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Exelon. Nuclear

April 4, 2006
BW060044

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Braidwood Station, Units 1 and 2
Facility Operating License Nos. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and STN 50-457

Subject: Groundwater Tritium Interim Remediation

Enclosed are a summary of our planned groundwater tritium interim remediation and a detailed Interim Remedial Action Plan. These documents are being submitted in response to a request from representatives of the NRC Region III office. The summary contains an outline of the Interim Remedial Action Plan, our actions to prevent leakage from the circulating water blowdown line vacuum breakers, and our community relations actions.

The Interim Remedial Action Plan describes the approach to retard the movement of tritium in the groundwater around a pond owned by Exelon Generation Company, LLC near the northern boundary of the Braidwood Station site. The plan involves the placement of a pump in the pond to transfer water from the pond into the Braidwood Station circulating water blowdown line. The lower water level in the pond will reverse groundwater flow to the north of the pond and mitigate the increase in concentrations of tritium over time.

If you have any questions about this letter, contact Kenneth Ainger at (630) 657-2800.

Respectfully,

Keith J. Polson

Keith J. Polson
Site Vice President

Enclosures

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Braidwood Station

A001

Braidwood Station
Groundwater Tritium Interim Remediation

I. Outline of Interim Remedial Action Plan

A comprehensive groundwater investigation program was conducted at Braidwood Station in 2005 and early 2006. An area was identified where tritium has been detected above the 35 Illinois Administrative Code 620 groundwater standard (20,000 picocuries per liter (pCi/L)). This area is located near Smiley Road, at the southeast corner of a pond owned by Exelon Generation Company, LLC (Exelon) (i.e., the Exelon pond) and just west of the circulating water blowdown pipeline (blowdown line) as it leaves the Braidwood Station property. This area is approximately 4.5 acres in size. Data indicate that tritium at concentrations above our lower detection capability (approximately 200 pCi/L) has migrated into the Exelon pond, north of Smiley Road and past the pond to a limited extent. Maps included in the attached Interim Remedial Action Plan (IRAP) illustrate the location of the plume.

The IRAP has been developed to capture the movement of tritium in the groundwater that is above the groundwater standard and retard the movement of tritium that has migrated into and downgradient of the Exelon pond at concentrations above 200 pCi/L. The removal of tritium in the groundwater will be achieved by pumping surface water from the Exelon pond to lower the water level in the pond and create a 'cone-of-depression' in the water table. This will reverse groundwater flow to the north of the Exelon pond and mitigate the increase in concentrations of tritium over time. This will allow for the removal of tritium within the main plume area to prevent further tritium migration beyond the Exelon pond which, if left unchecked, could elevate current concentrations above 200 pCi/L.

The IRAP involves the placement of a pump in the Exelon pond to transfer water from the pond into the Braidwood Station blowdown line. The pond water will be pumped via a forcemain (i.e., a discharge pipe to be installed from the pond to a connection point at a vacuum breaker on the blowdown line).

During the start-up of the system, the tritium concentration in the pumped water will be closely monitored and correlated with the flow rate. This will be done to ensure the tritium concentration entering the blowdown line will form a composite concentration in the blowdown line of less than 200 pCi/L. The system will also be closely monitored and modified during the start-up phase to ensure hydraulic capture and that the pond is not overdrawn in a manner that nearby shallow private wells are not overly dewatered.

The duration of the interim remediation operation will be based on a review of the operating conditions at the impacted area and the effectiveness of the remedial action over time. This review will consider how the current pond pumping system could be modified to shorten the cleanup time and to increase tritium recovery. We expect these considerations will be taken into account in the development of the final remediation plan for this site.

II. Actions to Prevent Leakage from the Blowdown Line Vacuum Breakers

Exelon is taking the following actions to prevent leakage from the blowdown line vacuum breaker valves while executing the IRAP.

- Each vacuum breaker valve that will be in service has recently been inspected in advance of initially commencing the interim remediation operation. In particular, float integrity and seating surface components within the vacuum breaker valves were inspected to ensure the proper sealing of those components to prevent leakage.

- During the interim remediation pumping operation, the blowdown line will be operated pressurized along the full length of the pipeline to ensure the vacuum breaker valves will remain seated (i.e., closed). This will be accomplished by throttling a valve at the end of the blowdown line near the discharge point into the Kankakee River.

- The above actions will provide a high level of confidence that leakage from the vacuum breaker valves will be prevented. In addition, an impermeable barrier is being installed in the bottom of the vacuum breaker enclosures (which are below ground level) to contain any leakage.

- A continuously monitored leakage detection system will be installed in all the vacuum breaker enclosures to promptly detect any leakage. The system will consist of sensors placed at the bottom of the vacuum breaker enclosure that will be wired to a transmitting device installed next to the vacuum breaker. If the sensors detect leakage, the transmitter will send a signal via a cellular telephone network to operators in the continuously manned Braidwood Station control room. Upon receipt of notification from the system, operators will promptly take action to turn off the pump at the pond to secure the interim remediation operation.

III. Interim Remediation Community Relations Actions

The communications plan for the interim remediation project consists of direct communication with the most affected stakeholders, outreach to local and county officials, media outreach and an information night to inform the general public (scheduled for April 6, 2006). Door-to-door communications were made with the most affected stakeholders on March 29, 2006. This included residents whose groundwater is affected as well as those who live in the vicinity of the plume or within 1000 feet of the blowdown line. These residents received an information packet that included a letter from the Braidwood Station Site Vice President and a copy of the news release that explained the interim remediation plan. They also received an invitation to the April 6, 2006 information night, and a page with frequently asked questions. Also on March 29, 2006, a news release was issued to inform the general public, and local and county officials were contacted by telephone and faxed pertinent information. The news release and frequently asked questions documents were loaded onto the Braidwood Station tritium communications website and the information was included in a previously established hardcopy repository of tritium project documents at the Fossil Ridge Library in Braidwood, IL. The information night will be held at Exelon's Services and Training Center from 4:00 p.m. to 8:00 p.m. The event is intended to educate the public on the planned remediation efforts and to allow those interested to engage in one-on-one conversations with Exelon, State and NRC representatives.

INTERIM REMEDIAL ACTION PLAN

EXELON GENERATION COMPANY, LLC

BRAIDWOOD STATION

BRACEVILLE, ILLINOIS

MARCH 2006

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(Following Text)

LIST OF APPENDICES

1.0 INTRODUCTION

This Interim Remedial Action Plan (IRAP) has been prepared by Conestoga-Rovers and Associates (CRA) on behalf of Exelon Generation Company, LLC (Exelon).

The purpose of this IRAP is to execute a remedial strategy as soon as possible in order to implement groundwater migration control and tritium removal at the area downgradient of vacuum breakers (VB) 2 and 3 at Braidwood Station located in Braceville, Illinois.

This plan is intended to meet the functional requirements of a remedial action plan in accordance with 35 IAC 740 Section 430 in the Illinois Environmental Protection Agency (Illinois EPA) Site Remediation Program (SRP). Exelon has prepared this plan consistent with discussions between the Illinois Attorney General's Office, the Will County State's Attorney, the Illinois EPA, the Illinois Emergency Management Agency (Illinois EMA), the Illinois Department of Public Health (Illinois DPH), and Exelon on March 2, 2006.

2.0 BACKGROUND

The Site, for the purposes of this IRAP, is defined as the area to the north and south of Smiley Road where tritium impacted groundwater resulting from past releases of blowdown line water to groundwater at VB) 2 and 3. Site features include the location of the Braidwood Station cooling lake to the south, a perimeter ditch which flows from the east and then to the northwest around the main generating station, ponds located to the north of Smiley Road on private property, and a number of private water supply wells located north of Smiley Road and the Braidwood Station property (Figure 2.1).

The Site is traversed by a cooling lake and a blowdown line and within the boundary of the Site are found three vacuum breaker valves installed on the blowdown line to prevent line damage. Braidwood Station employs the blowdown line to return water from the cooling lake back to the Kankakee River for the purposes of reducing the dissolved mineral concentration of the lake water. Flow in this line has ranged from 10,000 to 25,000 gallons per minute. This blowdown line also serves as a permitted discharge point for the station's sewage treatment plant and the liquid radwaste system.

An aggressive and comprehensive groundwater investigation program was implemented by Exelon in mid-November 2005 and has continued through the middle of March 2006. A routine program of private well sampling and monitoring well sampling is currently on-going at the Site.

The results of these groundwater and surface water studies will be presented in a "Focused Site Characterization Report" (FSCR).[1] Analysis of the data presented in the FSCR indicates the following key points with respect to this IRAP.

1) Groundwater flow in the shallow sand aquifer, where the tritium is detected, is generally from the south to north (Figures 2.2 and 2.3).
2) Groundwater flowing from the area on the Braidwood Station property south of Smiley Road discharges into the large pond located to the north, namely the Exelon Pond.
3) A localized area on the Site has been identified where tritium is detected above the 35 IAC 620 drinking water standard (20,000 picocuries per liter (pCi/L)). This area is located near Smiley Road, at the southeast corner of the pond and just west of the blowdown line as it leaves the Station property. This area is approximately 4.5 acres in size. Figures 2.4 and 2.5 provide plume maps depicting concentrations of tritium in the shallow and deep portions of the aquifer respectively.

[1] To be submitted under separate cover.

4) The data collected to date indicates that tritium at concentrations above 200 pCi/L has migrated into the Exelon Pond, north of Smiley Road and past the pond to a limited extent. The distance to the leading edge of this tritium level (above 200 pCi/L) from VB 2 and 3 is approximately 2,400 to 2,800 feet.

5) In the main areas of groundwater impacted by tritium (i.e., those where concentrations are above the groundwater standard), the tritium is detected at higher concentrations at depth. The cause of the vertical differences (over a small saturated interval of 20 feet) is expected to be the clean water recharge by precipitation. The depth to groundwater is at times less than five feet below ground surface in the areas of tritium impacts and as such the upper water table will be flushed with clean precipitation recharge.

