ATTACHMENT C

City Water Light & Power
Dallman & Lakeside Station
Water Conservation Study

CITY WATER LIGHT & POWER

DALLMAN & LAKESIDE STATION

WATER CONSERVATION STUDY

Report SL-008254
Revision 2

Sargent & Lundy LLC

55 East Monroe Street
Chicago, IL 60603

PROJECT NO. 11319-005
April 23, 2004

APPROVAL PAGE

CITY WATER POWER & LIGHT

Water Conservation Study

April 23, 2004

Sargent & Lundy's Illinois Department of Professional Regulation registration number is 184-000106.

Prepared by:	M. D. Rosen M. Rosen	Date:	4/23/04
Prepared by:	P. Hiller P. Hiller	Date:	4/23/04
Reviewed by:	R. L. Rupinskas R. Rupinskas	Date:	4/23/04
Approved by:	R. L. Rupinskas R. Rupinskas	Date:	4/23/04

Seal:

ROMAS L. RUPINSKAS
62-36427
LICENSED
PROFESSIONAL
ENGINEER
OF
ILLINOIS

License Expires 11/30/05

R. L. Rupinskas

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

A study was performed to identify alternatives for reducing consumptive water losses at Dallman Units 31, 32 and 33. Lakeside consumptive losses were noted, but not investigated further. When the Lakeside Units are retired, the average consumption of Lake Springfield water will decrease by 1.61 million gallons per day (MGD) and the consumption of potable water will decrease by 0.39 MGD. For purposes of this study, consumptive water losses were defined as water, which is lost within these units due to process evaporation, accumulation within solid waste, percolation from ponds, or water which is discharged to Sugar Creek. Two water balances were developed as EXCEL spreadsheets/diagrams. Figure ES-1 shows the consumption data usages at the average station on line utilization factor. The study considered major consumptive water losses associated with ash handling and FGD operation, as well as smaller consumptive losses which can be reduced by implementing better operating practices. The study also considered using lake water in lieu of potable water for office HVAC heat exchanger cooling.

Options were developed and conceptual cost estimates were prepared for the feasible water conservation options. The options were reviewed and compared to the calculated water consumption and the results are summarized below, ranked (based on average water consumption) from most cost efficient to least cost efficient:

- Proposed ash handling system water management practices would reduce water consumption by 1.84 MGD, essentially without a capital expenditure. Current CWLP operating procedures have been modified in the Unit 31-32 bottom ash area to save up to 1.5 MGD by cycling the pump motor. The results of these operating procedures are pending.

- Barring any unforeseen permit limitations, the use of sanitary effluent in lieu of lake water for ash sluicing and FGD makeup would reduce water consumption by 4.94 MGD, at a relatively low cost of about $1,200,000. The cost for the pipeline and storage tank would be included with the installation of the planned new unit. However, we are concerned about the fact that the final effluent from the sanitary treatment facilities is not disinfected. Biocide addition within the power plant would need to be adequately monitored and controlled to conform with public health requirements and to minimize the potential for microbiologically induced corrosion to occur within the FGD and ash handling systems. A further concern is that contamination of Lake Springfield could occur via leakage from process equipment to plant sumps. CWLP should also understand that use of sanitary effluent is contingent upon obtaining a revised NPDES permit from IEPA.

- Recovering all of the ash sluice water for fly ash and bottom ash sluicing would save 3.74 MGD and would cost $1,440,000. However, without mitigation of the high boron levels in the waste streams entering the ponds, this option would cause Boron levels in the water discharged to Sugar Creek to be 2.5 to 3.3 times higher than the present levels.

- The conversion of the Unit 33 wet fly ash disposal system to a dry fly ash handling system and the conversion of the Unit 31/32 slag handling system to a closed loop recirculating system with dewatering bins appear to offer a good balance of water saved versus installed cost. The Unit 33 dry fly ash handling system would save 0.84 MGD at an installed cost of about $4,100,000. The corresponding values for the conversion of the Unit 31/32 slag handling system to a closed loop recirculating system with dewatering bins are 2.39 MGD and $6,680,000, respectively.

- The recovery of FGD vacuum pump seal water would save 0.07 MGD of water at a cost of $280,000.

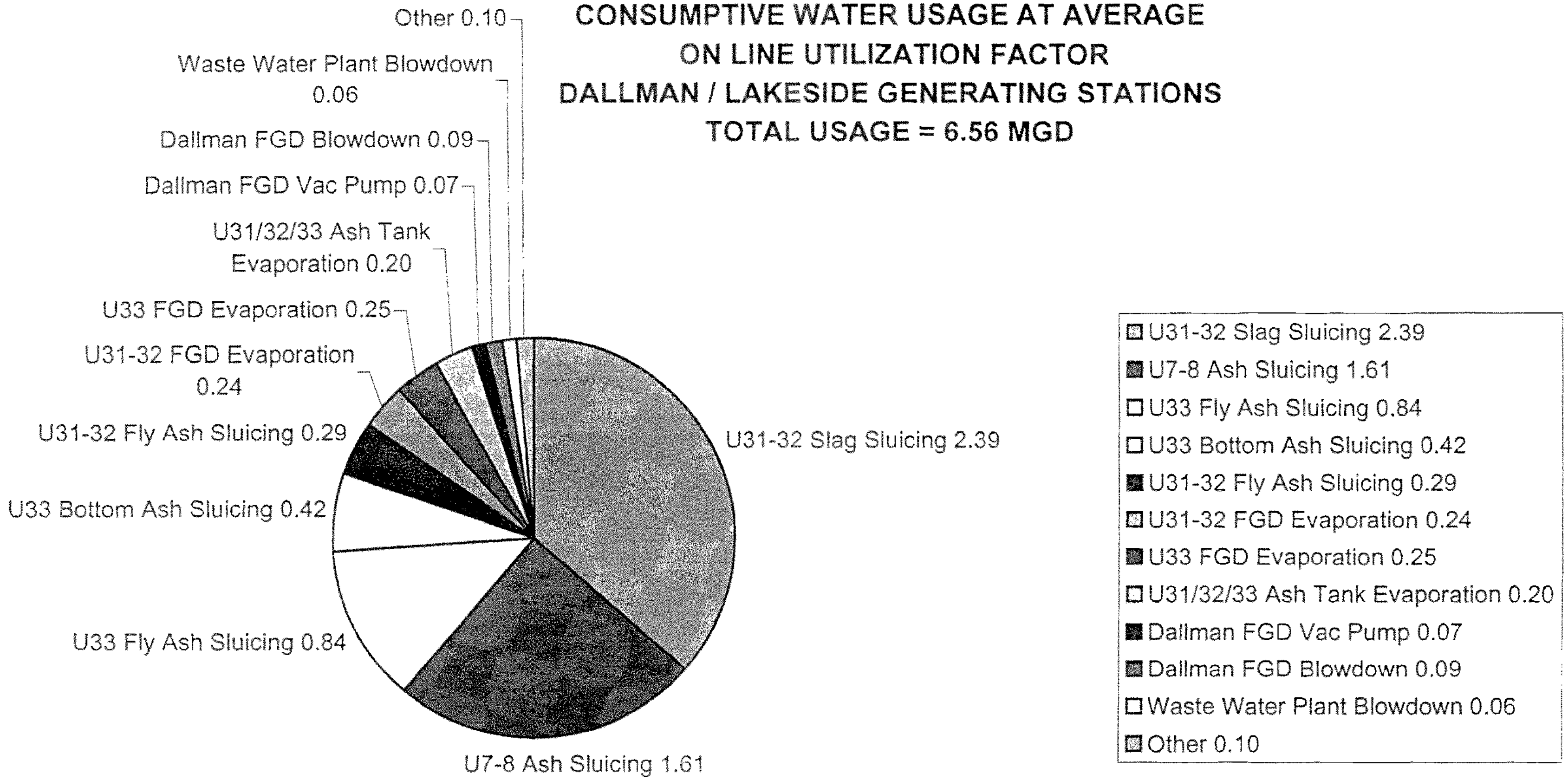
- Conversion of the Unit 31/32 wet fly ash disposal system to a dry system would save only 0.29 MGD at an estimated cost of $3,260,000. Similarly, the conversion of the Unit 33 bottom ash handling system to a recirculating system using dewatering bins would save only 0.42 MGD at a cost of $6,630,000. However, these costs may be justified when compared to the cost of additional water supply resources.

Lastly, converting the various office HVAC cooling heat exchangers to use lake water instead of potable water is not feasible. The current piping configuration includes twelve separate heat exchanger networks. Each could require a chlorination and dechlorination system. Converting only the main HVAC office cooler from potable water to lake water is technically feasible. However, the small savings in water consumption (0.05 MGD) does not appear to justify the capital cost expenditure.

The circulating water pump seals also use potable water and there appears to be an excessive usage of potable water for this application. Potable water consumption could be reduced by approximately 0.09 MGD if the root cause(s) of excessive water usage could be identified and corrected.

CWLP should review the above options in the context of the current and future water usage constraints for Lake Springfield and potable water. Depending on which Options are pursued, the water consumption from lake Springfield can be reduced by a maximum of 4.94 MGD. The installed cost of the Options ranges from negligible for the Ash Handling Water Management (1.84 MGD) through $1,200,000 for Use of Sanitary Effluent as an Additional Water Source (4.94 MGD) and up to $20,670,000 for all the Ash Handling System Changes (3.94 MGD). These Options should be compared to the financial resources that could be allocated for water conservation to determine which Options are economically and technically feasible and are good candidates for implementation.

FIGURE ES-1
CONSUMPTIVE WATER USAGE AT AVERAGE
ON LINE UTILIZATION FACTOR
DALLMAN / LAKESIDE GENERATING STATIONS
TOTAL USAGE = 6.56 MGD



SECTION I

INTRODUCTION

Dallman and Lakeside Stations are located on the same site on the northern shore of Lake Springfield. Lakeside Generator 6 Boiler 7 and Generator 7 Boiler 8 are rated for 33 MW gross each and are scheduled for retirement in 2009. Dallman Station has three active units and a fourth unit has begun preliminary engineering. Units 31 and 32 are each rated for 80 MW gross and Unit 33 is rated for 192 MW gross. Water from Lake Springfield and from the City of Springfield is used for equipment cooling, process makeup, and ash handling for both stations.

This study assesses the current usage of water from Lake Springfield and potable water from the City of Springfield by the Lakeside and Dallman Stations. Options were developed and evaluated with the potential to reduce the consumptive water usage that is not returned to Lake Springfield. The study addresses only process usage of the water by the stations. A separate Sargent & Lundy study in 2002 evaluated the cooling lake performance. Lakeside Station is included in the study for the purpose of determining the amount of water usage that will be eliminated when the station is shutdown in 2009.

SECTION II

WATER BALANCE

A. OVERVIEW OF SOURCES USED TO DEVELOP WATER BALANCE

Average and maximum water balances (Figures II-1 & 2) were developed for the purpose of characterizing overall water usage, with the primary emphasis being on quantifying "consumptive losses" within the Dallman and Lakeside generating stations. Consumptive losses are defined as water, which is lost within these units due to process evaporation, accumulation within solid waste, percolation from ponds, or water which is discharged to Sugar Creek. By quantifying these consumptive losses and identifying the specific operations within the power plant responsible for these losses, various water conservation alternatives can then be evaluated.

The water balances were developed based on various drawings, equipment data and previous studies, etc. provided by CWLP as well as information obtained during a three-day walkdown by S&L. During the site walkdown and at several intervals thereafter, CWLP used a portable ultrasonic flow meter to measure various flow rates, primarily within the ash handling areas. Data collected by CWLP during their flow monitoring program is provided in Appendix B. Table II-1 summarizes the basis for the individual flow rates noted in the water balance.

The water balances were developed using EXCEL, taking advantage of both the spreadsheet and graphics capabilities of this program. Using this methodology, certain flow rates, such as those associated with once-through condenser cooling, bottom ash and fly ash sluicing, and FGD evaporation/losses are input. Other flow rates, such as the total makeup water obtained from Lake Springfield are automatically calculated. Developing water balances using the ability of EXCEL to perform calculations facilitates revisions as additional data is obtained and allows the rapid evaluation of multiple cases associated with different load factors and process modifications.

