gain/Loss Running Closed vs. Open-Cycle
November	-3.70	-1.90	-1.80
December	-2.77	-0.59	-2.18
		Annual Average	-1.79

Nominal plant output: 348 MW gross
Annual-average capacity loss: 1.79 MW
Annual revenue loss: $432,000 (75% capacity, $36.71/MWh)

B. CRAWFORD STATION TECHNOLOGY OPTIONS AND COST ESTIMATE RESULTS

B1. CRAWFORD COOLING TOWER ARRANGEMENT

Exhibit A2 shows the layout for the two Crawford cooling tower sections. A ComEd switchyard is located to the east of the southern tower, with potential icing concerns. 138 kV transmission line crosses the tower location, and would need to be relocated, and a 345 kV line would need to be raised and more insulators added. Costs for relocation and insulation of ComEd transmission lines are included in the estimate, but because the lines are not owned by MWGen, it is not known whether permission will be granted to relocate these lines. If permission to relocate the ComEd transmission lines is not granted, an alternate location may not be available or feasible. The northern tower is not ideally oriented to the prevailing winds and may be subject to increased recirculation. The northern tower location requires routing of 10 ft diameter circulating water lines across the site.

See Exhibit B2 for the closed loop cycle diagram at Crawford. A wall with a gate would be constructed across the existing CW discharge channel. In closed-cycle operation, this gate would be closed and four 25% cooling tower supply pumps would pump the water from the discharge channel upstream of the wall to the cooling towers. The cooled water would be pumped by two 25% cooling tower discharge pumps from the northern tower and would flow by gravity from the southern tower to the existing CW intake channel, and would be discharged there to re-enter the existing crib house and condenser.

B2. CRAWFORD COOLING TOWER CAPITAL COST ESTIMATES

The capital costs (including the quoted pricing from Marley) for the wet/dry towers are shown in Exhibit I2. Below in Table 5-4, the cost for the 100% closed loop tower is broken into the key components. For the wet/dry tower option, the total estimated capital cost is approximately $165 million. This translates to a normalized capital cost of about $282 per kilowatt of generating capacity.

Table 5-4
Crawford Capital Costs

Unit	Marley Wet/Dry CT Cost w/Delivery ($)	BOP Equipment Material Cost ($)	Labor ($)	Indirect Costs ($)	Contingency ($)	Total Cost ($)	Total Cost ($/ kW)
Crawford 7&8	$24,900,000	$28,400,000	$61,300,000	$24,800,000	$25,800,000	$165,200,000	$282

B3. CRAWFORD COOLING TOWER O&M COST ESTIMATES

The operation and maintenance cost for the Crawford plume-abated (wet/dry) cooling tower consists of cooling tower fan and pump power (88,872 MWh at $36.71/MWh), tower maintenance costs such as gear oil replacement, and chemical costs for chlorination and anti-scaling additives. The total annual O&M cost is approximately $3,960,000. A detailed breakdown of these O&M costs is shown in Exhibit J. The breakdown of the costs is shown in Table 5-5.

Table 5-5
Crawford O&M Costs

Unit	Annual CT Fan Power Cost ($)	Annual Pump Power Cost ($)	Annual Maintenance Cost ($)	Annual Chemical Cost ($)	Total Annual O&M Cost ($)
Crawford 7&8	$1,460,000	$1,800,000	$112,500	$585,000	$3,957,500

B4. CRAWFORD DERATING IMPACTS WITH CLOSED-CYCLE COOLING TOWER

Tables 5-6 and 5-7 below summarize the month-by-month loss of plant capacity in closed-cycle operation for Crawford 7 and Crawford 8, respectively, compared to open-cycle operation weather and water temperature conditions.

Table 5-6
Crawford 7 Megawatt Loss Due to Closed v. Open-Cycle Operation

Period	Closed-Cycle MW Loss	Open-Cycle MW Gain/Loss	Total MW Gain/Loss Running Closed vs. Open-Cycle
January	-1.33	-0.24	-1.10
February	-1.60	-0 18	-1.43
March 1-15	-3.09	-0.51	-2.58
March 16-31	-3.09	-0.51	-2.58
April 1-15	-3.92	-0.92	-3.00
April 16-30	-3.92	-1.09	-2.83
May 1-15	-5.54	-2.28	-3.26
May 16-31	-5.54	-2.75	-2.78
June 1-15	-6.71	-3.45	-3.26
June 16-30	-6.71	-8.11	1.40
July 1-15	-7.81	-8.11	0.30
July 16-31	-7.81	-8.11	0.30
August 1-15	-7.52	-8.11	0.58
August 16-31	-7.52	-8.11	0.58
Sep. 1-15	-6.12	-8.11	1.98
Sep. 16-30	-6.12	-4.25	-1.88
October 1-15	-3.98	-3.19	-0.79
Oct. 16-31	-3.98	-2.36	-1.61
November	-3.09	-1.72	-1.37
December	-2.40	-0.81	-1.60
		Annual Average	**-1.27**

Nominal unit output: 237 MW gross
Annual-average capacity loss: 1.27 MW
Annual revenue loss: $306,000 (75% capacity, $36.71/MWh)

Table 5-7
Crawford 8 Megawatt Loss Due to Closed v. Open-Cycle Operation

Period	Closed-Cycle MW Loss	Open-Cycle MW Gain/Loss	Total MW Gain/Loss Running Closed vs. Open-Cycle
January	-2.08	0.71	-2.79
February	-2.66	0.89	-3.55
March 1-15	-5.44	-0.07	-5.37
March 16-31	-5.44	-0.07	-5.37
April 1-15	-6.78	-1.13	-5.66
April 16-30	-6.78	-1.53	-5.25
May 1-15	-9.11	-4.01	-5.10
May 16-31	-9.11	-4.87	-4.24
June 1-15	-10.61	-6.04	-4.58
June 16-30	-10.61	-12.27	1.66
July 1-15	-11.93	-12.27	0.34
July 16-31	-11.93	-12.27	0.34
August 1-15	-11.60	-12.27	0.68
August 16-31	-11.60	-12.27	0.68
Sep. 1-15	-9.87	-12.27	2.40
Sep. 16-30	-9.87	-7.28	-2.59
October 1-15	-6.87	-5.61	-1.26
Oct. 16-31	-6.87	-4.16	-2.71
November	-5.44	-2.91	-2.54
December	-4.24	-0.85	-3.39
		Annual Average	-2.50

Nominal unit output: 348 MW gross
Annual-average capacity loss: 2.5 MW
Annual revenue loss: $603,000 (75% capacity, $36.71/MWh)

C. WILL COUNTY STATION TECHNOLOGY OPTIONS AND COST ESTIMATE RESULTS

C1. WILL COUNTY COOLING TOWER ARRANGEMENT

Exhibit A3 represents the arrangement drawing for the Will County towers. Two transmission lines (including two river crossings) run parallel with the towers and would need to be relocated to prevent icing problems. As at Crawford and Fisk, denial of a request to ComEd to relocate these transmission lines may not leave any other feasible locations open. One pond would need to be partially filled under the area where towers would be installed. Costs for these site modifications are included in the estimate. Some interference between the towers is likely under prevailing wind conditions. It proved necessary to separate the tower into three tower sections in order to provide the number of cells required to accommodate the combined cooling water flow for both Unit 3 and Unit 4. There is not enough space for one long tower due to the roads and railroad tracks that cross the tower location.

See Exhibit B3 for the closed loop diagram at Will County. A wall with a gate would be installed in the existing discharge channel. Under closed-cycle operation, this gate would be closed and four 25% cooling tower supply pumps would pump the water from the channel upstream of the wall to the cooling towers. The cooled water would be pumped by two 20% and four 15% cooling tower discharge pumps through above ground steel-lined concrete piping to the existing screen houses, to re-enter the CW pumps and condensers.

C2. WILL COUNTY COOLING TOWER CAPITAL COST ESTIMATES

The capital costs (including the quoted pricing from Marley) for the wet/dry tower are shown in Exhibit I3. Below in Table 5-8, the cost for the 100% closed loop tower is broken into the key components. For the wet/dry tower option, the total estimated capital cost is approximately $257 million. This translates to a normalized capital cost of $307 per kilowatt.

Table 5-8
Will County Capital Costs

Unit	Marley Wet/Dry CT Cost w/Delivery ($)	BOP Equipment Material Cost ($)	Labor ($)	Indirect Costs ($)	Contingency ($)	Total Cost ($)	Total Cost ($/kW)
Will County 3&4	$33,200,000	$47,300,000	$108,300,000	$28,200,000	$40,100,000	$257,100,000	$309

Below in Table 5-9, the cost of plume-abated (wet/dry) towers is compared to the cost for a wet tower with and without the provisions for later conversion to a wet/dry configuration. (See Section 2 for a discussion of the provisions required for a wet convertible to wet/dry tower.)

Table 5-9
Will County Capital Costs for Three Tower Styles

Unit	Wet/Dry Total Installed Cost ($)	Wet With Dry Option Total Installed Cost ($)	Wet Without Dry Option Total Installed Cost ($)
Will County 3&4	$257,100,000	$230,200,000	$210,700,000

C3. WILL COUNTY COOLING TOWER O&M COST ESTIMATES

The operation and maintenance cost for the Will County plume-abated (wet/dry) cooling tower consists of cooling tower fan and pump power (137,832 MWh at $36,71/MWh), tower maintenance costs such as gear oil replacement, and chemical costs for chlorination and anti-scaling additives. The total annual O&M cost is approximately $5,750,000. A detailed breakdown of these O&M costs is shown in Exhibit J. The breakdown of the costs is shown in Table 5-10.

Table 5-10
Will County O&M Costs

Unit	Annual CT Fan Power Cost ($)	Annual Pump Power Cost ($)	Annual Maintenance Cost ($)	Annual Chemical Cost ($)	Total Annual O&M Cost ($)
Will County 3&4	$1,950,000	$2,820,000	$150,000	$832,000	$5,752,000

C4. WILL COUNTY DERATING IMPACTS WITH CLOSED-CYCLE COOLING TOWER

Tables 5-11 and 5-12 below summarize the month-by-month loss of plant capacity in closed-cycle operation for Will County 3 and Will County 4, respectively, compared to open-cycle operation weather and water temperature conditions.

Table 5-11
Will County 3 Megawatt Loss Due to Closed v. Open-Cycle Operation

Period	Closed-Cycle MW Loss	Open-Cycle MW Gain/Loss	Total MW Gain/Loss Running Closed vs. Open-Cycle
January	-1.37	0.41	-1.77
February	-1.67	0.50	-2.17
March 1-15	-4.64	-0.03	-4.61
March 16-31	-4.64	-0.03	-4.61
April 1-15	-6.26	-0.72	-5.54
April 16-30	-6.26	-1.02	-5.24
May 1-15	-9.49	-3.19	-6.30
May 16-31	-9.49	-4.10	-5.39
June 1-15	-11.95	-5.44	-6.51
June 16-30	-11.95	-14.93	2.98
July 1-15	-14.32	-14.93	0.62
July 16-31	-14.32	-14.93	0.62
August 1-15	-13.72	-14.93	1.21
August 16-31	-13.72	-14.93	1.21
Sep. 1-15	-11.00	-14.93	3.93
Sep. 16-30	-11.0	-7.03	-3.97
October 1-15	-6.67	-4.93	-1.73
Oct. 16-31	-6.67	-3.35	-3.32
November	-4.60	-2.15	-2.45
December	-1.93	-0.53	-1.40
		Annual Average	**-2.18**

Nominal unit output: 281 MW gross
Annual-average capacity loss: 2.18 MW
Annual revenue loss: $526,000 (75% capacity, $36.71/MWh)

Table 5-12
Will County 4 Megawatt Loss Due to Closed v. Open-Cycle Operation

Period	Closed-Cycle MW Loss	Open-Cycle MW Gain/Loss	Total MW Gain/Loss Running Closed vs. Open-Cycle
January	-0.57	1.06	-1.63
February	-0.85	1.14	-1.99
March 1-15	-3.63	0.66	-4.29
March 16-31	-3.63	0.66	-4.29
April 1-15	-5.16	0.03	-5.19
April 16-30	-5.16	-0.25	-4.91
May 1-15	-8.25	-2.27	-5.98
May 16-31	-8.25	-3.12	-5.14
June 1-15	-10.64	-4.38	-6.25
June 16-30	-10.64	-13.57	2.93
July 1-15	-12.96	-13.57	0.61
July 16-31	-12.96	-13.57	0.61
August 1-15	-12.37	-13.57	1.19
August 16-31	-12.37	-13.57	1.19
Sep. 1-15	-9.71	-13.57	3.85
Sep. 16-30	-9.71	-5.89	-3.82
October 1-15	-5.55	-3.91	-1.64
Oct. 16-31	-5.55	-2.41	-3.13
November	-3.59	-1.29	-2.29
December	-1.09	0.20	-1.29
		Annual Average	**-2.03**

Nominal unit output: 551 MW gross
Annual-average capacity loss: 2.03
Annual revenue loss: $490,000 (75% capacity, $36.71/MWh)

D. JOLIET 6 STATION TECHNOLOGY OPTIONS AND COST ESTIMATE RESULTS

D1. JOLIET 6 COOLING TOWER ARRANGEMENT

Exhibit A4 represents the arrangement drawing developed for the Joliet 6 cooling tower sections. The arrangement of the cooling towers is favorable, considering the space constraints. The towers are oriented to minimize recirculation and interference under prevailing wind conditions. The site would need to be filled to raise the elevation suitably above the canal. There is a microwave easement that crosses the tower location. It is assumed for purposes of this analysis that this easement is sufficiently elevated that the towers do not interfere with it.

Exhibit B4 is the closed loop cycle diagram for at Joliet 6. A wall with a gate would be installed across the existing discharge channel. Under closed-cycle operation, this gate would be closed and four 25% cooling tower supply pumps would pump the water from the channel upstream of the wall to the cooling towers. The cooled water would be pumped by four 25% cooling tower discharge pumps (two per tower section) through steel-lined concrete piping to the intake of the existing crib house, to re-enter the CW pumps and condensers. The crib house intake would be enclosed with gates on the north and west sides to prevent the circulating water from entering the canal.

D2. JOLIET 6 COOLING TOWER CAPITAL COST ESTIMATES

The capital costs (including the quoted pricing from Marley) for the wet/dry tower are shown in Exhibit I4. Below in Table 5-13, the cost for the 100% closed loop tower is broken into the key components. For the wet/dry tower option, the total estimated capital cost is approximately $116 million. This translates to a normalized capital cost of $339 per kilowatt.

Table 5-13
Joliet 6 Capital Cost

Joliet 6 Capital Costs Unit	Marley Wet/Dry CT Cost w/Delivery ($)	BOP Equipment Material Cost ($)	Labor ($)	Indirect Costs ($)	Contingency ($)	Total Cost ($)	Total Cost ($/kW)
Joliet 6	$14,900,000	$21,000,000	$42,600,000	$19,100,000	$18,100,000	$115,700,000	$339

Below in Table 5-14, the cost of plume-abated (wet/dry) towers is compared to the cost for a wet tower with and without provisions to convert to wet/dry. (See Section 2 for a discussion of the provisions required for a wet convertible to wet/dry tower.)

Table 5-14
Joliet 6 Capital Costs for Three Tower Styles

Unit	Wet/Dry Total Installed Cost ($)	Wet With Dry Option Total Installed Cost ($)	Wet Without Dry Option Total Installed Cost ($)
Joliet 6	$115,700,000	$103,600,000	$93,400,000

D3. JOLIET 6 COOLING TOWER O&M COST ESTIMATES

Operation and maintenance costs for plume-abated (wet/dry) cooling towers at Joliet 6 wet/dry consists of cooling tower fan and pump power (65,350 MWh at $36.71/MWh), tower maintenance costs such as gear oil replacement, and chemical costs for chlorination and anti-scaling additives. The total annual O&M cost is approximately $2,660,000. A detailed breakdown of these O&M costs is shown in Exhibit J. The breakdown of the costs is shown in Table 5-15.

Table 5-15
Joliet 6 O&M Costs

Unit	Annual CT Fan Power Cost ($)	Annual Pump Power Cost ($)	Annual Maintenance Cost ($)	Annual Chemical Cost ($)	Total Annual O&M Cost ($)
Joliet 6	$880,000	$1,370,000	$67,500	$341,000	$2,660,000

D4. JOLIET 6 DERATING IMPACTS WITH CLOSED-CYCLE COOLING TOWER

Table 5-16
Joliet 6 Megawatt Loss Due to Closed v. Open-Cycle Operation

Period	Closed-Cycle MW Loss	Open-Cycle MW Gain/Loss	Total MW Gain/Loss Running Closed vs. Open-Cycle
January	-1.26	0.47	-1.73
February	-1.71	0.58	-2.29
March 1-15	-3.85	-0.04	-3.81
March 16-31	-3.85	-0.04	-3.81
April 1-15	-5.14	-0.76	-4.38
April 16-30	-5.14	-1.05	-4.09
May 1-15	-7.35	-2.94	-4.41
May 16-31	-7.35	-3.64	-3.71
June 1-15	-9.08	-4.64	-4.43
June 16-30	-9.08	-9.82	0.75
July 1-15	-10.36	-9.82	-0.54
July 16-31	-10.36	-9.82	-0.54
August 1-15	-10.06	-9.82	-0.24

Period	Closed-Cycle MW Loss	Open-Cycle MW Gain/Loss	Total MW Gain/Loss Running Closed vs. Open-Cycle
August 16-31	-10.06	-9.82	-0.24
Sep. 1-15	-8.26	-9.82	1.56
Sep. 16-30	-8.26	-5.76	-2.50
October 1-15	-5.39	-4.27	-1.11
Oct. 16-31	-5.39	-3.06	-2.32
November	-3.85	-2.07	-1.77
December	-2.88	-0.57	-2.30
		Annual Average	-2.08

Nominal plant output:	341 MW gross
Annual-average capacity loss:	2.08
Annual revenue loss:	$502,000 (75% capacity, $36.71/MWh)

E. JOLIET 7&8 STATION TECHNOLOGY OPTIONS AND COST ESTIMATE RESULTS

E1. JOLIET 7&8 COOLING TOWER ARRANGEMENT

Exhibit A4 represents the arrangement drawing developed for the Joliet 7&8 towers. Interference between the towers is likely under prevailing wind conditions, as the spacing between the towers is less than desired. Recirculation may also be a problem with westerly winds.

See Exhibit B5 for the closed loop diagram corresponding to Joliet 7&8 case. A dividing wall would be installed down the center of the existing discharge channel, and a wall with a gate would be installed at the southwestern end of the channel formed north of this wall. Under closed-cycle operation, this gate would be closed and six 17% cooling tower supply pumps would pump the water from this channel to the cooling towers. The cooled water would be pumped by six cooling tower discharge pumps (two per tower) through buried steel-lined concrete piping to the channel south of the dividing wall. This channel would be isolated from the canal by a new wall and gate. The flow in the southern section of the divided discharge channel would be reversed and a new flume with a gate would connect this channel with the existing inlet channel. From the inlet channel, the circulating water would re-enter the CW pumps and condensers.

E2. JOLIET 7&8 COOLING TOWER CAPITAL COST ESTIMATES

The capital costs (including the quoted pricing from Marley) for the wet/dry tower are shown in Exhibit I5. Below in Table 5-17, the cost for the closed loop tower is broken into the key components. For the wet/dry tower option, the total estimated capital cost is approximately $301 million. This translates to a normalized capital cost of $264 per kilowatt.

Table 5-17
Joliet 7&8 Capital Costs

Unit	Marley Wet/Dry CT Cost w/Delivery ($)	BOP Equipment Material Cost ($)	Labor ($)	Indirect Costs ($)	Contingency ($)	Total Cost ($)	Total Cost ($/kW)
Joliet 7&8	$53,100,000	$58,800,000	$115,400,000	$26,600,000	$47,000,000	$300,900,000	$264

Table 5-18 presents a comparison of the cost of plume-abated (wet/dry) towers is compared to the cost for a wet tower with or without the option to convert to wet/dry.

Table 5-18
Joliet 7&8 Tower Capital Cost for Three Tower Styles

Unit	Wet/Dry Total Installed Cost ($)	Wet With Dry Option Total Installed Cost ($)	Wet Without Dry Option Total Installed Cost ($)
Joliet 7&8 100%	$300,900,000	$257,900,000	$223,800,000

E3. JOLIET 7&8 COOLING TOWER O&M COST ESTIMATES

The operation and maintenance cost for the Joliet 7&8 plume-abated (wet/dry) cooling tower consists of cooling tower fan and pump power (230,962 MWh at $36.71/MWh), tower maintenance costs such as gear oil replacement, and chemical costs for chlorination and anti-scaling additives. The total annual O&M cost is approximately $9,080,000. A detailed breakdown of these O&M costs is shown in Exhibit J. The breakdown of the costs is shown in Table 5-19.

Table 5-19
Joliet 7&8 O&M Costs

Unit	Annual CT Fan Power Cost ($)	Annual Pump Power Cost ($)	Annual Maintenance Cost ($)	Annual Chemical Cost ($)	Total Annual O&M Cost ($)
Joliet 7&8	$3,100,000	$4,570,000	$240,000	$1,138,000	$9,050,000

Total O&M costs for Joliet 7&8 are markedly higher than the O&M costs for other MWGen station units for two reasons: 1) Most O&M costs are related to plant generating capacity, and Joliet 7&8 is the largest station of the five stations considered in this study, and 2) Joliet 7&8 have three cooling tower sections, which requires one additional set of large pumps than is required for the other stations.