The objectives of this IRAP are provided in Section 3.0 below and are intended to address a remedy for the area of tritium located just south of Smiley Road.

3.0 OBJECTIVES OF THE IRAP

The major objective of the IRAP is to implement a "control and capture" remedy for tritium detected in groundwater downgradient of vacuum breakers (VB) 2 and 3. Specifically, this IRAP will be implemented in order to retard the movement of tritium in the groundwater that is above the groundwater standard (20,000 pCi/L) and tritium that has migrated into and downgradient of the Exelon Pond at concentrations determined to be above 200 pCi/L. The removal of tritium within the groundwater will be achieved by pumping surface water from the Exelon Pond that will suppress the water level within the pond and create a 'cone-of-depression' within the water table. This will act to reverse groundwater flow to the north of the Exelon Pond and mitigate the increase in concentrations of tritium over time. This will allow for the removal of tritium within the main plume areas (downgradient of VB 2 and 3 and south of Smiley Road) in order to prevent further tritium migration beyond the Exelon Pond which if left unchecked would elevate current concentrations above background levels. Figures 3.1 and 3.2 present a planview and schematic cross-section of the conceptual remedial action, respectively.

A secondary objective of the IRAP is to ensure that the concentrations of tritium within the blowdown line are below 200 pCi/L when groundwater pumped from the Exelon Pond and water in the blowdown line are mixed together.

4.0 FEASIBILITY

The proposed IRAP includes pumping surface water from the Exelon Pond and piping the water to the south and discharging the water (untreated) to the blowdown line through VB 2.

This interim remedy has been selected for consideration because of the following:

- It employs simple remedial technology that can be quickly designed, built and started. It also lends itself to easy modifications at start up and allows for future design changes.
- The technology behind the design of the remedial system is composed of standard components that have been proven as an effective design for many pump and treat systems.
- It is a proven method for pumping down the Exelon Pond. The Exelon Pond has been pumped down in the past during borrow pit (sand mining) operations and, as such, the design drawdown is easily maintained.
- The remedy will utilize the existing NDPES permit allowing discharge of the water to the Kankakee River through the blowdown line, therefore eliminating the need for additional agency permitting.
- It is the most effective approach when compared to other technologies such as extraction well systems and test trenching with respect to operation and maintenance (O&M), modifications at start-up and speed of implementation.
- It is a remedy that can reduce the mass of tritium within the groundwater and Exelon Pond.
- The remedy will require groundwater level monitoring, flow rate monitoring and chemical sampling which are all standard requirements for pump and treat systems.

5.0 BASIS OF DESIGN

The proposed IRAP has been designed to achieve the following objectives:

1) Prevent further migration of the main plume (areas above the 20,000 pCi/L groundwater standard);
2) Limit the further migration of residual tritium at levels above 200 pCi/L, but below the groundwater standard;
3) Slow or stop the migration of tritium above 200 pCi/L to private property north of the Exelon Pond; and
4) Remove the mass of tritium in groundwater located south of Smiley Road.

This remedial action plan will involve the installation of a pump in the Exelon Pond[2]. The pump will be installed in the pond and operated at a rate sufficient to drop the pond level by approximately 7 feet (refer to Section 5.1 below). The actual level that the pond water will be dropped will be dependent upon the groundwater level responses in monitoring wells surrounding the pond. The flow rate in the pump and the water level in the pond will be such that the flow of groundwater (downgradient of the pond with tritium levels above 200 pCi/L) will be reversed back to the pond. This will accomplish the objectives listed above by lowering the concentrations of tritium in the groundwater to the south and north of the Exelon Pond.

In order to predict the pumping rates required to reverse groundwater flow a number of groundwater model simulations were conducted[3]. In addition preliminary calculations were conducted in order to estimate the average concentration of tritium discharged from the pond into the blowdown line. The following discussion presents a summary of the model simulations and concentration calculations that are discussed in detail in Appendix A. Although preliminary modeling was performed to develop the initial design criteria, the system will be closely monitored and modified during the start-up phase (see Section 7.0) to ensure the pond is not overdrawn and that nearby shallow private wells are not dewatered.

[2] The exact location of the pump will be determined during start-up at a later date.
[3] These simulations were done for preliminary purposes only and do not reflect calibrated groundwater conditions.

5.1 PRELIMINARY MODELING OF GROUNDWATER

The purpose of the preliminary modeling was to evaluate the following initial requirements for the system:

1) Drawdown required to flatten the gradient north of Exelon Pond.
2) Average pumping rate required to achieve the required drawdown.

To determine these two requirements a numerical groundwater model was built and various simulations were conducted. The pumping rate was determined by modeling the required drawdown within the pond that would be necessary to reverse the flow of groundwater downgradient of the pond, essentially flattening the gradients to the north of the pond. The most representative simulation indicates that steady-state pumping rates of 237 gpm are needed (rounded to 250 gpm for pump selection purposes).

The model simulation indicated that 27 gpm of groundwater flowed into the Exelon Pond through the plume area (when pumped at 237 gpm from the pond). The remaining inflow to the Exelon Pond was due to the rest of the aquifer surrounding the pond, i.e., 210 gpm of groundwater flow into Exelon Pond from the non-plume area surrounding the pond.

5.2 CALCULATIONS OF TRITIUM IN PUMPED WATER

Calculations of tritium in pumped water were performed, determining that the tritium concentration within the force-main running to VB 2 would be at a maximum of approximately 10,000 to 11,000 pCi/L at a pumping rate of approximately 250 gpm. The modeling used to perform this analysis resulted in a very conservative value for tritium concentration since it neglected the dilution effects from the pond and precipitation. It also did not take into account the fact that the plume has a limited tritium supply, especially on the east side of the pond. The initial concentrations when first drawing down the pond is expected to be approximately the same as its current concentration; 2,500 pCi/L. Then, as the pond is drawn down the levels of tritium will increase. These concentrations would increase toward 10,000 to 11,000 pCi/L, based upon an assumption of a constant source in the plume to the south, but could not reach this concentration due to the dilution effects described above. Another calculation determined that if all the tritium could be added to the pond at once, the pond's tritium concentration would be 3,577 pCi/L. These concentrations would further reduce in time and with precipitation recharges as the tritium levels in the plume south of Smiley Road decrease, over time. It is known that water within the blowdown line flows at approximately 20,000 to 25,000 gpm at less than 200 pCi/L. At this rate of flow and concentration the dilution factor would be 100 fold (under average steady-state conditions) for pumped pond water entering the blowdown line and would therefore reduce the tritium concentrations to less than 100 pCi/L.

In any event, during the start-up (Section 7.0) of the system the concentrations in the pumped water will be closely monitored and correlated with the flow rate. This will be done so that the levels entering the blowdown line will form a composite concentration in the blowdown line of less than 200 pCi/L.

6.0 DESCRIPTION OF THE REMEDIAL ACTION

The following sections present the proposed conceptual design for the site remedial action which includes the pump to be installed within the Exelon Pond as well as the vacuum breaker monitoring system.

6.1 POND TO VACUUM BREAKER

The proposed remedial action involves standard remedial technology and equipment, including the following components:

1) Pump.
2) Forcemain.
3) Control Center.
4) Instrumentation and Controls.

Figures 6.1 and 6.2 provides a plan view and flow diagram for the proposed remedial system, respectively.

6.1.1 PUMP DESIGN

A pump will be installed in the Exelon Pond. The pump size will be determined based on the flow and head requirements of the system. The pump size, impeller size, and motor size will be selected to meet the required flow conditions and maximize efficiency at the full design flow rates and the highest expected head.

The pump will be operated at a flow rate sufficient to suppress the pond level. This suppression will be dependent upon the groundwater level responses in monitoring wells surrounding the pond during pump operation. As described previously, the design flow rate of the pump and the design water level in the pond will reverse the flow of groundwater (downgradient of the pond with tritium levels above 200 pCi/L) back to the pond. These pumping rates and pond levels are estimated in the models described in Section 5.0. The initial flow rate is estimated to be approximately 250 gpm with a drawdown of about seven feet. This flow rate will be adjusted following start up and monitoring of the system.

The pump will be designed with a maximum capacity of 1,000 gpm. Based on the estimated flows, the pump will run for about six to eight hours per day. The head will be determined during a more detailed design. The pond suppression will be controlled using a level switch set initially at the level predicted by the groundwater modeling. The level switch will send a level signal to the controller, which will automatically control the pump to maintain the required level in the pond. If the level falls below or rises above a set level, an alarm will sound.

The pond will need to be pumped down seven feet prior to steady state pumping. Based on previous pumping of the pond it may take two to three weeks to pump the pond to the desired drawdown of seven feet. The pump will initially pump at a flow rate of 1,000 gpm during the initial pumping of the pond until the proper level is reached. The pump will then maintain that level or will be changed as appropriate based on the performance monitoring results.

6.1.2 FORCEMAIN DESIGN

The pumped water will be transferred from the pond to the blowdown line at VB 2 via a forcemain (i.e., discharge pipe from the pond to the vacuum breaker). This forcemain will traverse an area upgradient of the groundwater capture zone.

The remaining portion of the forcemain which transverses the site will be installed below ground, and it will be constructed of high density polyethylene (HDPE) pipe. The pipe will be buried below the frost line eliminating the need for freeze protection.

Sizing of the forcemain piping is based on maintaining a fluid velocity between four and seven feet per second and maintaining a diameter pipe to allow easy cleaning during maintenance. Line sizing is also based on maintaining a minimum pressure drop in the pipe, minimizing the size of the pump. Assuming a flowrate of 1,000 gpm, the pipe is estimated to be eight inches in diameter.

6.1.3 CONTROL CENTER

The control center will house any equipment required to run the pumping system.

The main panel at the control center will contain a small pump control system and other equipment required for the operation of the system.

The pumping system's control logic will be designed to allow the system to operate without supervision in a fail-safe mode. Control signals will be fed to a control center. The control center will supply appropriate responses to these signals. An operator can monitor and control the treatment system through the control center. Process equipment can be shut down locally, or through the remote alarm agent. An emergency shut down button is located at the control center, which will shut down the entire pumping system.