B. WATER BALANCE RESULTS

Figures II-1 and II-2 represent the current site water balances based on average and maximum load conditions, respectively. The plant utilizes water from Lake Springfield for once-through condenser cooling. A portion of the circulating water is drawn off before each condenser and is used for sluicing fly ash, bottom ash and slag, as well as makeup to the FGD and auxiliary circulating water systems. All of the water used for ash sluicing is ultimately discharged to Sugar Creek after settling within ash ponds and final treatment in a common clarification pond. Bottom ash and slag tank hopper overflows along with low volume waste, including boiler blowdown and demineralizer regenerant waste are sent to a common wastewater treatment system, which primarily provides settling of suspended solids. The treated wastewater is returned to Lake Springfield. The wastewater treatment system sludge is routed to the Dallman ash pond.

TABLE II-1
BASIS FOR FLOWS USED IN PLANT WATER BALANCE

1. All flows are in Million Gallons per Day, MGD, and are rounded to the nearest 0.01 MGD.

2. Two water balances have been developed associated with average and maximum load conditions, respectively. The basis for the individual flow rates shown within these two water balances is explained in the following notes.

3. Ash handling flow rates are based on the information in the Ash Handling Water Study Draft Report prepared by Patrick Giacommini of CWLP on 2/16/04 (Appendix F). The individual flow rates under average and maximum load conditions were based on the results of previous flow measurements using a portable ultrasonic flow meter and were adjusted based on the on-line utilization factors of 73% for Unit 31-32 and 76.8% for Unit 3-3 as defined by CWLP in this report.

4. Demineralized water flow rates are based on monthly production of 3.5 million gallons under average load conditions and 4.5 million gallons under maximum load conditions, and a distribution to the various units as follows:

   Dallman Unit 31/32 .... 40%
   Dallman Unit 33 .... 50%
   Lakeside.................................. 10%

5. Percolation from ponds is based on an overall recovery of 70% under both average and maximum load conditions in accordance with the Hanson Report "Evaluation of Impacts Associated with Recycle of Treated Wastewater Effluents" dated August 1998.

6. Units 31 & 32 FGD wastewater flow rates under maximum load conditions are based on the Lurgi "Design" Mass Balance included in a Lurgi letter of 5/19/00. The wastewater flow rates under average conditions were developed by reducing the maximum load condition values by 25% which corresponds to the difference between the average and maximum on-line utilization factors.

7. Unit 33 FGD wastewater flow rates under maximum load conditions are based on CWLP mass balances provided in drawings 5011-006-101, and 5011-006-102. The Unit 33 FGD wastewater flow rates under average load conditions were calculated by reducing the maximum load condition values by 25%.

8. FGD vacuum pump seal water flow rate under both average and maximum load conditions is based on the Komine Sanderson Mass Balance for a Gypsum Dewatering System for a single vacuum filter. Normally, only one of the two vacuum filters is in operation.

9. Sludge from the water treatment facility is 0.06 MGD under both average and maximum conditions based on the information listed in item 7 of an e-mail from Patrick Giacomini to S&L dated 1/30/04.

10. FGD system total blowdown for Unit 31/32 and 33 is based on Greg Finigan's e-mail to S&L dated 11/06/03. This information was applied to the maximum load condition water balance. The wastewater flow rates under the average load condition were calculated by reducing the maximum load condition valves by 25%.

11. Condenser cooling water flows are based on information listed in item 8 of Patrick Giacomini's e-mail to SL dated 1/30/04.

12. Potable water flow rates associated with Unit 31/32, Unit 33 FGD, Dallman intake, Lakeside, and the heat exchangers for Unit 31/32 and Unit 33 are based on the information listed in Note 1 of Patrick Giacomini's e-mail to S&L dated 11/07/03. As indicated in Patrick Giacomini's subsequent e-mail dated 3/05/04, potable water supplied to the Dallman intake is used for circulating water pump seals rather than screen backwash and the notation on the water balance has been revised accordingly.

13. Routing of the FGD blowdown under both average and maximum load conditions is based on 90% of the blowdown being routed to the lime pond via the filter plant and 10% routed to Lake Springfield via the FGD pond in accordance with information in Greg Finigan's e-mail to S&L.

14. Lakeside cooling water and ash handing system flow rates under maximum load conditions are based on information previously provided by CWLP. The cooling water flow rate under average load conditions was reduced by 50%. The ash handling system flow rates under average load conditions was reduced to 1.61 MGD in accordance with the e-mail from Patrick Giacomini to S&L dated 4/13/04.

15. Lakeside flow rate to the wastewater treatment system is based taking the difference between the reported daily throughput of the wastewater treatment system (5 to 6 MGD) and the Dallman wastewater flows shown within the water balance. The Lakeside flow to the wastewater treatment system should, therefore, be considered primary.

16. The flow rate from the filtration plant to the lime pond (0.40 to 0.60 MGD) is based on the information in listed in item 6 of Patrick Giacomini's e-mail to S&L dated 1/30/04.

In addition to water, which is obtained directly from Lake Springfield, a portion of the plant makeup is obtained indirectly from the lake as potable water from the CWLP filtration plant. This water is supplied to potable users, the cycle makeup treatment system and various HVAC and service water heat exchangers. Sanitary waste is routed to the city sewer. Cooling water and cycle makeup treatment system wastes (i.e. filter backwash, RO reject and demineralizer regenerant waste) are returned to Lake Springfield and are, therefore, not considered consumptive losses. However, because the power plant incurs a considerable annual cost for purchasing a large quantity of potable water from the CWLP filtration plant, alternatives, which would allow raw lake water to be used for heat exchanger cooling are considered later in this study.

The primary focus of the current water conservation study is to identify consumptive losses within the power plant and to develop alternatives for reducing these losses. The various consumptive losses are summarized in Tables II-2 and II-3 for the average and maximum load water balances, respectively. Conceptually, the average and maximum load water balances are identical. The various ash handling flow rates differ by approximately 5% and 35% between the two water balances. The basis for the flow rates shown within the water balances under average and maximum load conditions is summarized in Table II-1. When Lakeside is retired in 2009, the consumptive water losses for the overall site will be reduced by approximately 25%. In reviewing the other consumptive losses associated with the average load water balance, the following should be noted:

- Ash sluicing accounted for 66.0% of the consumptive losses, broken down as follows:
  - -- Unit 31/32 slag - 36.5% (2.39 MGD)
  - -- Unit 33 fly ash - 12.8% (0.84MGD)
  - -- Unit 31/32 fly ash - 4.4% (0.29 MGD)
  - -- Unit 33 bottom ash - 6.4% (0.42 MGD)
- Total makeup to the Unit 31, 32 and 33 FGD systems to replace water lost due to evaporation, blowdown, solid waste transfer and once-through vacuum pump seal water consumption accounts for 10.4% of consumptive water uses (0.64 MGD).
- The remaining losses associated with evaporation in the ash hoppers, sludge blowdown from the wastewater treatment system, boiler losses/vents, and sanitary and water treatment plant wastewater discharged to the city sewer account for 4.9% of the total consumptive losses (0.32 MGD).

Based on the above information, the primary objective of this study is to reduce, eliminate or recycle water used for sluicing of fly ash, bottom ash or slag associated with each of the Dallman units. We have also identified vacuum pump seal water within the FGD system as an additional consumptive loss. This is large enough and relatively easy to recover, so as to warrant further investigation. At present, and based on the limited data currently available, we do not believe that there are any additional consumptive losses, which are significant or would be considered excessive compared with other power plants. In this regard, it should be noted that CWLP did provide monthly data for demineralized water production over the past three years. Monthly demineralized water production is approximately 3.5 million gallons or 81 gpm, on a continuous average basis. Demineralized water consumption is well within industry guidelines, given that a common water treatment plant serves the three Dallman and two Lakeside units with a combined output of approximately 418 MW gross.

The following section identifies and provides a technical assessment of specific water conservation alternatives, for reducing or eliminating the major consumptive losses, summarized above. In addition, that section considers alternatives, which would allow the various HVAC and service water heat exchangers to use untreated lake water instead of potable water purchased from the CWLP filtration plant.

TABLE II-2
SUMMARY OF CONSUMPTIVE LOSSES IN AVERAGE LOAD WATER BALANCE

UNIT	SYSTEM	PROCESS	CONSUMPTIVE LOSS (MGD)	PERCENT OF TOTAL
Dallman Unit 31/32	Slag	Sluicing	2.39	36.5
Lakeside Unit 7/8	Fly Ash Bottom Ash	Sluicing	1.61	24.6
Dallman Unit 33	Fly Ash	Sluicing	0.84	12.8
Dallman Unit 33	Bottom Ash	Sluicing	0.42	6.4
Dallman Unit 31/32	Fly Ash	Sluicing	0.29	4.4
Dallman Unit 33	FGD	Evaporation	0.25	3.8
Dallman Unit 31/32	FGD	Evaporation	0.24	3.7
Dallman Unit 31/32/33	Slag Bottom Ash	Tank/Hopper Evaporation	0.20	3.1
Dallman Common	FGD	Blowdown	0.09*	1.4
Dallman Common	Wastewater Treatment	Clarifier Blowdown	0.06	0.9
Dallman Common	FGD	Vacuum Pump Seal Water	0.06*	0.9
Dallman Unit 31/32/33	Boiler	Losses/Vents	0.05	0.8
Dallman Common	FGD	Water Losses in Gypsum Product	0.04	0.6
Dallman Common	Potable	Losses to City Sewer	0.01	0.2
		TOTAL	**6.55**	**100**

*Flow rates are based on 90% of the total FGD blowdown and vacuum pump seal water being routed to the lime pond via the filtration plant.

TABLE II-3
SUMMARY OF CONSUMPTIVE LOSSES IN MAXIMUM LOAD WATER BALANCE

UNIT	SYSTEM	PROCESS	CONSUMPTIVE LOSS (MGD)	PERCENT OF TOTAL
Dallman Unit 31/32	Slag	Sluicing	2.53	33.0
Lakeside Unit 7/8	Fly Ash Bottom Ash	Sluicing	2.05	26.7
Dallman Unit 33	Fly Ash	Sluicing	0.9	11.7
Dallman Unit 33	Bottom Ash	Sluicing	0.52	6.8
Dallman Unit 31/32	Fly Ash	Sluicing	0.44	5.7
Dallman Unit 31/32	FGD	Evaporation	0.33	4.3
Dallman Unit 33	FGD	Evaporation	0.32	4.2
Dallman Unit 31/32/33	Slag Bottom Ash	Tank/Hopper Evaporation	0.20	2.6
Dallman Common	FGD	Blowdown	0.11*	1.4
Dallman Common	Wastewater Treatment	Clarifier Blowdown	0.06	0.8
Dallman Unit 31/32/33	Boiler	Losses/Vents	0.09	1.2
Dallman Common	FGD	Vacuum Pump Seal Water	0.06*	0.8
Dallman Common	FGD	Water Losses in Gypsum Product	0.05	0.7
Dallman Common	Potable	Losses to City Sewer	0.01	0.1
		TOTAL	**7.67**	**100**

*Flow rates are based on 90% of the total FGD blowdown and vacuum pump seal water being routed to the lime pond via the filtration plant.

SECTION III

TECHNICAL EVALUATION OF ALTERNATIVES

A. DRY FLY ASH HANDLING SYSTEM

The existing fly ash systems use a wet fly ash handling system to remove the fly ash from the precipitator and economizer hoppers. The system consists of hydroveyors that use water to create a vacuum to evacuate the ash from the hoppers, mix it with water, and slurry the ash to an ash pond. On the bottom of each hopper is a valve that feeds the ash into the vacuum line for transport. The system is dry from the hopper discharge up to the hydroveyor. In order to save the water that is used to produce the vacuum and sluice the slurry to the pond, a dry fly ash handling system can be used. The dry portion of the existing system would be reused. The hydroveyor and the rest of the wet part of the system would be left in place for emergency backup use. The Unit 31/32 system and the Unit 33 system are described individually below:

Unit 31/32

The new Unit 31/32 dry fly ash handling system would transport the fly ash to the existing fly ash pond. At the discharge point, a wetting head using ash pond water would be used to produce a slurry for discharge to the existing fly ash pond. Since the distance from Unit 31/32 to the ash pond exceeds the ability of a vacuum system to transport fly ash, a new vacuum/pressure system would be used for Unit 31/32. The Unit 31/32 fly ash would not be sold for construction uses because of a high carbon content, over 3%. The vacuum/pressure system would consist of two full size mechanical vacuum producers, a filter separator, two full size pressure transport blowers and associated piping valves and accessories. A new segregating valve would be installed in the existing fly ash vacuum header to the hydroveyor. New vacuum piping would be added from the new segregating valve to the new filter separator. The filter separator would remove the fly ash from the conveying air stream and collect the ash in a hopper under the filter separator. The fly ash would be transferred from the filter separator under vacuum and fed into the pressure system using two air lock feeders beneath the hopper. Two full size pressure transport blowers would blow the fly ash from the air lock feeders to the ash pond via a new transport pipe. The mechanical vacuum producers, filter separator, pressure transport blowers and related MCCs would be housed in a 30' x 60' fly ash equipment building east of the Unit 31 precipitator.