E4. JOLIET 7&8 DERATING IMPACTS WITH CLOSED-CYCLE COOLING TOWER

Table 5-20
Joliet 7&8 Megawatt Loss Due to Closed v. Open-Cycle Operation

Period	Closed-Cycle MW Loss	Open-Cycle MW Gain/Loss	Total MW Gain/Loss Running Closed vs. Open-Cycle
January	-2.19	-0.71	-1.48
February	-2.91	-0.71	-2.20
March 1-15	-7.31	-0.28	-7.02
March 16-31	-7.31	-0.28	-7.02
April 1-15	-9.53	-0.64	-8.89
April 16-30	-9.53	-1.30	-8.23
May 1-15	-13.36	-5.32	-8.04
May 16-31	-13.36	-6.71	-6.64
June 1-15	-16.13	-8.61	-7.53
June 16-30	-16.13	-17.29	1.15
July 1-15	-18.20	-17.29	-0.91
July 16-31	-18.20	-17.29	-0.91
August 1-15	-17.65	-17.29	-0.36
August 16-31	-17.65	-17.29	-0.36
Sep. 1-15	-15.02	-17.29	2.27
Sep. 16-30	-15.02	-10.63	-4.38
October 1-15	-10.26	-7.92	-2.34
Oct. 16-31	-10.26	-5.56	-4.70
November	-7.24	-3.53	-3.71
December	-5.50	-0.20	-5.30
		Annual Average	**-3.72**

Nominal plant output: 569 MW gross (each unit)
Annual-average capacity loss: 3.72
Annual revenue loss: $897,000 (75% capacity, $36.71/MWh)

F. CAPITAL COSTS ASSOCIATED WITH OPEN-CYCLE CAPABILITY

Conversion of Crawford 7/8, Fisk, Joliet 6, Joliet 7/8 and Will County 3/4 to closed-cycle cooling requires isolation of the existing cooling water intake and discharge canals from the river. For cost estimating purposes, S&L assumed this isolation would be accomplished by installing a combination of fixed barrier walls with moveable gates at the points of isolation from the river. Although there are many other systems and structures required to convert these stations to closed-cycle cooling, conversion does not require any changes to existing plant equipment which would prevent the plant from operating in open-cycle mode if access to the river were maintained. Thus, the only additional equipment included in the capital cost estimates to allow the stations to maintain their current open-cycle capability is the inclusion of moveable gates as part of the fixed barrier walls.

Table 5-21 provides a comparison of the capital costs of conversion from open-cycle to closed-cycle cooling with and without moveable gates. For the estimates without gates, S&L substituted continuous fixed barrier walls for walls with moveable gates.

Table 5-21
Capital Costs With and Without Moveable Gates (2007 $)

	Crawford	Fisk	Joliet 6	Joliet 7/8	Will County
Open-Cycle Capability Costs	$144,652,125	$119,952,645	$109,045,489	$296,100,668	$225,485,626
Closed-Cycle Costs	$141,995,107	$118,832,840	$107,185,075	$292,252,428	$224,095,727
Difference	$2,657,018	$1,119,805	$1,860,414	$3,846,240	$1,389,899
Percentage Difference	1.9	0.9	1.7	1.3	0.6

6. TYPICAL COOLING TOWER PROJECT SCHEDULE

A typical schedule for the design, procurement, fabrication and erection of a cooling tower and other closed-cycle conversion activities for a single station is shown in Figure 6-1. If all of the towers at each of the MWGen stations had to be installed to meet a single compliance deadline and therefore, schedules for the work to install the cooling towers would need to overlap, the overall schedule duration would be considerably longer than that shown for a single station.

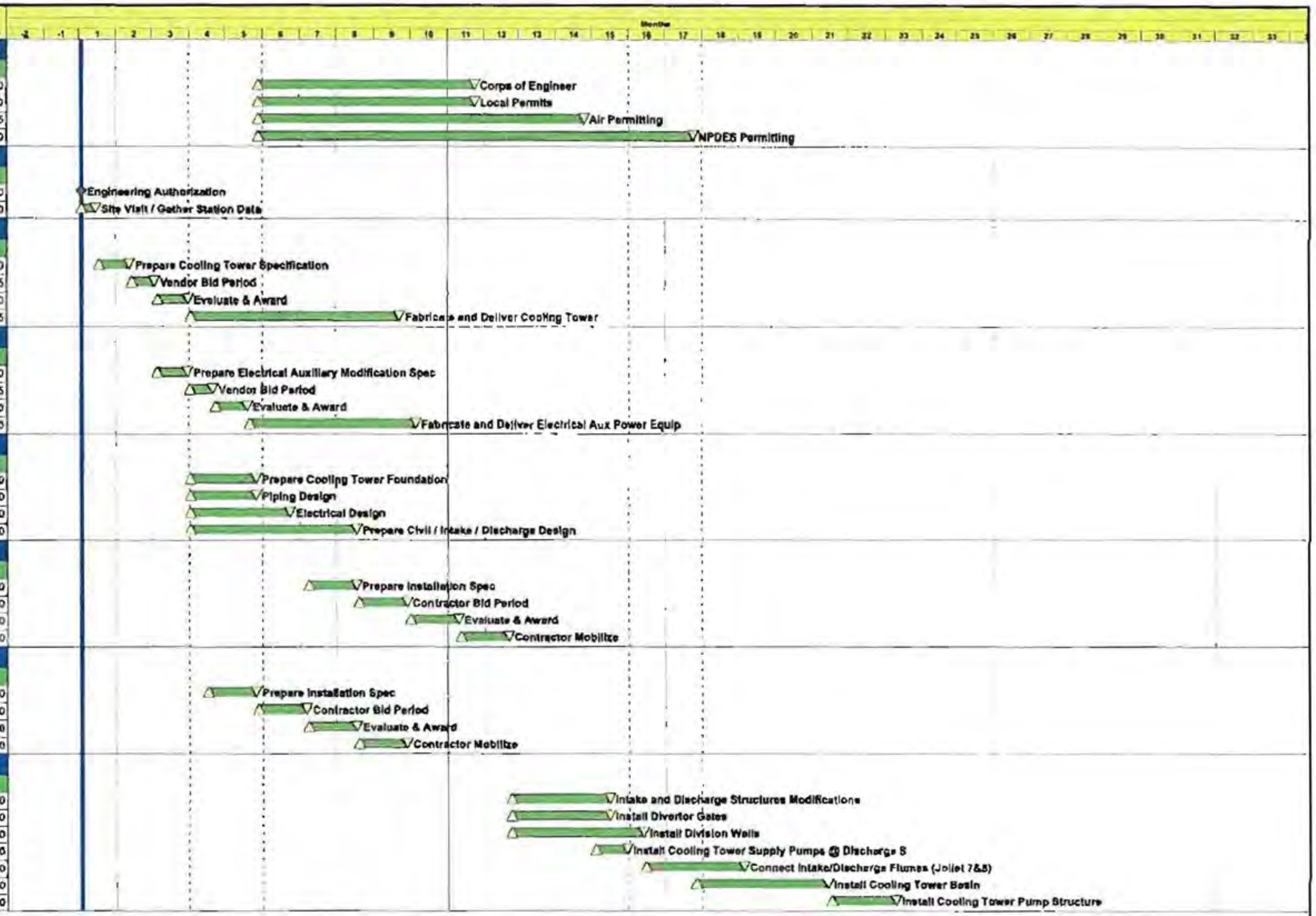
As shown on Figure 6-1, S&L estimates that a typical single-station installation will require about 29 months to complete, not including the time needed both to conduct necessary design studies and to complete critical design criteria. The 29-month duration is applicable to Fisk, Crawford and Joliet 6; the overall durations for closed-cycle conversion at Will County 3/4 and Joliet 7/8 are estimated to be 31 months and 33 months, respectively.

The overall duration for a multiple station cooling tower installation will require over twice as much time as a single-station installation. From a design standpoint, much of the required effort will be largely repetitive. For example, once a cooling tower specification is prepared for one station, it will take considerably less time to prepare a comparable specification for another station. However, it is likely that MWGen's ability to pursue multiple cooling tower projects in parallel will be limited by the time required to fabricate and deliver the cooling tower material and equipment and/or by the time required to construct the tower and other structures. At present, there are few utility-size cooling tower projects underway nationally and the construction labor market is favorable. With such conditions, and assuming the necessary funds are available, one might be able to execute projects at Fisk and Crawford stations in parallel, and to start projects at the next stations in sequence with a 12- to 15-month lag. Assuming such "best case" scenario circumstances, after the time required to complete the final design criteria, the overall time required to implement closed-cycle cooling at the five MWGen stations is estimated to be a minimum of 60 months. However, as the economy improves, lead times will lengthen and construction labor will become less available. Therefore it is not possible to predict accurately the overall time required to design, fabricate and install cooling towers at five power stations. Again, assuming that funding can be obtained when needed, for planning purposes, S&L recommends that at least 72 months should be allowed for that process.

There are several permits required to install cooling towers at the MWGen stations. S&L believes the time frames we have indicated in Figure 6-1 for acquisition of those permits for a single tower installation is reasonable, but any delay in preparation, agency review or agency issue of those permits will result in a commensurate delay in the overall project schedule. If all of the towers at each of the MWGen stations had to be installed to meet a single compliance deadline and therefore, multiple permit applications were submitted to the Agency simultaneously or close in time, it is expected that the time frames indicated in Figure 6-1 for agency review and issuance of permits for a single cooling tower installation would increase significantly due to the additional permit applications review burden this would place on the Agency.

The extent of transmission line relocation was not examined in any detail during this study. The time required to obtain permission for line relocation and to actually relocate the lines has not been considered in the schedule discussion above.

Activity ID	Activity Description	Days
Permitting		
30	Corps of Engineer	130
40	Local Permits	130
10	Air Permitting	195
20	NPDES Permitting	260
Engineering Study		
100	Engineering Authorization	0
110	Site Visit / Gather Station Data	10
Cooling Tower Procurement		
160	Prepare Cooling Tower Specification	20
170	Vendor Bid Period	15
180	Evaluate & Award	20
190	Fabricate and Deliver Cooling Tower	125
Electical Aux. Power Modification Procurement		
240	Prepare Electrical Auxiliary Modification Spec	20
250	Vendor Bid Period	15
260	Evaluate & Award	20
270	Fabricate and Deliver Electrical Aux Power Equip	100
Engineering / Design		
280	Prepare Cooling Tower Foundation	40
300	Piping Design	40
310	Electrical Design	60
290	Prepare Civil / Intake / Discharge Design	100
Civil Contractor Procurement		
312	Prepare Installation Spec	30
313	Contractor Bid Period	30
314	Evaluate & Award	30
315	Contractor Mobilize	30
Construction Contractor Procurement		
320	Prepare Installation Spec	30
330	Contractor Bid Period	30
340	Evaluate & Award	30
350	Contractor Mobilize	30
Construction / Startup		
Structural		
365	Intake and Discharge Structures Modifications	60
375	Install Divertor Gates	60
385	Install Division Walls	80
367	Install Cooling Tower Supply Pumps @ Discharge S	20
410	Connect Intake/Discharge Flumes (Joliet 7&8)	60
360	Install Cooling Tower Basin	60
395	Install Cooling Tower Pump Structure	40



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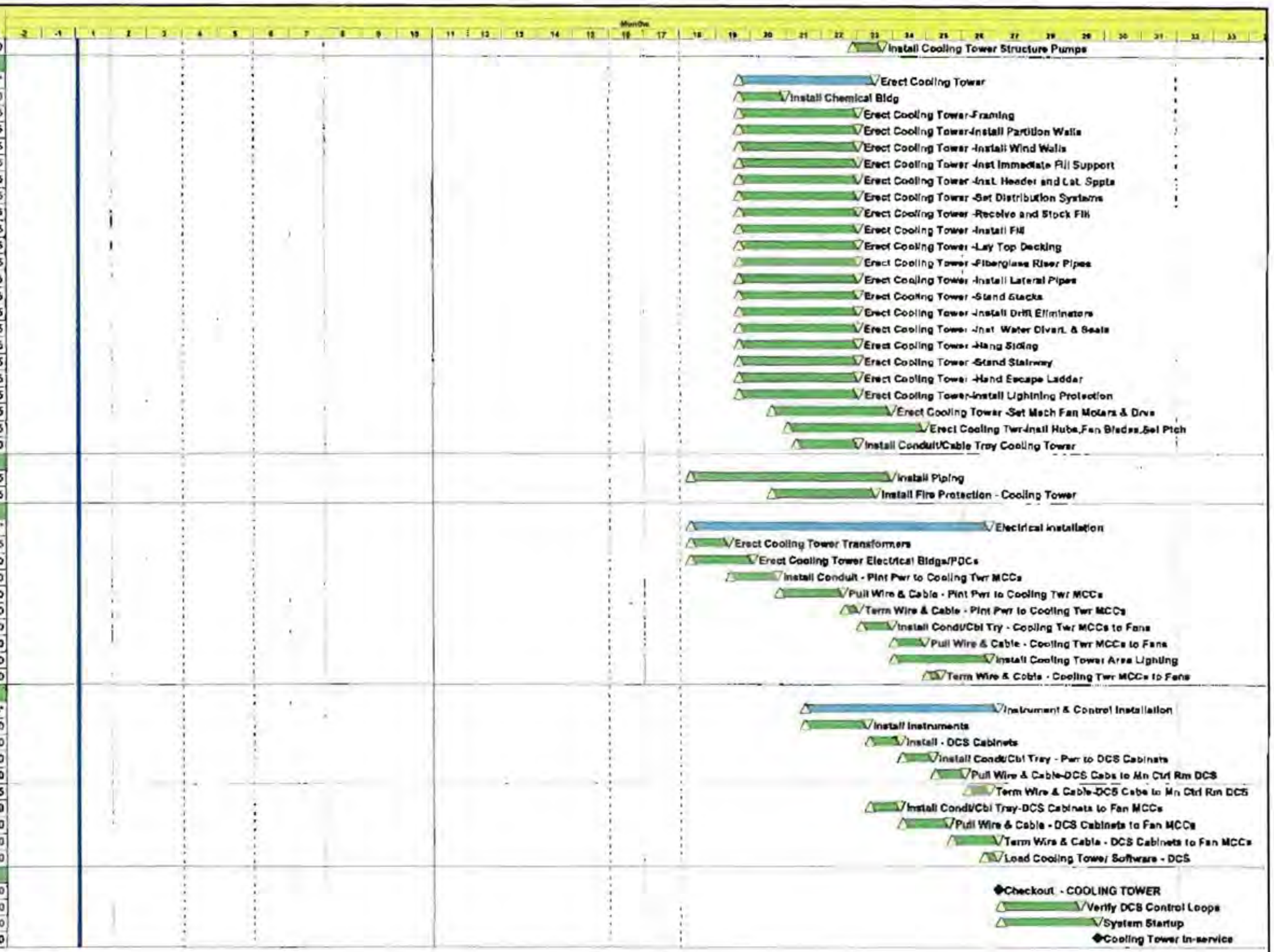
Typical Single Station
Project Schedule
Cooling Tower Addition
Design-Fabrication-Installation

Sheet 1 of 2

Sergent & Lundy LLC

Activity ID	Activity Description	Days
400	Install Cooling Tower Structure Pumps	20
Cooling Tower/Mechanical		
C5CWGVC000	Erect Cooling Tower	85*
405	Install Chemical Bldg	30
C5CWGVC016	Erect Cooling Tower-Framing	75
C5CWGVC017	Erect Cooling Tower-Install Partition Walls	75
C5CWGVC018	Erect Cooling Tower -Install Wind Walls	75
C5CWGVC019	Erect Cooling Tower -Inst Immediate Fill Support	75
C5CWGVC020	Erect Cooling Tower -Inst. Header and Lat. Sppts	75
C5CWGVC022	Erect Cooling Tower -Set Distribution Systems	75
C5CWGVC023	Erect Cooling Tower -Receive and Stock Fill	75
C5CWGVC024	Erect Cooling Tower -Install Fill	75
C5CWGVC025	Erect Cooling Tower -Lay Top Decking	75
C5CWGVC026	Erect Cooling Tower -Fiberglass Riser Pipes	75
C5CWGVC027	Erect Cooling Tower -Install Lateral Pipes	75
C5CWGVC030	Erect Cooling Tower -Stand Stacks	75
C5CWGVC031	Erect Cooling Tower -Install Drift Eliminators	75
C5CWGVC032	Erect Cooling Tower -Inst. Water Divert. & Seals	75
C5CWGVC033	Erect Cooling Tower -Hang Siding	75
C5CWGVC034	Erect Cooling Tower -Stand Stairway	75
C5CWGVC035	Erect Cooling Tower -Hand Escape Ladder	75
C5CWGVC036	Erect Cooling Tower-Install Lightning Protection	75
C5CWGVC028	Erect Cooling Tower -Set Mech Fan Motors & Drvs	75
C5CWGVC029	Erect Cooling Twr-Instl Hubs,Fan Blades,Set Ptch	85
C5CWPEW000	Install Conduit/Cable Tray Cooling Tower	40
Piping/Fire Protection		
380	Install Piping	125
C5FPGVF010	Install Fire Protection - Cooling Tower	65
Electrical		
420	Electrical Installation	185*
455	Erect Cooling Tower Transformers	25
450	Erect Cooling Tower Electrical Bldgs/PDCs	40
460	Install Conduit - Plnt Pwr to Cooling Twr MCCs	30
465	Pull Wire & Cable - Plnt Pwr to Cooling Twr MCCs	40
470	Term Wire & Cable - Plnt Pwr to Cooling Twr MCCs	10
475	Install Cond/Cbl Try - Cooling Twr MCCs to Fans	20
480	Pull Wire & Cable - Cooling Twr MCCs to Fans	20
490	Install Cooling Tower Area Lighting	60
485	Term Wire & Cable - Cooling Twr MCCs to Fans	10
I&C		
495	Instrument & Control Installation	120*
C5CWPND010	Install Instruments	40
500	Install - DCS Cabinets	20
505	Install Cond/Cbl Tray - Pwr to DCS Cabinets	20
510	Pull Wire & Cable-DCS Cabs to Mn Ctrl Rm DCS	20
C5CWPEW020	Term Wire & Cable-DCS Cabs to Mn Ctrl Rm DCS	15
545	Install Cond/Cbl Tray-DCS Cabinets to Fan MCCs	20
550	Pull Wire & Cable - DCS Cabinets to Fan MCCs	30
555	Term Wire & Cable - DCS Cabinets to Fan MCCs	30
580	Load Cooling Tower Software - DCS	10
Start-Up & Commissioning		
C514-820	Checkout - COOLING TOWER	0
565	Verify DCS Control Loops	50
430	System Startup	60
440	Cooling Tower In-service	0



EXHIBITS

A. COOLING TOWER EQUIPMENT ARRANGEMENTS

B. CLOSED-CYCLE COOLING TOWER FLOW DIAGRAMS

C. COOLING TOWER SIZING AND SPECIFICATION DATA

D. DESIGN BASIS FOR COOLING TOWER SELECTION

E. PARTICULATE EMISSIONS CALCULATIONS

F. METROPOLITAN WATER RECLAMATION DISTRICT WATER QUALITY DATA

G. COOLING TOWER BLOWDOWN, EVAPORATION, AND MAKE-UP WATER DATA

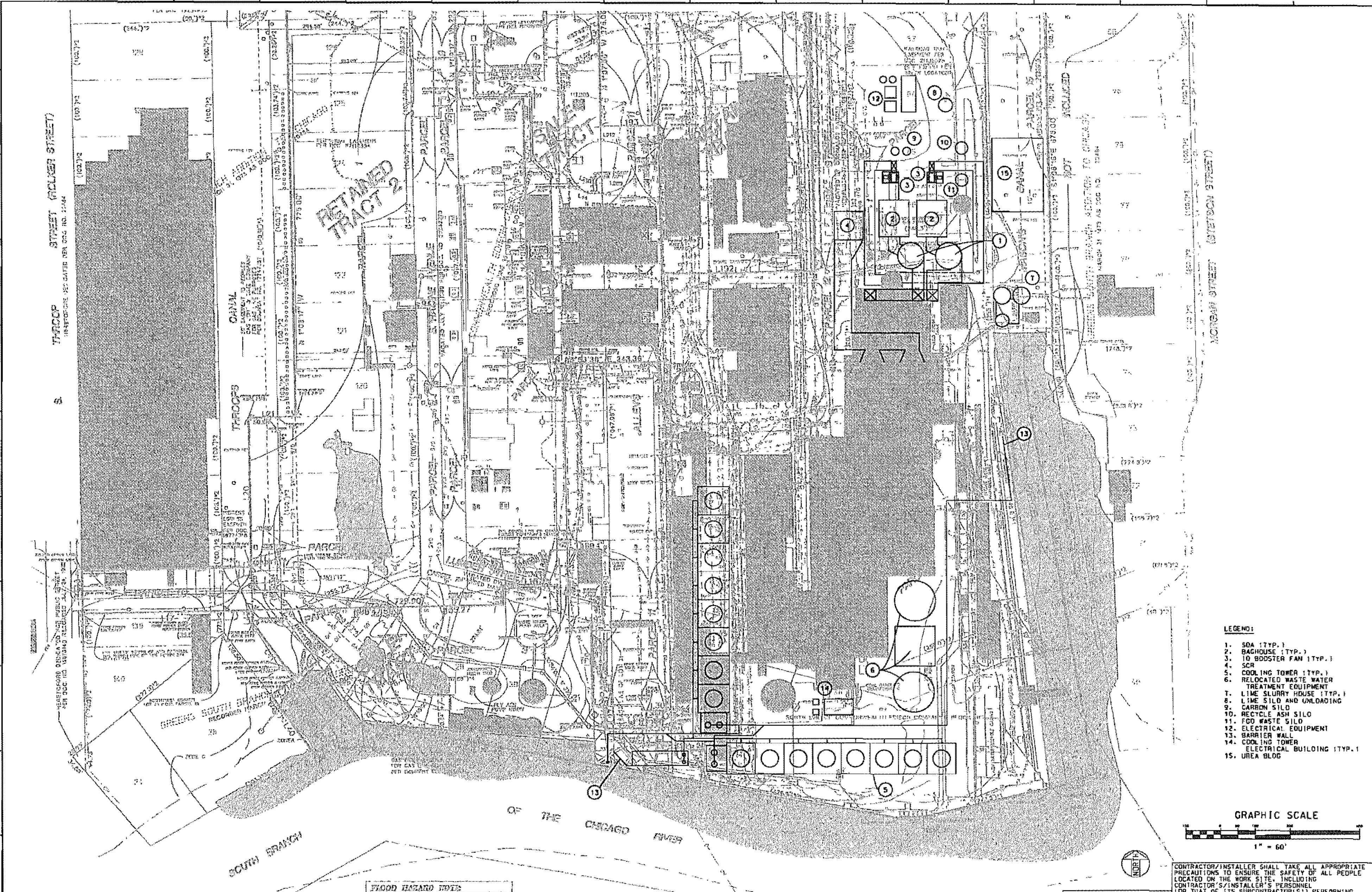
H. COOLING TOWER BLOWDOWN TEMPERATURE DATA

I. CAPITAL COST ESTIMATES

J. OPERATION AND MAINTENANCE COST ESTIMATES

EXHIBIT A

Cooling Tower Equipment Arrangements



LEGEND:

1. SDA (TYP.)
2. BAGHOUSE (TYP.)
3. ID BOOSTER FAN (TYP.)
4. SCR
5. COOLING TOWER (TYP.)
6. RELOCATED WASTE WATER TREATMENT EQUIPMENT
7. LIME SLURRY HOUSE (TYP.)
8. LIME SILO AND UNLOADING
9. CARBON SILO
10. RECYCLE ASH SILO
11. FGD WASTE SILO
12. ELECTRICAL EQUIPMENT
13. BARRIER WALL
14. COOLING TOWER ELECTRICAL BUILDING (TYP.)
15. UREA BLDG

CONTRACTOR/INSTALLER SHALL TAKE ALL APPROPRIATE PRECAUTIONS TO ENSURE THE SAFETY OF ALL PEOPLE LOCATED ON THE WORK SITE, INCLUDING CONTRACTOR'S/INSTALLER'S PERSONNEL (OR THAT OF ITS SUBCONTRACTOR(S)) PERFORMING THE WORK.