Operator presence at the control center will only be required during the initial start-up, during maintenance activities, and in order to respond to major alarms of the system. The operator will initiate the process from the control center, and the process will continue to operate until stopped from the control center by the operator or from the logic due to an alarm condition (e.g., level too low). The control center will also display any necessary process variables and alarms.

As stated above, the system will be connected to an alarm agent to allow for emergency shutdown of the pumping system.

6.1.4 INSTRUMENTATION AND CONTROLS

The instrumentation for the system will consist of flow transmitters, level switches, valving, etc.

Instrumentation, monitoring systems, alarms, controls, and other design details will be finalized during the final design.

7.0 STARTUP

During the initial phase of the interim remedial action (startup) monitoring of the pumping system, as well as, groundwater monitoring will be required in order to insure that the appropriate amount of capture is occurring as predicted by the concentration and drawdown calculations stated previously.

Initial monitoring of the pond-to-blowdown line system is expected to involve the following activities:

1) Continuous monitoring of flow and volumes of water discharged to the blowdown line.
2) Periodic monitoring of tritium concentrations discharging to the forcemain from the pump.
3) Continuous monitoring of pond water levels for operational purposes.
4) Water level monitoring of shallow monitoring wells surrounding the pond to insure capture and to prevent drawdown below private well intake levels.

A separate startup and optimization plan will be provided with details of these monitoring activities.

8.0 OPERATION AND MAINTENANCE (O&M) PLAN

An O&M plan will be developed for long term monitoring of the effectiveness of the system. The O&M plan will be finalized after the results of the start-up phase have been compiled and operation criteria have been established. These O&M activities are anticipated to include the following:

1) Recording flow and volumes of water discharged to the blowdown line.
2) Monitoring of tritium concentrations discharging to the forcemain from the pump.
3) Monitoring of the pond water level for operational purposes.
4) Water level monitoring of shallow monitoring wells located north of the pond to insure capture and to prevent significant drawdown below private well intake levels.
5) Sampling of temporary monitoring wells, permanent monitoring wells and private wells determined to be with the influence (cone-of-depression) of the pump within the Exelon Pond.
6) Routine reporting of monitoring and operational data.

An O&M plan will be provided, under separate cover with details of these monitoring activities.

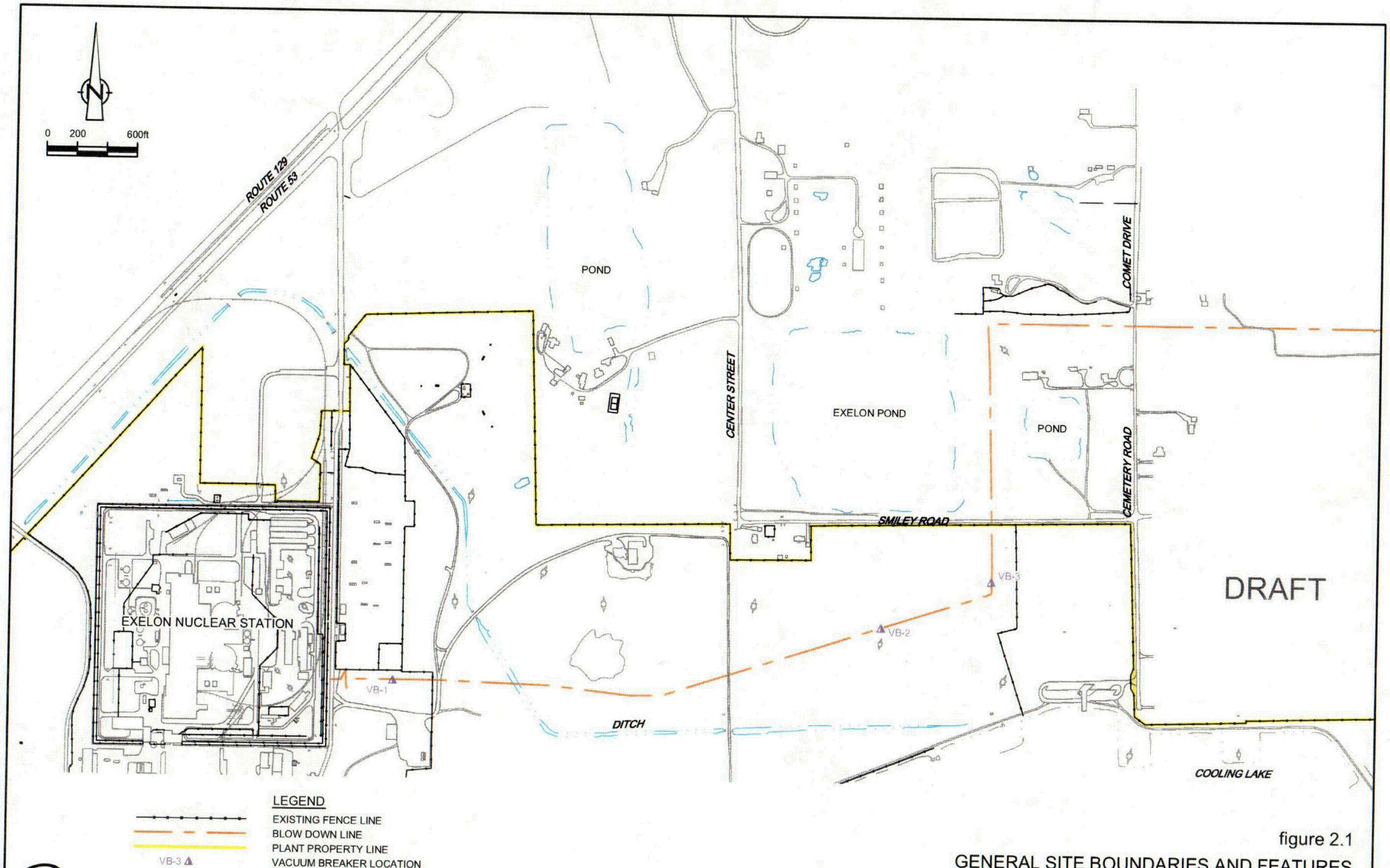

figure 2.1

GENERAL SITE BOUNDARIES AND FEATURES
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

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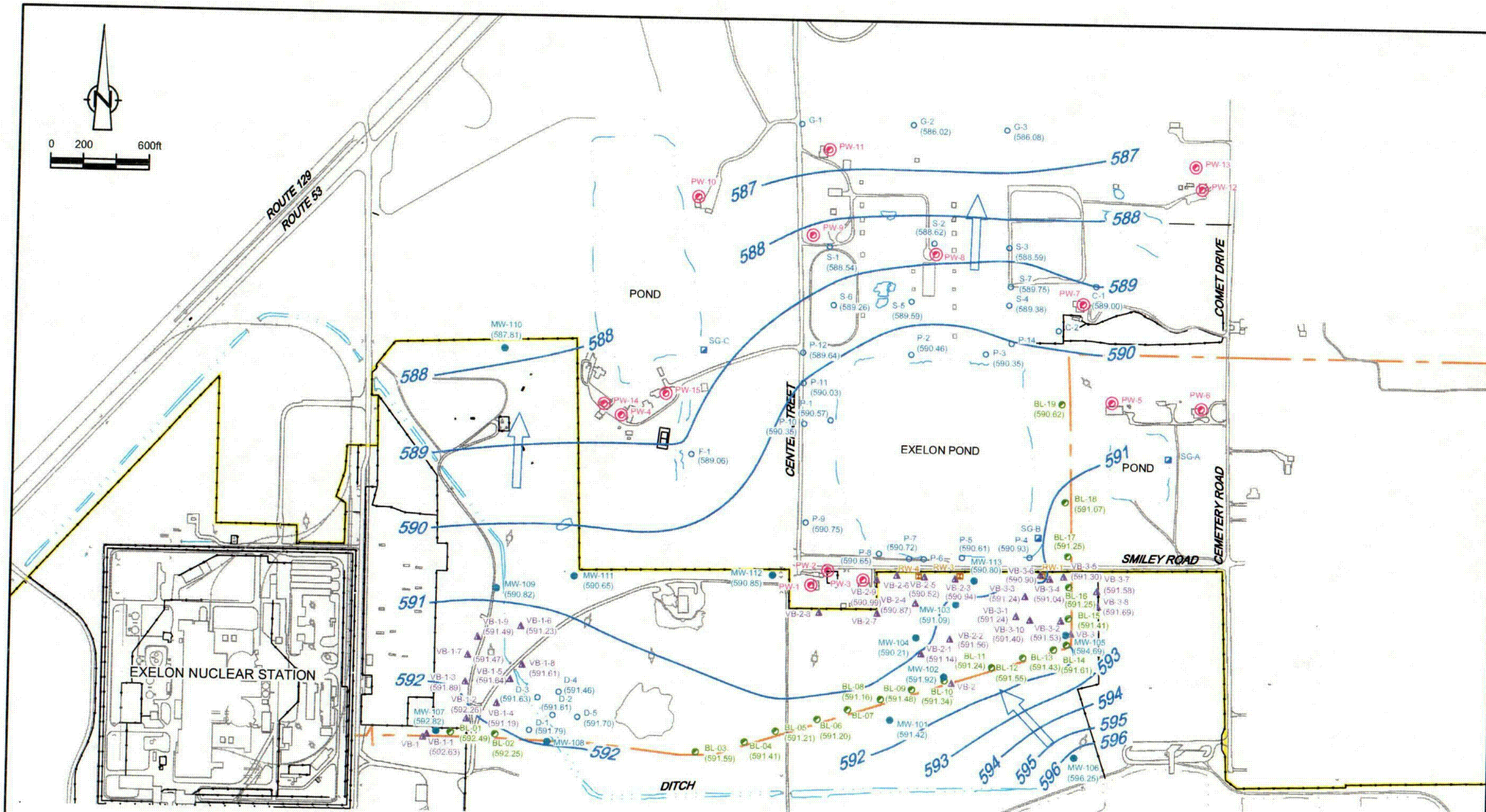
C01



LEGEND

	EXISTING FENCE LINE	MW-105	MONITORING WELL LOCATION
	BLOW DOWN LINE	PW-5	PRIVATE WELL LOCATION
	PLANT PROPERTY LINE	P-11	TEMPORARY WELL LOCATION
VB-3	VACUUM BREAKER LOCATION	RW-3	RECOVERY WELL LOCATION
BL-19	BLOW DOWN LINE SAMPLING LOCATION	(590.80)	GROUNDWATER ELEVATION (ft AMSL)
VB-3-7	VACUUM BREAKER SAMPLING LOCATION	591	GROUNDWATER ELEVATION CONTOUR (ft AMSL)
SG-B	STAFF GAUGE LOCATION		GROUNDWATER FLOW DIRECTION

NOTE:
MONITORING WELL DATA TAKEN JANUARY 3, 2006 TO JANUARY 5, 2006.