Unit 33

The new Unit 33 dry fly ash handling system would be a vacuum system including two full size mechanical vacuum producers, a filter separator and vacuum conveying piping and valves. A new segregating valve would be installed on the existing vacuum header to the hydroveyor. New vacuum piping would be added from the segregating valve to the filter separator located on top of the silo. The filter separator would collect the ash in a hopper. The ash would be fed into the silo via an air lock valve. Clean air piping would connect the filter separator to the vacuum producers which would be located on an operating floor beneath the silo, about 20' above grade. Trucks would remove the fly ash from the silo and haul it off site for either commercial use or to a licensed landfill. The silo would be sized for 72 hours of fly ash production by Unit 33 operating at maximum load and using coal with an average of 10% ash. Initial investigation by CWLP suggests that there is a market for Unit 33 fly ash during the construction season. During other times of the year, the fly ash would be hauled to a licensed landfill or stored in a building for use during the construction season.

The silo equipment would include a filter separator and a bin vent filter on the silo roof, an enclosed operating floor beneath the silo containing the two vacuum producers, a fluidizing air system, wet silo unloader, dry silo unloader, and MCCs.

Table III-1 summarizes the amount of water that could be saved if the fly ash was conveyed pneumatically using mechanical vacuum producers.

TABLE III-1
DECREASE IN LAKE SPRINGFIELD WATER CONSUMPTION
DRY FLY ASH CONVERSION

	Unit 31	Unit 32	Unit 33
Decrease in water consumption at Average load , MGD	0.145	0.145	0.84

Based on the above, at average load a maximum of 1.13 MGD of Lake Springfield water could be saved if the fly ash systems were converted from wet to dry.

The vacuum/pressure system proposed for Unit 31/32 and the mechanically produced vacuum system proposed for Unit 33 are both well proven, reliable systems that have been used for many years. The wetting head proposed for Unit 31/32 at the pond discharge is a newer technology and may require a higher degree of maintenance.

B. CLOSED LOOP RECIRCULATING BOTTOM ASH SYSTEM (DEWATERING BINS)

Presently, slag and bottom ash are wet sluiced from the slag or bottom ash tank to the ash ponds. To save the water that is used to sluice slag/bottom ash to the pond, a closed loop recirculating bottom ash system can be used. The tanks, jet pumps and a portion of the discharge piping system would be reused. The rest of the discharge piping would be left in place for emergency backup use. The Unit 31/32 system and the Unit 33 system are described individually below:

Unit 31/32

The new Unit 31/32 closed loop recirculating slag handling system would consist of two hydrobins, one water settling tank, one water surge tank, two full size transport water pumps and associated piping. The tanks and equipment would be located east of the Unit 31 precipitator and east of the proposed dry fly ash system for Unit 31/32. The hydrobins and tanks would be located outside. The water transport pumps and MCCs would be located in a pumphouse. A segregating valve would be installed in the common slag line to the ash ponds. New slag piping would transport the slag to two new dewatering bins. The dewatered slag would be dumped into trucks for commercial use off site. The water would be decanted from the dewatering bins and flow into a settling tank and then into a surge tank. The water in the surge tank would be used for the next slag conveying cycle. The two new full size water transport pumps would move the water from the surge tank to the suction of the existing 31/32 ash sluice pump to form a closed loop.

The two hydrobins together would be sized to store 87 hours of slag produced by both units at the annual capacity factor and using the original design coal. The water settling tank and water surge tank would be sized to handle the amount of water used during one conveying cycle for both Unit 31 and 32.

Unit 33

The equipment described for Unit 31/32 also applies to Unit 33. The hydrobins, settling tank, surge tank and pumphouse would be located south of Unit 33 in the northern part of the former coal yard. This area would become available with the redesign of the coal handling systems for the new unit.

Table III-2 summarizes the amount of water that could be saved if slag and bottom ash were conveyed using a closed loop recirculation system.

TABLE III-2
DECREASE IN LAKE SPRINGFIELD WATER CONSUMPTION
BOTTOM ASH CLOSED LOOP RECIRCULATION SYSTEM (DEWATERING BINS)

	Unit 31	Unit 32	Unit 33
Decrease in water consumption at average load, MGD	1.20	1.20	0.42

Based on the above, at average load a maximum of 2.82 MGD of Lake Springfield water could be saved if the slag handling and bottom ash handling systems were converted to a closed loop recirculation system.

The closed loop recirculation system proposed for Unit 31/32 and Unit 33 is a well proven, reliable system that has been used for many years, especially in the west where water is scarce and on zero discharge plants.

C. DRY BOTTOM ASH HANDLING SYSTEM

The use of a completely dry bottom ash handling system is possible on Unit 33. The Unit 31 and 32 boilers produce a molten slag. A water impounded tank is required to quench the slag and form smaller particles for disposal. Consequently, a dry tank cannot be used.

Since about 2000 United Conveyor has offered the PAX Pneumatic Ash Extractor dry bottom ash vacuum system. This system consists of a dry hopper, a pneumatic ash transport system and a storage bin for truck loading. It would be located south of Unit 33 at the edge of the coal handling yard.

The existing bottom ash hopper would be demolished and replaced with a new bottom ash hopper with steeper slopes, extra refractory, and air assists to facilitate ash movement. The remainder of the bottom ash system would be abandoned in place. The bottom ash would be collected in the new tank, then crushed in a high temperature single roll crusher and fed into the vacuum system. The vacuum producer would be located at the storage bin operating floor. The storage bin would be set up for dry unloading into a truck for commercial use or off site disposal, as required.

A drag chain type bottom ash handling system is also available. The existing bottom ash hopper would be demolished and replaced with a flat bottom hopper and a drag chain would be used to remove the ash. One end of the hopper would be sloped up at about a 16 degree angle to allow the dry ash to be placed onto a conveyor belt for transport to a silo or a ground storage area. The inclined end of the bottom ash hopper would extend beyond the boiler and would not fit in the available space of Unit 33. Consequently, the drag chain type bottom ash system was given no further consideration.

Table III-3 summarizes the amount of water that could be saved if a dry bottom ash system was used.

TABLE III-3
DECREASE IN LAKE SPRINGFIELD WATER CONSUMPTION
DRY BOTTOM ASH SYSTEM

	Unit 31	Unit 32	Unit 33
Decrease in water consumption at average load, MGD	NA	NA	0.42

United Conveyor is the only supplier of a dry bottom ash system vacuum system. The equipment would cost about $2,200,000 and the installed cost would be in the range of $5,500,000 - $6,500,000. Only one system has been installed on a 400 MW Unit in the U.S. and it has been in service for five years. While a dry bottom ash system has potential, the availability of suppliers and in service experience is limited. Also with this concept, the existing wet sluice system could not be used as an emergency backup. Since there is another more widely used bottom ash option available, and that option allows the use of the existing wet sluice bottom ash system as an emergency backup, we do not consider the dry bottom ash system a feasible option for Dallman 33.

D. SANITARY EFFLUENT AS ADDITIONAL WATER SOURCE

Water conservation could also be implemented by utilizing treated sanitary effluent from the Springfield Metro Sanitary District (SMSD) Sugar Creek Plant for bottom ash, slag and fly ash sluicing, as well as makeup to the FGD system. The Sugar Creek Plant is located approximately three (3) miles north of the power plant. CWLP is considering the use of treated sanitary effluent as a sole source of makeup to a new 200 MW coal-fired power plant which is planned to commence operation in 2010. Based on information provided by CWLP, a pipeline would be routed from the Sugar Creek Plant to the new unit along an easement immediately adjacent to Interstate 55. The conceptual design would also include a storage tank located within the expanded CWLP site property. The size of the pipe line and the storage tank will be determined when the new unit is designed. There would also be provisions to chlorinate, or otherwise disinfect the treated sanitary effluent prior to use within the power plant.

We have reviewed three complete sets of water quality data for the effluent from the Sugar Creek plant based on samples which were collected from the final settling pond in November 2003 and analyzed by Prairie Analytical (Appendix C). As indicated, the concentrations of all metals are either below the reported limits of detection or are present in low ppb concentrations. The levels of other key constituents, which are sometimes a concern in effluent, including ammonia, nitrate, phosphate, suspended solids, TOC, BOD are also relatively low. Based on the available data, it is our opinion that the use of effluent is a viable option. The effluent could be used without further treatment (except for disinfection) for all the consumptive processes within the existing power plant, with the possible exception of cycle makeup and FGD system slaking/seal water. Therefore, the use of treated sanitary effluent could reduce consumptive water uses by more than 95%.

In addition to water quality data, we have also reviewed flow data for the Sugar Creek Plant in 2001 (Appendix D). As shown in Table III-4, the daily average flow that was treated ranged from as little as 7.04 MGD in August to as much as 17.98 MGD in February due to variations in rainfall and stormwater runoff. The water requirements for a new 200 MW pulverized coal unit with a wet cooling tower, dry ash handling and a wet flue gas desulfurization system are approximately 2200 gpm or 3.2 MGD. After Lakeside Station is retired and the new unit is placed into service, the consumptive water uses for the existing Dallman units would range from 4.94 to 5.62 MGD under average and maximum load conditions, respectively. For the purposes of this evaluation, we considered consumptive water uses associated with maximum load conditions (5.62 MGD) during the summer and average load conditions (4.94 MGD) during the remainder of the year. Therefore, the output of the Sugar Creek Plant is insufficient to support the water demands of both the new unit and the existing Dallman units during four months of the year. As shown in Table III-4, approximately 70% to 80% of the consumptive water losses could be replaced by sanitary effluent during July, August and September, while still meeting the water demand for the new unit. In November, there is sufficient sanitary effluent to replace approximately 95% of the consumptive losses. Therefore, although we believe that the use of effluent is a viable option, it would also be necessary to use lake water as a supplemental water source at least during the three summer months and also possibly during May and November. On a yearly average basis, use of effluent would reduce consumptive water losses by 4.7 MGD or 93%.

TABLE III-4
COMPARISON OF SUGAR CREEK PLANT SANITARY EFFLUENT VERSUS DALLMAN POWER PLANT REQUIREMENTS

Month/Year	Sugar Creek Effluent (MGD)	Dallman New Unit Reqmts (MGD)	Dallman Consumptive Losses (MGD)	Effluent Available for Unit 31-33 (MGD)	Percent of Consumptive Losses
Jan-01	10.42	3.2	4.94	7.22	100
Feb-01	17.98	3.2	4.94	14.78	100
Mar-01	15.06	3.2	4.94	11.86	100
Apr-01	11.09	3.2	4.94	7.89	100
May-01	8.39	3.2	4.94	5.19	100
Jun-01	11.71	3.2	5.62	8.51	100
Jul-01	7.08	3.2	5.62	3.88	69.0
Aug-01	7.04	3.2	5.62	3.84	68.3
Sep-01	7.15	3.2	4.94	3.95	80.0
Oct-01	10.94	3.2	4.94	7.74	100
Nov-01	7.93	3.2	4.94	4.73	95.7
Dec-01	12.62	3.2	4.94	9.42	100

Notes:
1. Consumptive water losses are listed for Dallman only. Lakeside is considered retired.
2. Maximum consumptive losses for Dallman are used during the summer months. Average consumptive losses are used during the remainder of the year.

In addition to flow limitations during part of the year, we are also concerned about the potential for microbiologically induced corrosion (MIC) within the ash handling and FGD systems if the effluent is not properly disinfected after it is received at the power plant. We believe that MIC could occur because the final effluent from the Sugar Creek Plant is not disinfected prior to discharge and also because the operating temperatures within the ash handling and FGD systems (e.g. 100°F to 140°F) may be optimum for bacterial growth. No material is entirely immune to MIC. Therefore, use of effluent within the power plant may require more frequent inspections of equipment within the ash handling and FGD systems, as well as routine sampling and microbiological testing to verify that MIC is not occurring.

A further concern is the potential for leakage from process equipment to plant sumps, which ultimately discharges to Lake Springfield via the wastewater treatment plant. This could potentially represent a serious public health issue.

From a public health perspective, additional sampling and monitoring may be required to verify that levels of residual biocide are adequate, microbial populations are being kept under control, and contamination of Lake Springfield via leakage from process equipment to plant sumps is not occurring.

CWLP should also understand that use of sanitary effluent is contingent upon obtaining a revised NPDES permit from IEPA.