FILENAME: msk-fis-1.dgn

DRAWING RELEASE RECORD					
REV.	DATE REL'D.	PREPARED	REVIEWED	APPROVED	PURPOSE

DRAWING RELEASE RECORD					
REV.	DATE REL'D.	PREPARED	REVIEWED	APPROVED	PURPOSE

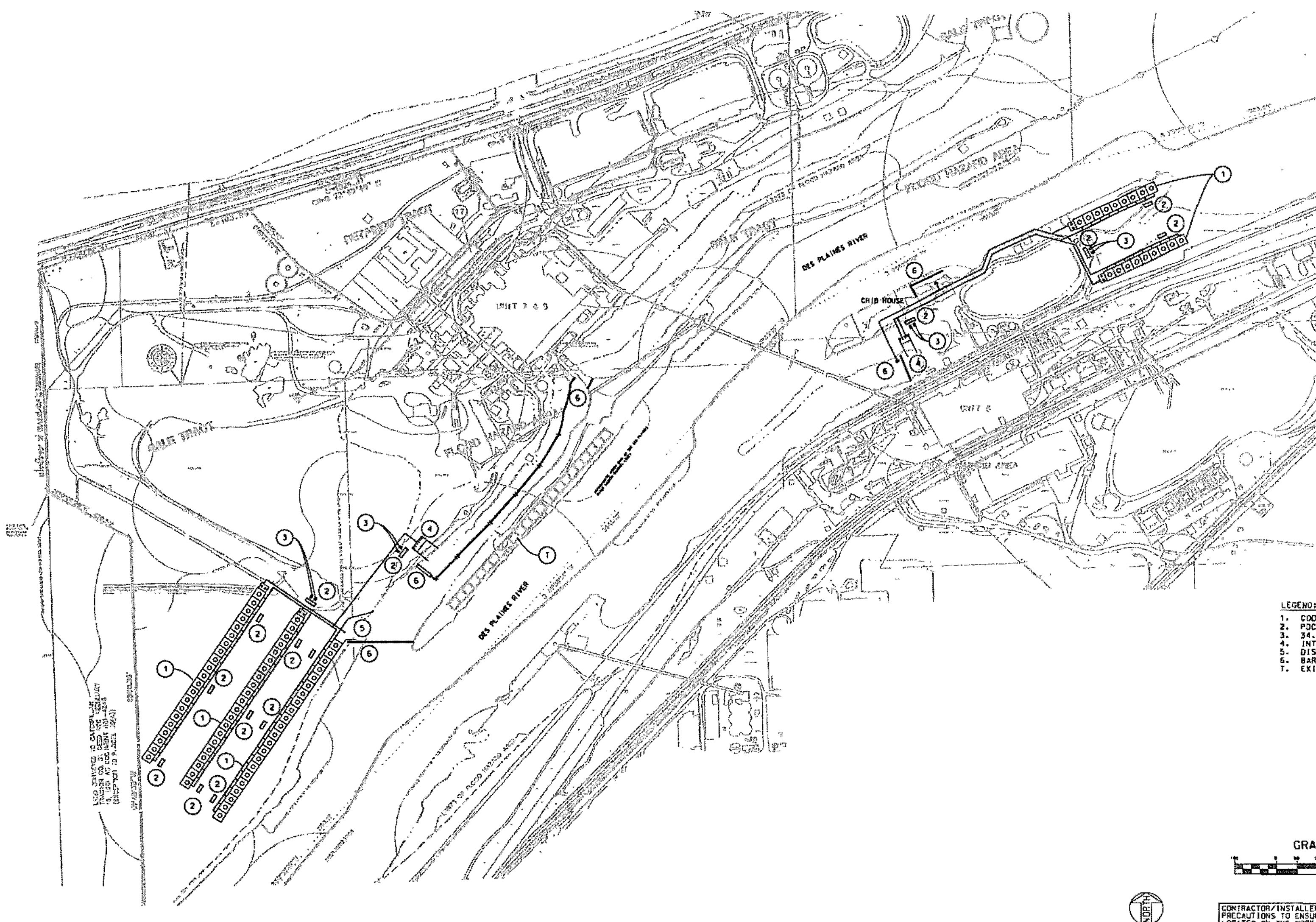
SCALE: 1"=60'
PROJECT NUMBER: 01683-068

GENERAL ARRANGEMENT
SCR/DRY FGD/COOLING TOWER
UNIT 19
FISK STATION
MIDWEST GENERATION
CHICAGO, ILLINOIS

Sargent & Lundy

DRAWING NO.: MSK-FIS-1 REV.: 1
SHEET OF


DES PLAINES
PARCEL
PROPOSED
RETAINED TRACT
TRANSMISSION EASEMENT
CHICAGO SANITARY AND SHIP
UNIT 3
UNIT 4
LEGEND:
1. SDA
2. BAGHOUSE
3. ID BOOSTER FANS
* 4. RECYCLE ASH SILO
* 5. FGD WASTE SILO
* 6. SLURRY HOUSE
7. CARBON SILOS
* 8. LIME SILO
* 9. AMMONIA STORAGE
* 10. COOLING TOWER
* 11. BARRIER WALL
* 12. INTAKE STRUCTURE
* - COMMON WITH UNIT 3&4
GRAPHIC SCALE
1" = 100'
NORTH
CONTRACTOR/INSTALLER SHALL TAKE ALL APPROPRIATE PRECAUTIONS TO ENSURE THE SAFETY OF ALL PEOPLE LOCATED ON THE WORK SITE, INCLUDING CONTRACTOR'S/INSTALLER'S PERSONNEL (OR THAT OF ITS SUBCONTRACTOR(S)) PERFORMING THE WORK.
FILENAME:msk-wil-1.dgn
DRAWING RELEASE RECORD
REV. | DATE REL'D. | PREPARED | REVIEWED | APPROVED | PURPOSE
SCALE
1"=100'
PROJECT NUMBER
GENERAL ARRANGEMENT
DRY FGD COOLING TOWER
STATION 8 - UNIT 3&4
WILL COUNTY STATION
MIDWEST GENERATION
CHICAGO, ILLINOIS
Sargent & Lundy
DRAWING NO.
MSK-WIL-1
REV.
3
SHEET OF



LEGEND:

1. COOLING TOWER
2. PDC
3. 34.5 - 4.16 KV TRANSFORMER
4. INTAKE STRUCTURE
5. DISCHARGE STRUCTURE
6. BARRIER WALL
7. EXISTING PSI HELPER TOWER

GRAPHIC SCALE

1" = 200'

CONTRACTOR/INSTALLER SHALL TAKE ALL APPROPRIATE PRECAUTIONS TO ENSURE THE SAFETY OF ALL PEOPLE LOCATED ON THE WORK SITE, INCLUDING CONTRACTOR'S/INSTALLER'S PERSONNEL (OR THAT OF ITS SUBCONTRACTOR(S)) PERFORMING THE WORK.

FILENAME: msk-jol-8.dgn

DRAWING RELEASE RECORD					
REV.	DATE REL'D.	PREPARED	REVIEWED	APPROVED	PURPOSE

DRAWING RELEASE RECORD					
REV.	DATE REL'D.	PREPARED	REVIEWED	APPROVED	PURPOSE

SCALE: 1"=200'

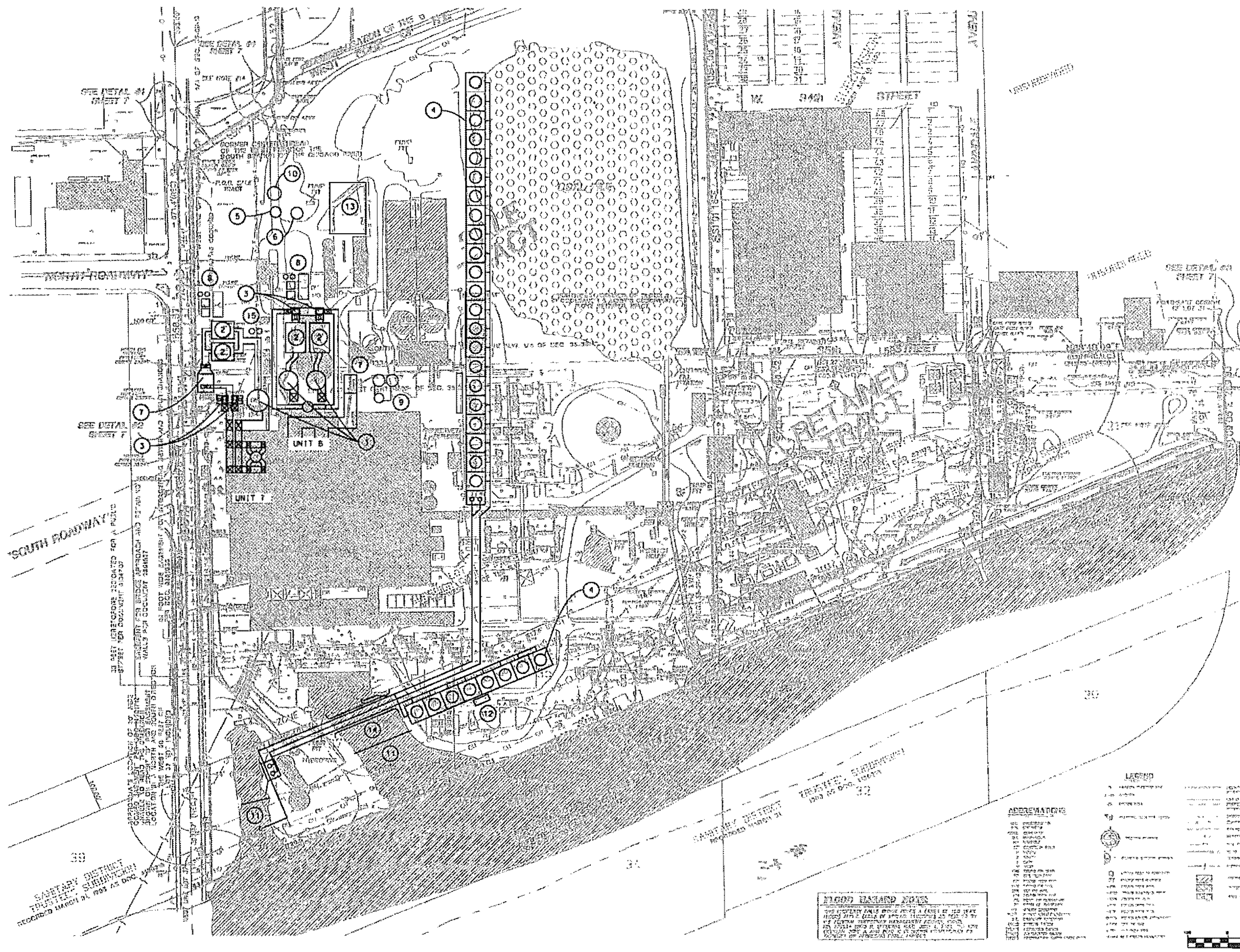
PROJECT NUMBER: 01683-068

GENERAL ARRANGEMENT
COOLING TOWERS
STATION 9 & 29
JOLIET STATION
MIDWEST GENERATION
CHICAGO, ILLINOIS

Sargent & Lundy

DRAWING NO.	REV.
MSK-JOL-8	2

SHEET OF



LEGEND:

1. SDA (TYP.)
2. BAGHOUSE (TYP.)
3. ID BOOSTER FAN (TYP.)
* 4. COOLING TOWER (TYP.)
* 5. FGD WASTE SILO
* 6. LIME SILO/UNLOADING
7. SCR
8. SCR/FGD ELECTRICAL EQUIPMENT BUILDINGS
* 9. SLURRY HOUSE
* 10. RECYCLED ASH SILO
* 11. BARRIER WALLS
* 12. COOLING TOWER ELECTRICAL BUILDING (TYP.)
* 13. UREA BLDG.
* 14. PIPE BRIDGE
* 15. CARBON SILO

* - COMMON WITH UNIT 7&8

CONTRACTOR/INSTALLER SHALL TAKE ALL APPROPRIATE PRECAUTIONS TO ENSURE THE SAFETY OF ALL PEOPLE LOCATED ON THE WORK SITE, INCLUDING CONTRACTOR'S/INSTALLER'S PERSONNEL (OR THAT OF ITS SUBCONTRACTOR(S)) PERFORMING THE WORK.

FILENAME: msk-cra-1.dgn

DRAWING RELEASE RECORD					
REV.	DATE REL'D.	PREPARED	REVIEWED	APPROVED	PURPOSE

DRAWING RELEASE RECORD					
REV.	DATE REL'D.	PREPARED	REVIEWED	APPROVED	PURPOSE

SCALE: 1"=100'