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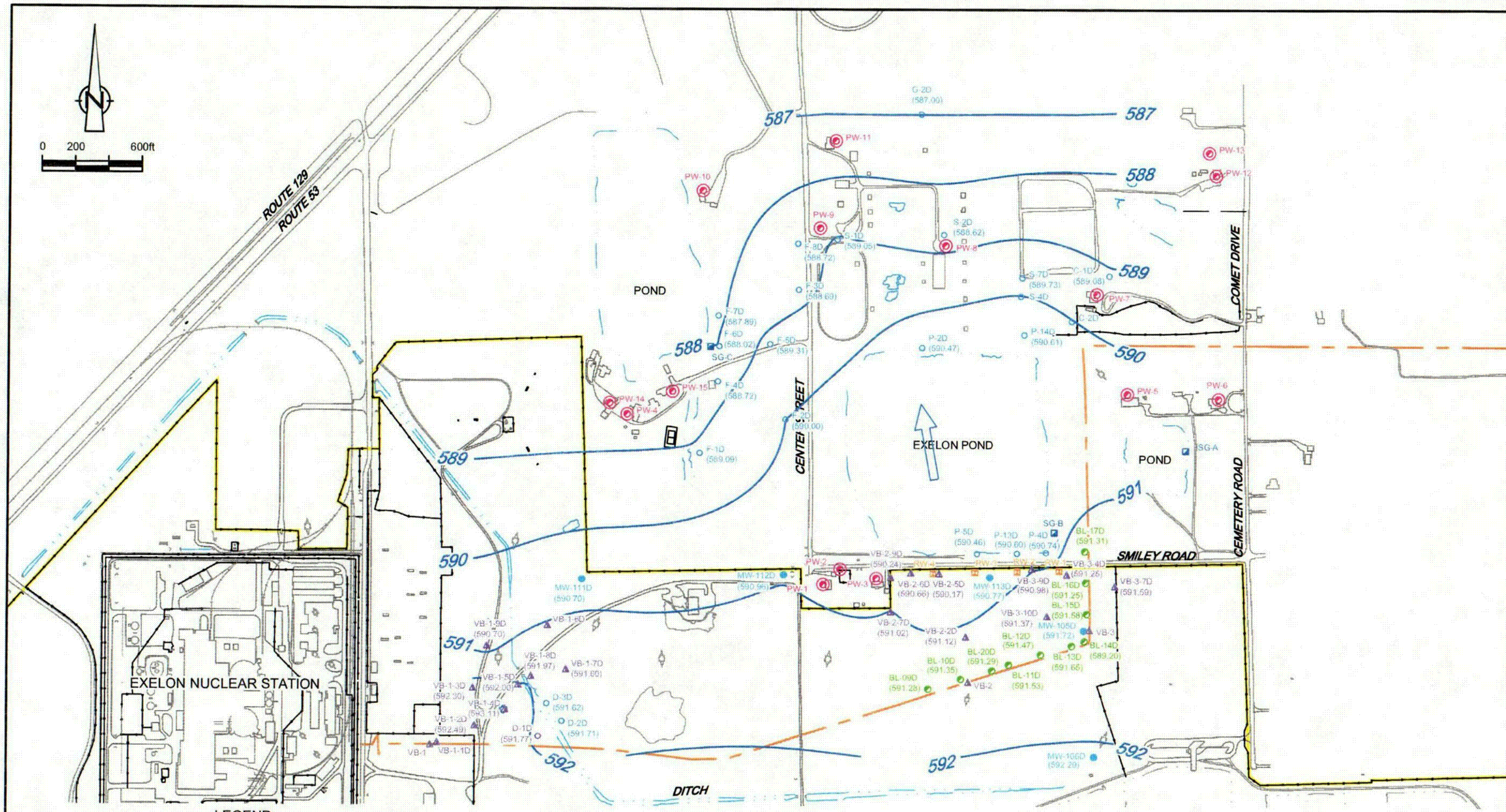
figure 2.2

GROUNDWATER LEVEL CONTOURS - JANUARY 2006
SHALLOW GROUNDWATER ZONE
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

45065-01(001)GN-WA002 MAR 07/2006

C02



LEGEND

	EXISTING FENCE LINE	
	BLOW DOWN LINE	
	PLANT PROPERTY LINE	
BL-17D	BLOW DOWN LINE SAMPLING LOCATION	
VB-3	VACUUM BREAKER LOCATION	
VB-3-7D	VACUUM BREAKER SAMPLING LOCATION	
MW-113D	MONITORING WELL LOCATION	
SG-B	STAFF GAUGE LOCATION	
PW-5	PRIVATE WELL LOCATION	
P-4D	TEMPORARY WELL LOCATION	
RW-2	RECOVERY WELL LOCATION	
(590.59)	GROUNDWATER ELEVATION (ft AMSL)	
591	GROUNDWATER ELEVATION CONTOUR (ft AMSL)	
	GROUNDWATER FLOW DIRECTION	

CRA

NOTE:
MONITORING WELL DATA TAKEN JANUARY 3, 2006 TO JANUARY 24, 2006.

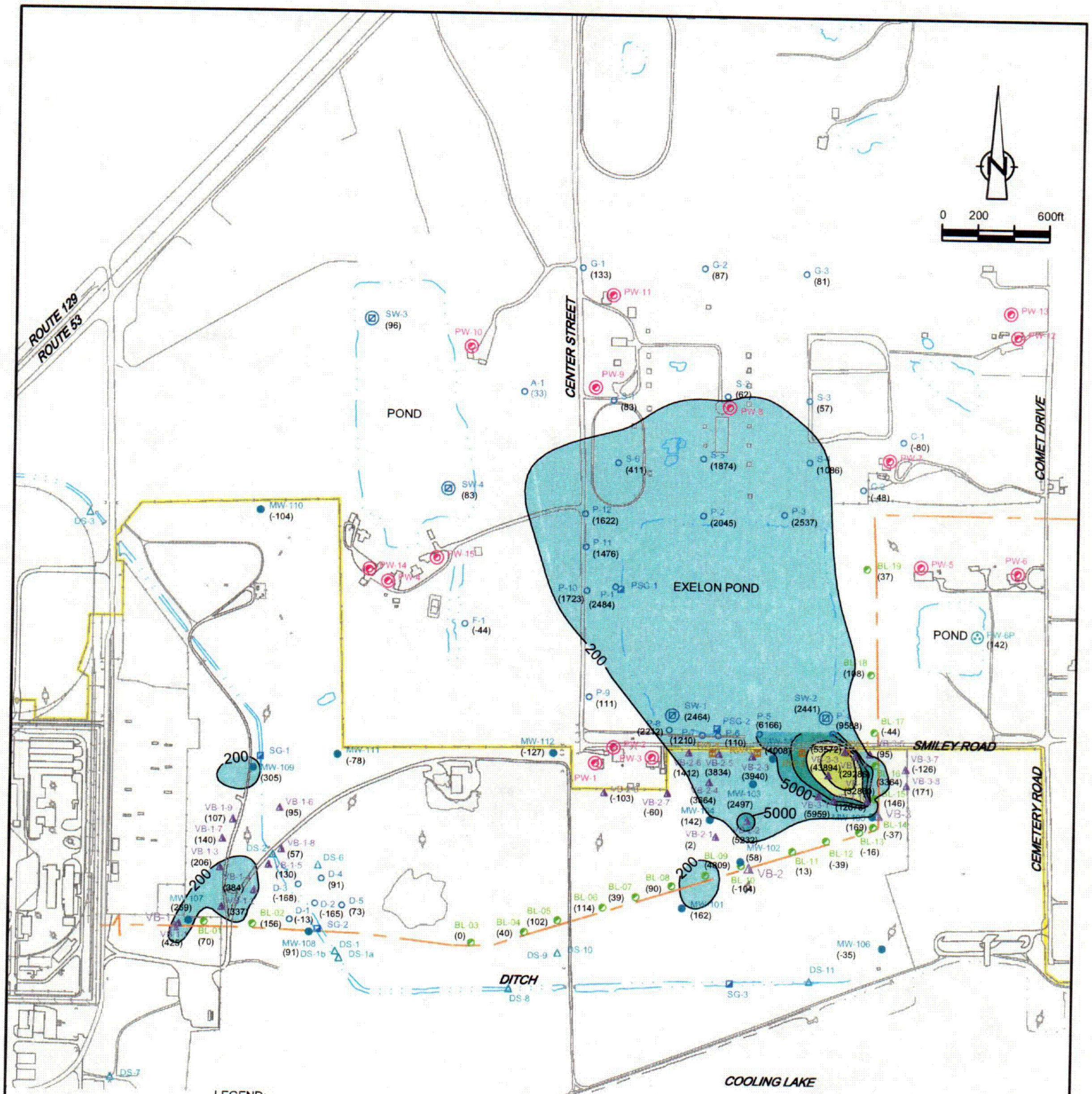
DRAFT

figure 2.3

GROUNDWATER LEVEL CONTOURS - JANUARY 2006
DEEP GROUNDWATER ZONE
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

45065-01(001)GN-WA003 MAR 07/2006

C03



LEGEND:

EXISTING FENCE LINE

EXISTING PERIMETER DITCH LIMITS

BLOW DOWN LINE

PLANT PROPERTY LINE

BL-19 SHALLOW BLOW DOWN LINE SAMPLING LOCATION

VB-3 VACUUM BREAKER LOCATION

VB-3-7 VACUUM BREAKER SAMPLING LOCATION

MW-105 SHALLOW MONITORING WELL LOCATION

PW-5 PRIVATE WELL LOCATION

P-11 SHALLOW TEMPORARY WELL LOCATION

PSG-1 STAFF GAUGE LOCATION

DS-6 DITCH SAMPLING LOCATION

SW-2 SURFACE WATER SAMPLING LOCATION

RW-3 SHALLOW RECOVERY WELL LOCATION

PW-6P POND SAMPLING LOCATION

(2,484) TRITIUM RESULT IN GROUNDWATER

—200— TRITIUM CONTOUR

DRAFT

TRITIUM RESULTS 200,000 TO 250,000 (PICOCURRIES/LITER)

TRITIUM RESULTS 100,000 TO 200,000

TRITIUM RESULTS 60,000 TO 100,000

TRITIUM RESULTS 40,000 TO 60,000

TRITIUM RESULTS 20,000 TO 40,000

TRITIUM RESULTS 10,000 TO 20,000

TRITIUM RESULTS 5,000 TO 10,000

TRITIUM RESULTS 200 TO 5,000

TRITIUM RESULTS 0 TO 200

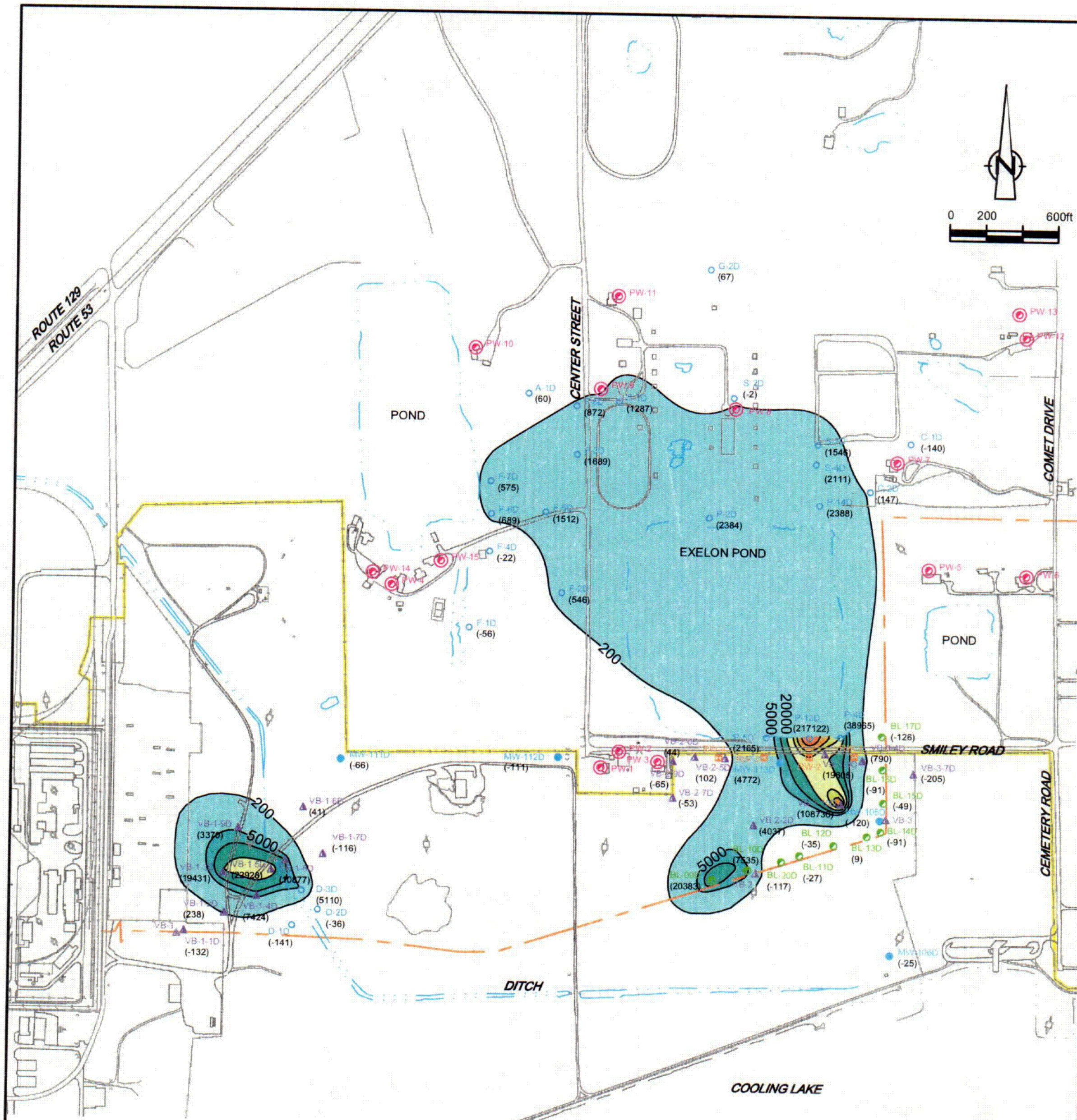
NOTE:
BACKGROUND TRITIUM CONCENTRATION: 200 pCi/L
DRINKING WATER STANDARD FOR TRITIUM: 20,000 pCi/L
TRITIUM DATA FOR SAMPLES COLLECTED THROUGH JANUARY 30, 2006. CONTOURS WERE GENERATED USING LOG VALUES.

figure 2.4

ESTIMATED TRITIUM RESULTS
SHALLOW GROUNDWATER ZONE
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

45065-01(001)GN-WA006 MAR 07/2006

C04



LEGEND:

EXISTING FENCE LINE

EXISTING PERIMETER DITCH LIMITS

BLOW DOWN LINE

PLANT PROPERTY LINE

BL-17D DEEP BLOW DOWN LINE SAMPLING LOCATION

VB-3 VACUUM BREAKER LOCATION

VB-3-7D DEEP VACUUM BREAKER SAMPLING LOCATION

MW-113D DEEP MONITORING WELL LOCATION

PW-5 PRIVATE WELL LOCATION

P-4D DEEP TEMPORARY WELL LOCATION

PW-6P POND SAMPLING LOCATION

RW-2 DEEP RECOVERY WELL LOCATION

(2,484) TRITIUM RESULT IN GROUNDWATER

—200— TRITIUM CONTOUR

TRITIUM RESULTS 200,000 TO 250,000 (PICOCURRIES/LITER)

TRITIUM RESULTS 100,000 TO 200,000

TRITIUM RESULTS 60,000 TO 100,000

TRITIUM RESULTS 40,000 TO 60,000

TRITIUM RESULTS 20,000 TO 40,000

TRITIUM RESULTS 10,000 TO 20,000

TRITIUM RESULTS 5,000 TO 10,000

TRITIUM RESULTS 200 TO 5,000

TRITIUM RESULTS 0 TO 200

NOTE:
BACKGROUND TRITIUM CONCENTRATION: 200 PCI/L
DRINKING WATER STANDARD FOR TRITIUM: 20,000 PCI/L
TRITIUM DATA FOR SAMPLES COLLECTED THROUGH JANUARY 30, 2006. CONTOURS WERE GENERATED USING LOG VALUES.

figure 2.5

ESTIMATED TRITIUM RESULTS
DEEP GROUNDWATER ZONE
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

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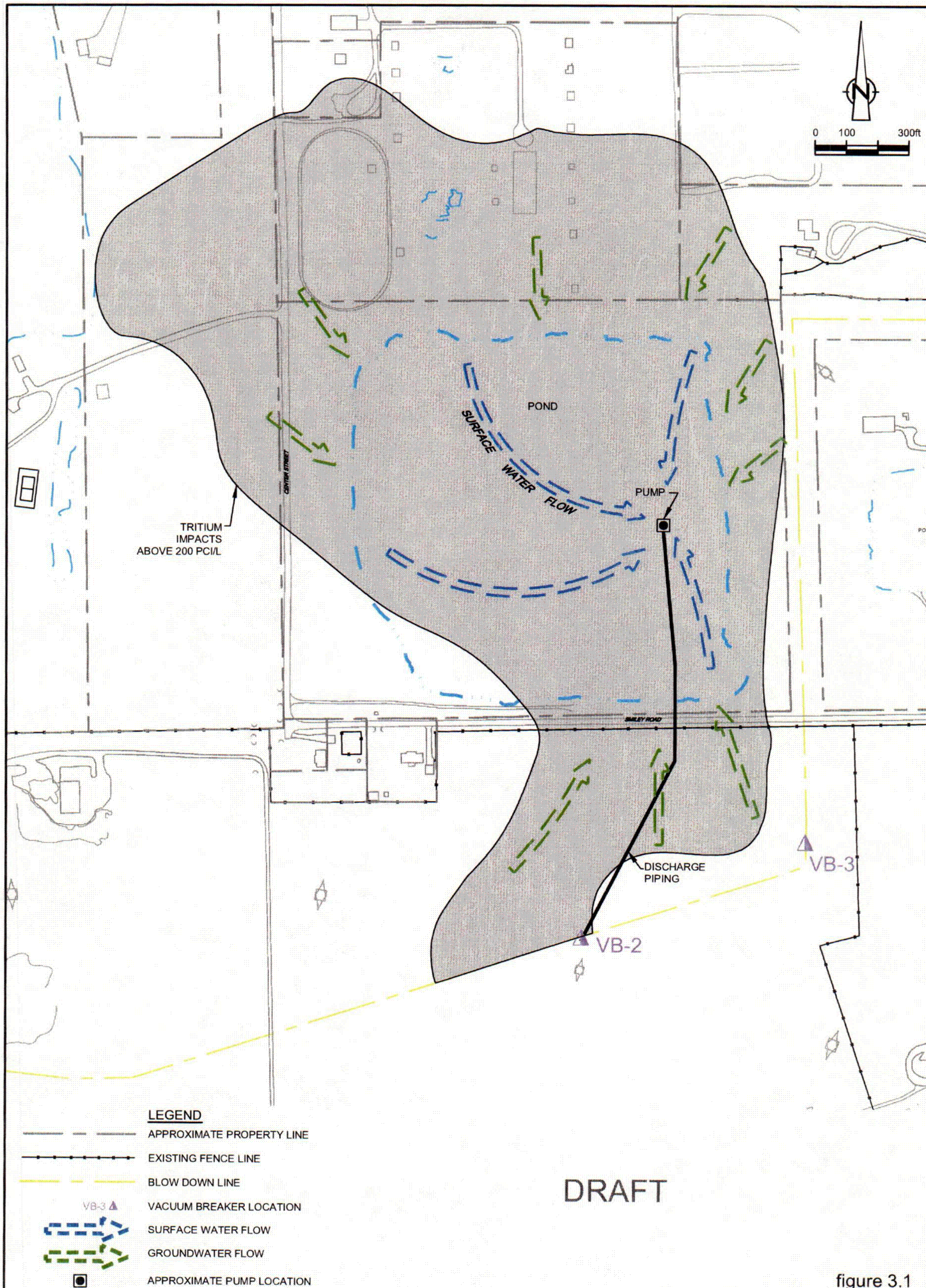