E. RECYCLE OF ASH POND EFFLUENT TO ASH HANDLING SYSTEMS

In addition to dry fly ash handling and the conversion of the existing once-through systems to recirculating systems, a third water conservation option would be to recover the ash sluice water from the clarifier pond and reuse it for ash sluice water. The existing clarifier pond pumps and piping can pump into Lake Springfield but have not been used recently because of the boron discharge limits. Instead of flowing from the clarifier pond to Sugar Creek, new piping would be installed to use the existing clarifier pumps to move the flow into a new surge tank at Dallman. New ash sluice transfer pumps and piping would move the water from the surge tank to the inlet of the existing ash sluice pumps.

Table III-5 summarizes the amount of water that could be saved if all the ash sluice water was recycled from the clarifier pond assuming 5% blowdown.

TABLE III-5
DECREASE IN LAKE SPRINGFIELD WATER CONSUMPTION
RECYCLE ASH POND EFFLUENT

	Unit 31	Unit 32	Unit 33
Decrease in water consumption at average load, MGD	1.27	1.27	1.20

Based on the above, at average load 3.74 MGD of Lake Springfield water could be saved if all the ash sluice water was recycled from the clarifier pond (5% blowdown).

The ash sluice water recovery system proposed would consist simply of additional pumps and new piping. No new or unproven technology would be used.

Although recycle of ash pond effluent to the existing ash handing systems requires some relatively simple equipment and piping modifications, there are adverse environmental impacts associated with this modification. In a previous water study performed by Hanson Engineers in 1998, it was determined that conversion of the existing ash handling systems to closed loop operation would result in ground water standards being exceeded for a number of water quality parameters. This issue is discussed in more detail in Section IV dealing with environmental issues.

F. WATER MANAGEMENT PRACTICES

The options previously discussed address the major uses of water at Dallman and Lakeside and provide the opportunity to considerably reduce consumptive water losses. As requested by CWLP, we have also investigated smaller consumptive water uses, which could be reduced by changing present water management practices. At present, the only consumptive water uses within this category that warrants further consideration are FGD vacuum pump seal water and ash handling system water management. We have also reviewed, at the request of CWLP, the feasibility of using lake water instead of potable water as the cooling source in various plant heat exchangers. Although the cooling water is returned to the lake and is not actually a consumptive loss, some cost is incurred by the power plant to purchase potable water from the filtration plant.

1. FGD Vacuum Pump Seal Water and Routing of FGD Sump Pit Effluent.

The FGD rotary drum filter vacuum pump seal water is currently discharged to the sump pit along with the blowdown. The wastewater collected in the sump pit is usually routed to the lime pond via the filtration plant, but is also occasionally returned to Lake Springfield via the FGD pond and the wastewater treatment system. For evaluation purposes, the water balance is based on 90% of this FGD wastewater being routed to the lime pond and 10% being routed to Lake Springfield.

We believe that CWLP should continue to route most of the FGD blowdown to the lime pond to prevent accumulation of chlorides, total dissolved solids and metals in Lake Springfield. However, provisions should be made for recovering the vacuum pump seal water, which is a clean water source. This could be implemented by rerouting the vacuum pump seal water to the demister wash tank.

Recycling of the vacuum pump seal water would reduce consumptive losses by 0.06 MGD, or 0.9%.

2. Ash Handling System Water Management

CWLP prepared an Ash Handling Water Study (Appendix F) to determine the actual ash handling water usages and to develop water conservation recommendations for CWLP's Operations Department. The report had two recommendations that could be implemented by making operational changes without significant equipment cost. First, the Unit 31 ash sluice pump could be placed in the recirculation mode after the first bottom ash transport cycle is completed in each shift (1.5 MGD savings). Second, the Unit 33 sluice pump could be placed in the recirculation mode after fly ash has been conveyed in each shift (0.34 MGD savings). Together, these two recommendations could save 1.84 MGD and could reduce the consumptive losses for the ash handling systems by 45%.

We agree with the principle of these recommendations to stop pumping water to the pond when ash is not being conveyed. However, extended operation in the recirculation mode has the potential to shorten the life and eventually damage the ash sluice pumps. If ash would not be conveyed for more than an hour, we would recommend simply turning the pump off. One start per hour is well within the capability of NEMA motors.

G. HEAT EXCHANGER CONVERSION FROM CITY WATER TO LAKE WATER

As discussed previously, the source of cooling water used in the various HVAC and service water heat exchangers is potable water obtained from the CWLP filtration plant. The use of potable water does not represent a consumptive loss because all of the warm water exiting these heat exchangers is returned to Lake Springfield. However, because the power plant incurs a cost to purchase the potable water from the filtration plant, CWLP has requested that use of raw lake water for this application be evaluated. Reducing potable water usage also would result in an increase in the available wastewater treatment system capacity and higher available potable water pressures during the summer.

Based on discussions with plant personnel, it is our understanding that raw lake water was used for office HVAC cooling until approximately 1985. After 1985, the plant switched to potable water because it was difficult to control biofouling and maintain cleanliness, especially during the summer. The difficulty in maintaining heat exchanger cleanliness is understandable, considering that the plant is only allowed to chlorinate the circulating water for two hours per day and the level of total residual chlorine (TRC) in the water returned to the lake must be < 0.1 mg/l. As a side issue, the plant uses chlorine dioxide in lieu of conventional chlorine or sodium hypochlorite (bleach) as the biocide agent. According to plant personnel, the plant started using chlorine dioxide in the early 1980's because studies performed at that time indicated that it was more effective than chlorine or bleach.

The plant could resume using raw lake water in lieu of potable water for heat exchanger cooling if biofouling could be adequately controlled. This could be accomplished by feeding biocide to the heat exchangers and dechlorinating the effluent. This would require getting a revised NPDES permit. Unfortunately, the configuration of these heat exchangers is actually twelve separate cooling networks, each of which would require a separate biocide feed and dechlorination system. The number of biocide and dechlorination systems could be minimized by feeding these chemicals to the common inlet and outlet headers for Unit 31/32 and Unit 33, which currently supply potable water to these heat exchangers. However, because these heat exchanger networks include safety showers, emergency eye wash stations, washroom facilities, and also provide the source of pump seal water, this approach would require extensive piping and/or equipment modifications to allow these users to continue receiving potable water. Based on these considerations, a complete conversion of the entire network of heat exchangers would not be practical.

At CWLP's request, we also considered a simpler approach in which only the main HVAC office cooler would be converted from potable water to lake water. This would require some relatively simple piping modifications, a single biocide and dechlorination system, and a small micron strainer immediately upstream of the heat exchanger. However, the average flow to the main HVAC office cooler (0.05 MGD) is so small that even this relatively simple modification is difficult to justify. Therefore, we are not recommending the conversion of any of the various HVAC and service water heat exchangers from potable water to lake water.

We found that an excessive quantity (0.13 MGD) of potable water is being used for circulating water pump seals at the intake structure. With six circulating water pumps and a 5 gpm flow of seal water to each pump, the total seal water requirements should be in the range of a 0.04 MGD to 0.05 MGD. The actual seal water usage (0.13 MGD) is approximately three times higher than expected. CWLP was unable to provide any more definitive information during the course of this study and stated that they would evaluate this issue in more detail in the near future. We concur with CWLP's intent to pursue this issue as a means of reducing potable water consumption.

SECTION 4

ENVIRONMENTAL ISSUES

A. BORON LEVELS IN DISCHARGE TO SUGAR CREEK

CWLP is currently operating with an adjusted water quality standard, which limits the concentration of boron (<11 ppm) in Outfall 004 from the clarification pond to Sugar Creek. Until recently, CWLP was able to comply with the boron standard. However, the boron standard is currently being exceeded. According to a recent study prepared by Hanson Engineers to characterize the sources of boron within the power plant, the higher boron levels may be due to ammonia in the flue gas associated with SCR operation. Regardless of the specific reasons for the recent increase in boron levels, there is the possibility that water conservation measures could result in a further increase in these levels.

Comparing the various wastewater streams discharged to the ash pond and ultimately to Sugar Creek, FGD blowdown has by far, the highest boron concentration. Currently, CWLP relies on the dilution provided by once-through fly ash bottom ash sluicing to comply with the adjusted water quality standard for boron. If the quantity of ash sluice water is reduced or eliminated entirely, the level of boron in the discharge to Sugar Creek could increase. To further complicate this issue, the adjusted water quality standard for boron also applies to other locations further downstream in Sugar Creek between the power plant and the creek's discharge into the Sangamon River. For example, immediately downstream of the discharge from Springfield Metro Sanitary District's (SMSD) Sugar Creek facility into the creek (Outfall 008), the boron concentration is limited to <5.5 ppm. Currently, actual boron concentrations at this location are well below the limit because the sanitary discharge contains relatively little boron. Also, the sanitary discharge flow is much larger than the CWLP discharge. However, if sanitary effluent were to be used as makeup to the power plant, the boron limit immediately downstream of Outfall 008 could be exceeded because there would be less sanitary effluent available for diluting the power plant discharge.

A detailed evaluation of various alternatives for boron remediation is beyond the scope of this study. However, based on water quality data for boron recently collected by CWLP, we were able to develop a simplified mass balance model (Figure IV-1 and Table IV-2) to estimate the increase in boron concentration in the discharge to Sugar Creek as a result of implementing various water conservation alternatives. This model is in general agreement with recently measured boron levels in the discharge to Sugar Creek and is not intended to provide exact boron levels. Rather, the model is intended to illustrate order of magnitude changes, which could be expected under the various scenarios.

The results of the mass balance model are summarized in Table IV-1.

TABLE IV-1
BORON CONCENTRATION FOR VARIOUS ALTERNATIVES

Water Conservation Alternatives	Boron Concentration
Current Operating Mode	27.79 ppm
Dry Fly Ash Handling System	
Unit 31/32	29.16 ppm
Unit 33	25.68 ppm
Closed Loop Recirculating Bottom Ash System (Dewatering Bins)	
Unit 31/32	42.06 ppm
Unit 33	29.29 ppm
Conversion of Entire Ash Handling System to Closed Loop Operation	
0% Blowdown (30% percolation losses)	92.62 ppm
5% Blowdown (30% percolation losses)	79.39 ppm
10% Blowdown (30% percolation losses)	69.46 ppm
Sanitary Effluent as Additional Water Source	27.79
Water Management Practices	
FGD Vacuum Pump Seal Water and Rerouting of FGD Sump Pit Effluent	28.06 ppm

Our model predicts that the boron concentration in the discharge to Sugar Creek should be 27.79 ppm, which is in general agreement with measured boron concentrations (in the range of 12.4 to 37.6 ppm, (17.9 ppm average) in the recent Hanson study. Conversion of Unit 31/32 to dry fly ash handing would increase the boron concentration by approximately 5%, because the sluice water would be eliminated, but the fly ash would continue to be sent to the ash pond since it cannot be sold. However, Unit 33 conversion to dry fly ash handling would actually reduce the boron concentration in the discharge to Sugar Creek by approximately 5% to 10%. Although this appears contrary to expectations, the model results are consistent with the flow rates and the reported values for boron in fly ash sluice water, which although lower than corresponding levels in FGD blowdown, are still significant (41.1 to 48.35 ppm vs. 201 ppm).

With regard to conversion of bottom ash systems for once-through operation to dewatering bins, there would be little change in the boron concentration if only Unit 33 was converted. This is because Unit 33 produces only 20% bottom ash and the associate sluice water flow rate is relatively small (0.44 MGD) based on the current mode of operation. However, conversion of the Unit 31/32 bottom ash systems, which process more bottom ash and have much higher sluice water flow rates would increase the boron concentration in the discharge to Sugar Creek by more than 50%.

The largest increase in boron concentration would occur if the entire ash handling system were converted to closed loop operation. As indicated, boron concentration could increase by a factor of approximately 2.5 to 3.5 depending on the quantity of blowdown to Sugar Creek, which would supplement the 30% percolation losses (i.e. natural blowdown) reported by Hanson Engineers in a previous study.

There would be little or no change in boron concentration if sanitary effluent replaced water from Lake Springfield as the plant makeup source. This is because the majority (>90%) of the boron originates from the sluicing of ash or the removal of ash within the FGD system. The small (<10%) contribution from boron in the makeup water source would be essentially the same since the reported boron concentrations in both lake water and sanitary effluent are in the range of 400 ppb.

Other water conservation measures such as the recovery of FGD vacuum pump seal water and the dewatering of the wastewater treatment plant sludge would also be expected to have a minimal impact on the boron concentration in the discharge to Sugar Creek.