PROJECT NUMBER: 01683-068

GENERAL ARRANGEMENT
SCR/DRY FGD/COOLING TOWER
UNIT 7&8
CRAWFORD STATION
MIDWEST GENERATION
CHICAGO, ILLINOIS

Sargent & Lundy LLC

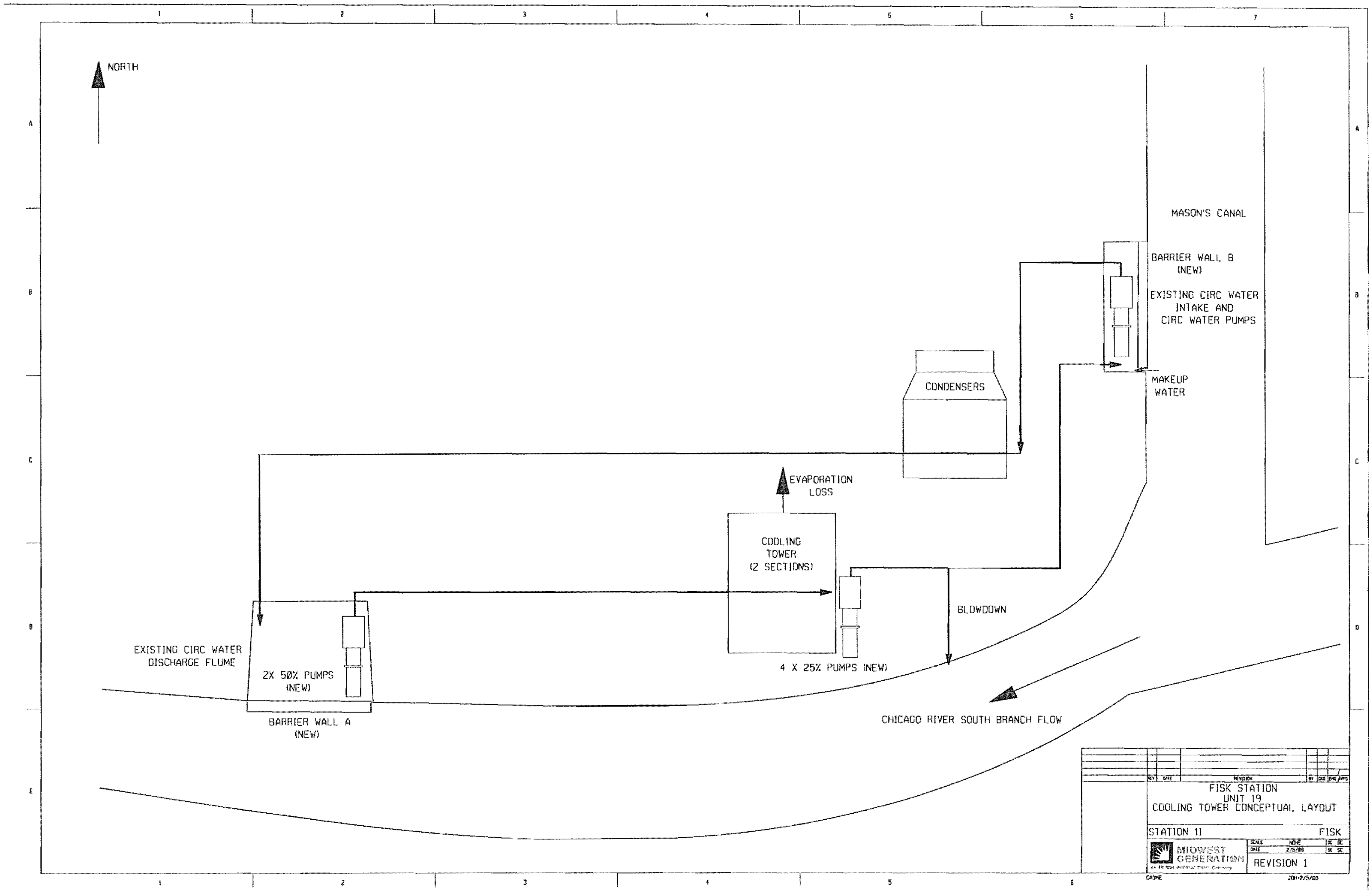
DRAWING NO.: MSK-CRA-1

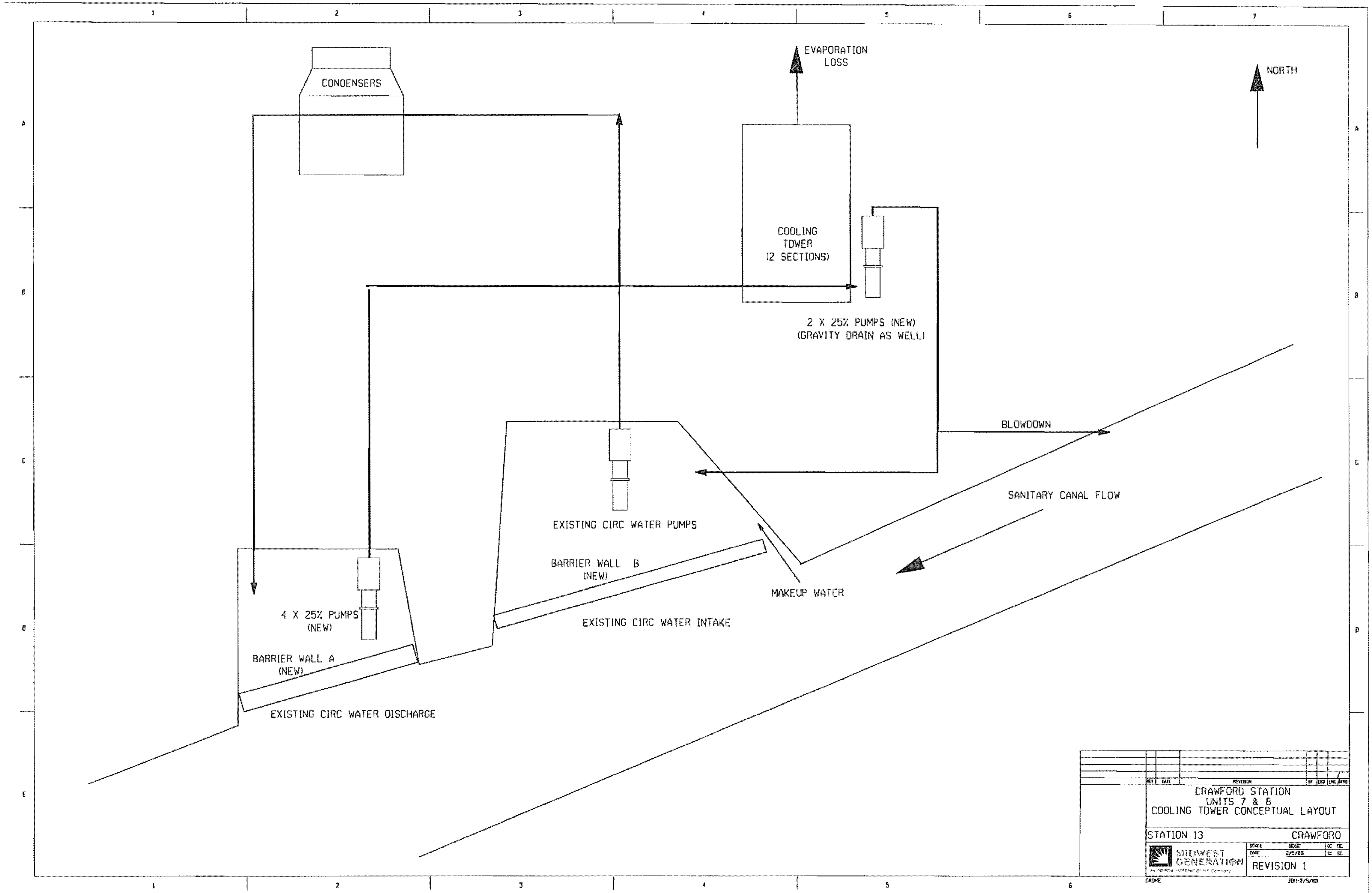
REV.: 1

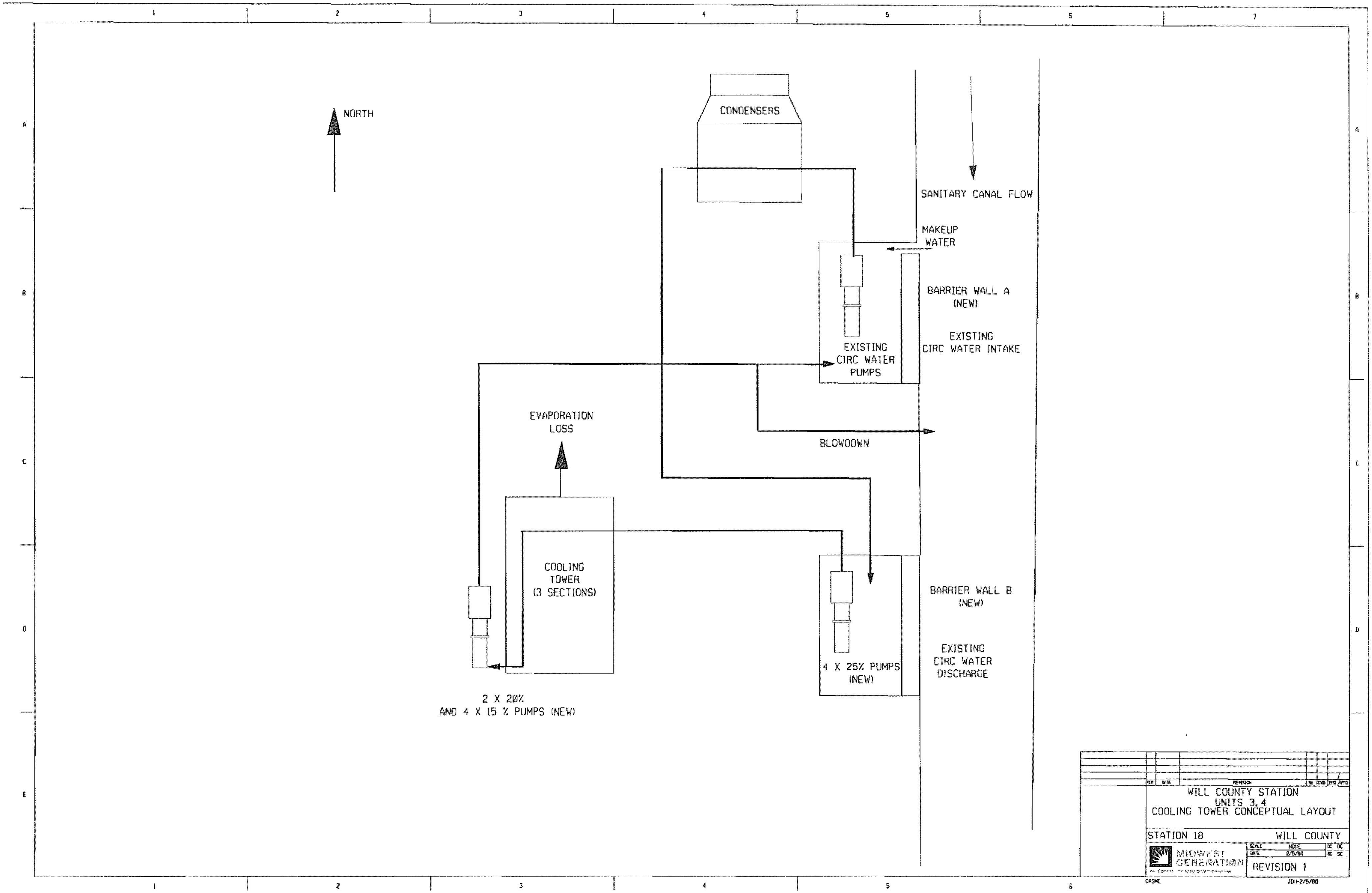
SHEET OF

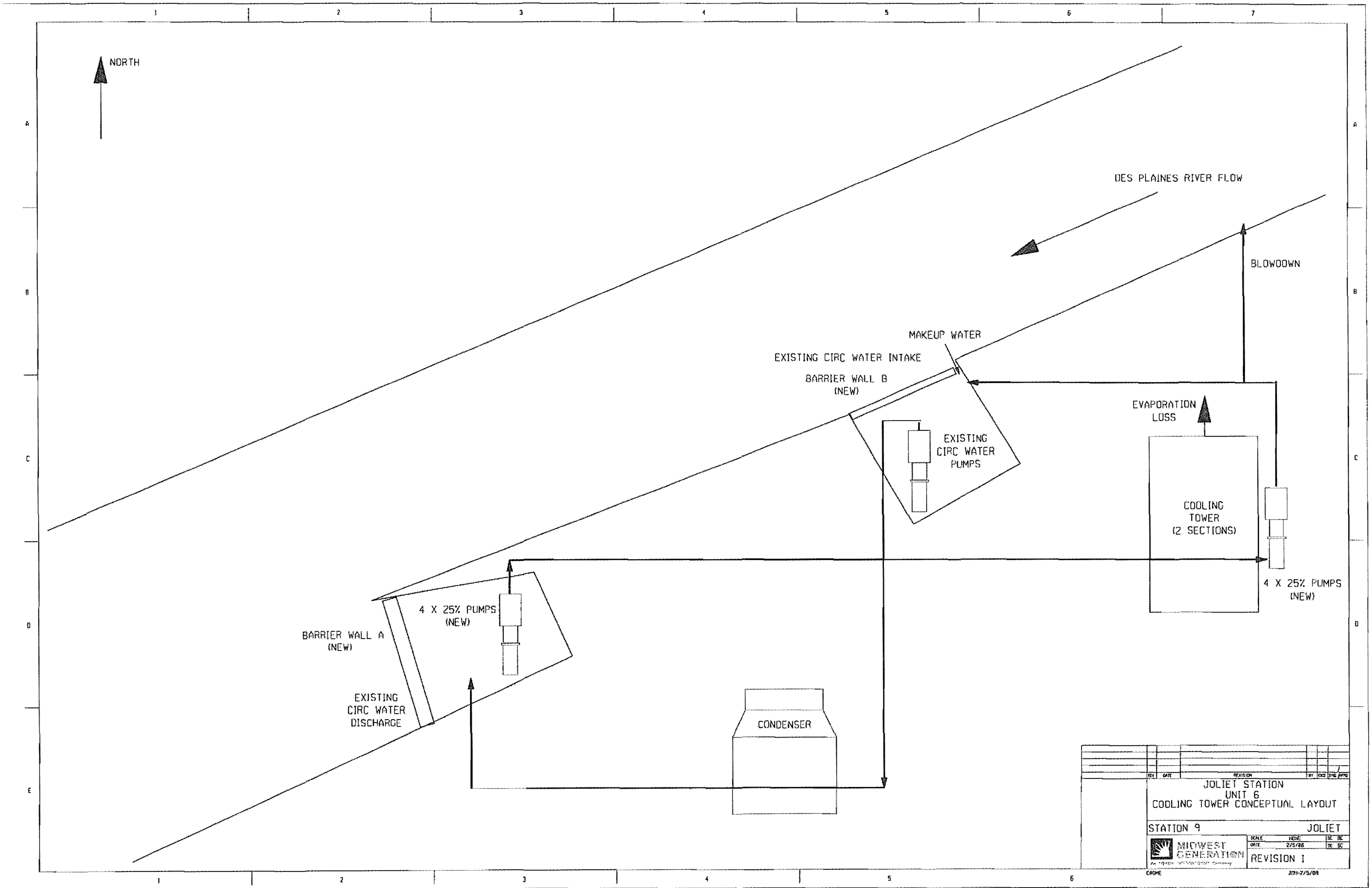
EXHIBIT B

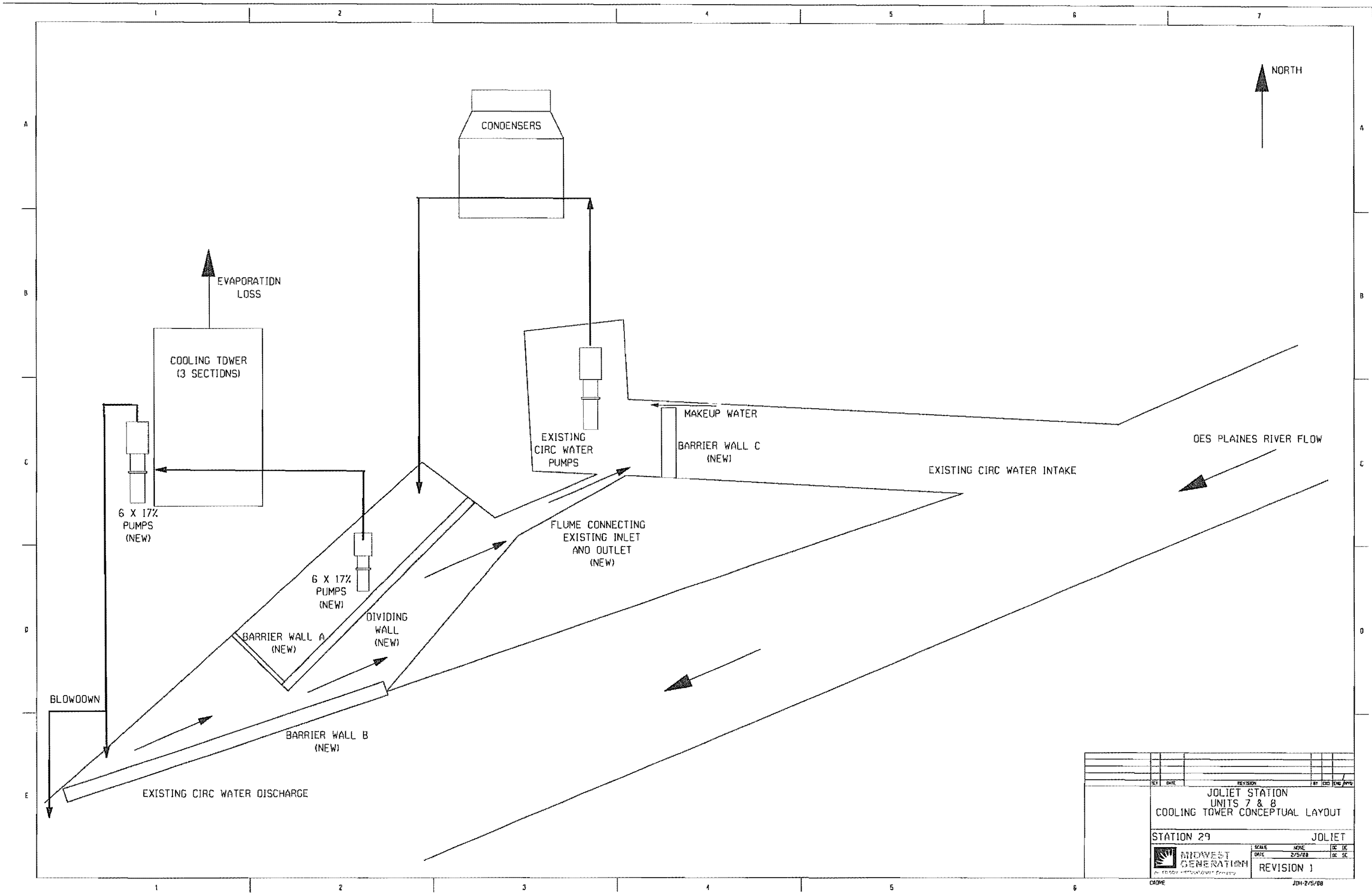
Closed-Cycle Cooling Tower Flow Diagrams


NORTH
MASON'S CANAL
BARRIER WALL B
(NEW)
EXISTING CIRC WATER
INTAKE AND
CIRC WATER PUMPS
MAKEUP
WATER
CONDENSERS
EVAPORATION
LOSS
COOLING
TOWER
(2 SECTIONS)
BLOWDOWN
4 X 25% PUMPS (NEW)
EXISTING CIRC WATER
DISCHARGE FLUME
2X 50% PUMPS
(NEW)
BARRIER WALL A
(NEW)
CHICAGO RIVER SOUTH BRANCH FLOW
FISK STATION
UNIT 19
COOLING TOWER CONCEPTUAL LAYOUT
STATION 11
FISK
MIDWEST
GENERATION
REVISION 1


CONDENSERS
EVAPORATION LOSS
NORTH
COOLING TOWER (2 SECTIONS)
2 X 25% PUMPS (NEW) (GRAVITY DRAIN AS WELL)
BLOWDOWN
SANITARY CANAL FLOW
EXISTING CIRC WATER PUMPS
BARRIER WALL B (NEW)
MAKEUP WATER
EXISTING CIRC WATER INTAKE
4 X 25% PUMPS (NEW)
BARRIER WALL A (NEW)
EXISTING CIRC WATER DISCHARGE
CRAWFORD STATION
UNITS 7 & 8
COOLING TOWER CONCEPTUAL LAYOUT
STATION 13
CRAWFORD
MIDWEST GENERATION
REVISION 1


NORTH
CONDENSERS
SANITARY CANAL FLOW
MAKEUP WATER
BARRIER WALL A (NEW)
EXISTING CIRC WATER INTAKE
EXISTING CIRC WATER PUMPS
EVAPORATION LOSS
BLOWDOWN
COOLING TOWER (3 SECTIONS)
BARRIER WALL B (NEW)
EXISTING CIRC WATER DISCHARGE
4 X 25% PUMPS (NEW)
2 X 20%
AND 4 X 15 % PUMPS (NEW)
WILL COUNTY STATION
UNITS 3, 4
COOLING TOWER CONCEPTUAL LAYOUT
STATION 18
WILL COUNTY
MIDWEST GENERATION
REVISION 1


NORTH
DES PLAINES RIVER FLOW
BLOWDOWN
MAKEUP WATER
EXISTING CIRC WATER INTAKE
BARRIER WALL B
(NEW)
EVAPORATION
LOSS
EXISTING
CIRC WATER
PUMPS
COOLING
TOWER
(2 SECTIONS)
4 X 25% PUMPS
(NEW)
BARRIER WALL A
(NEW)
4 X 25% PUMPS
(NEW)
EXISTING
CIRC WATER
DISCHARGE
CONDENSER
REV DATE REVISION BY CKD ENG APPD
JOLIET STATION
UNIT 6
COOLING TOWER CONCEPTUAL LAYOUT
STATION 9
JOLIET
MIDWEST
GENERATION
SCALE NONE
DATE 2/5/08
REVISION I



NORTH
CONDENSERS
EVAPORATION LOSS
COOLING TOWER (3 SECTIONS)
6 X 17% PUMPS (NEW)
EXISTING CIRC WATER PUMPS
MAKEUP WATER
BARRIER WALL C (NEW)
DES PLAINES RIVER FLOW
EXISTING CIRC WATER INTAKE
FLUME CONNECTING EXISTING INLET AND OUTLET (NEW)
6 X 17% PUMPS (NEW)
DIVIDING WALL (NEW)
BARRIER WALL A (NEW)
BLOWDOWN
BARRIER WALL B (NEW)
EXISTING CIRC WATER DISCHARGE
JOLIET STATION
UNITS 7 & 8
COOLING TOWER CONCEPTUAL LAYOUT
STATION 29
JOLIET
MIDWEST GENERATION
SCALE NONE
DATE 2/5/08
REVISION 1

EXHIBIT C

Cooling Tower Sizing and Specification Data

Cooling Tower Design Data - Fisk Unit 19
Cooling Tower Design Data

Case	Units	Wet/Dry
Total Number of Tower Sections		2
Water Flow to be Cooled	gpm	210,000 total
Ambient Wet Bulb Temperature	°F	78
Ambient Dry Bulb Temperature	°F	94
Cooling Tower Approach	°F	7
Cooling Tower Range	°F	12.72
Cooling Tower Drift	%	0.0005
Cycles of Concentration		5
Makeup Source		South Branch of Chicago River
Makeup Total Suspended Solids*	mg/l	17.1
Makeup Total Dissolved Solids*	mg/l	736
Makeup BOD*	mg/l	6
Cooling Tower Cell Arrangement		Single Row

Cooling Tower Design Data - Crawford Units 7&8
Cooling Tower Design Data

Case	Units	Wet/Dry
Total Number of Tower Sections		2
Water Flow to be Cooled	gpm	382,400 total
Ambient Wet Bulb Temperature	°F	78
Ambient Dry Bulb Temperature	°F	94
Cooling Tower Approach	°F	7
Cooling Tower Range	°F	12.61
Cooling Tower Drift	%	0.0005
Cycles of Concentration		5
Makeup Source		Chicago Sanitary and Ship Canal
Makeup Total Suspended Solids*	mg/l	17.1
Makeup Total Dissolved Solids*	mg/l	736
Makeup BOD*	mg/l	6
Cooling Tower Cell Arrangement		Single Row

Cooling Tower Design Data - Will County Units 3&4
Cooling Tower Design Data

Case	Units	Wet/Dry
Total Number of Tower Sections		3
Water Flow to be Cooled	gpm	600,000 total
Ambient Wet Bulb Temperature	°F	78
Ambient Dry Bulb Temperature	°F	94
Cooling Tower Approach	°F	7
Cooling Tower Range	°F	11.12
Cooling Tower Drift	%	0.0005
Cycles of Concentration		5
Makeup Source		Chicago Sanitary and Ship Canal
Makeup Total Suspended Solids*	mg/l	18.7
Makeup Total Dissolved Solids*	mg/l	844
Makeup BOD*	mg/l	6.4
Cooling Tower Cell Arrangement		Single Row

Cooling Tower Design Data - Joliet Unit 6
Cooling Tower Design Data

Case	Units	Wet/Dry
Total Number of Tower Sections		2
Water Flow to be Cooled	gpm	261,000 total
Ambient Wet Bulb Temperature	°F	78
Ambient Dry Bulb Temperature	°F	94
Cooling Tower Approach	°F	7
Cooling Tower Range	°F	10.69
Cooling Tower Drift	%	0.0005
Cycles of Concentration		5
Makeup Source		Lower Des Plaines River
Makeup Total Suspended Solids*	mg/l	21.7
Makeup Total Dissolved Solids*	mg/l	587
Makeup BOD*	mg/l	3
Cooling Tower Cell Arrangement		Single Row

Cooling Tower Design Data - Joliet Units 7&8
Cooling Tower Design Data

Case	Units	Wet/Dry
Total Number of Tower Sections		3
Water Flow to be Cooled	gpm	920,000 total
Ambient Wet Bulb Temperature	°F	78
Ambient Dry Bulb Temperature	°F	94
Cooling Tower Approach	°F	7
Cooling Tower Range	°F	12.44
Cooling Tower Drift	%	0.0005
Cycles of Concentration		5
Makeup Source		Lower Des Plaines River
Makeup Total Suspended Solids*	mg/l	21.7
Makeup Total Dissolved Solids*	mg/l	587
Makeup BOD*	mg/l	3
Cooling Tower Cell Arrangement		Single Row

* Total Suspended Solids, Total Dissolved Solids and BOD data are 90th percentile values for locations adjacent to each station. Water quality information was obtained from the Metropolitan Water Reclamation District. Refer to Exhibit F.

EXHIBIT D

Design Basis for Cooling Tower Selection

The following are unit specific design criteria that were used for developing the cooling tower options for each station. All O&M and lost capacity costs were developed using an annual-average plant capacity factor of 75 percent.

A. Design Features for Fisk Station:

1) The cooling system design and cost estimate are for cooling towers for Fisk Unit 19. Tower design data is shown in Exhibit C.

2) The heat rejection at the current unit gross rating of 348 MW was calculated to be 1,335 mmBtu/hr based on condenser heat balance calculations using the original heat balance diagrams.

3) The CW flow rate through the condenser was assumed to be 210,000 gpm, the original design value. This results in a calculated condenser temperature rise of 12.72°F. However, plant personnel indicate that the temperature rise can be as high as 20°F. It is not known if this is due to deteriorated CW pump performance or operation with a CW pump offline. The calculated rise and original flow rate were used in the tower design and cost estimate, resulting in a larger tower and higher cost estimate.

4) At the summer design wet bulb temperature, an 85°F condenser inlet temperature would occur under closed-cycle operation. This is calculated to result in a turbine backpressure of 2.29 in HgA at a 70% cleanliness factor.

5) Based on station data and Metropolitan Water Reclamation District data provided by Midwest Generation, the cooling tower was designed for river water makeup with a total suspended solids level of 17.1 ppm, a total dissolved solids level of 736 ppm, and a BOD of 6 ppm. Based on the relatively low total suspended solids levels in the make-up, Marley designed the cooling towers to use anti-clog film fill.

6) The cooling system design includes two cooling towers of 8 cells each. Each cell is 48 ft x 48 ft and has a 250 hp fan that is 30 ft in diameter.

B. Design Features for Crawford Station:

1) The cooling system design and cost estimate are for cooling towers shared by Crawford Units 7&8. Tower design data is shown in Exhibit C.

2) The heat rejection for the cooling towers at the current unit gross rating was calculated based on condenser heat balance calculations using the original heat balance diagrams. For Unit 7 the heat rejection was calculated to be 992 mmBtu/hr at 237 MW. For Unit 8 the heat rejection was calculated to be 1,417 mmBtu/hr at 348 MW.

3) The combined CW flow rate through the Units 7 and 8 condensers was assumed to be 382,400 gpm, the original design value. This results in a calculated combined Unit 7 and 8 CW temperature rise of 12.61°F. However, plant personnel indicate that the temperature rise can be as high as 16°F for Unit 7 and 15°F for Unit 8. It is not known if this is due to deteriorated CW pump performance or operation with a CW pump offline. The calculated rise and original flow rate were used in the tower design and cost estimate, resulting in a larger tower and higher cost estimate.

4) At the summer design wet bulb temperature, an 85°F condenser inlet temperature would occur under closed-cycle operation. This is calculated to result in turbine backpressure of 2.94 and 2.41 in HgA the Units 7 and 8, respectively, at a 70% cleanliness factor.