figure 3.1

CONCEPTUAL PLAN-INTERIM REMEDIAL ACTION
FOR MIGRATION CONTROL AND TRITIUM RECOVERY
EXELON GENERATION BRAIDWOOD STATION
Braidwood, Illinois

45065-01(001)GN-WA004 MAR 08/2006

C06

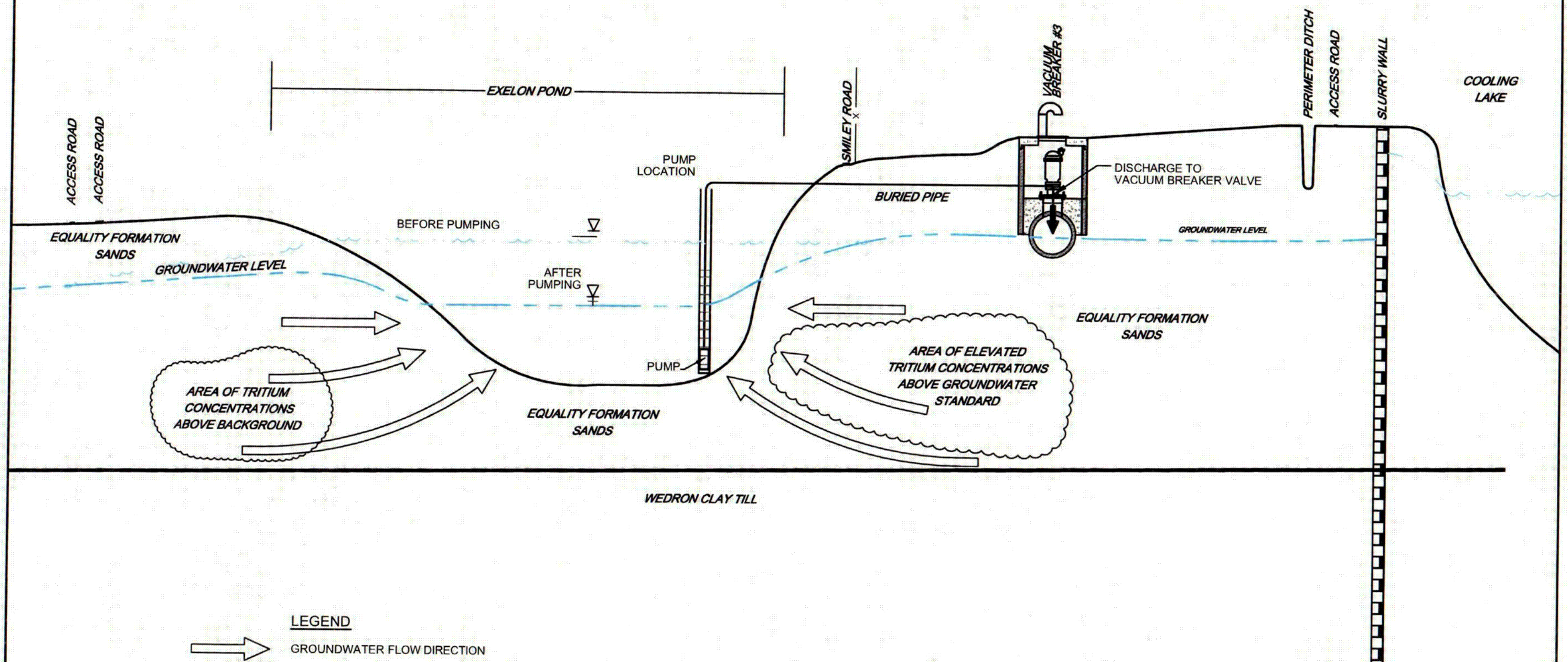

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figure 3.2

CONCEPTUAL PLAN
INTERIM REMEDIAL ACTION FOR MIGRATION CONTROL AND TRITIUM RECOVERY
EXELON GENERATION BRAIDWOOD STATION
Braidwood, Illinois

CRA

45065-01(001)GN-WA005 MAR 08/2006

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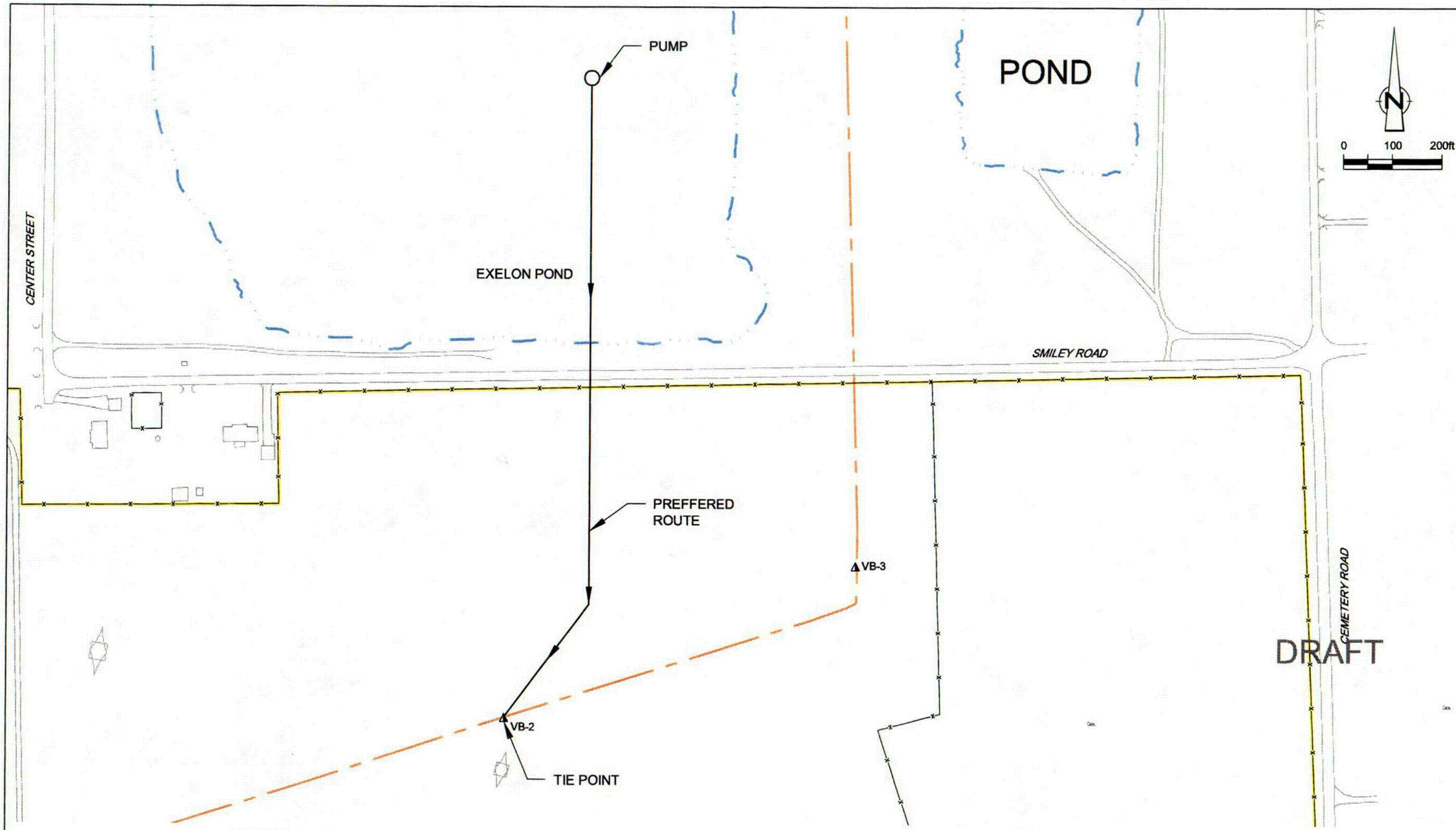

LEGEND

EXISTING FENCE LINE
BLOW DOWN LINE
PLANT PROPERTY LINE
VB-3 ▲ VACUUM BREAKER LOCATION

figure 6.1
PUMPING SYSTEM SITE PLAN
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

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45065-01(001)GN-NF001 MAR 08/2006