In summary, conversion of the Unit 31/32 bottom ash system to dewatering bins or converting the entire ash handling system to closed loop operation could result in a substantial increase in the concentration of boron in the discharge to Sugar Creek. In order to comply with environmental regulations, it would be necessary for CWLP to obtain a further adjustment to the water quality standard for boron or to obtain a different type of standard entirely with mass based rather than concentration based limits for boron. Alternately, as suggested in the recent Hanson study, a wastewater treatment system could be installed to remove boron from the FGD blowdown. However, such a system could be costly and may require additional plant staffing. Moreover, the wastewater treatment system would produce a liquid or solid waste byproduct with a high boron content requiring disposal.

CWLP has also recently indicated that they are seeking permission to discharge some of the FGD wastewater to the city sewer to mitigate the boron issue. A detailed evaluation of this proposed modification is beyond the scope of this study. Additional mass balances developed as part of a future study could be used to estimate the impact on boron levels in Outfall 04 by rerouting FGD wastewater to the sewer.

B. Ash Pond TDS Levels Associated With Closed Loop Operation

As requested by CWLP, we evaluated recycling the ash pond effluent to the existing ash handling systems, which would result in a conversion to closed loop operation. This is a relatively simple modification, which would require minimal piping and equipment changes. However, in a previous water conservation study by Hanson Engineers in August 1998, it was concluded that conversion of the ash handling systems to closed loop operation would affect the quality of ash pond leachate and result in groundwater standards being exceeded for a number of water quality parameters.

The Hanson study included theoretical modeling as well as laboratory studies, which included an elaborate setup with several agricultural tanks, simulating the ash pond system. The laboratory studies included daily additions of actual plant wastewater to the model system as well as wastewater withdrawals to simulate percolation and/or blowdown. Daily samples were collected over a one-month period to characterize the wastewater quality within the model system.

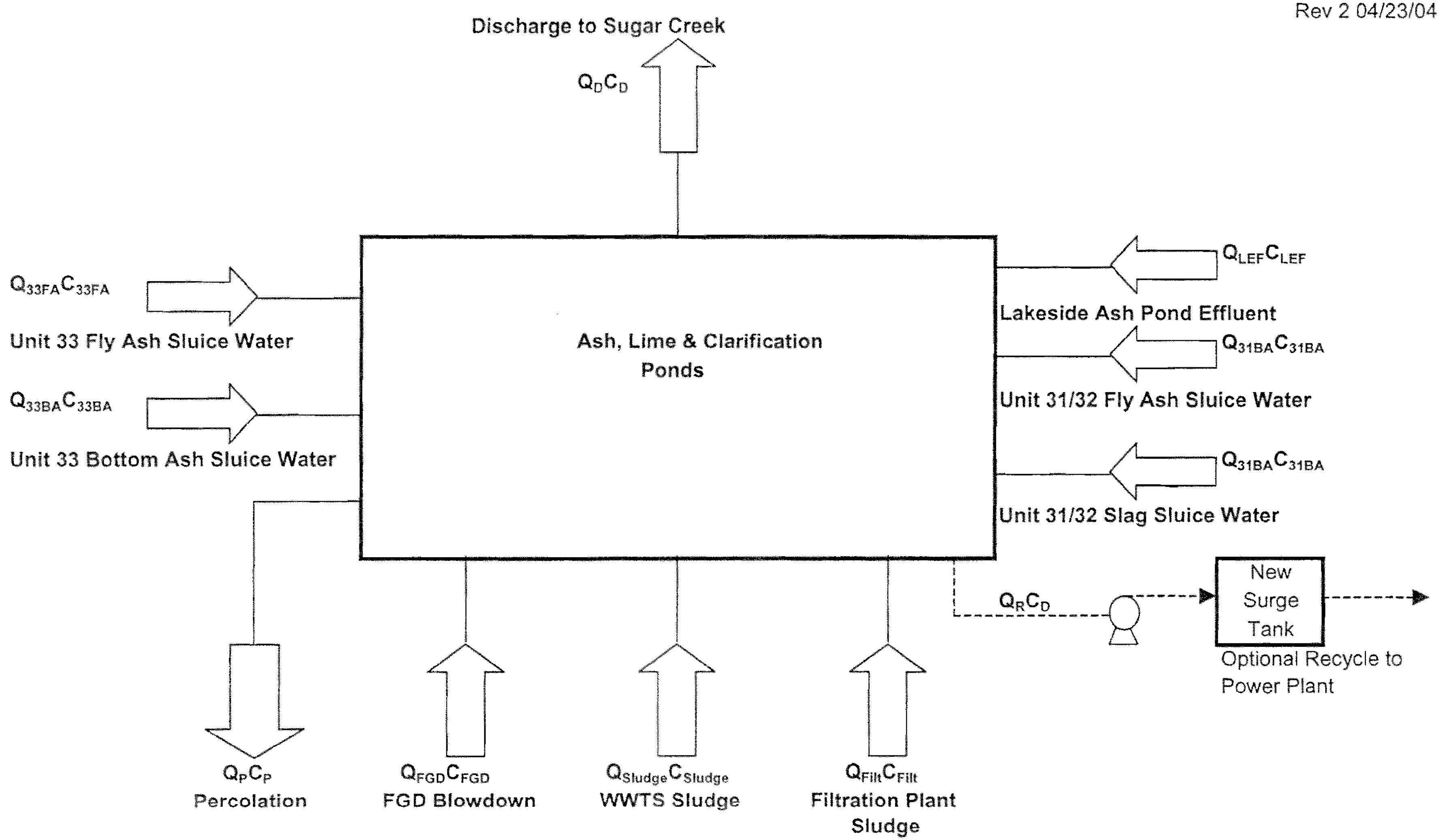
Hanson compared the sampling results vs. the Class I groundwater standards and a second set of more restrictive groundwater standards, which were established as part of the landfill operation permit for scrubber sludge. Hanson noted that in addition to boron, the Class I standards were exceeded at least once for several water quality parameters including antimony, cadmium, chloride, iron, lead, manganese, sulfate, TDS and pH. Additional parameters that exceed the more restrictive groundwater standards at lease once included arsenic, fluoride, nitrate and zinc.

A detailed review of the Hanson study is beyond the scope of this study. However, based on simple mass balance considerations, we believe there should be at least a two-fold to three-fold increase in ash pond dissolved solids levels if the system is converted to closed loop operation. This assessment is based on approximately 30% percolation losses (estimated by Hanson) and an additional 5% to 10% blowdown to Sugar Creek to control water quality. Our assessment is in general agreement with the results in the Hanson study. Therefore, we agree with Hanson that conversion of the ash handling systems to closed loop operation would likely result in some water quality parameters exceeding the groundwater standards governing ash pond leachate.

City Water Light & Power
Dallman Power Station
Water Conservation Study

Figure IV-1 - Mass Balance Model for Boron

Sargent & Lundy LLC
Prep'd MR
Rvw'd PAH
App'd RLR
Rev 2 04/23/04



SECTION V.

COST ESTIMATES

Conceptual cost estimates were developed for the following alternatives to reduce the use of Lake Springfield water.

- Estimate 1 – Dry Fly Ash Handling System
- Estimate 2 – Closed Loop Recirculating Bottom Ash System (Dewatering Bins)
- Estimate 3 – Sanitary Effluent as Additional Water Source
- Estimate 4 – FGD Vacuum Pump Seal Water Recovery
- Estimate 5 – Ash Sluice Water Recovery Systems

Estimates for the major components were based on vendor budget quotes submitted specifically for these concepts. Commodity material costs were based on recent similar projects, S&L's in-house cost data base, and published estimating manuals. Quantities of bulk material commodities were based on engineering estimates and preliminary design data for these concepts. Installation costs and labor rates were based on recent projects of similar size in the region. A contingency of 20% is used based on the preliminary nature of the engineering work performed.

The estimates did not include the following items:

- Asbestos removal or lead paint removal
- Overtime or allowances to attract labor
- S&L engineering costs
- CWLP indirects
- Sales and Use Taxes
- Allowance for funds used during construction

The conceptual cost estimates are summarized in Table V-1. Refer to Appendix A for the complete estimates.

TABLE V-1
SUMMARY OF CONCEPTUAL COST ESTIMATES

	Unit 31 &32	Unit 33	Total
Dry Fly Ash Handling System	$3,260,000	$4,100,000	$7,360,000
Closed Loop Recirculating Bottom Ash System	$6,680,000	$6,630,000	$13,310,000
Sanitary Effluent as Additional Water Source	N/A*	N/A*	$1,200,000
FGD Vacuum Pump Seal Water Recovery	N/A*	N/A*	$280,000
Ash Sluice Water Recovery System	N/A	N/A	$1,440,000

*Indicates not applicable. Costs are provided for the reuse of effluent for all three units and the modification of the common Dallman FGD sludge dewatering facilities.

SECTION V1

SUMMARY & CONCLUSIONS

A. REVIEW OF OPTIONS

1. Consumptive Water Losses

The alternatives that were reviewed in this study, along with their installed costs and benefits in terms of reduced water consumption at average load, are summarized in Table VI-1.

The use of a dry bottom ash system is not feasible for Unit 31/32, which produce a molten slag and cannot use a dry tank. A dry bottom ash system can be used for Unit 33. However, the installed cost is significant, and experience with this technology in the US is limited. Therefore, we believe a dry bottom ash system for Unit 33 is not feasible. Ash pond recycle and conversion of all the ash handling systems to closed loop operation was reviewed from a technical perspective and in terms of reduced water consumption. Although a cost estimate was developed for this option, there were potential environmental concerns that would prevent it from being used.

The use of sanitary effluent in lieu of lake water for ash sluicing and FGD makeup would provide the greatest benefit, in terms of reduced water consumption and at a relatively low cost. This assessment is contingent upon CWLP constructing a new unit and incurring only a small incremental cost (not included in this study) to increase the size of the sanitary effluent pipeline, and on-site storage and chlorination facilities needed to support the new unit.

With regard to ash handling, conversion of Unit 31/32 to recirculating bottom ash handling offers the greatest benefit in terms of reduced water consumption but also has the highest cost. Conversion of Unit 33 to recirculating bottom ash handling incurs nearly the same cost but offers much lower benefits, in terms of reduced water consumption. Conversion of Unit 33 to dry fly ash handling appears to offer the greatest benefit, in terms of reduced water consumption, relative to the installed cost.

With regard to water management practices, modifying the current ash handling system practices offers significant water savings at a negligible cost. Additionally, a relatively small quantity of FGD vacuum pump seal water and wastewater treatment system sludge (0.07 MGD) can be recovered at a reasonable cost.

It should be noted that regardless of whether any of the above alternatives are implemented, retirement of Lakeside Units 7 & 8 in 2009 will reduce consumptive water losses by approximately 25%.

TABLE VI-1
SUMMARY OF CONCEPTUAL COSTS AND BENEFITS FOR REDUCED CONSUMPTIVE LOSSES

	Installed Cost	Consumptive Water Reduction (MGD)
Dry Fly Ash Handling System		
Unit 31/32	$3,260,000	0.29
Unit 33	$4,100,000	0.84
Closed Loop Recirculating Bottom Ash System (Dewatering Bins)		
Unit 31/32	$6,680,000	2.39
Unit 33	$6,630,000	0.42
Dry Bottom Ash Handling System		
Unit 31/32	N/A	N/A
Unit 33	Not Feasible	0.42
Sanitary Effluent as Additional Water Source		
Unit 31/32/33	$1,200,000	4.94
Recycle of Ash Pond Effluent to Unit 32/32 & 33 Ash Handling Systems		
(5% Blowdown)	$1,440,000	3.74
Water Management Practices		
FGD Vacuum Pump Seal Water Recovery	$280,000	0.07
Ash Handling Water Management	Negligible	1.84

2. **Lake Water Versus Potable Water for Heat Exchanger Cooling**

In addition to the above consumptive water loss reduction alternatives, we also reviewed using raw lake water in lieu of potable water as the cooling source in the HVAC office cooling heat exchangers. Although use of potable water for the HVAC office cooling heat exchangers does not represent a consumptive loss (i.e. the water is returned to Lake Springfield), the power plant incurs a cost to purchase the water from the filtration plant. We considered supplemental biocide injection with dechlorination to allow raw lake water to be used without fouling of these heat exchangers. However, with the existing piping configurations, in effect there are actually twelve separate heat exchanger networks, each of which would require its' own chlorination and dechlorination systems. Therefore, conversion of the entire heat exchanger network from potable water to lake water is not practical. A simpler approach, which could provide some tangible benefits, would be to convert only the main HVAC office cooler from potable water to lake water. This would require some minor piping modifications, installation of packaged chemical feed systems for biocide addition and dechlorination and a small micron strainer. However, due to the small flow to this heat exchanger (0.05 MGD), even this relatively simple modification would be difficult to justify. Therefore, we do not recommend converting any of the various HVAC and service water heart exchangers from potable water to lake water.