5) Based on station data and Metropolitan Water Reclamation District data provided by Midwest Generation, the cooling tower was designed for river water makeup with a total suspended solids level of 17.1 ppm, a total dissolved solids level of 736 ppm, and a BOD of 6 ppm. Based on this data, Marley designed the cooling towers to use anti-clog film fill.

6) The cooling system design includes two cooling tower sections with a total of 30 cells. Each cell is 48 ft x 48 ft and has a 250 hp fan that is 28 ft in diameter.

C. Design Features for Will County Station:

1) The cooling system design and cost estimate are for cooling towers shared by Will County Units 3 and 4. Tower design data is shown in Exhibit C.

2) The heat rejection for the cooling towers at the current unit gross rating was calculated based on condenser heat balance calculations using the original heat balance diagrams. For Unit 3 the heat rejection was calculated to be 1,099 mmBtu/hr at 281 MW. For Unit 4 the heat rejection was calculated to be 2,235 mmBtu/hr at 551 MW.

3) The combined CW flow rate through the Units 3 and 4 condensers was assumed to be 600,000 gpm, the original design value. This results in a calculated combined Unit 3 and 4 CW temperature rise of 11.12°F.

4) At the summer design wet bulb temperature, an 85°F condenser inlet temperature would occur under closed-cycle operation. This is calculated to result in turbine backpressures of 2.34 for Unit 3, and 2.17 HgA for Unit 4, at a 70% cleanliness factor.

5) Based on station data and Metropolitan Water Reclamation District data provided by Midwest Generation, the cooling tower was designed for river water makeup with a total suspended solids level of 18.7 ppm, a total dissolved solids level of 844 ppm, and a BOD of 6.4 ppm. Based on this data, Marley designed the cooling towers to use anti-clog film fill.

6) The cooling system design includes three cooling tower sections with a total of 40 cells. Each cell is 48 ft long x 48 ft wide and has a 250 hp fan that is 28 ft in diameter.

D. Design features for Joliet Unit 6:

1) The cooling system design for the Joliet 6 cooling towers are shown in Exhibit C.

2) The heat rejection at the current unit gross rating of 341 MW was calculated to be 1,395 mmBtu/hr based on condenser heat balance calculations using the original heat balance diagrams.

3) The CW flow rate through the Unit 6 condenser was assumed to be 261,000 gpm, the original design value. This results in a calculated CW temperature rise of 10.69°F.

4) At the summer design wet bulb temperature, an 85°F condenser inlet temperature would occur under closed-cycle operation. This results in a turbine backpressure of 2.30 in HgA at a 70% cleanliness factor.

5) Based on station data and Metropolitan Water Reclamation District data provided by Midwest Generation, the cooling tower was designed for river water makeup with a total suspended solids level of 21.7 ppm, a total dissolved solids level of 587 ppm, and a BOD of 3 ppm. Based on this data, Marley designed the cooling towers to use anti-clog film fill.

6) The cooling system design includes two cooling towers with a total of 18 cells. Each cell is 48 ft long x 48 ft wide and has a 240 hp fan that is 30 ft in diameter.

E. Design Features for Joliet Unit 7&8:

1) The cooling system design and cost estimate are for cooling towers shared by Joliet Units 7&8. This is shown in Exhibit C.

2) The heat rejection at the current unit gross rating of 569 MW was calculated to be 2,861 mmBtu/hr based on condenser heat balance calculations using the original heat balance diagrams.

3) The CW flow rate through the Units 7&8 condensers was assumed to be 920,000 gpm, the original design value. This results in a calculated CW temperature rise of 12.44°F.

4) At the summer design wet bulb temperature, an 85°F condenser inlet temperature would occur under closed-cycle operation. This results in a calculated turbine backpressure of 2.32 in HgA for Unit 7 or 8.

5) Based on station data and Metropolitan Water Reclamation District data provided by Midwest Generation, the cooling tower was designed for river water makeup with a total suspended solids level of 21.7 ppm, a total dissolved solids level of 587 ppm, and a BOD of 3 ppm. Based on this data, Marley designed the cooling towers to use anti-clog film fill.

6) The cooling system design includes three cooling tower sections with a total of 64 cells. Each cell is 48 ft long x 48 ft wide and has a 250 hp fan that is 30 ft in diameter.

7) The existing Psychometric System Inc (PSI) helper cooling tower was assumed to be abandoned in place. The high drift rate of this tower would make permitting more difficult, and the tower would be difficult to incorporate into a closed-cycle operating scenario.

EXHIBIT E

Particulate Emissions Calculations

PROJECT: MidWest Gen Cooling Tower Evaluation

		Wet Cooling Towers				
Case Description		Fisk 19	Crawford 7&8	W/C 3&4	Joliet 6	Joliet 7&8
Number of Total Cells		16	30	40	18	64
Number of Cooling Towers (Marley info is all in terms of 2 towers)		2	2	2	2	2
Water						
Makeup Water TDS	ppm	736	736	844	587	587
Maximum Cycles of Concentration		5	5	5	5	5
TDS of Circ. Water	ppm (mg/L)	3,680	3,680	4,220	2,935	2,935
Cooling Tower						
Hours of Operation per Year	hours/year	8,760	8,760	8,760	8,760	8,760
Total Circulating Water Flow per Cell	gpm	**13,125**	**12,747**	**15,000**	**14,500**	**14,375**
Total Circulating Water Flow per Cell	gal/hr	787,500	764,800	900,000	870,000	862,500
Total Circulating Water Flow per Cell	lb/hr	6,567,750	6,378,432	7,506,000	7,255,800	7,193,250
Total Circulating Water Flow per Cell	L/hr	2,981,003	2,895,074	3,406,860	3,293,298	3,264,908
Approximate Cooling Water Make-up Flow	%	1.575%	1.575%	1.575%	1.575%	1.575%
Approximate Cooling Water Make-up Flow per Cell	gpm	207	201	236	228	226
Approximate Cooling Water Make-up Flow per Cell	MGD	0.30	0.29	0.34	0.33	0.33
Approximate Cooling Water Make-up Flow (Total)	MGD	4.80	8.70	13.60	5.94	21.12
Mist Eliminator/Drift Rate	%	0.0005%	0.0005%	0.0005%	0.0005%	0.0005%
Calculated Drift Loss per Cell	lb/hr	32.8	31.9	37.5	36.3	36.0
Calculated Drift Loss per Cell	gpm	0.066	0.064	0.075	0.073	0.072
Calculated Drift Loss (Total)	gpm	1.0	1.9	3.0	1.3	4.6
PM10:PM Ratio	ratio	41.6%	41.6%	36.3%	50.7%	50.7%
PM2.5:PM Ratio	ratio	0.20%	0.20%	0.20%	0.20%	0.20%
EMISSIONS						
PER CELL						
PM Emissions per Cell (TDS x Drift Loss)	lb/hr	0.121	0.117	0.158	0.107	0.106
PM Emission per Cell	tons/year	0.53	0.51	0.69	0.47	0.46
PM-10 Emissions per Cell	lb/hr	0.05	0.05	0.06	0.05	0.05
PM-10 Emissions per Cell	tons/year	0.22	0.21	0.25	0.24	0.23
PM2.5 Emissions per Cell	lb/hr	0.00024	0.00023	0.00032	0.00021	0.00021
PM2.5 Emissions per Cell	tons/year	0.0011	0.0010	0.0014	0.0009	0.0009
COOLING TOWER EMISSIONS RESULTS						
Total PM Emissions (Total emissions per cell x # of cells)	lb/hr	1.94	3.51	6.32	1.93	6.78
Total PM Emissions (Total emissions per cell x # of cells)	tons/year	8.5	15.4	27.7	8.5	29.7
PM10 Emissions (Total Cooling Tower)	lb/hr	0.81	1.46	2.29	0.98	3.44
PM10 Emissions (Total Cooling Tower)	tons/year	3.53	6.40	10.05	4.29	15.06
PM2.5 Emissions (Total Cooling Tower)	lb/hr	0.0039	0.0070	0.0126	0.0039	0.0136
PM2.5 Emissions (Total Cooling Tower)	tons/year	0.017	0.031	0.055	0.017	0.059

Conversion Factors

Typical density of water	lb/gal	8.34
Conversion from gallons to liters	L/gal	3.7854
conversion from lbs. to grams	grams/lb	453.59

EXHIBIT F

Metropolitan Water Reclamation District Water Quality Data

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

WATER QUALITY DATA FOR SELECTED PARAMETERS AND LOCATIONS AT THE CHICAGO RIVER SYSTEM IN 2004

Location Code	Location	Date	BOD_5 (mg/L)[1]	TSS (mg/L)[2]	TDS (mg/L)[3]
	Fisk/Crawford Input:				
40	Damen Avenue, Chicago Sanitary & Ship Canal	01/20/04	3.000	11.0	658
40	Damen Avenue, Chicago Sanitary & Ship Canal	02/17/04	3.000	24.0	756
40	Damen Avenue, Chicago Sanitary & Ship Canal	03/15/04	6.000	14.0	644
40	Damen Avenue, Chicago Sanitary & Ship Canal	04/19/04	7.000	13.0	620
40	Damen Avenue, Chicago Sanitary & Ship Canal	05/17/04	3.000	11.0	414
40	Damen Avenue, Chicago Sanitary & Ship Canal	06/21/04	0.000	18.0	340
40	Damen Avenue, Chicago Sanitary & Ship Canal	07/19/04	3.000	11.0	296
40	Damen Avenue, Chicago Sanitary & Ship Canal	08/16/04	0.000	9.0	262
40	Damen Avenue, Chicago Sanitary & Ship Canal	09/20/04	0.000	11.0	342
40	Damen Avenue, Chicago Sanitary & Ship Canal	10/18/04	0.000	23.0	344
40	Damen Avenue, Chicago Sanitary & Ship Canal	11/15/04	0.000	15.0	424
40	Damen Avenue, Chicago Sanitary & Ship Canal	12/20/04	4.000	15.0	566
41	Harlem Avenue, Chicago Sanitary & Ship Canal	01/20/04	5.000	6.0	776
41	Harlem Avenue, Chicago Sanitary & Ship Canal	02/17/04	6.000	9.0	750
41	Harlem Avenue, Chicago Sanitary & Ship Canal	03/15/04	4.000	8.0	704
41	Harlem Avenue, Chicago Sanitary & Ship Canal	04/19/04	9.000	12.0	662
41	Harlem Avenue, Chicago Sanitary & Ship Canal	05/17/04	3.000	5.0	512
41	Harlem Avenue, Chicago Sanitary & Ship Canal	06/21/04	0.000	12.0	442
41	Harlem Avenue, Chicago Sanitary & Ship Canal	07/19/04	3.000	7.0	404
41	Harlem Avenue, Chicago Sanitary & Ship Canal	08/16/04	5.000	12.0	360
41	Harlem Avenue, Chicago Sanitary & Ship Canal	09/20/04	0.000	8.0	420
41	Harlem Avenue, Chicago Sanitary & Ship Canal	10/18/04	0.000	13.0	418
41	Harlem Avenue, Chicago Sanitary & Ship Canal	11/15/04	0.000	10.0	434
41	Harlem Avenue, Chicago Sanitary & Ship Canal	12/20/04	3.000	0.0	610
	Average Fisk/Crawford Values		2.792	11.5	507
	Max Fisk/Crawford Values		9.000	24.0	776
	Min Fisk/Crawford Values		0.000	0.0	262
	90% value		6.000	17.1	736
	95% value		6.850	22.3	755
	Will County Input:				
42	Route 83, Chicago Sanitary & Ship Canal	01/20/04	4.000	7.0	1124
42	Route 83, Chicago Sanitary & Ship Canal	02/17/04	3.000	7.0	866
42	Route 83, Chicago Sanitary & Ship Canal	03/15/04	3.000	6.0	520
42	Route 83, Chicago Sanitary & Ship Canal	04/19/04	8.000	9.0	728
42	Route 83, Chicago Sanitary & Ship Canal	05/17/04	7.000	5.0	504
42	Route 83, Chicago Sanitary & Ship Canal	06/21/04	0.000	10.0	498
42	Route 83, Chicago Sanitary & Ship Canal	07/19/04	5.000	9.0	476
42	Route 83, Chicago Sanitary & Ship Canal	08/16/04	0.000	10.0	364
42	Route 83, Chicago Sanitary & Ship Canal	09/20/04	4.000	10.0	460
42	Route 83, Chicago Sanitary & Ship Canal	10/18/04	0.000	21.0	430
42	Route 83, Chicago Sanitary & Ship Canal	11/15/04	0.000	14.0	466
42	Route 83, Chicago Sanitary & Ship Canal	12/20/04	0.000	0.0	622

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

WATER QUALITY DATA FOR SELECTED PARAMETERS AND LOCATIONS AT THE CHICAGO RIVER SYSTEM IN 2004

Location Code	Location	Date	BOD_5 (mg/L)[1]	TSS (mg/L)[2]	TDS (mg/L)[3]
48	Stephen Street, Chicago Sanitary & Ship Canal	01/20/04	3.000	10.0	794
48	Stephen Street, Chicago Sanitary & Ship Canal	02/17/04	3.000	9.0	1094
48	Stephen Street, Chicago Sanitary & Ship Canal	03/15/04	3.000	16.0	754
48	Stephen Street, Chicago Sanitary & Ship Canal	04/19/04	10.000	12.0	758
48	Stephen Street, Chicago Sanitary & Ship Canal	05/17/04	0.000	15.0	508
48	Stephen Street, Chicago Sanitary & Ship Canal	06/21/04	0.000	14.0	516
48	Stephen Street, Chicago Sanitary & Ship Canal	07/19/04	0.000	10.0	492
48	Stephen Street, Chicago Sanitary & Ship Canal	08/16/04	0.000	18.0	386
48	Stephen Street, Chicago Sanitary & Ship Canal	09/20/04	0.000	10.0	384
48	Stephen Street, Chicago Sanitary & Ship Canal	10/18/04	0.000	19.0	450
48	Stephen Street, Chicago Sanitary & Ship Canal	11/15/04	0.000	41.0	530
48	Stephen Street, Chicago Sanitary & Ship Canal	12/20/04	3.000	15.0	428
	Average Will County Values		2.333	12.4	590
	Max Will County Values		10.000	41.0	1124
	Min Will County Values		0.000	0.0	364
	90% value		6.400	18.7	844
	95% value		7.850	20.7	1060
	Joliet Input:				
92	Lockport Forebay, Chicago Sanitary & Ship Canal	01/05/04	0.000	11.0	590
92	Lockport Forebay, Chicago Sanitary & Ship Canal	01/12/04	3.000	10.0	1320
92	Lockport Forebay, Chicago Sanitary & Ship Canal	01/20/04	0.000	11.0	840
92	Lockport Forebay, Chicago Sanitary & Ship Canal	01/26/04	6.000	7.0	684
92	Lockport Forebay, Chicago Sanitary & Ship Canal	02/02/04	0.000	7.0	1150
92	Lockport Forebay, Chicago Sanitary & Ship Canal	02/09/04	3.000	9.0	1458
92	Lockport Forebay, Chicago Sanitary & Ship Canal	02/17/04	4.000	10.0	1060
92	Lockport Forebay, Chicago Sanitary & Ship Canal	02/23/04	3.000	13.0	908
92	Lockport Forebay, Chicago Sanitary & Ship Canal	03/01/04	3.000	13.0	964
92	Lockport Forebay, Chicago Sanitary & Ship Canal	03/08/04	4.000	26.0	752
92	Lockport Forebay, Chicago Sanitary & Ship Canal	03/15/04	0.000	29.0	750
92	Lockport Forebay, Chicago Sanitary & Ship Canal	03/22/04	0.000	7.0	802
92	Lockport Forebay, Chicago Sanitary & Ship Canal	03/29/04	5.000	12.0	706
92	Lockport Forebay, Chicago Sanitary & Ship Canal	04/05/04	0.000	8.0	690
92	Lockport Forebay, Chicago Sanitary & Ship Canal	04/12/04	3.000	8.0	736
92	Lockport Forebay, Chicago Sanitary & Ship Canal	04/19/04	5.000	13.0	740
92	Lockport Forebay, Chicago Sanitary & Ship Canal	04/26/04	0.000	16.0	666
92	Lockport Forebay, Chicago Sanitary & Ship Canal	05/03/04	6.000	14.0	532
92	Lockport Forebay, Chicago Sanitary & Ship Canal	05/10/04	0.000	18.0	501
92	Lockport Forebay, Chicago Sanitary & Ship Canal	05/17/04	4.000	11.0	452
92	Lockport Forebay, Chicago Sanitary & Ship Canal	05/24/04	3.000	23.0	560
92	Lockport Forebay, Chicago Sanitary & Ship Canal	06/01/04	ND	24.0	419
92	Lockport Forebay, Chicago Sanitary & Ship Canal	06/07/04	0.000	30.0	654
92	Lockport Forebay, Chicago Sanitary & Ship Canal	06/14/04	4.000	30.0	377
92	Lockport Forebay, Chicago Sanitary & Ship Canal	06/21/04	0.000	13.0	518

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

WATER QUALITY DATA FOR SELECTED PARAMETERS AND LOCATIONS AT THE CHICAGO RIVER SYSTEM IN 2004

Location Code	Location	Date	BOD_5 (mg/L)[1]	TSS (mg/L)[2]	TDS (mg/L)[3]
92	Lockport Forebay, Chicago Sanitary & Ship Canal	06/28/04	0.000	5.0	476
92	Lockport Forebay, Chicago Sanitary & Ship Canal	07/06/04	ND	ND	348
92	Lockport Forebay, Chicago Sanitary & Ship Canal	07/12/04	0.000	13.0	416
92	Lockport Forebay, Chicago Sanitary & Ship Canal	07/19/04	0.000	5.0	504
92	Lockport Forebay, Chicago Sanitary & Ship Canal	07/26/04	3.000	17.0	382
92	Lockport Forebay, Chicago Sanitary & Ship Canal	08/02/04	0.000	18.0	442
92	Lockport Forebay, Chicago Sanitary & Ship Canal	08/09/04	3.000	13.0	418
92	Lockport Forebay, Chicago Sanitary & Ship Canal	08/16/04	0.000	22.0	370
92	Lockport Forebay, Chicago Sanitary & Ship Canal	08/23/04	0.000	10.0	458
92	Lockport Forebay, Chicago Sanitary & Ship Canal	08/30/04	3.000	18.0	308
92	Lockport Forebay, Chicago Sanitary & Ship Canal	09/07/04	0.000	10.0	496
92	Lockport Forebay, Chicago Sanitary & Ship Canal	09/13/04	0.000	14.0	480
92	Lockport Forebay, Chicago Sanitary & Ship Canal	09/20/04	0.000	10.0	376
92	Lockport Forebay, Chicago Sanitary & Ship Canal	09/27/04	0.000	13.0	446
92	Lockport Forebay, Chicago Sanitary & Ship Canal	10/04/04	0.000	19.0	472
92	Lockport Forebay, Chicago Sanitary & Ship Canal	10/11/04	0.000	21.0	517
92	Lockport Forebay, Chicago Sanitary & Ship Canal	10/18/04	0.000	22.0	466
92	Lockport Forebay, Chicago Sanitary & Ship Canal	10/25/04	0.000	23.0	468
92	Lockport Forebay, Chicago Sanitary & Ship Canal	11/01/04	0.000	15.0	496
92	Lockport Forebay, Chicago Sanitary & Ship Canal	11/08/04	3.000	12.0	399
92	Lockport Forebay, Chicago Sanitary & Ship Canal	11/15/04	0.000	16.0	526
92	Lockport Forebay, Chicago Sanitary & Ship Canal	11/22/04	0.000	9.0	610
92	Lockport Forebay, Chicago Sanitary & Ship Canal	11/29/04	0.000	10.0	603
92	Lockport Forebay, Chicago Sanitary & Ship Canal	12/06/04	0.000	15.0	442
92	Lockport Forebay, Chicago Sanitary & Ship Canal	12/13/04	4.000	14.0	552
92	Lockport Forebay, Chicago Sanitary & Ship Canal	12/20/04	3.000	7.0	404
92	Lockport Forebay, Chicago Sanitary & Ship Canal	12/27/04	0.000	20.0	602
	Average Joliet Values		1.500	14.6	602
	Max Joliet Values (Max TSS Used from USGS data. Not Available		6.000	30.0	1458
	Min Joliet Values		0.000	5.0	308
	90% value		3.000	21.7	587
	95% value		3.000	22.0	603

[1]Biochemical Oxygen Demand

[2]Total Suspended Solids

[3]Total Dissolved Solids

ND = No Data

EXHIBIT G

Cooling Tower Blowdown, Evaporation and Make-Up Water Data

Average Summer Water Usage – Closed-Cycle

Station	Evaporation (gpm)	Makeup (gpm)	Blowdown (gpm)
Fisk 19	2608	3261	652
Crawford 7&8	4776	5972	1194
Will County 3&4	6834	8546	1709
Joliet 6	3006	3759	752
Joliet 7&8	11888	14865	2972

Average Winter Water Usage – Closed-Cycle

Station	Evaporation (gpm)	Makeup (gpm)	Blowdown (gpm)
Fisk 19	1708	2136	427
Crawford 7&8	3082	3855	771
Will County 3&4	4430	5541	1108
Joliet 6	1914	2394	479
Joliet 7&8	7788	9740	1947

Station	Average Annual Makeup (Mgal/yr) – Closed-Cycle
Fisk 19	1418
Crawford 7&8	2582
Will County 3&4	3702
Joliet 6	1617
Joliet 7&8	6466

Note: The total annual fresh water makeup (Mgal/yr) is bounded by the winter and summer values. Averaging the winter and summer values is a reasonable approximation for annual average.