C08

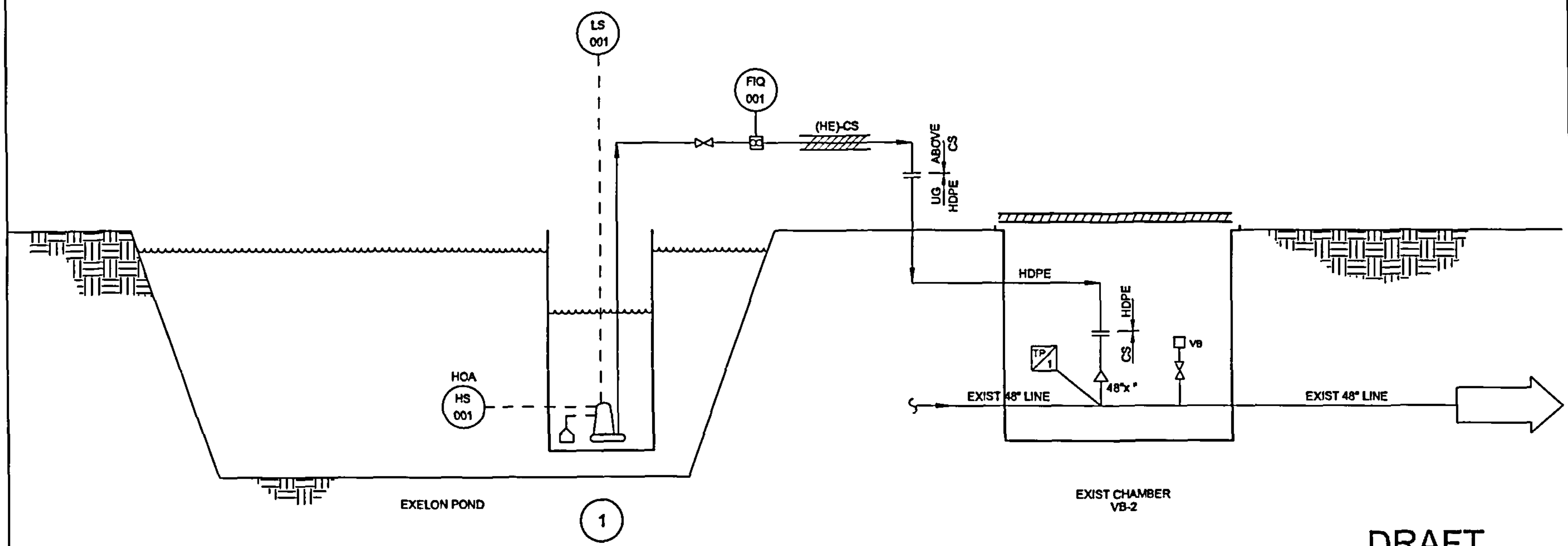

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figure 6.2
PUMPING SYSTEM FLOW DIAGRAM
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

45065-01(001)GN-NF002 MAR 07/2006

APPENDIX A

MEMORANDUM (CONCEPTUAL SITE DESIGN – PUMPING FROM EXELON POND TO THE BLOWDOWN LINE)

CONESTOGA-ROVERS
& ASSOCIATES

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www.CRAworld.com

TECHNICAL MEMORANDUM

TO:	James Gosnell, Exelon	REF. NO.:	016841-15/pw/11
FROM:	PNF Nicholas Fitzpatrick/Beiyan Zhang	DATE:	March 8, 2006
C.C.:	Phil Harvey		
RE:	**Modeling of Groundwater and Calculations of Surface Water Concentrations of Tritium Exelon Generation Braidwood Station, Braceville, Illinois**		

The purpose of this memorandum is to estimate the following requirements for the system:

1. Drawdown required to flatten the gradient north of Exelon Pond.
2. Average pumping rate required to achieve the required drawdown.
3. Average concentration of tritium in the Exelon pond surface water.

To determine the first two requirements, and partially determine requirement 3, a numerical groundwater model was built and various simulations were conducted. Requirement 3 was finalized using mass balance calculations. There are two aspects of mass balance in hydrologic studies, balance in water quantity and balance in contaminant mass quantity. They are referred to as water balance and mass balance respectively in this memorandum.

MODFLOW

The 3-D finite-difference groundwater flow model MODFLOW (Harbaugh and MacDonald, 1996a and 1996b, MacDonald and Harbaugh, 1988) developed by the United State Geological Survey (USGS) was selected to simulate groundwater flow for this analysis. MODFLOW has been extensively verified and is readily accepted by many regulatory agencies throughout North America and Europe. It is capable of representing the various hydrogeologic components.

MODEL DESCRIPTION

A simple one layer model was developed with a model domain of 15,000 by 9,150 feet and a uniform grid size of 50 by 50 feet. Constant head boundary conditions were included along the northern and southern boundary of the model domain, and no-flow boundary conditions were on the east and west sides of the model. Groundwater elevations along the constant head boundaries were adjusted to achieve groundwater levels and hydraulic gradients similar to those measured in January 2006 around Exelon Pond (Figure 1). These are detailed below as 'Model 1' and 'Model 2'.

MODEL 1

For Model 1, hydraulic conductivity was set to 0.0254 cm/s (72 ft/day) based on slug tests performed at the Site in October 2005. Groundwater recharge from precipitation was adjusted to better match the groundwater levels and observed hydraulic gradient. A hydraulic conductivity of 100,000 ft/day was assigned to the Exelon Pond area to represent its open water hydraulic nature, i.e. flat gradient within the pond. The resulting groundwater recharge was 2.9 inch/year, and a 12 inch/year recharge was assigned to the Exelon Pond area to represent precipitation (less evaporation) that falls within the undrained pond. Figure 2 details the Model 1 simulated groundwater contours. The simulated hydraulic gradient north of Exelon Pond is 0.003, which is consistent with the gradient measured from the observed contours.

MODEL 2

For Model 2, a groundwater recharge rate of 6 inch/year was used, and hydraulic conductivity was adjusted to match the observed groundwater contours. The resulting hydraulic conductivity was 0.049 cm/s (140 ft/day). The values of recharge and the hydraulic conductivity for the Exelon Pond area are the same as Model 1, i.e. they are 12 in/year and 100,000 ft/day respectively. Figure 3 details the Model 2 simulated groundwater contours. Again, Model 2 has a simulated gradient of 0.003.

MODEL SIMULATIONS AND PROBLEM SOLVING

A well was placed in the model by placing a constant head cell, with a lower groundwater head, into the Exelon Pond area, flattening the hydraulic gradient north of Exelon Pond. It was determined using both models, that when water level in Exelon Pond decreased to 583.7 feet AMSL, which was 7 feet lower than its original level of 590.7 feet AMSL, the hydraulic gradient north of Exelon Pond was flattened to a distance of 600 feet upgradient. The water balances of the models indicated that 123 and 237 gallons per minute (gpm) of groundwater flowed to this constant head cell for Model 1 and Model 2, respectively. This indicated that steady-state pumping rates of 123 and 237 gpm are needed for Model 1 and 2 correspondingly. Figures 4 and 5 show the Model 1 and 2 simulated groundwater contours, with a flattened gradient north of Exelon Pond, when pumped from Exelon Pond.

Figure 6 shows the groundwater tritium concentration distribution at the Site. To determine the flow portion to Exelon Pond from the plume area, a single water balance zone along the plume leading edge was defined in both models. The water balances indicated that 13 and 27 gpm of groundwater flowed into Exelon Pond through the plume zone when Models 1 and 2 pumped 123 and 237 gpm of water, respectively, from the pond. Tritium concentrations above the drinking water standard of 20,000 pCi/L (USEPA & IEPA, 35 IAC 620) were assumed to be part of the plume, i.e. concentrations below this level was assumed to be background concentrations of 200 pCi/L (Nicholas, 1988).

CONCENTRATION CALCULATIONS

The concentration calculations for Exelon Pond were based on the principle of mass balance. The mass balance discussed in this section refers to the tritium mass balance, which is different from the water balance discussed in the modeling section. Steady-state was assumed, therefore, the mass balance equation below applies to Exelon Pond.

$$Q_{in}C_{in} = Q_{out}C_{out} \qquad (1)$$

The concentration calculations, or the applications of Equation (1) to the pond, are discussed in the following paragraphs.

The model simulations, discussed previously, indicated that 13 and 27 gpm of groundwater flowed to Exelon Pond through the plume area when pumped at 123 and 237 gpm from the pond in Models 1 and 2 respectively. The remaining inflow to Exelon Pond was due to the rest of aquifer surrounding the pond, i.e. 110 and 210 gpm of groundwater flowed into Exelon Pond from the non-plume area surrounding the pond for Models 1 and 2 respectively. Therefore Equation (1) is in the form below:

$$Q_{plume-in}C_{plume-in} + Q_{non-plume-in}C_{non-plume-in} = Q_{out}C_{out} \tag{2}$$

where $Q_{plume-in}$, $Q_{non-plume-in}$, and Q_{out} are 13 gpm, 110 gpm, and 123 gpm for Model 1; and 27 gpm, 210 gpm, and 237 gpm for Model 2. The concentration of 100,000 pCi/L, representing the average plume concentration ranging from 20,000 to 200,000 pCi/L (Figure 6), was used for $C_{plume-in}$, the background concentration of 200 pCi/L was used for $C_{non-plume-in}$, and the concentration of water pumped from Exelon Pond (C_{out}) was calculated as 10,748 pCi/L and 11,149 pCi/L for Models 1 and 2 respectively.