We are, however, recommending that CWLP investigate the excessive usage of potable water for the circulating water pump seals at the intake structure. CWLP was unable to provide any further information regarding this issue during the course of this study.

3. **Environmental Issues**

A. **Boron Levels in Discharge to Sugar Creek**

In addition to the evaluation of water usage alternatives from the perspective of cost vs. consumptive water reduction, there are also environmental issues related to the concentration of boron in the discharge to Sugar Creek. CWLP is currently operating under an adjusted boron standard issued by IEPA, which limits the boron concentration in the discharge to <11 ppm. A boron standard also applies further downstream along Sugar Creek in the immediate vicinity of the sanitary treatment facility's discharge, where the boron concentration is limited to <5.5 ppm. Based on data provided in a recent study by Hanson Engineers, the boron limit applicable to CWLP's discharge to Sugar Creek is already being exceeding by nearly a factor of two. CWLP is concerned that implementation of water conservation measures would further concentrate boron levels in the discharge to Sugar Creek. CWLP is also concerned that the boron limits, which apply to the sanitary treatment facility's discharge and are currently being met, could also be exceeded as a result of implementing water conservation measures within the power plant.

Based on the data in the Hanson study, we developed a simplified mass balance model, which is in general agreement with the actual boron levels currently measured in the discharge to Sugar Creek. We applied this model to the various water conservation alternatives to estimate the impact on boron levels. The model predicts that conversion of the Unit 31/32 bottom ash sluice systems to recirculating operation (dewatering bins) would increase the boron concentration by more than 50% (from 27.79 ppm to 42.06 ppm). However, conversion of the Unit 33 bottom ash sluice system to recirculating operation (dewatering bins) would have only a minor impact on boron levels (from 27.79 ppm to 29.29 ppm). The largest increases in boron concentration would occur if wastewater from the ash ponds was recycled to the plant and the ash handling systems were converted to closed loop operation. Depending on the level of blowdown to Sugar Creek, compared to current levels, the boron concentration could increase by a factor of 2.5 to 3.5.

The model predicts that boron concentration would increase by approximately 5% if Unit 31/32 were converted to dry fly ash handling. However, the model predicts that the boron concentration would actually decrease if Unit 33 were converted to dry fly ash handling. Although contrary to expectations, the results are consistent with the relatively high boron concentrations reported in the fly ash sluice water.

The use of sanitary effluent in lieu of lake water would have little or no impact on boron levels in the discharge to Sugar Creek because most of the boron originates in the fuel and because the boron levels in these two water sources are nearly identical. If sanitary effluent were used by the power plant to conserve lake water, the existing and future Dallman units would consume most, if not all of the available effluent. There would be little or no effluent available for dilution within Sugar Creek immediately downstream of the sanitary treatment facility. Consequently, the boron limit at this location (5.5 ppm) would now be exceeded.

A detailed evaluation of boron issues is beyond the scope of this study. However, it should be noted, that the recent Hanson study included a brief evaluation of technologies that could remove boron from FGD wastewater to mitigate the boron issue. CWLP has also recently indicated that they are seeking permission to discharge some of the FGD wastewater to the city sewer as a means of mitigating the boron issue without the installation of wastewater treatment equipment.

B. Total Dissolved Solids (TDS) Levels Within Ash Ponds

At CWLP's request, we evaluated the conversion of the entire ash handling system to closed loop operation by recirculating ash sluice water from the ponds back to the power plant. We estimated that this would result in at least a two-fold to three-fold increase in boron levels, depending on the blowdown to Sugar Creek and the percolation losses from the ash ponds. In addition to boron, total dissolved solids (TDS) and other water quality parameters would also increase.

The previous water conservation study by Hanson included theoretical modeling and laboratory simulation of closed loop ash handling system operation. In addition to boron, Hanson concluded that concentrations of several other water quality parameters and various metals could either exceed the Class I groundwater standards or the additional groundwater limits established as part of the scrubber sludge landfill operating permit. Although a detailed review of the Hanson results is beyond the scope of this study, we agree with their basic conclusions regarding this issue.

B. CONCLUSIONS

The main consumptive losses of water at the Dallman and Lakeside stations are associated with ash handling. The flow rates for ash handling used in this study were based on the results of a flow monitoring program which was performed by CWLP using a portable ultrasonic flow meter. CWLP believes that the information obtained from this flow monitoring program is reasonably accurate. However, the program was relatively limited in duration and the benefits, in terms of reduced water consumption, associated with the various ash handling water conservation alternatives, may be somewhat conservative.

The cost estimates were based on vendor quotes prepared specifically for this study, but the overall estimates should still be considered conceptual in nature with an overall accuracy of +30%, -20%.

We believe that the use of sanitary effluent for ash sluicing and FGD makeup is a viable alternative. However, we are concerned about the fact that the final effluent from the sanitary treatment facility is not disinfected. Biocide addition within the power plant will need to be adequately monitored and controlled to conform with public health requirements and to minimize the potential for microbially induced corrosion (MIC). Additionally, the cost estimate for this alternative includes only a limited quantity of additional piping within the site boundary and does not consider the cost of the pipeline from the Sugar Creek sanitary treatment plant or new on-site storage or chlorination facilities. CWLP needs to add the incremental costs to increase the sizes of the effluent pipeline and for on-site storage and chlorination facilities associated with the new unit to determine the total cost of this alternative.

Although not directly related to consumptive losses and the review of alternatives for reducing these losses, it should be noted that there might be some inaccuracies in the plant water balance. As explained in the water balance notes (Table II-1), the Dallman flows to the wastewater treatment system are much lower than the total daily flow of 5-6 MGD which is measured by the wastewater treatment system totalizer. To resolve this discrepancy, the Lakeside flow to the wastewater treatment system was arbitrarily increased to 2.0 MGD. Since a flow of this magnitude from Lakeside is unlikely to occur on a consistent basis, it is likely that there are additional flows from Dallman to the wastewater treatment system, which are unaccounted for.

A cost/benefit analysis for the various alternatives considered is beyond the scope of this study. Therefore, we cannot provide recommendations with regard to specific alternatives, which should either be implemented or evaluated in further detail. Prior to performing any further studies to better define consumptive water losses or the costs for implementing various alternatives, CWLP will need to establish specific water usage constraints for Lake Springfield and determine the financial resources which can be allocated for water conservation.

A detailed environmental assessment is also beyond the scope of this study. CWLP will need to further review alternatives which increase boron levels within Sugar Creek and/or overall dissolved solids levels within the ash ponds. Additional adjustments in surface and groundwater standards may need to be obtained from the IEPA.

APPENDICES

ATTACHMENT D

Burns and McDonnell Engineering Co. Letter

Burns & McDonnell
SINCE 1898

May 18, 2007

Mr. Douglas Brown
City Water Light & Power
3100 Stevenson Drive
Springfield, IL 62703

City Water Light & Power
Wastewater Treatment Facility
Burns & McDonnell Project 39600
Wastewater Treatment Equipment (ENVIR)
Electrocoagulation

Dear Mr. Brown:

This letter was prepared to assist in City Water Light & Power's (CWLP) efforts to evaluate boron removal using electrocoagulation (EC).

Introduction

The Illinois Environmental Protection Agency (IEPA) has requested that CWLP evaluate pre-treating the Flue Gas Desulphurization (FGD) scrubber blowdown wastewater from Dallman 31, 32 and 33 generating facilities using electrocoagulation (EC). prior to discharge.

Boron in FGD scrubber blowdown is derived from naturally occurring compounds found in coal. The boron is carried in the flue gas after combustion and is ultimately dissolved in the FGD wastewater.

Boron removal by electrocoagulation from FGD wastewaters has not been verified by the EPA. Verification studies by the EPA and the Department of Energy (DOE) have focused on contamination in such waters as drinking water and radionuclides in wastewater. Contamination removal efficiencies (CRE) calculated in these studies indicate that boron removal by EC ranges from 3% – 71%. Research papers on EC also indicate that EC can remove boron from solution depending on its form or speciation. The range of boron CRE is explained by studies indicating that EC works by creating stable precipitates from contaminants in waters based on the oxide/hydroxide activation energies.

EPA-DOE results also indicate that EC is unreliable for inorganic contaminants that do not form precipitates or do not absorb to solids. Certain forms of boron are among these contaminants.

9400 Ward Parkway
Kansas City, Missouri 64114-3319
Tel: 816 333-9400
Fax: 816 333 3690
www.burnsmcd.com

Background

Electrocoagulation is a method of treating wastewater with electricity and sacrificial metal plates to cause contaminants in wastewater to become destabilized and precipitate.

The EC reactor consists of metallic electrode plates separated by thin annular spaces. Wastewater in the annular space conducts electricity which dissolves the electrodes. The dissolved metal ions react with contaminants creating precipitates that are removed by filtration. The metal plates can be made from several materials, aluminum representing the most effective material in boron removal.

Theory

The principle of EC begins when an electric current is applied to a cathode-anode electrode system in order to destabilize dissolved ionic or electrostatically suspended contaminants. Metal ions (cations) generated by the dissolution of the electrodes react with contaminants creating colloidal flocculation of metal oxides and hydroxides that precipitate as solids or remain in solution as suspended solids.

Below is the typical EC dissolution chemistry for an aluminum electrode:

Anode: $Al^o \leftrightarrow Al^{+3} + 3\ e^-$
Cathode: $3H_2O + 3e^- \leftrightarrow 1.5H_2 + 3OH^-$
Resulting in the Reaction: $Al^{+3} + 3H_2O \rightarrow Al(OH)_3 + 3H^+$

The general boron base reaction is expected to be:

$$Al^{+3} + BO_2^- + 2OH^- + nH_2O \leftrightarrow Al(OH)_2BO_2{\cdot}nH_2O$$

Where:

Al^o = Aluminum metal
Al^{+3} = Aluminum ion
e^- = Electron
H_2O = Water
H_2 = Hydrogen gas
OH^- = Hydroxide ion
$Al(OH)_3$ = Aluminum hydroxide
H^+ = Hydrogen ion

BO_2^- = Metaborate ion
$Al(OH)_2BO_2 \cdot nH_2O$ = Aluminum borohydrate

Contaminant reduction occurs via two mechanisms: flocculation/precipitation and adsorption. Adsorption occurs when contaminants electrostatically adhere to the flocculated solids and are removed along with the precipitates. The adsorption of boron on aluminum flocculants has been reported to be no greater than 20% of available boron when adsorption is not inhibited by other contaminants such as chlorides and sulfates, both of which exist in the FGD blowdown in high concentrations[1]. The remaining boron removal is due to flocculation/precipitation.

Parameters affecting EC efficiency

Typical parameters affecting EC efficiency are:

- pH
- Oxidation Reduction Potential (ORP)
- Specific conductivity
- Temperature
- Total dissolved solids (TDS)
- Total suspended solids (TSS)
- Speciation
- Passivation/oxidation of EC electrodes

Targeting boron specifically for removal by electrocoagulation in the FGD blowdown wastewater is more difficult because boron is known to exist in at least six pH dependent species in water. The predominant forms are boric acid [H_3BO_3] and borate [$B(OH)_4^-$]. Boric acid predominates at pH ranges below 4 (100% boric acid), whereas, borate predominates at pH ranges above 12 (100% borate)[1]. Boric acid is a form that is difficult to remove by most available technologies. With the FGD wastewater in the 6.5 – 7.0 pH range, 50% – 65% of boron will be in the boric acid form.

Additionally, competing reactions from other FGD blowdown wastewater constituents with lower activation energies may dramatically lower boron removal. Activation energy is the amount of energy needed to initiate a chemical reaction. The lower the activation energy, the easier it is for the reaction to occur. Several chemical species such as chlorides and sulfates are present in large quantities in the FGD blowdown and have lower activation energies than

---

[1] J.-Q Jiang, Y. Xu, J. Simon, K. Quill and K. Shettle. "Mechanisms of Boron Removal with Electrocoagulation" Environ. Chem. 2006, 3, 350-354.

boron. The aluminum ion would naturally react with these other chemical species before boron.

Boron Removal in EC Process

Boron is a semi-conductor (metalloid) that can form several species as described above and is not easily oxidized to a compound which can precipitate. Boron does not have a strong ionic charge and thus will not react with the aluminum ions as readily as anions such as chlorides and sulfates.