EXHIBIT H

Cooling Tower Blowdown Temperature Data

Fisk:

Based on the SPX/Marley wet/dry cooling tower design data tabulated in Exhibit C, the temperature of the cooling tower blowdown from the Fisk 19 cooling system under summer design conditions would be as shown in Table H-1:

Table H-1
Fisk 19 Cooling Tower Blowdown Temperatures at B/D Flowrate = 652 gpm
Towers Designed for 7 F Approach at 78 F Wet Bulb

Month	1% WB Temp (F)	Blowdown Temperature (F)	UAA Proposed Average ALU B Temp Limits (F)
January	47.5	63.9	54.3
February	50.1	65.6	53.6
March	60.9	72.5	57.2
April	65.3	76	60.8/62.1
May	72.1	80.9	69.2/71.4
June	76.2	83.8	74.2/86.7
July	79.5	86	86.7
August	78.5	85.5	86.7
September	74.6	82.5	86.7/77
October	66.3	76.5	73.2/69.6
November	60.7	72.5	66.2
December	56.3	69.5	59.9
Maximum Temperature, Any Month			90.3

Crawford:

Based on the SPX/Marley wet/dry cooling tower design data tabulated in Exhibit C, the temperature of the cooling tower blowdown from the Crawford 7&8 cooling system under summer design conditions would be as shown in Table H-2:

Table H-2
Crawford 7&8 Cooling Tower Blowdown Temperatures at B/D Flowrate = 1194 gpm
Towers Designed for 7 F Approach at 78 F Wet Bulb

Month	1% WB Temp (F)	Cooling Tower Blowdown Temperature (F)	UAA Proposed Average ALU B Temp Limits (F)
January	47.5	63.8	54.3
February	50.1	65.5	53.6
March	60.9	72.8	57.2
April	65.3	75.9	60.8/62.1
May	72.1	80.8	69.2/71.4
June	76.2	83.7	74.2/86.7
July	79.5	86.1	86.7
August	78.5	85.5	86.7
September	74.6	82.3	86.7/77
October	66.3	76.1	73.2/69.6
November	60.7	72.8	66.2
December	56.3	69.8	59.9
Maximum Temperature, Any Month			90.3

Will County:

Based on the SPX/Marley wet/dry cooling tower design data tabulated in Exhibit C, the temperature of the cooling tower blowdown from the Will County 3&4 cooling system under summer design conditions would be as shown in Table H-3:

Table H-3
Will County 3&4 Cooling Tower Blowdown Temperatures at B/D Flowrate = 1709 gpm
Towers Designed for 7 F Approach at 78 F Wet Bulb

Month	1% WB Temp (F)	Cooling Tower Blowdown Temperature (F)	UAA Proposed Average ALU B Temp Limits (F)
January	47.5	63.5	54.3
February	50.1	64.6	53.6
March	60.9	72.6	57.2
April	65.3	75.7	60.8/62.1
May	72.1	80.6	69.2/71.4
June	76.2	83.6	74.2/86.7
July	79.5	86.1	86.7
August	78.5	85.5	86.7
September	74.6	82.5	86.7/77
October	66.3	76.4	73.2/69.6
November	60.7	72.5	66.2
December	56.3	65.5	59.9
Maximum Temperature, Any Month			90.3

Joliet 6:

Based on the SPX/Marley wet/dry cooling tower design data tabulated in Exhibit C, the temperature of the cooling tower blowdown from the Joliet 6 cooling system under summer design conditions would be as shown in Table H-4:

Table H-4
Joliet 6 Cooling Tower Blowdown Temperatures at B/D Flowrate = 752 gpm
Towers Designed for 7 F Approach at 78 F Wet Bulb

Month	1% WB Temp (F)	Cooling Tower Blowdown Temperature (F)	UAA Proposed UDIP Temp Limits (F)
January	47.5	63	54.3
February	50.1	64.8	53.6
March	60.9	72	57.2
April	65.3	75.5	60.8/62.1
May	72.1	80.5	69.2/71.4
June	76.2	83.8	74.2/86.7
July	79.5	86	85.1
August	78.5	85.5	85.1
September	74.6	82.3	85.1/77
October	66.3	76.1	73.2/69.6
November	60.7	72	66.2
December	56.3	69	59.9
Maximum Temperature, Any Month			88.7

Joliet 7&8:

Based on the SPX/Marley wet/dry cooling tower design data tabulated in Exhibit C, the temperature of the cooling tower blowdown from the Joliet 7&8 cooling system under summer design conditions would be as shown in Table H-5:

Table H-5
Joliet 7&8 Cooling Tower Blowdown Temperatures at B/D Flowrate = 2972 gpm
Towers Designed for 7 F Approach at 78 F Wet Bulb

Month	1% WB Temp (F)	Cooling Tower Blowdown Temperature (F)	IEPA UDIP Temp Limits (F)
January	47.5	63.8	54.3
February	50.1	65.1	53.6
March	60.9	72.3	57.2
April	65.3	75.5	60.8/62.1
May	72.1	80.5	69.2/71.4
June	76.2	83.8	74.2/86.7
July	79.5	86.1	85.1
August	78.5	85.5	85.1
September	74.6	82.5	85.1/77
October	66.3	76.5	73.2/69.6
November	60.7	72.2	66.2
December	56.3	69.5	59.9
Maximum Temperature, Any Month			90.3

EXHIBIT I

Capital Cost Estimates

Estimate No.: 21870D
Project No.: 10683-130
Issue Date: 1/14/11
Preparer: JMK
Reviewer: RK

Exhibit I1

Sargent Lundy

Fisk 19

Wet/Dry Cooling Towers

Conceptual Cost Estimate

Item No.	Description	Equipment & Material Cost	Labor Cost	Total Cost
1	COOLING TOWER - WET / DRY	13,271,040	6,082,560	19,353,600
2	COOLING TOWER SUPPLY PUMPS	1,613,520	541,200	2,154,720
3	COOLING TOWER DISCHARGE PUMPS	909,060	204,180	1,113,240
4	YARD PIPING	2,166,000	2,642,640	4,808,640
5		0	0	0
6	BLOWDOWN PUMPS	0	0	NOT REQUIRED
7	BLOWDOWN PIPING	35,090	37,510	72,600
8	MAKEUP PUMPS	0	0	NOT REQUIRED
9	MAKEUP PIPING	0	0	NOT REQUIRED
10	WATER TREATMENT	1,614,600	2,127,840	3,742,440
11	OPEN	0	0	0
20	SITEWORK	0	764,750	764,750
21	CONSTRUCTABILITY ACTIVITIES	0	1,529,500	1,529,500
22	COOLING TOWER BASINS	750,070	1,965,540	2,715,610
23	CT SUPPLY PUMP STRUCTURE AND BASIN	797,040	2,122,130	2,919,170
24	CT DISCHARGE PUMP STRUCTURE AND BASIN	791,640	2,166,600	2,958,240
25	NEW GATE IN EXISTING CW DISCHARGE PIPE	663,000	774,700	1,437,700
26	TIE-IN CT DISCHARGE PIPING	19,720	103,600	123,320
27	MODIFY CRIBHOUSE FOR CT DISCHARGE PIPING	111,360	424,200	535,560
28	FOUNDATIONS FOR NEW CLARIFIERS AND MU WT PLANT	80,040	348,600	428,640
29	NEW MU WT BUILDING	1,173,920	973,000	2,146,920
30	CW PIPE SLEEPERS	419,920	2,072,000	2,491,920
31	MISCELLANEOUS STRUCTURES AND FOUNDATIONS	208,800	715,400	924,200
32	DEMOLISH OLD OIL/WATER SEPARATOR BLDG	0	89,600	89,600
33	DEMOLISH OLD METAL CLEANING TANK	0	89,600	89,600
34	DEMOLISH EXISTING MUW FACILITY	0	361,200	361,200
41	AUXILIARY POWER SYSTEM FOR CT	3,417,120	3,408,790	6,825,910
42	DCS INTEGRATON	186,840	27,930	214,770
43	REPLACE ACTIVE EQUIPMENT IN DEMOLISHED OLD SWITCH-HOUSE NO. 1	2,484,000	11,910,090	14,394,090
44	BOP INSTRUMENTATION	37,800	14,630	52,430
51	CLEANUP ALLOWANCE	0	305,900	305,900
52	WASTE DISPOSAL	0	152,950	152,950
53	MOBILIZE / DEMOBILIZE	524,458	2,097,832	2,622,290

Estimate No.: 21870D
Project No.: 10683-130
Issue Date: 1/14/11
Preparer: JMK
Reviewer: RK

Exhibit I1

Fisk 19

Wet/Dry Cooling Towers

Conceptual Cost Estimate

Sargent Lundy

Item No.	Description	Equipment & Material Cost	Labor Cost	Total Cost
54	EQUIPMENT RENTAL SUPPLEMENT, LARGE CRANES	0	1,101,362	1,101,362
	Total Equipment, Material and Labor Costs	**31,275,038**	**45,155,834**	**76,430,872**
	Consumables	156,375	0	156,375
	Freight-ExWorks To Site	720,160	0	720,160
	Taxes - Sales	**0**	**0**	0
	Contractor's General and Administration Expense	1,563,752	2,257,792	3,821,544
	Contractor's Profit	3,127,504	4,515,583	7,643,087
	Total Direct Project Costs	**36,842,829**	**51,929,209**	**88,772,038**
	Indirect Project Costs			
	Engineering			16,310,528
	Construction Management/Field Engineering			INCL. IN ENGR.
	Permitting			0
	Startup, testing			467,943
	Owner's cost			0
	Spare parts			1,529,000
	Subtotal			**107,079,509**
	EPC Differential			8,566,000
	Project Contingency			21,415,902
	Total Construction Cost			**137,061,411**

Estimate No.: 21871D
Project No.: 10683-130
Issue Date: 1/14/11
Preparer: JMK
Reviewer: RK

Exhibit I2

Crawford 7 & 8

Wet/Dry Cooling Towers

Conceptual Cost Estimate

Sargent & Lundy

Item No.	Description	Equipment & Material Cost	Labor Cost	Total Cost
1	COOLING TOWER - WET / DRY	24,883,200	11,404,800	36,288,000
2	COOLING TOWER SUPPLY PUMPS	3,040,200	859,770	3,899,970
3	COOLING TOWER DISCHARGE PUMPS	674,710	157,440	832,150
4	YARD PIPING	4,652,400	5,740,240	10,392,640
5		0	0	0
6	BLOWDOWN PUMPS	0	0	NOT REQUIRED
7	BLOWDOWN PIPING	35,090	37,510	72,600
8	MAKEUP PUMPS	0	0	NOT REQUIRED
9	MAKEUP PIPING	0	0	NOT REQUIRED
10	WATER TREATMENT	322,920	303,800	626,720
11	WASTE WATER TREATMENT	0	0	NOT REQUIRED
19	SITEWORK	0	917,700	917,700
20	CONSTRUCTABILITY ACTIVITIES	0	1,529,500	1,529,500
21	OPEN	0	0	0
22	COOLING TOWER BASINS	1,647,800	4,575,450	6,223,250
23	CT SUPPLY PUMP STRUCTURE AND BASIN	221,400	1,075,450	1,296,850
24	CT DISCHARGE PUMP STRUCTURE AND BASIN	478,440	2,517,120	2,995,560
25	DISCHARGE STRUCTURE TO EXISTING CW DISCHARGE CHANNEL	32,860	105,820	138,680
26	NEW WALL AND GATE IN EXISTING CW DISCHARGE CHANNEL	614,900	419,100	1,034,000
27	DISCHARGE STRUCTURE TO EXISTING CW INLET CHANNEL	38,280	109,200	147,480
28	NEW WALL AND GATE ACROSS MOUTH OF EXISTING INTAKE CHANNEL	768,200	610,560	1,378,760
29	CW PIPE BRIDGE AND SLEEPERS	1,086,920	2,770,600	3,857,520
31	MISCELLANEOUS STRUCTURES AND FOUNDATIONS	208,800	715,400	924,200
32	DEMOLISH OLD SWITCHYARD STRUCTURE	0	180,600	180,600
33	DEMOLISH PEAKER UNITS	0	0	0
34	DEMOLISH LOCOMOTIVE MAINTENANCE BLDG	0	193,200	193,200
35	RELOCATE PART OF THE COAL PILE	0	89,600	89,600
36	TRANSMISSION LINE MODIFICATIONS	248,400	611,800	860,200
41	AUXILIARY POWER SYSTEM FOR CT	5,762,880	5,764,220	11,527,100
42	DCS INTEGRATON	185,760	29,260	215,020
44	BOP INSTRUMENTATION	49,680	22,610	72,290
51	CLEANUP ALLOWANCE	0	305,900	305,900
52	WASTE DISPOSAL	0	152,950	152,950

Estimate No.: 21871D
Project No.: 10683-130
Issue Date: 1/14/11
Preparer: JMK
Reviewer: RK

Exhibit I2

Crawford 7 & 8

Wet/Dry Cooling Towers

Conceptual Cost Estimate

Sargent & Lundy

Item No.	Description	Equipment & Material Cost	Labor Cost	Total Cost
53	MOBILIZE / DEMOBILIZE	514,995	2,059,980	2,574,975
54	EQUIPMENT RENTAL SUPPLEMENT, LARGE CRANES	0	1,081,490	1,081,490
	Total Equipment, Material and Labor Costs	**45,467,835**	**44,341,070**	**89,808,905**
	Consumables	227,339	0	227,339
	Freight-ExWorks To Site	823,385	0	823,385
	Taxes - Sales	0	0	0
	Contractor's General and Administration Expense	2,273,392	2,217,053	4,490,445
	Contractor's Profit	4,546,784	4,434,107	8,980,890
	Total Direct Project Costs	**53,338,735**	**50,992,230**	**104,330,965**
	Indirect Project Costs			
	Engineering			22,497,280
	Construction Management/Field Engineering			INCL. IN ENGR.
	Permitting			0
	Startup, testing			467,943
	Owner's cost			0
	Spare parts			1,796,000
	Subtotal			**129,092,188**
	EPC Differential			10,327,000
	Project Contingency			25,818,438
	Total Construction Cost			**165,237,626**

Estimate No.: 21873D
Project No.: 10683-130
Issue Date: 1/14/11
Preparer: JMK
Reviewer: RK

Exhibit I3

Will County 3 & 4

Wet/Dry Cooling Towers

Sargent & Lundy

Item No.	Description	Equipment & Material Cost	Labor Cost	Total Cost
1	COOLING TOWER - WET / DRY	33,177,600	15,206,400	48,384,000
2	COOLING TOWER SUPPLY PUMPS	3,942,000	947,100	4,889,100
3	COOLING TOWER DISCHARGE PUMPS	2,027,400	319,800	2,347,200
4	YARD PIPING	9,240,000	11,253,000	20,493,000
5		0	0	0
6	BLOWDOWN PUMPS	0	0	NOT REQUIRED
7	BLOWDOWN PIPING	35,090	37,510	72,600
8	MAKEUP PUMPS	0	0	NOT REQUIRED
9	MAKEUP PIPING	0	0	NOT REQUIRED
10	WATER TREATMENT	216,000	198,400	414,400
11	WASTE WATER TREATMENT	0	0	NOT REQUIRED
20	SITEWORK	0	3,059,000	3,059,000
21	CONSTRUCTABILITY ACTIVITIES	0	764,750	764,750
22	COOLING TOWER BASINS	3,413,300	6,316,800	9,730,100
23	CT SUPPLY PUMP STRUCTURE AND BASIN	259,200	1,109,700	1,368,900
24	CT DISCHARGE PUMP STRUCTURE AND BASIN	1,032,480	4,927,980	5,960,460
25	DISCHARGE STRUCTURE TO EXISTING CW DISCHARGE CHANNEL	165,360	391,820	557,180
26	NEW WALL AND GATE IN EXISTING CW DISCHARGE CHANNEL	614,900	628,650	1,243,550
27	MODIFY CRIB HOUSES	133,400	338,800	472,200
28	FILL ABANDONED POND	0	292,600	292,600
29	BRIDGE SYSTEM FOR CW PIPING	1,708,680	3,936,800	5,645,480
30	CW PIPE SLEEPERS	1,202,920	5,924,800	7,127,720
31	MISCELLANEOUS STRUCTURES AND FOUNDATIONS	605,520	2,489,200	3,094,720
32	RELOCATE TRANSMISSION LINES	496,800	1,529,500	2,026,300
33	OPEN	0	0	0
34	OPEN	0	0	0
41	AUXILIARY POWER SYSTEM FOR CT	9,007,200	14,310,800	23,318,000
42	DCS INTEGRATON	185,760	29,260	215,020
44	BOP INSTRUMENTATION	37,800	14,630	52,430
51	CLEANUP ALLOWANCE	0	305,900	305,900
52	WASTE DISPOSAL	0	152,950	152,950
53	MOBILIZE / DEMOBILIZE	931,077	3,724,308	4,655,384
54	EQUIPMENT RENTAL SUPPLEMENT, LARGE CRANES	0	1,955,261	1,955,261

Estimate No.: 21873D
Project No.: 10683-130
Issue Date: 1/14/11
Preparer: JMK
Reviewer: RK

Exhibit I3

Sargent & Lundy

Will County 3 & 4

Wet/Dry Cooling Towers

Item No.	Description	Equipment & Material Cost	Labor Cost	Total Cost
	Total Equipment, Material and Labor Costs	**68,432,487**	**80,165,719**	**148,598,206**
	Consumables	342,162	0	342,162
	Freight-ExWorks To Site	1,410,195	0	1,410,195
	Taxes - Sales	0	0	0
	Contractor's General and Administration Expense	3,421,624	4,008,286	7,429,910
	Contractor's Profit	6,843,249	8,016,572	14,859,821
	Total Direct Project Costs	**80,449,718**	**92,190,577**	**172,640,295**
	Indirect Project Costs			
	Engineering			24,747,008
	Construction Management/Field Engineering			INCL. IN ENGR.
	Permitting			0
	Startup, testing			467,943
	Owner's cost			0
	Spare parts			2,972,000
	Subtotal			**200,827,246**
	EPC Differential			16,066,000
	Project Contingency			40,165,449
	Total Construction Cost			**257,058,695**

Estimate No.: 21874D
Project No.: 10683-130
Issue Date: 1/14/11
Preparer: JMK
Reviewer: RK

Exhibit I4

Sargent & Lundy

Joliet 6

Wet/Dry Cooling Towers

Conceptual Cost Estimate

Item No.	Description	Equipment & Material Cost	Labor Cost	Total Cost
1	COOLING TOWER- WET / DRY	14,929,920	6,842,880	21,772,800
2	COOLING TOWER SUPPLY PUMPS	2,705,400	751,530	3,456,930
3	COOLING TOWER DISCHARGE PUMPS	1,014,790	205,410	1,220,200
4	YARD PIPING	3,258,000	3,798,190	7,056,190
5		0	0	0
6	BLOWDOWN PUMPS	0	0	NOT REQUIRED
7	BLOWDOWN PIPING	35,090	35,090	70,180
8	MAKEUP PUMPS	0	0	NOT REQUIRED
9	MAKEUP PIPING	0	0	NOT REQUIRED
10	WATER TREATMENT	0	0	NOT REQUIRED
11	WASTE WATER TREATMENT	0	0	NOT REQUIRED
20	SITEWORK INCL FLOOD PLAIN WORK	919,080	1,098,580	2,017,660
21	CONSTRUCTABILITY ACTIVITIES	0	764,750	764,750
22	COOLING TOWER BASINS	1,178,070	2,487,240	3,665,310
23	CT SUPPLY PUMP STRUCTURE AND BASIN	157,680	790,490	948,170
24	CT DISCHARGE PUMP STRUCTURE AND BASIN	333,720	1,489,020	1,822,740
25	DISCHARGE STRUCTURE TO EXISTING CW DISCHARGE CHANNEL	72,080	188,760	260,840
26	NEW WALL AND GATE IN EXISTING CW DISCHARGE CHANNEL	612,300	541,020	1,153,320
27	NEW WALL IN SANITARY CANAL AROUND EXISTING CRIBHOUSE WITH GATES	550,450	689,110	1,239,560
28	BRIDGE SYSTEM FOR CW PIPE	40,600	226,800	267,400
29	CW PIPE SLEEPERS	440,800	1,050,000	1,490,800
31	MISCELLANEOUS STRUCTURES AND FOUNDATIONS	393,240	1,365,000	1,758,240
32	DEMOLISH	0	0	0
33	OPEN	0	0	0
41	AUXILIARY POWER SYSTEM FOR CT	3,321,000	5,724,320	9,045,320
42	DCS INTEGRATON	186,840	29,260	216,100
44	BOP INSTRUMENTATION	37,800	14,630	52,430
51	CLEANUP ALLOWANCE	0	305,900	305,900
52	WASTE DISPOSAL	0	152,950	152,950
53	MOBILIZE / DEMOBILIZE	356,887	1,427,547	1,784,433
54	EQUIPMENT RENTAL SUPPLEMENT, LARGE CRANES	0	749,462	749,462

Estimate No.: 21874D
Project No.: 10683-130
Issue Date: 1/14/11
Preparer: JMK
Reviewer: RK

Exhibit I4

Joliet 6

Wet/Dry Cooling Towers

Conceptual Cost Estimate

Sargent & Lundy

Item No.	Description	Equipment & Material Cost	Labor Cost	Total Cost
	Total Equipment, Material and Labor Costs	**30,543,747**	**30,727,938**	**61,271,685**
	Consumables	152,719	0	152,719
	Freight-ExWorks To Site	624,553	0	624,553
	Taxes - Sales	0	0	0
	Contractor's General and Administration Expense	1,527,187	1,536,397	3,063,584
	Contractor's Profit	3,054,375	3,072,794	6,127,169
	Total Direct Project Costs	**35,902,580**	**35,337,129**	**71,239,710**
	Indirect Project Costs			
	Engineering			17,435,392
	Construction Management/Field Engineering			INCL. IN ENGR.
	Permitting			0
	Startup, testing			467,943
	Owner's cost			0
	Spare parts			1,225,000
	Subtotal			**90,368,045**
	EPC Differential			7,229,000
	Project Contingency			18,073,609
	Total Construction Cost			**115,670,654**

Estimate No.: 21875D
Project No.: 10683-130
Issue Date: 1/14/11
Preparer: JMK
Reviewer: RK

Exhibit I5

Joliet 7 & 8

Wet/Dry Cooling Towers

Conceptual Cost Estimate

Sargent & Lundy

Item No.	Description	Equipment & Material Cost	Labor Cost	Total Cost
1	COOLING TOWER - WET / DRY	53,084,160	24,330,240	77,414,400
2	COOLING TOWER SUPPLY PUMPS	6,046,000	1,293,000	7,339,000
3	COOLING TOWER DISCHARGE PUMPS	2,391,000	326,000	2,717,000
4	YARD PIPING	9,855,000	6,464,000	16,319,000
5		0	0	0
6	BLOWDOWN PUMPS	0	0	NOT REQUIRED
7	BLOWDOWN PIPING	35,000	35,000	70,000
8	MAKEUP PUMPS	0	0	NOT REQUIRED
9	MAKEUP PIPING	0	0	NOT REQUIRED
10	WATER TREATMENT	323,000	283,000	606,000
11	WASTE WATER TREATMENT	0	0	NOT REQUIRED
20	SITEWORK	0	3,059,000	3,059,000
21	CONSTRUCTABILITY ACTIVITIES	0	1,529,500	1,529,500
22	COOLING TOWER BASINS	4,292,000	9,019,000	13,311,000
23	CT SUPPLY PUMP STRUCTURE AND BASIN	357,000	1,341,000	1,698,000
24	CT DISCHARGE PUMP STRUCTURE AND BASIN	414,000	1,857,000	2,271,000
25	DISCHARGE STRUCTURE TO EXISTING DISCHARGE TUNNEL	220,000	392,000	612,000
26	NEW WALL AND GATE IN EXISTING DISCHARGE CHANNEL	1,344,000	1,738,000	3,082,000
27	NEW CHANNEL AND GATE ACROSS MOUTH OF EXISTING INLET AND DISCHARGE CHANNEL	849,000	1,629,000	2,478,000
28	NEW 2ND CHANNEL AND GATE ACROSS MOUTH OF EXISTING INLET AND DISCHARGE CHANNEL	802,000	756,000	1,558,000
29	CW PIPE EARTHWORK	0	492,100	492,100
31	MISCELLANEOUS STRUCTURES AND FOUNDATIONS	737,000	2,584,000	3,321,000
32	OPEN	0	0	0
33	OPEN	0	0	0
41	AUXILIARY POWER SYSTEM FOR CT	13,460,040	20,418,160	33,878,200
42	DCS INTEGRATON	185,760	29,260	215,020
44	BOP INSTRUMENTATION	37,800	14,630	52,430
51	CLEANUP ALLOWANCE	0	305,900	305,900
52	WASTE DISPOSAL		152,950	152,950
53	MOBILIZE / DEMOBILIZE	975,609	3,902,437	4,878,046
54	EQUIPMENT RENTAL SUPPLEMENT, LARGE CRANES	0	2,048,779	2,048,779

Estimate No.: 21875D
Project No.: 10683-130
Issue Date: 1/14/11
Preparer: JMK
Reviewer: RK

Exhibit I5

Joliet 7 & 8

Wet/Dry Cooling Towers

Conceptual Cost Estimate

Sargent & Lundy

Item No.	Description	Equipment & Material Cost	Labor Cost	Total Cost
	Total Equipment, Material and Labor Costs	**95,408,369**	**83,999,956**	**179,408,326**
	Consumables	477,042	0	477,042
	Freight-ExWorks To Site	1,692,968	0	1,692,968
	Taxes - Sales	0	0	0
	Contractor's General and Administration Expense	4,770,418	4,199,998	8,970,416
	Contractor's Profit	9,540,837	8,399,996	17,940,833
	Total Direct Project Costs	**111,889,635**	**96,599,950**	**208,489,585**
	Indirect Project Costs			
	Engineering			22,497,280
	Construction Management/Field Engineering			INCL. IN ENGR.
	Permitting			0
	Startup, testing			467,943
	Owner's cost			0
	Spare parts			3,588,000
	Subtotal			**235,042,808**
	EPC Differential			18,803,000
	Project Contingency			47,009,000
	Total Construction Cost			**300,854,808**

EXHIBIT J

Operation and Maintenance Cost Estimates

Sargent & Lundy LLC

Midwest Generation

Project No. 10683-130

Cooling Tower Operations & Maintenance Costs

	Fisk 19	Crawford 7&8	Will County 3&4 Plume Abated	Will County 3&4 Wet Tower	Joliet 6 Plume Abated	Joliet 6 Wet Tower	Joliet 7&8 Plume Abated	Joliet 7&8 Wet Tower
Total Gross MW of Site	348	585	832	832	341	341	1,138	1,138
Approach, F	7	7	7	7	7	7	7	7
Capacity Factor	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Aux Power Cost $/MWh	$37	$37	$37	$37	$37	$37	$37	$37
No of CT Cells	16	30	40	40	18	16	64	60
Fan BHP	250	250	250	250	250	250	250	250
CT MWh/yr	21,287	39,913	53,217	53,217	23,948	21,287	85,147	79,826
CT Power Cost	$781,438	$1,465,197	$1,953,596	$1,953,596	$879,118	$781,438	$3,125,754	$2,930,394
No of Supply Pumps	2	4	4	4	4	4	6	6
Supply Pump BHP	2,000	2,000	3,000	3,000	1,500	1,250	3,500	3,000
Supply Pump MWh/yr	21,287	42,574	63,860	63,860	31,930	26,609	111,756	95,791
Supply Pump Power Cost	$781,438	$1,562,877	$2,344,315	$2,344,315	$1,172,158	$976,798	$4,102,552	$3,516,473
No of Discharge Pumps	4	4	2	2	4	4	6	6
Discharge Pump BHP	200	300	500	500	250	250	400	400
Discharge Pump MWh/yr	4,257	6,386	5,322	5,322	5,322	5,322	12,772	12,772
Discharge Pump Power Cost	$156,288	$234,432	$195,360	$195,360	$195,360	$195,360	$468,863	$468,863
No of Discharge Pumps			4	4				
Discharge Pump BHP			350	300				
Discharge Pump MWh/yr			7,450	6,386				
Discharge Pump Power Cost			$273,503	$234,432				
Total MWh/yr	46,831	88,872	129,849	128,785	61,200	53,217	209,675	188,388
Total Pump Power Cost per year	$937,726	$1,797,308	$2,813,178	$2,774,106	$1,367,517	$1,172,158	$4,571,415	$3,985,336
Total Power Cost per year	$1,719,165	$3,262,505	$4,766,774	$4,727,702	$2,246,635	$1,953,596	$7,697,169	$6,915,730
Inspection $/cell	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
Total Cell Inspection Cost / year	$48,000	$90,000	$120,000	$120,000	$54,000	$48,000	$192,000	$180,000
Annual Cell Inspection and Pump Maintenance $/yr.	$60,000	$112,500	$150,000	$150,000	$67,500	$60,000	$240,000	$225,000
CW Treatment Chemicals $/MW/yr	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Total CW Treatment Chemicals $/yr.	$348,000	$585,000	$832,000	$832,000	$341,000	$341,000	$1,138,000	$1,138,000
Total O&M Costs ($/year)	$2,127,165	$3,960,005	$5,748,774	$5,709,702	$2,655,135	$2,354,596	$9,075,169	$8,278,730

EXHIBIT I

AUGUST 4, 2008 JULIA WOZNIAK PRE-FILED TESTIMONY UAA RULEMAKING R08-9(C)

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
WATER QUALITY STANDARDS AND	)	R08-9
EFFLUENT LIMITATIONS FOR THE	)	(Rulemaking – Water)
CHICAGO AREA WATERWAY SYSTEM	)	
AND LOWER DES PLAINES RIVER	)	
PROPOSED AMENDMENTS TO 35 ILL.	)	
ADM. CODE 301, 302, 303, and 304	)	

NOTICE OF FILING

TO:

John Therriault, Clerk
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph Street, Suite 11-500
Chicago, IL 60601

Marie Tipsord, Hearing Officer
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph Street, Suite 11-500
Chicago, IL 60601

Deborah J. Williams, Assistant Counsel
Stefanie N. Diers, Assistant Counsel
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

Persons included on the attached
SERVICE LIST

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Pollution Control Board PRE-FILED TESTIMONY OF JULIA WOZNIAK, by Midwest Generation, a copy of which is herewith served upon you.

MIDWEST GENERATION, L.L.C.

____

Susan M. Franzetti

Date: August 4, 2008

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CERTIFICATE OF SERVICE

I, the undersigned, certify that on this 4th day of August, 2008, I have served electronically the attached PRE-FILED TESTIMONY OF JULIA WOZNIAK, by Midwest Generation, and NOTICE OF FILING upon the following persons:

John Therriault, Clerk
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph Street, Suite 11-500
Chicago, IL 60601

and by U.S. Mail, first class postage prepaid, to the following persons:

Marie Tipsord, Hearing Officer
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph Street, Suite 11-500
Chicago, IL 60601

Deborah J. Williams, Assistant Counsel
Stefanie N. Diers, Assistant Counsel
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The participants listed on the attached
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SERVICE LIST

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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
WATER QUALITY STANDARDS AND	)	
EFFLUENT LIMITATIONS FOR THE	)	R08-9
CHICAGO AREA WATERWAY SYSTEM	)	(Rulemaking - Water)
AND THE LOWER DES PLAINES RIVER:	)	
PROPOSED AMENDMENTS TO 35 Ill.	)	
Adm. Code Parts 301, 302, 303 and 304	)	

PRE-FILED TESTIMONY OF JULIA WOZNIAK

Good morning, my name is Julia Wozniak. I am currently employed as an Environmental Project Manager with Midwest Generation ("MWGen" or "Midwest Generation"). I have worked in the electric power industry since 1982. I have been employed by MWGen since December 1999, and prior to that time, its corporate predecessor, Commonwealth Edison ("ComEd"). My career began with ComEd in the Nuclear Technical Services Group (from 1982 to 1984), and then as a biologist with ComEd and MWGen (from 1984 to present). I have a Bachelor of Science in Environmental Sciences from the University of Illinois.

For the past 24 years (8 years with MWGen and 16 years with ComEd), I have been directly involved in overseeing, coordinating and implementing water quality related biological and physicochemical monitoring and analytical sampling activities for all Midwest Generation facilities, modeling the complex thermo-hydrodynamics of power plant and waterway interactions, and participating actively in state and federal policy and rulemakings. I am responsible for overseeing thermal compliance monitoring and developing and running complex models that are used to optimize station loads during critical generation periods, while maintaining environmental compliance.

My testimony will focus on the following areas: (1) providing an overview of MWGen's generating stations along the Chicago Area Waterways (CAWS) and the Lower Des Plaines River ("LDP"), (2) describing the existing thermal water quality standards applicable to MWGen, (3) describing the procedures used by MWGen to achieve compliance with existing thermal water quality standards, and (4) describing MWGen's active involvement in the public participation process related to the Illinois Environmental Protection Agency's ("IEPA") Proposed UAA Rules.

Midwest Generation's UIW Stations

MWGen is an independent power producer that owns and operates seven electric generating stations in Illinois and one in western Pennsylvania. MWGen has the generating capacity to provide electricity to more than eight million households. As depicted on Attachment 1, Five of MWGen's stations (Fisk, Crawford, Will County, Joliet 6 and Joliet 7&8) are located along and discharge heated water into the Upper Illinois Waterway ("UIW"), although only the Fisk, Crawford, and Will County stations are located along the CAWS. With the exception of Joliet 7&8, which began operations in 1966, the other stations have been in operation since the mid- to late-1950s. Collectively, these five facilities employ over 600 individuals and have a generating capacity of a little over 3,500 gross megawatts of electricity.

<u>MWGen Chicago Area Waterway Facilities</u>

The generating units at each of MWGen's CAWS Stations are coal-fired, and each utilizes an open cycle, once-through condenser cooling system. The MWGen Stations are steam-electric generating process that require the use of large volumes of surface water. For open cycle, once-through cooling, water from a lake, river or canal enters the plant, is circulated through the station's condensers to cool steam produced by the electric generating process, and then is discharged directly back into the same receiving waterbody from which it was taken at a higher temperature. The Fisk station is located on the South Branch of the Chicago River near downtown Chicago, just upstream of the South Fork and the confluence with the Chicago Sanitary and Ship Canal ("CSSC") at River Mile 322. Fisk is a one-unit steam electric generating facility capable of producing 342 megawatts of electricity, with a design circulating water flow rate of approximately 324 million gallons per day ("MGD"). The Crawford station is located in Chicago near the intersection of the Stevenson Expressway and Pulaski Avenue at River Mile 318.5 on the CSSC. Crawford is a two-unit steam electric generating facility which is capable of producing 581 megawatts of electricity, with a design circulating flow rate of approximately 585 MGD. The Will County station is located in Romeoville at River Mile 295.5, and is a four-unit steam electric facility with a 1154 megawatt capacity and a design circulating water flow rate of approximately 1292 MGD.

The three CAWS facilities (Fisk, Crawford and Will) are designed and operated with open-cycle, once through cooling system technology, and engineered so that the maximum temperature rise for cooling water discharge is 12.2°F, 12.0°F, and 11.1°F, respectively. In contrast to the Joliet stations, none of the CAWS located stations is equipped with cooling towers.

MWGen Lower Des Plaines River Facilities (a/k/a "Joliet Facilities")

MWGen's Joliet Facilities, located in Will County, consist of two separate generating stations, (1) Unit 6 along the east bank of the river and (2) Units 7&8 along the west bank. All three units are located approximately one mile southwest of the City of Joliet, adjacent to the Lower Des Plaines River in the Upper Dresden Pool ("UDP"). Both Joliet 6 and Joliet 7&8 are steam electric coal-fired generating facilities, and utilize open-cycle once through cooling systems. Both thermal discharges from the Joliet facilities flow into the Des Plaines River within the approximately one mile segment downstream of the Brandon Road Lock and Dam, (between River Miles 285 and 284), which is about seven miles upstream from the I-55 Bridge.

Unit 6 is capable of producing 341 megawatts of electricity and has a design circulating water flow rate of approximately 376 MGD. The design maximum temperature rise in the circulating cooling water is approximately 10.7°F. Unit 6 has been in operation since 1959. Units 7&8 are capable of producing approximately 1100 megawatts, with a design circulating water flow rate of approximately 1325 MGD. The design maximum temperature rise in the circulating cooling water is approximately 12.4°F.

Joliet Facilities – Units 7&8 Cooling Towers

The cooling towers for Units 7&8 were voluntarily installed in 1999 at a cost of approximately $23,000,000 (1999 dollars), with ongoing annual operating costs of $300,000 (2008 dollars). These costs do not include the cost of station labor associated with the operation and maintenance of the cooling towers. The annual costs reflect the fact that the towers are used on an as-needed basis and run an average of about 46 days per year (2003-2007)). They are "helper cooling towers" which are not designed for long-term, continuous runs. They are capable of cooling approximately one-third of Units 7&8's total design discharge. The purpose of the towers is to minimize potential thermal impacts to the river ecosystem and maintain compliance with existing thermal water quality standards, while optimizing MWGen's ability to produce needed power during critical weather conditions.

The towers are currently used primarily to maintain compliance with existing far-field adjusted thermal water quality standards that apply at the I-55 Bridge, pursuant to the terms of the Adjusted Standard issued by the Board in AS 96-10, as further discussed below. The towers are also used to meet near-field thermal standards during critical low flow periods that occur in the Dresden Pool. The use of the towers is necessary during the summer months and also at times of unseasonably warm spring and fall periods. Operation of the towers (the number of towers turned on and the duration of run time) is largely determined by a thermal model that assesses weather, station load, discharge temperature, river flow and intake temperature conditions on a real-time basis. Generally, the towers are used when the circulating water discharge temperature exceeds 93°F for an extended period of time. The towers do not work efficiently when the temperature of the station condenser discharge flow is less than 90°F or when the dew point temperature (*i.e.*, temperature to which the air must be cooled at constant pressure for it to become saturated) approaches 78-80°F. The towers cool warm water through an evaporative process, which requires that the ambient air be relatively dry, or the existence of a relatively low dew point (*i.e.*, less than 78-80°F). The tower pumps are also not equipped with freeze protection and associated appurtenances needed to sustain winter usage under rapidly changing winter weather conditions. Further, the towers are neither designed nor equipped with plume arrestors to minimize misting and vapor plumes and, therefore, cannot be used during the winter months due to the potential for creating hazardous icing conditions on nearby power lines and roadways.

Adjusted Thermal Standards Currently Applicable to MWGen

All five MWGen stations are currently subject to Secondary Contact and Indigenous Aquatic Life Water Quality Standards on a near-field basis. This means that the point of compliance for thermal discharges from each of the stations is the edge of the allowed mixing zone, which is currently the maximum area of 26 acres. All five stations are also subject to the I-55 Adjusted Thermal Standards (the "Adjusted Standards"), which were adopted pursuant to

AS 96-10, and whose limits must be achieved further downstream at the I-55 Bridge. Extensive multi-year biological, physical and chemical monitoring and modeling work was performed as part of the UIW Studies to support the Adjusted Standards. The Adjusted Standards were originally proposed by ComEd, adopted by the Board in 1996, and transferred to MWGen in 2000.

The IEPA and Board agreed to the Adjusted Standards based on a number of factors, including the fact that ComEd had successfully demonstrated that the heat discharges from the Joliet facilities did not cause nor could be reasonably expected to cause significant ecological damage to the waters of the Five-Mile Stretch (the Lower Des Plaines below I-55). *See Attachment 2, Opinion and Order of the Board in AS96-10, dated October 3, 1996 ("1996 Board Opinion") and Attachment 3, Response of the Illinois EPA to the Amended Petition of Commonwealth Edison Company Adjusted Standard from 35 Ill. Adm. Code 302.211 (d) and (e) ("1996 IEPA Response").* Both the Board and IEPA also agreed as part of the AS 96-10 proceedings that heat was not a factor limiting the quality of the aquatic habitat of the Five-Mile Stretch, but rather other factors such as the loss of habitat due to channelization, disruption of habitat due to barge traffic, and the presence of heavy metals and other pollutants in the system, were overriding the effect of temperature on the waterway. *See 1996 IEPA Response at pp. 5, 9-10.* In 1996, IEPA did not view the thermal discharges as limiting aquatic diversity in the receiving waters. *Id. at 9.* And although the IEPA believed that the installation of cooling towers may be technically feasible to reduce temperature of the effluents, the Agency ultimately concluded as part of the AS 96-10 proceedings that the cost of providing this cooling was not economically reasonable when compared to the likelihood of no improvement in the aquatic community. *Id. at 7.*

The Adjusted Standards are in-stream temperature limits applicable specifically to the I-55 Bridge location and consist of a set of monthly/semi-monthly temperature limits which vary on a seasonal basis. The Adjusted Standards have been incorporated into each of the NPDES Permits issued to the five MWGen stations. The following NPDES Permits thermal limits must be met at the I-55 Bridge by all five upstream MWGen UIW generating stations: :

January:	60 °F
February:	60 °F
March:	65 °F
April 1-15:	73 °F
April 16-30:	80 °F
May 1-15:	85 °F
May 16-31:	90 °F
June 1-15:	90 °F
June 16-30:	91 °F
July:	91 °F
August:	91 °F
September:	90 °F
October:	85 °F
November:	75 °F
December:	65 °F

These standards may be exceeded by no more than 3°F during 2% of the hours in the 12-month period ending December 31, except that at no time shall MWGen's plants cause the water temperature at the I-55 Bridge to exceed 93°F. The Adjusted Standards replace the General Use numerical limits in 35 Ill. Adm. Code 302.211(d) and (e), which limit monthly temperatures and the maximum temperature rise above natural temperatures up to 5°F or less.

The Adjusted Standards are identical to the existing General Use numeric thermal standards during the months of January and February, and are within 1°F of the General Use numeric thermal standards during June, July and August. During the transitional months of the year, the Adjusted Standards limits at the I-55 Bridge are actually <u>more stringent</u> than the corresponding General Use Standards:

Period	Gen. Use Limit	AS 96-10 Limit
April 1-15	90°F	73°F
April 16-30	90°F	80°F
May 1-15	90°F	85°F
October	90°F	85°F
November	90°F	75°F

March and December are the only months in which the Adjusted Standards allow a temperature up to 65°F, when the General Use numeric standard is 60°F. Thus, for the remaining ten months of the year, the thermal standards applicable at the I-55 Bridge are at least as stringent as or more stringent than the existing General Use thermal standards that apply to the UIW waterway downstream of the I-55 Bridge.

Applicability of these Adjusted Standards was transferred to MWGen by the Board on March 16, 2000. *See Attachment 4, AS 96-10, Opinion and Order of the Board, dated March 16, 2000 ("2000 Board Opinion").* Since that time, MWGen has performed physicochemical and biological studies of the waterway in order to determine whether there are any adverse impacts from the thermal discharges on the resident aquatic community (the "UIW Studies"). The monitoring data collected during the annual UIW Studies is submitted to IEPA each year and continues to serve as the basis for the continuation of the Adjusted Standards at the I-55 Bridge. The UIW Studies will be discussed in greater detail by other witnesses providing pre-filed testimony on behalf of MWGen

Based on my experience and first hand observations through the UIW Studies, the Adjusted Standards provide an adequate level of protection for the aquatic community below I-55, and provide a more representative normal, seasonal fluctuation than either the Secondary Contact or the General Use numeric standards. These Adjusted Standards were also designed to be complementary to the Secondary Contact thermal water quality standards upstream, in that by adhering to compliance with these far-field thermal limits, thermal inputs from upstream are regulated such that both sets of thermal water quality standards are met at the point at which they are applicable. This provides a needed transition zone from Secondary Contact to General Use waters.

MWGen's Compliance with Applicable Thermal Water Quality Standards

Since October 1996, when the Adjusted Standards went into effect, there have been no instances of noncompliance by MWGen Stations with thermal standards. Control over the thermal discharges and effect on ambient stream temperature is achieved by: (1) use of supplemental cooling towers at Joliet Facilities Units 7&8; (2) a process known as "unit derating" or lowering the megawatt load for one or more of the Joliet Facilities' units; or (3) a combination of both.