Boric acid is considered to be a substance that does not form a solid when in the presence of flocculating substances. Research has shown that solutions prepared under laboratory conditions without competing reactions have achieved removal rates of approximately 70%[1].

Competing reactions from other anions in the FGD wastewater will generally increase the aluminum consumption. Anions are ions with a negative charge and will seek out cations such as the aluminum ion that are positively charged. Anions present in significant quantities in the FGD wastewater include chlorides and sulfates.

The sludge created is estimated based on precipitated aluminum borate and other aluminum byproducts. The estimated amount of wet solids created is 49,000 lbs/day at 45% solids content at a flowrate of 240 gpm. Estimated sludge does not include precipitation reactions with other constituents in water.

Cost Estimate

Cost estimates associated with the EC unit was provided by Powell Water Systems, Inc. Other costs were based on current Dallman construction contracts, equipment supplier estimates, and aluminum supplier pricing.

The Powell EC reactor chamber has 217 slots for sheets 10 ft x 1.5 ft x 1/8 inch thick. On a pound basis for aluminum, this equates to 26.5 lbs per slot, or 5,750 lbs total. With an estimated consumption of about 11,900 lbs Al/day, there would be more than two complete electrode change outs per day based on 100% utilization, resulting in significant operating costs. The utilization rate for aluminum electrodes may be closer to 50%.

---

[1] J.-Q Jiang, Y. Xu, J. Simon, K. Quill and K. Shettle. "Removal of boron (B) from waste liquors" Water Science & Technology Vol 53 No 11 pp 73-79.

Power consumption from an EPA verification study on a Kaselco EC system was 67.9 kWh/1,000 gal of wastewater treated using steel electrodes and a maximum TDS concentration of 250 mg/l. The actual power consumption is expected to be greater due to the higher 20,000 mg/l TDS concentration of the FGD blowdown wastewater.

Capital and operating costs are summarized below:

Capital Costs ($)			
Item	**Quantity**	**Unit Cost ($)**	**Cost ($)**
EC Reactor System	2 x 100%	500,000	1,000,000
Clarifier	1 x 100%	700,000	700,000
Thickener	1 x 100%	160,000	160,000
Filter Press	2 x 100%	480,000	960,000
Installation (foundations, building, interconnecting piping, electrical and equipment erection)	1	4,000,000	4,000,000
Engineering (10%)	1	682,000	682,000
Contingency (25%)	1	1,705,000	1,705,000
		Total Capitalized Cost	**9,207,000**

Operating Cost ($/year)			
Item	**Quantity**	**Unit Cost ($)**	**Cost ($/year)**
Aluminum (11,900 lbs Al/day)	4, 343,500 lbs/yr	$2.50/lb	10,860,000
Labor	50,000 man-hours/yr	$50/hr	2,500,000
Landfill Disposal (49,000 lbs sludge/day)	9,000 tons/yr	$35/ton	315,000
Landfill Trucking	9,000 tons/yr	$30/ton	270,000
Electricity	8,565,000 kWh/yr	$0.015/kWh	129,000
		Total Operating Cost	**14,074,000**

Conclusion

Economically, electrocoagulation is not recommended for FGD wastewater due to high capital and operating costs relative to low boron removal efficiencies. Additionally, these high operating costs are based on assumptions extrapolated from studies performed on wastewaters with characteristics much different than FGD wastewater. The operating costs were conservatively estimated assuming 100% utilization of the aluminum electrodes with no inhibiting reactions. Decreasing aluminum electrode utilization will influence costs by increasing the size of the EC reactors and increase operating costs due to additional aluminum electrode handling. Inhibiting reactions will increase the consumption of aluminum and costs associated with the additional aluminum consumption.

Electrocoagulation is technically feasible for boron removal from the FGD wastewater; however boron removal efficiency cannot be predicted due to the lack of verified boron removal efficiencies in high boron and high TDS wastewaters. Boron removal efficiency is expected to be dramatically decreased from theoretical estimates due to competing reactions in the electrocoagulation process.

If you have any questions on the above, please give us a call.

Sincerely,

Donald A. Schilling

Don Schilling, P.E.

cc: Patrick Giacomini
Dan Fugate
Ronald Vering

ATTACHMENT E

Crawford, Murphy & Tilly, Inc.
Summary of Anticipated Constituents in the
FGDS Wastewater Stream and Jar Test Results

CWLP - Boron Mitigation Project

Analysis summary of raw scrubber blowdown wastewater

Date	Location	pH (units)	TDS (mg/l)	TSS (mg/l)	Chloride (mg/l)	Boron (mg/l)
9/12/2006	Units 31-32	7.00	22,530	511		
10/2/2006	Unit 33	6.60	24,727	1,330		
2/14/2007	Units 31-32		18,371	3,357		
2/14/2007	Unit 33		15,485	5,158		
2/14/2007	Units 31-32			2,871		
4/17/2007	Units 31-32	6.75	21,956	2,530	7,200	452
5/7/2007	Unit 33	6.70	18,475	545	5,390	250
5/10/2007	Unit 33	6.57	24,360	3,880	6,320	333
6/12/2007	Unit 33	6.85	26,948	16,386	10,200	522
	Min	6.57	15,485	511	5,390	250
	Ave	6.75	21,607	4,063	7,278	389
	Max	7.00	26,948	16,386	10,200	522

Analyses by Prairie Analytical and CMT

CWLP Boron Mitigation Project

Jar tests with polymer and/or lime

Date - May 7, 2007

		Analyses by Prairie Analytical										
	pH* (units)	**Arsenic (ppm)**	**Barium (ppm)**	**Boron (ppm)**	**Cadmium (ppb)**	**Chromium (ppb)**	**Iron (ppb)**	**Lead (ppb)**	**Manganese (ppb)**	**Mercury (ppb)**	**Selenium (ppb)**	**Zinc (ppb)**
Raw	6.70	<0.05	0.371	268	<10	74.8	3,440	6.43	4,910	21.20	551	<100
Raw settled	6.70	<0.05	0.433	250	11.00	74.8	4,870	9.68	5,980	37.20	541	<100
Jar 1	7.31	<0.05	0.390	169	10.30	<50	<1,000	<2	4,340	8.12	524	<100
Jar 2	7.57	<0.05	0.379	197	<10	<50	<1,000	<2	4,010	7.96	546	<100
Jar 3	7.78	<0.05	0.349	201	10.30	<50	<1,000	<2	3,780	6.59	556	<100
Jar 4	7.94	<0.05	0.391	219	<10	<50	<1,000	<2	4,130	8.16	527	<100
Jar 5	8.07	<0.05	0.367	207	<10	<50	<1,000	<2	3,850	6.78	418	<100
Jar 6**	7.62	<0.05	0.410	216	<10	<50	<1,000	<2	4,300	2.77	426	<100
Reduction from raw to settled			-16.7%	6.7%		0.0%	-41.6%	-50.5%	-21.8%	-75.5%	1.8%	
Reduction from raw to Jar 1			-5.1%	36.9%		33.2%	70.9%	68.9%	11.6%	61.7%	4.9%	
Reduction from raw to Jar 2			-2.2%	26.5%		33.2%	70.9%	68.9%	18.3%	62.5%	0.9%	
Reduction from raw to Jar 3			5.9%	25.0%		33.2%	70.9%	68.9%	23.0%	68.9%	-0.9%	
Reduction from raw to Jar 4			-5.4%	18.3%		33.2%	70.9%	68.9%	15.9%	61.5%	4.4%	
Reduction from raw to Jar 5			1.1%	22.8%		33.2%	70.9%	68.9%	21.6%	68.0%	24.1%	
Reduction from raw to Jar 6			-10.5%	19.4%		33.2%	70.9%	68.9%	12.4%	86.9%	22.7%	

		Chloride (ppm)	**Sulfate (ppm)**	**Fluoride (ppm)**	**Nitrate (ppm)**	**Ammonia (ppm)**
Raw						
Raw settled		5,390	1,370	<0.5	112	0.209
Jar 1		5,250	1,520	<0.5	110	0.220
Jar 2		5,480	1,120	<0.5	112	
Jar 3		5,450	1,190	<0.5	112	0.229
Jar 4		5,450	1,180	<0.5	113	
Jar 5		5,550	1,180	<0.5	114	0.259
Jar 6**		5,650	1,190	<0.5	113	

* Analyses by CMT

** Combined sludge from jars 1-5.

Electronic Filing - Received, Clerk's Office, November 21, 2008
* * * * * PC #1 * * * * *

ATTACHMENT F

Intergovernmental Cooperation Agreement

This Agreement made this AN INTERGOVERNMENTAL COOPERATION AGREEMENT BETWEEN THE CITY OF SPRINGFIELD, ILLINOIS AND THE SPRINGFIELD METRO SANITARY DISTRICT

10 day of March, 2008, by and between the City of Springfield, Illinois, a municipal corporation in the County of Sangamon and State of Illinois (City), and the Springfield Metro Sanitary District, incorporated and organized under the laws of the State of Illinois (District), with respect to the treatment of an industrial waste water stream. This Agreement is made by authority of Article 7, Section 10 of the Illinois Constitution of 1970, and Section 5 of the Illinois Intergovernmental Cooperation Act (5 ILCS 020/1 et seq.).

WHEREAS the City owns and operates an electric generating facility at 3100 Stevenson Drive in Springfield, and

WHEREAS, the City's operations at its generating facilities create several waste water streams which the City treats and manages and ultimately discharges through various outfalls pursuant to its National Pollutant Discharge Elimination System (NPDES) Permit issued by the Illinois Environmental Protection Agency (IEPA), and

WHEREAS, the City has an effluent limitation at certain outfalls for boron concentrations based upon an adjusted standard issued for the City by the Illinois Pollution Control Board (Board), and

WHEREAS, since 2003 the City has experienced exceedances of its permit limits for boron concentrations in its discharges, and

WHEREAS, IEPA issued a Notice of Violation to the City in the fall of 2003 for such exceedances, and

WHEREAS, the City has conducted an investigation to determine what waste water streams were contributing to such exceedances, and

WHEREAS, the City has identified high concentrations of boron in certain waste water streams produced by its Flue Gas Desulfurization (FGD) Systems at its Dallman Units 1, 2 and 3, which have historically been routed to the City's Dallman Ash Pond treatment facility, and

WHEREAS, the City has attempted to identify a technically and economically feasible method to treat these waste water streams to reduce or eliminate the boron concentrations such that the remaining waste water could still be routed to the Dallman Ash Pond Treatment

Facility with that discharge again meeting the permit boron concentration limitations, without success, and

WHEREAS, the City has approached the District regarding a proposal to discharge these FGD waste water streams to the District for treatment at its Spring Creek Waste Water Treatment Facility, and

WHEREAS, the City proposed such a plan to IEPA as a means to achieve compliance with the exceedances for which a notice of violation was issued, and

WHEREAS, the data the City presented indicated that the District would be given an effluent limitation for concentration of boron in its discharge based upon the Board's general water quality standard for boron and the data further suggested the District's discharge would not consistently meet this proposed effluent limitation, and

WHEREAS, in principle IEPA agreed that the City's proposal appeared to be the most feasible solution to eliminate the City's exceedances, but that the District would need to obtain regulatory relief from the Board in the form of a new site specific water quality standard for the Sangamon River for boron such that an effluent limitation for boron could be calculated for the District's NPDES permit for its Spring Creek Facility and the District would be able to maintain compliance with during various conditions, and

WHEREAS, the City has submitted a written proposal to IEPA to direct the FGD streams to the District after seeking the above described site specific standard for boron as the City's compliance commitment plan, and
WHEREAS, the District is willing to accept the City's FGD waste water streams in accordance with the following terms and conditions of its Agreement.

NOW THEREFORE, it is agreed as follows:

1. The City will install at its cost all facilities necessary to deliver the FGD waste water stream from its generating facility to the District facilities located in the vicinity of Bergen Park where the District has a 39 inch sewer collection main that routes to the District's Spring Creek Treatment Plant. This entails the following:

a. The City would be responsible for securing all necessary rights and easements to construct and operate a force sewer main between the above described locations.

b. The City shall be responsible for the construction, operation, and maintenance of said force main.

2. The City at its cost will install and operate a pretreatment system at its generation facility for the purpose of reducing solids, metals, and dissolved matter in the waste stream before the same would enter the City's force main.

3. The City at its cost will install any additional chemical feed sites as deemed necessary by the District for the District's collection system for the purpose of controlling odors that might be anticipated to emanate after the City's waste water stream enters the District's mains and collection system.