Through subsequent studies and modeling efforts, MWGen determined that the Joliet Facilities (and not the three CAWS stations) had the greatest influence on water temperature at the I-55 Bridge. Therefore, efforts by MWGen to maintain thermal compliance at the I-55 Bridge revolve mostly around the operations of the Joliet Facilities. Maintaining compliance with thermal standards at the I-55 Bridge, located seven miles downstream from the Joliet Facilities, is a very complex process. Ambient stream temperature is largely associated with the volume of flow in the river. MWGen's compliance efforts are therefore largely dictated by the upstream flow manipulations and perturbations in the CAWS that in turn affect the volume of flow to the Upper Dresden Pool.

To factor and account for the many constantly changing variables that affect heat dissipation in the waterway over the seven mile stretch between the Joliet Facilities and the I-55 Bridge, a customized thermo-hydrodynamic model of the waterway is used. This model (known as JOLDER) was originally developed in 1988 by ComEd, in conjunction with researchers at the

Iowa Institute of Hydraulic Research at the University of Iowa. The model has undergone several rounds of revision and refinement since its inception. To run the model, numerous factors, such as river flow, weather, megawatt loading, and conditions that affect cooling tower module operations, must be routinely monitored to determine what operational steps need to be taken by the Joliet Facilities to ensure continuing compliance at the I-55 Bridge Adjusted Standards. Thus, while MWGen must closely monitor river conditions and its thermal discharges for both Secondary Contact and Adjusted Standards compliance purposes, it is more often the Adjusted Standards compliance needs that dictate unit deratings and the use of the cooling towers.

River Flow

River flow in the CAWS can fluctuate dramatically (*e.g.*, thousands of cubic feet per second over several hours or less) depending upon weather or regulated flow. *See Attachment 5, Example Flow Graphs.* The regulated flow stems from the artificially controlled nature of the flow of the Lower Des Plaines River. Flow in the Lower Des Plaines River is largely dictated by upstream wastewater effluents, as well as storm events and ensuing flood control measures instituted by the U.S. Army Corps of Engineers ("Corps") at the two existing upstream lock and dams—Lockport and Brandon Road). Flow conditions at any given time cannot be predicted with great precision and flow does not follow any type of normal trend. As such, MWGen obtains continuous electronic flow data at the Brandon Road Lock and Dam from the Corps, Rock Island District, as a primary thermal model input. In addition to recent past (3 days prior) and real-time current flow conditions, the model must also take into account the potential for changes in flow conditions within approximately a three-day period, by two hour increments, which is the frequency at which the Corps provides updated flow information. These future flow conditions are manually inputted, based on the modeler's experience, and take into consideration weather forecast information available at the time, as well as upstream canal manipulation data from the Corps' website. Predicted future flow inputs to the model are then adjusted every two hours, depending on how well the predicted flow matches the actual value reported by the Corps for each two hour increment. This iterative process often requires continuous attention by MWGen (24 hours a day, 7 days a week), especially during critical periods when river flows are often low and the demand for power is high.

<u>Weather Conditions</u>

Past and future predicted hourly air temperature, relative humidity, dew point and local wind speed/wind direction are critical in determining ambient river cooling potential. Along with these factors, the effectiveness of cooling tower operation under such conditions must also be taken into consideration. MWGen subscribes to an on-line weather forecasting service, and also uses local newspaper, weather channel and on-site meteorological data to fine-tune model weather inputs to the extent reasonably possible.

<u>Station Megawatt Load</u>

Megawatt loading is also a factor which must be entered into the computational modeling. Hourly Joliet unit load data is automatically entered into the model. Future predictions of load are made based on the past day's load cycle, as well as weather forecast predictions.

<u>Cooling Tower Module Operation</u>

There are total of 24 cooling tower modules at Joliet Units 7&8, each with a fan and two pumps. Each of these individual components must be monitored on a real-time basis, and operating data is manually inputted into the model. Individual towers are cycled on and off manually by station personnel, in accordance with model projections.

The thermal model is used by MWGen on a real-time basis to assimilate existing and projected variable data and provide predictions of what the future water temperature at the I-55 Bridge will be, based on modeled conditions. The model has been field-verified and has been shown to be accurate to within 2^{o}F (assuming that model input parameters are also accurate). The model can project out three days, although accuracy tends to fall off with time. For this reason, the model is constantly updated with real-time data and manually run in an iterative, continuous manner during critical periods, in order to gage compliance and provide continuing operating guidance to Joliet station personnel in order to both optimize station load, as well as maintain thermal compliance.

MWGen's Participation In The UAA Stakeholder Process

Beginning in 2000, when the IEPA first invited MWGen to join the LDP UAA Workgroup, MWGen has participated extensively in the stakeholder process, sharing data and information, providing informational presentations, and attending each and every meeting. I have personally participated in each and every meeting. Our participation in the ad-hoc UAA Biological Committee for the LDP UAA was also requested based on the fact that, aside from the MWRDGC, MWGen had the most extensive biological monitoring database in the UIW waterway system, particularly for the LDP portion of the UIW. MWGen made several informational presentations over the course of the UAA Stakeholder meeting process to both the LDP and the CAW UAA Stakeholder workgroups. Included in Attachment 6 is a chronology and summary of no less than 16 examples of correspondence between MWGen and IEPA spanning from March 2002 through August 2007. As reflected in the correspondence, MWGen has provided extensive comments over many years on the LDP and CAWS UAA processes, the significant issues involved in those processes and the draft UAA and thermal standards reports prepared by IEPA's consultants. MWGen also consistently participated on the CAWS Stakeholder's Advisory Committee, which began in 2002.

The sole purpose of the LDP UAA stakeholder process was for IEPA to bring all interested parties together on a regular basis to discuss use designation and water quality issues to help develop the basis and support for the conclusions of the UAA Report. Representatives from IEPA, USEPA Region 5, municipalities, industries, environmental groups and academia were all invited to share information and data that could be used to inform and improve the UAA process. Over the course of the first two to three years of the stakeholder meetings, it became abundantly clear that major differences existed between IEPA and the stakeholders regarding what the appropriate thermal and bacterial standards should be for the waterway; consequently, at IEPA's direction, the workgroup set aside these two parameters from further general discussion and focused on other issues. With respect to thermal standards, in a draft version of the LDP UAA Report, circulated to stakeholders in August 2003, it was generally stated by the UAA contractor that the General Use thermal standards could be applied to the LDP without supporting data or justification that such standards would be appropriate. MWGen provided extensive comments showing that the potential applicable of the General Use thermal standards to the LDP was not warranted or justified based on the lack of adequate habitat to support an aquatic community that needed such stringent thermal standards, as well as identifying numerous inaccuracies contained in the draft report. *See Attachment 8.* Subsequently, IEPA issued a revised LDP UAA report, but only a few of the inaccuracies identified by MWGen had been corrected (the report still contained many inaccuracies noted in prior MWGen comments). *See, e.g., Attachments 9 and 14.* MWGen's comments regarding the draft report also raised substantive issues that were seemingly ignored as part of the revised UAA report. In December 2003, the issuance of the revised final draft LDP UAA report marked the cessation of further LDP UAA stakeholder meetings.

It was only after the cessation of the UAA LDP stakeholder meetings that information on the proposed methodology for the development of thermal standards for the LDP started to be distributed to stakeholders. In early 2004, USEPA Region 5 enlisted the services of Mr. Chris Yoder of MBI to develop temperature standards for the Lower Des Plaines River, based on the methodology that Mr. Yoder had used in Ohio. Several draft reports from MBI were subsequently circulated by IEPA to the LDP UAA Workgroup for review, but no stakeholder meetings were held to discuss these reports. Extensive written comments on the MBI reports were prepared by MWGen and submitted to IEPA, as well as a request for a meeting with Mr. Yoder to discuss his findings, all without any response from either IEPA or Mr. Yoder. *See Attachment UU to IEPA's Pre-filed Testimony*. MWGen also submitted two alternative thermal standards reports to IEPA and the LDP workgroup during the2004 to 2006 time period, but no stakeholder meetings were held to discuss this matter, nor were any comments received by MWGen from IEPA on these alternative thermal standards proposals. *See Attachment 6*.

It was not until January 2007, when IEPA issued its draft UAA proposal that MWGen became aware of the intended thermal water quality standard values for the Lower Des Plaines River. The IEPA meetings on March 20 and 22, 2007, were the first public forum in which the proposed thermal standards were publicly discussed. In response, MWGen developed another alternative thermal standards proposal for the Lower Des Plaines River, which was submitted to IEPA in August 2007. This proposal, according to IEPA, was not reviewed because it was submitted "too late". *See March 11 Hearing Transcript at p. 192.*

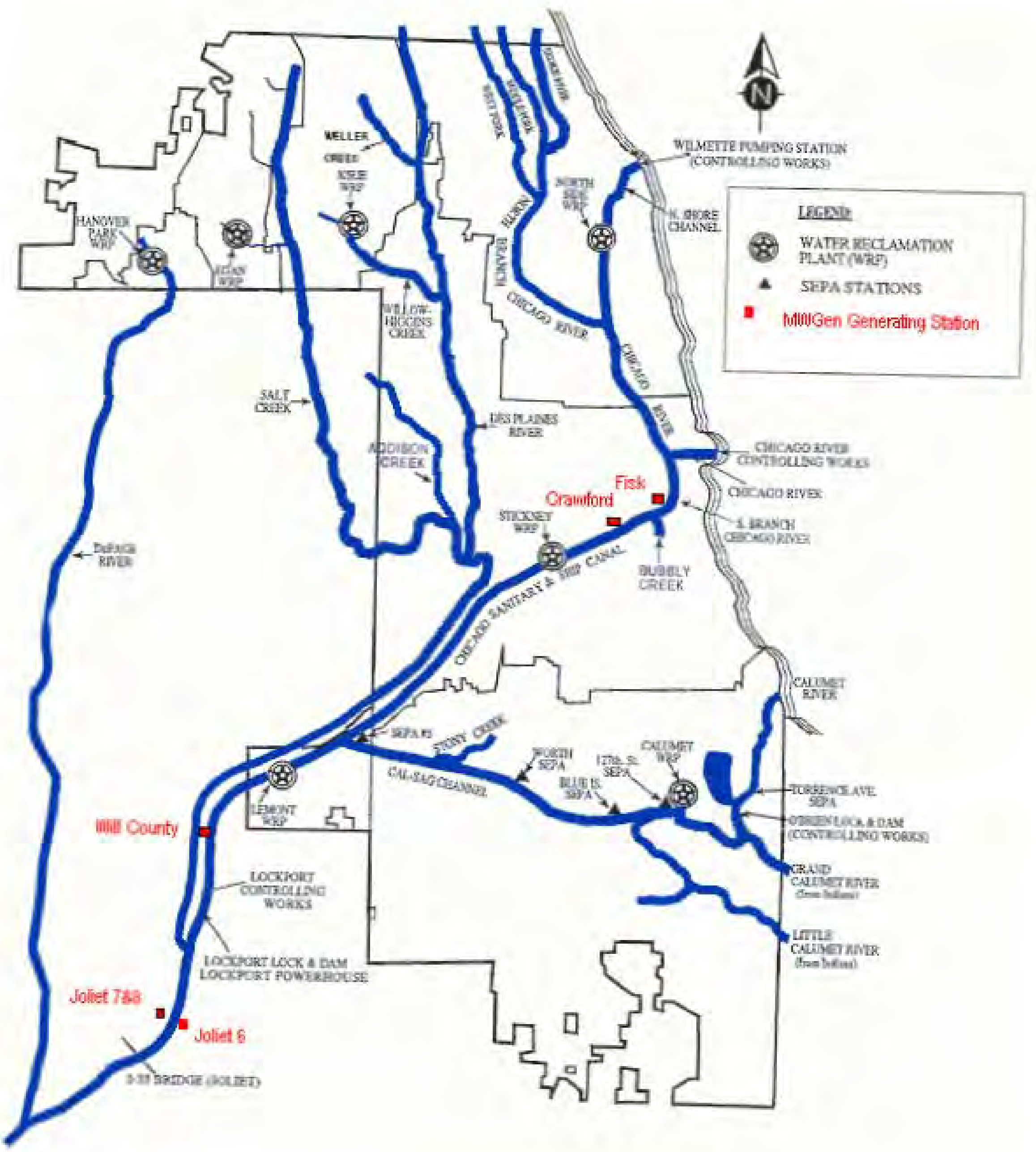
Similarly, for the CAW UAA process, which began in early 2003, there were no thermal water quality standard options put forth for open discussion throughout the course of the stakeholder meetings. General language was developed for each proposed use designation (as proposed by the CDM CAWS UAA report), but no specific thermal numbers were discussed. *See Attachment K to IEPA's Pre-filed Testimony.* It was also MWGen's understanding that no additional standard derivation work was being conducted by or for IEPA/USEPA Region 5 specifically for the CAWS. Once again, however, in January 2007, MWGen and the other stakeholders were presented with IEPA's proposed numeric thermal water quality standards for the CAWS without the benefit of stakeholder participation. Moreover, the proposed numeric limits were modified during the intervening period between January 2007 and October 2007, when IEPA submitted its proposal currently pending before the Board. These modifications were made without any prior notification, clarification or discussion with any of the CAWS or LDP stakeholders.

In conclusion, over the past eight years, MWGen has expended substantial time and effort in helping to inform the UAA process, including providing key, long-term biological monitoring program data and comprehensive UIW Study information. Based on the extensive amount of data and information collected as part of this comprehensive effort, it is my professional belief that IEPA has ignored an overwhelming amount of information and data that, if fairly considered, would not only not support the Agency's current proposal, but rather would support the ultimate conclusion (1) that the physical features of the waterway are the primary factors limiting further biological improvements, and (2) that the current contribution of heat from MWGen's generating station discharges is not having an adverse impact on the biological communities of the CSSC or the LDP.

Julia Wozniak

ATTACHMENT 1

Map of Upper Illinois Waterway Showing Location of MWGen Plants



ATTACHMENT 2

1996 AS 96-10 BOARD OPINION

ATTACHMENT 3

1996 IEPA RESPONSE TO AS 96-10

ATTACHMENT 4

2000 BOARD OPINION

ATTACHMENT 5

EXAMPLE OF BRANDON FLOW FLUCTUATIONS FOR ’05 – ‘08

ATTACHMENT 6

Chronology of Midwest Generation (MWGen) Correspondence to Illinois EPA Regarding the Chicago Area Waterway and Lower Des Plaines Use Attainability Analyses (UAAs)

No.	Correspondence Chronology	Description of Correspondence
1	March 26, 2002, MWGen letter to Toby Frevert, IEPA, regarding Lower Des Plaines UAA	Original MWGen letter sent to the IEPA during the UAA process, raising various issues which ultimately lead to the need to submit detailed comments. MWGen points out that the draft documents prepared by IEPA's consultants either ignore or misrepresent data submitted by MWGen.
2	January 24, 2003, EA Engineering report entitled "Appropriate Thermal Water Quality Standards for the Lower Des Plaines River" and revised October 3003 versions to IEPA **(Attachment 7)**	MWGen's original 64-page thermal report, which was submitted as a hard copy to Toby Frevert, IEPA, and subsequently distributed to the workgroup by mail.
3	August 26, 2003, MWGen letter to Linda Holst, USEPA Region 5 **(Attachment 8)**	MWGen's response to USEPA Region 5's comments on MWGen's Thermal Limit Proposal (Region 5 letter from Linda Holst to Toby Frevert, dated June 3, 2003). While MWGen agrees to make certain revisions to its January 24, 2003 thermal standards report, MWGen continues to point out serious inaccuracies, misrepresentations, and misuse MWGen data in the draft UAA report.
4	September 12, 2003, MWGen letter to Toby Frevert, IEPA, regarding revision of Temperature Section of Draft UAA on the Lower Des Plaines River	MWGen still identifies numerous errors in the draft UAA report concerning MWGen data and cautions that IEPA's consultant appears to have pre-judged the outcome of the UAA, regardless of the available data.
5	October 7, 2003, MWGen comments to IEPA regarding Des Plaines UAA	MWGen comments on the most recently revised version of the thermal chapter of the draft UAA report as well as the supplemental material included in Chapter 8.
6	October 13, 2003, MWGen summary report	MWGen provides a revised MWGen/EA Engineering to IEPA incorporating changes received from IEPA, USEPA Region 5 and

	entitled "Appropriate Thermal Water Quality Standards for the Lower Des Plaines" to Toby Frevert, IEPA	MWRDGC personnel.
7	October 14, 2003, Dr. G. Allen Burton's review of the draft Lower Des Plaines UAA Report to Toby Frevert, IEPA, submitted on behalf of MWGen	Summary of the draft UAA report prepared by Dr. G. Allen Burton, who was requested by MWGen to provide this review in response to the misinterpretations of prior studies he performed on the lower Des Plaines River by the UAA consultants. Dr. Burton's comments corroborated many concerns voiced by MWGen regarding inaccurate and misleading data and findings in the draft UAA report.
8	October 15, 2003, MWGen comments on revised, draft Thermal Section of the Lower Des Plaines UAA Report to IEPA **(Attachment 9**	MWGen provides further comment to IEPA on the errors and misinterpretations of the draft UAA report with respect to thermal issues. Serious problems with the report have still not been corrected.
9	October 22, 2003, MWGen comments on the entire draft Lower Des Plaines UAA Report (34 pp) **(Attachment 10**	MWGen provides further comment to IEPA on the errors and misinterpretations of the entire draft UAA report. Serious problems with the report have still not been corrected.
10	November 18, 2003, E-mail to Vladimir Novotny (with cc to Toby Frevert) **(Attachment 11**	MWGen continues to identify and explain errors in draft report and provide corrections.
11	March 24, 2004, MWGen letter to Toby Frevert, IEPA, with comments on final UAA Report for Lower Des Plaines River **(Attachment 12)**	MWGen provides more comments regarding the final UAA Report for the LDP and includes an attachment of all prior comments submitted to IEPA. MWGen expresses disappointment that many of the significant comments and corrections made by MWGen and other stakeholders were ignored.
12	July 28, 2004, MWGen comments on Lower Des Plaines Temperature Criteria Derivation Report prepared by Yoder and Rankin (June 2004 draft version) (See Attachment UU)	MWGen identifies errors in MWRDGC temperature data used by Yoder to set "ambient conditions." Includes extensive critique of methodology and assumptions made.
13	March 29, 2005, MWGen comments on the draft CAW UAA Report to Scott Twait, IEPA. **(Attachment 13)**	Extensive comments (21 pp. of comments) by MWGen regarding draft UAA report.

14	June 28, 2005, MWGen Supplemental Comments and Information Regarding the Draft CAW UAA Report which was prepared by CDM. **(See Attachment 14)**	MWGen comments including data to show that General Use temperatures are not being met in waterway, contrary to assertions in draft CDM report.
15	June 1, 2006, MWGen letter and comments on Yoder October 11, 2005 Report to Toby Frevert, IEPA. (See Attachment UU)	MWGen letter including data to show that MWRDGC's discharges would not be able to meet proposed non-summer limits and includes a significant critique of MBI's methodology. MWGen expresses extreme disappointment with the MBI draft report dated October 11, 2005, and the fact that MWGen received no response to its prior comments and that its comments have been largely ignored.
16	February 27, 2007, MWGen letter to Marcia Willhite, IEPA.	MWGen is forced to respond to allegations that arise from the continued errors an inaccuracies in the LDP UAA report. MWGen responds to an allegation by Prairie Rivers regarding "violations" of existing temperature limits by MWGen (letter dated December 11, 2006). MWGen continues to point out erroneous conclusions in the UAA report.

ATTACHMENT 7

January 24, 2003, EA Engineering report entitled "Appropriate Thermal Water Quality Standards for the Lower Des Plaines River" to IEPA (and revised version October 2003)

ATTACHMENT 8

August 26, 2003, MWGen letter to Linda Holst, USEPA Region 5

ATTACHMENT 9

October 15, 2003, MWGen comments on revised, draft Thermal Section of the LDP UAA Report to IEPA

ATTACHMENT 10

October 22, 2003, MWGen comments on the entire draft LDP UAA Report

ATTACHMENT 11

November 18, 2003, E-mail to Vladimir Novotny (with cc to Toby Frevert)

ATTACHMENT 12

March 24, 2004, MWGen letter to Toby Frevert, IEPA, with comments on final LDP UAA Report

ATTACHMENT 13

March 29, 2005, MWGen comments on the draft CAW UAA Report

ATTACHMENT 14

June 28, 2005, MWGen Supplemental Comments and Information Regarding the draft CAW UAA Report prepared by CDM

EXHIBIT J

EXCERPT OF JULY 29, 2013 SCOTT TWAIT TESTIMONY, HEARING TRANSCRIPT, EXHIBIT 480 UAA RULEMAKING R08-9(C)

ORIGINAL

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:)
WATER QUALITY STANDARDS AND)
EFFLUENT LIMITATIONS FOR THE)
CHICAGO AREA WATERWAY SYSTEM) R08-09(D)
AND THE LOWER DES PLAINES RIVER:)(Rulemaking-
PROPOSED AMENDMENTS TO 35 Ill.) Water)
Adm. Code Parts 301, 302,)
303 and 304.)

The TRANSCRIPT FROM THE PROCEEDINGS taken before the HEARING OFFICER MARIE TIPSORD by Kari Wiedenhaupt, CSR, at the Thompson Center, 100 West Randolph Street, Room 9-040, Chicago, Illinois, on the 29th day of July, 2013, A.D., at 10:30 o'clock a.m.

February, September 16 to 30, October, November and December, end quote.

The question is, was the purpose of using the MWRDGC's effluent temperature as the background temperature on which to establish the proposed thermal period average temperatures during these non-summer month periods instead of using the Cal-Sag Channel, Route 83 station temperatures to avoid proposing period average standards that the District's discharges would likely violate during these non-summer month periods?

A. We believe in this system that the effluent is the true background of this system. At times they are 100 percent of the flow.

MR. ETTINGER: So was that yes?

THE WITNESS: Yes. I'm sorry. That's a no.

We believe that they are the true background. We didn't -- we believe they are the true background of this system.

BY MS. FRANZETTI:

Q. Okay. Now, if you believe the District's discharge is the true background for