4. The City at its cost shall cause the District's 39 inch main from the above described point of delivery to the District's system to be relined to the point where that 39 inch main connects with the District's 42 inch main as well as relining the 42 inch main to the vicinity of the intersection of Daniels and Carpenter, and any subsequent relining of this 39 inch main and the above portion of the 42 inch main shall be the City's responsibility. The City shall also coat the manhole at the delivery point described above in paragraph 1.

5. The City shall timely submit to the District an application for an industrial waste stream permit in a packet encompassing the following forms:

a. Construction/operation permit approval WPC-PS-1
b. Service Sewer Connections Schedule A/B
c. Waste Characteristics Schedule N
d. Lift Stations Schedule F, if necessary
e. Pretreatment Schedule J

6. The City shall pay the District $100,000 per month for the District to accept this waste stream beginning with the first full month of operation of the City's force main. The parties shall revisit this provision five (5) years from the execution of this Agreement.

7. The City and the District shall submit a joint petition to the Board for a site specific standard for boron for the Sangamon River for

the District's discharge from its Spring Creek Plant at the City's cost and expense, with the City being responsible for securing joint legal representation for the City and the District and retaining all requisite professional and technical support for the site specific standard proceeding before the Board.

a. The District shall cooperate with the agents, attorneys and consultants retained by the City for such proceedings and provide such information necessary to support this endeavor.

b. Should the Board fail to grant the site specific standard necessary to implement the intent of this agreement, the District may at its sole discretion declare this Agreement null and void, unless such regulatory relief is determined by IEPA, the City and the District not necessary for this Agreement to otherwise be performed.

8. To the extent allowable by law, the City shall defend and hold harmless the District against any and all claims, demands, and causes of action arising out of or connected with this Agreement, including any action or claim brought against the District by reason of exceedances of the type that are the subject of this Agreement, and shall indemnify the District for any costs, expenses, fines, or damages resulting therefrom (including all court costs, fees, and reasonable attorneys' fees), except where such claims arise out of the gross negligence or willful misconduct of the officers, agents or employees of the District.

9. This Agreement shall be in effect until the City finds it no longer necessary to deliver the FGD waste water streams to the District as provided for herein, at which time the City and District may agree to terminate this Agreement. Either party may also choose to terminate this agreement for convenience by providing notice of termination in writing to the other party with a forty-eight (48) month notice of the date of termination.

10. In the event that both: (1) subsequent operational problems arise after the City begins to deliver the FGD waste water streams to the District as provided herein; and (2) such problems are directly related to and caused by the characteristics of the City's waste stream and exclusive of normal wear and tear of the District's facilities and equipment, then the District shall notify the City in writing of such problems. After receipt of the written notification by the City, the

parties shall meet and work together to reach a mutually agreed to solution within 90 days of the date the City receives written notice of the problem(s), (the "90 Day Solution Period"). "Operational Problems" are defined herein to include, but shall not be limited to, sewer system surcharging due to the FGD waste stream, accelerated corrosion of the District's facilities due to the corrosive nature of the FGD waste stream, breakdown or temporary shutdown of any City facility constructed or used to carry out the obligations of this agreement, and violations of the District's NPDES Permit discharge limitations which are directly attributable to the FGD waste stream. If such a solution cannot be reached within the 90 Day Solution Period, then this Agreement shall terminate one (1) year from the start of the 90 Day Solution Period, unless the Parties agree otherwise in writing.

11. In the event that one Party believes the other to be in default under this Agreement, that Party acting through its chief administrator, shall notify the other Party in writing of the specified default. The other Party shall have ninety (90) days from the date of receipt of the notice to cure the default (90 Day Correction Period), or within any mutually agreed upon extension thereof. If the default is not then corrected, then this Agreement shall terminate one (1) year from the start of the 90 Day Correction Period, unless the Parties agree otherwise in writing. No waiver of any default shall be implied by the failure of either Party to give notice of default, and no express waiver shall affect any other default except the one specified in the waiver.

12. Any notice or communication permitted or required under the Agreement shall be in writing and shall become effective on the day of mailing thereof by first class mail, registered or certified mail, postage prepaid, addressed to:

<u>If to District to:</u>

Springfield Metro Sanitary District
Attention: Director/Engineer
3017 North Eighth Street
Springfield, IL 62707

<u>With a copy to:</u>

Stratton & Reichert
725 S. Fourth St.
Springfield, IL 62703

<u>If to City to:</u>

City of Springfield
Office of Public Utilities
Attention: General Manager
4th Floor, Municipal Center East
800 East Monroe
Springfield, IL 62757

<u>With a copy to:</u>

Office of Corporation Counsel
Room 313

Municipal Center East
800 East Monroe
Springfield, IL 62701

13. This Agreement shall be binding upon the successors and assigns of the District and the City and their respective governing bodies.

14. This Agreement may not be amended except by means of written document, including an addendum, signed by authorized representatives of both the District and the City.

15. This Agreement shall be deemed dated and become effective on the date the last of the Parties signs as set forth below the signature of their duly authorized representatives.

Attest: THE CITY OF SPRINGFIELD, IL

By: Cecilia K Tumulty By: Timothy J Davlin
City Clerk Mayor

Date: 3·10·08

Attest: SPRINGFIELD METRO SANITARY DISTRICT

By: ______ By: Richard ______
Clerk President

Date: 3/11/08

ATTACHMENT G

BORON MITIGATION OPTIONS TABLE

BORON MITIGATION OPTIONS TABLE

Treatment Technology	Cost			Reason For Not Implementing	Discussion
	Present Value ($)	Capital Cost ($)	O&M Cost ($)		
Brine Concentrator followed by Spray Dryer	$22,100,000	$8,222,000	$798,539	Technology was attempted. See discussion included in "pilot plant" below.	CWLP entered a contract with Aquatech International Corporation to provide a Zero Liquid Discharge Brine Concentrator/Spray Dryer System in December 2005. See the discussion below for the results of this pilot plant test. Costs cited are for comparative purposes only and do not include site preparation (site grading, providing utilities, etc.) or disposal of wastes generated by the process. Present Value assumes Annual O&M Costs escalate by $40,000/year; calculation also assumes power plant life of 30 years and an interest rate of 8 percent.
Reverse Osmosis followed by Crystallizer and Spray Dryer	$25,600,000	$6,120,000	$1,118,649	Not selected for pilot plant test based on cost and operational issues with high concentrations of salts and suspended solids in the waste stream.	Reverse Osmosis technology is currently not considered to be a viable technology for this application and is no longer marketed by the vendor to remove high concentrations of boron in liquid waste streams. Costs cited are for comparative purposes only and do not include site preparation (site grading, providing utilities, etc.) or disposal of wastes generated by the process. Present Value assumes Annual O&M Costs escalate by $56,000/year; calculation also assumes power plant life of 30 years and an interest rate of 8 percent.
Electrocoagulation (EC)	$254,000,000	$9,207,000	$14,074,000	Not selected for pilot plant test based on high cost relative to low boron removal efficiencies.	Targeting boron in FGDS wastewater specifically for removal by EC is difficult because boron is known to exist in at least six pH dependent species in water. Additionally, competing reactions from other FGDS wastewater constituents was expected to dramatically lower boron removal. It was concluded that boron removal efficiency could not be predicted due to lack of verified boron removal efficiencies in high boron and high TDS waters. An on-site small scale test was performed with no success of demonstrating the removal of boron. Costs cited are for comparative purposes only and do not include site preparation (site grading, providing utilities, etc.) or disposal of wastes generated by the process. Present Value assumes Annual O&M Costs escalate by $700,000/year; calculation also assumes power plant life of 30 years and an interest rate of 8 percent.
"Pilot Plant" Brine Concentrator/ Spray Dryer System	$104,500,000	$40,000,000	$3,700,000	Increased cost and uncertainty in how to dispose of solid waste generated by treatment process.	As detailed design of the Brine Concentrator/Spray Dryer system progressed, it became apparent that the FGDS blowdown water was a unique application of this technology. This relatively unique application translated into design changes and increased cost as the project progressed. The question of how to dispose of large quantities of solid waste generated was never resolved; therefore, the cost of waste disposal is not included in the referenced costs. Present Value assumes Annual O&M Costs escalate by $185,000/year; calculation also assumes power plant life of 30 years and an interest rate of 8 percent.

Alternative Operational Modifications	Reason For Not Implementing	Discussion
Alternative Coal Supply	Economic analysis favored continued use of Illinois coal.	Studies showed that continued use of Illinois coal was the lowest cost long term solution; resulted in economic benefits for Springfield and the State of Illinois; took advantage of CWLP's experience operating and maintaining FGDS systems; as well as avoiding major plant equipment and railway modifications and concerns about handling explosive dust. See section 6.1 on pages 6-1 through 6-3 of the TSD.
Convert to Dry Ash Systems	Will not reduce boron in the wastewater generated by the air pollution control systems that are the subject of this site-specific boron standard.	Conversion to a dry ash system has been studied by CWLP; however, the particular waste stream that is the subject of this technical support document is generated by the air pollution control equipment and would not be eliminated by modifying the plant ash handling system. The new Dallman Unit 4 will include dry fly ash and bottom ash handling systems. See section 6.2 on pages 6-3 through 6-5 of the TSD.

Alternative Operational Modification	Cost			Reason For Implementing	Discussion
	Present Value ($)	Capital Cost ($)	O&M Cost ($)		
Pretreatment/Discharge to SMSD	$36,100,000	$15,500,000	$1,600,000	Pretreatment and Discharge to the SMSD Spring Creek Plant is proposed for implementation.	SMSD has entered into a contract with CWLP to accept the FGDS wastewater stream for a price of $100,000/month provided that acceptance of the wastewater does not upset normal Spring Creek Plant operations. CWLP intends to treat the FGDS waste stream with conventional treatment process for solids removal prior to pumping the wastewater to the SMSD Spring Creek Plant. CWLP is also providing a chemical feed system to control odor to the SMSD plant. See section 6.4 on pages 6-13 through 6-14 of the TSD. The capital cost includes the pretreatment system and the pipeline to transfer the pretreated FGDS wastewater and chemical feed system(s) to control odor to the SMSD Spring Creek Plant. Present Value assumes a fixed monthly payment to SMSD, with other operating and maintenance costs escalating by $10,000 per year, a pretreatment system life of 30 years and an interest rate of 8 percent.

Electronic Filing - Received, Clerk's Office, November 21, 2008
* * * * * PC #1 * * * * *

ATTACHMENT H

Coordinates for the Affected Stream Segments

**Site-Specific Boron Standard for the Springfield Metro Sanitary District Spring Creek Plant
Sangamon County, Illinois
Hanson No. 07E0039**

Sangamon River and Illinois River Coordinates*

Location	Latitude	Longitude
SMSD Spring Creek Plant Outfall 007	39°51`37.234"	89°38`30.082"
182 Yards Downstream of the SMSD Outfall 007	39°51`42.595"	89°38`30.089"
Confluence of the Sangamon River with Salt Creek	40°7`33.009"	89°49`40.224"
Confluence of the Sangamon River with the Illinois River	40°1`20.995"	90°25`59.451"
100 Yards Downstream of the Confluence of the Sangamon River with the Illinois River	40°1`20.197"	90°26`3.205"

* Coordinates are approximate and were determined using the Illinois State Water Survey's Illinois Streamflow Assessment Model GIS files and ArcGIS.

Electronic Filing - Received, Clerk's Office, November 21, 2008
* * * * * PC #1 * * * * *

ATTACHMENT I

Corrected Footnote 1 of Table 6-2 of the TSD

TABLE 6-2

COST OF TREATMENT ALTERNATIVES FOR THE REMOVAL OF BORON

Treatment Process	Capital Cost[1] ($)	Annual O&M[1] ($)	Present Value[2] ($)	Present Value per Electric Service[3] ($)
Brine Concentrator followed by Spray Dryer	8,222,000	798,539	22,100,000	333
Reverse Osmosis followed by Crystallizer and Spray Dryer	6,120,000	1,118,649	25,600,000	385
Electrocoagulation	9,207,000	14,074,000	254,000,000	3,822

[1] **Costs from Burns and McDonald reports cited in sections 6.3.1, 6.3.2 and 6.3.3 of this report.**

[2] **Present Value calculated assuming Annual O & M Costs escalate by $40,000/year for the Brine Concentrator; $56,000/year for Reverse Osmosis; and $700,000/year for the Electrocoagulation process. Calculation also assumes power plant life of 30 years and an interest rate of 8 percent.**

[3.] **Cost based on 66,489 electric services (58,443 residential electric customers and 8,046 commercial electric customers)**