REFERENCES

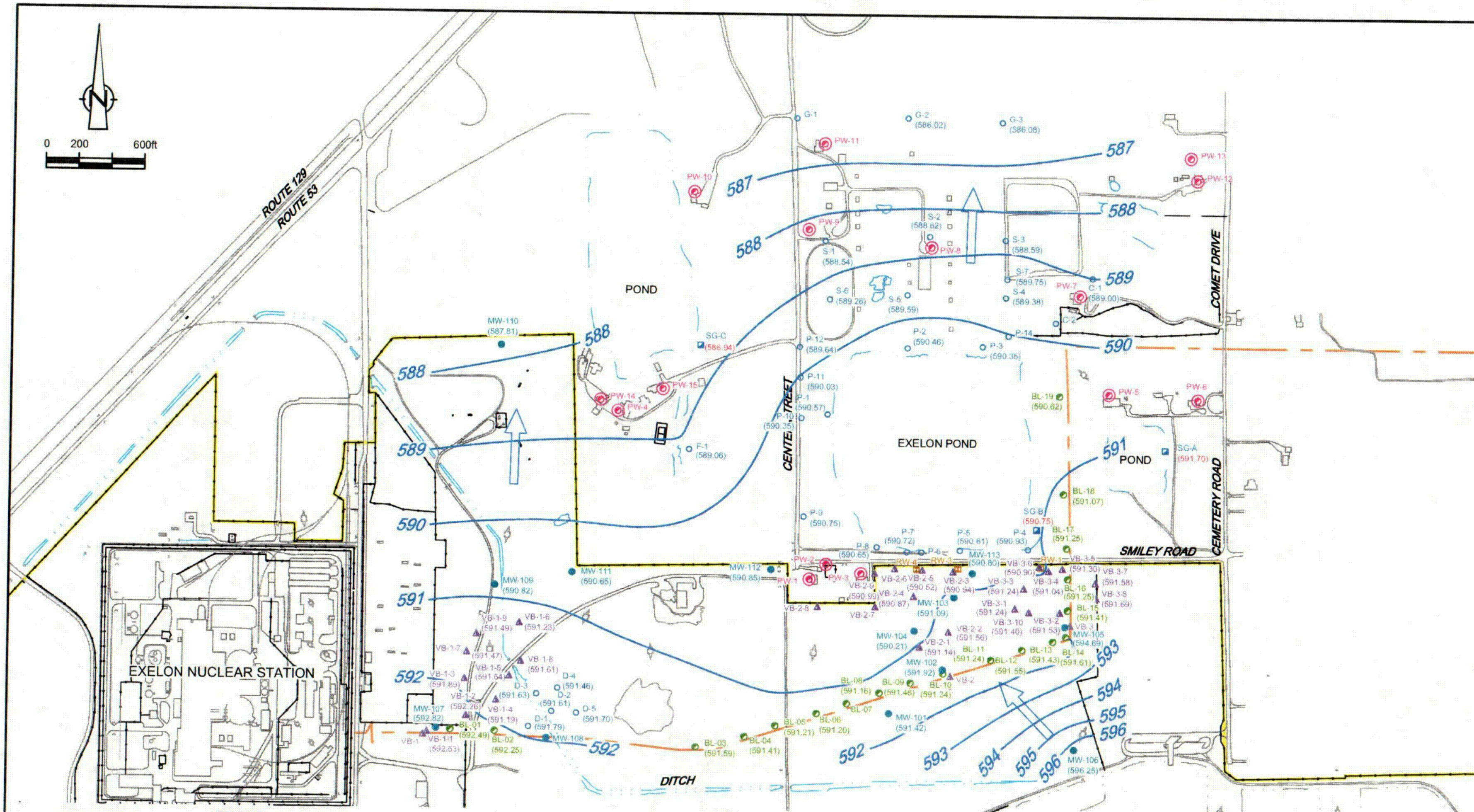
Harbaugh, A.W. and M.G. McDonald. *User's Documentation for MODFLOW-96, an update to the U.S. Geological Survey Modular Finite-Difference Ground-Water Flow Model, United States Geological Survey Open-File Report 96-485*, Reston, Virginia, 1996a.

Harbaugh, A.W. and M.G. McDonald. *Programmer's Documentation for MODFLOW-96, an update to the U.S. Geological Survey Modular Finite-Difference Ground-Water Flow Model, United States Geological Survey Open-File Report 96-486*, Reston, Virginia, 1996b.

McDonald, M.G. and A.W. Harbaugh. *A modular Three-Dimensional Finite-Difference Ground-Water Flow Model, United States Geological Survey Open-File Report 83-875*, 1988.

Nicholas, J. R. and R. W. Healy. *Tritium Migration from a Low-Level Radioactive-Waste Disposal Site Near Chicago, Illinois U. S. Geological Survey Water-Supply Paper 2333*, Denver, CO, 1988.

USEPA. *EPA – Tritium – Information Page.* www.epa.gov/radiation/radionuclides/tritium.htm, November 30, 2004, accessed on February 14, 2006.



LEGEND

	EXISTING FENCE LINE
	BLOW DOWN LINE
	PLANT PROPERTY LINE
VB-3	VACUUM BREAKER LOCATION
BL-19	BLOW DOWN LINE SAMPLING LOCATION
VB-3-7	VACUUM BREAKER SAMPLING LOCATION
SG-B	STAFF GAUGE LOCATION
MW-105	MONITORING WELL LOCATION
PW-5	PRIVATE WELL LOCATION
P-11	TEMPORARY WELL LOCATION
RW-3	RECOVERY WELL LOCATION
(590.80)	GROUNDWATER ELEVATION (ft AMSL)
591	GROUNDWATER ELEVATION CONTOUR (ft AMSL)
	GROUNDWATER FLOW DIRECTION

NOTE:
STAFF GAUGE ELEVATIONS TAKEN ON JANUARY 25, 2006.
MONITORING WELL DATA TAKEN JANUARY 3, 2006 TO JANUARY 5, 2006.

figure 1

GROUNDWATER LEVEL CONTOURS - JANUARY 2006
SHALLOW GROUNDWATER ZONE
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

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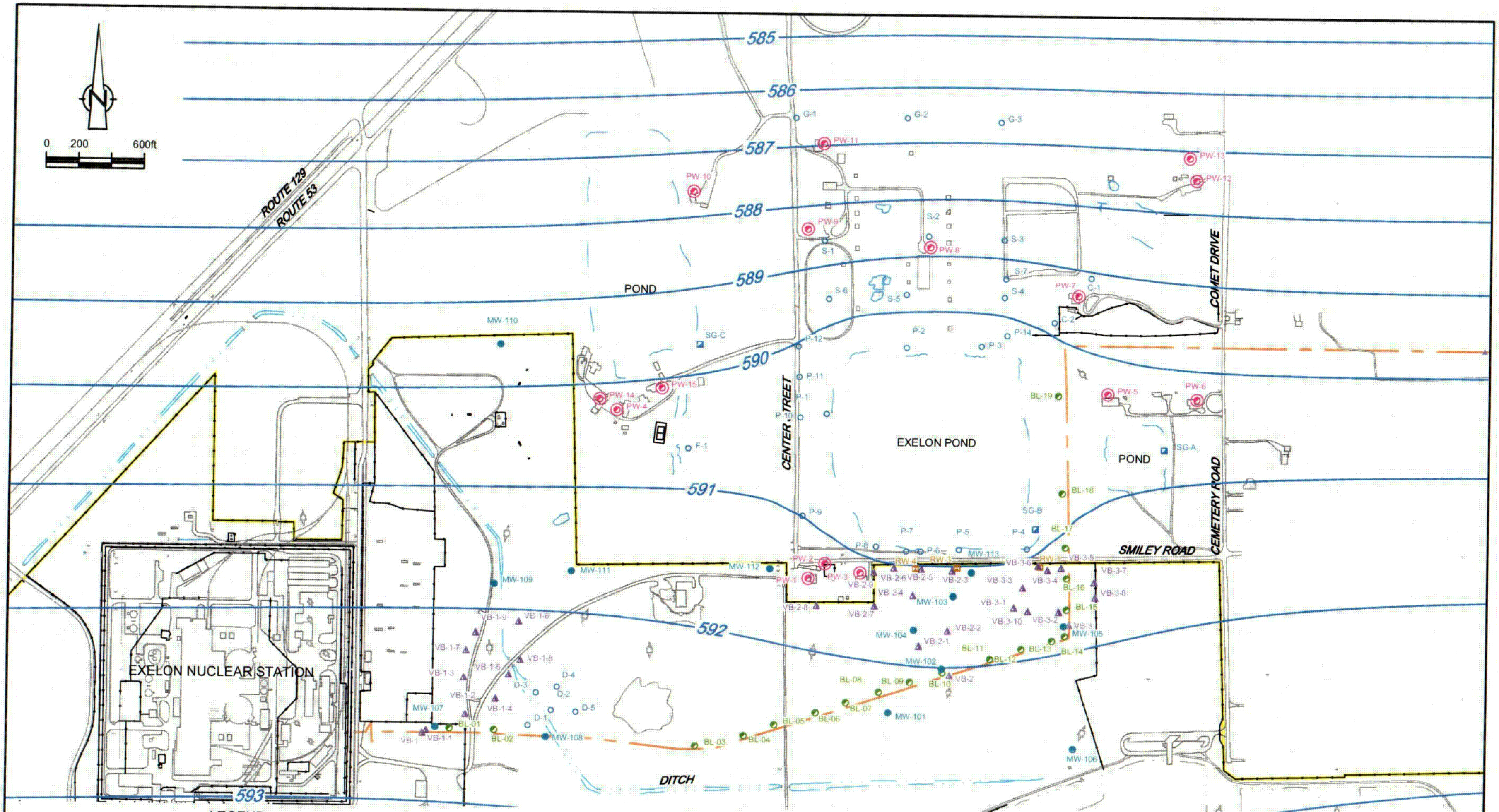

LEGEND

	EXISTING FENCE LINE
	BLOW DOWN LINE
	PLANT PROPERTY LINE
VB-3	VACUUM BREAKER LOCATION
BL-19	BLOW DOWN LINE SAMPLING LOCATION
VB-3-7	VACUUM BREAKER SAMPLING LOCATION
SG-B	STAFF GAUGE LOCATION
MW-105	MONITORING WELL LOCATION
PW-5	PRIVATE WELL LOCATION
P-11	TEMPORARY WELL LOCATION
RW-3	RECOVERY WELL LOCATION
591	MODEL SIMULATED GROUNDWATER CONTOUR

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NOTE:
STAFF GAUGE ELEVATIONS TAKEN ON JANUARY 25, 2006.
MONITORING WELL DATA TAKEN JANUARY 3, 2006 TO JANUARY 5, 2006.

figure 2

MODEL 1 SIMULATED GROUNDWATER LEVELS
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

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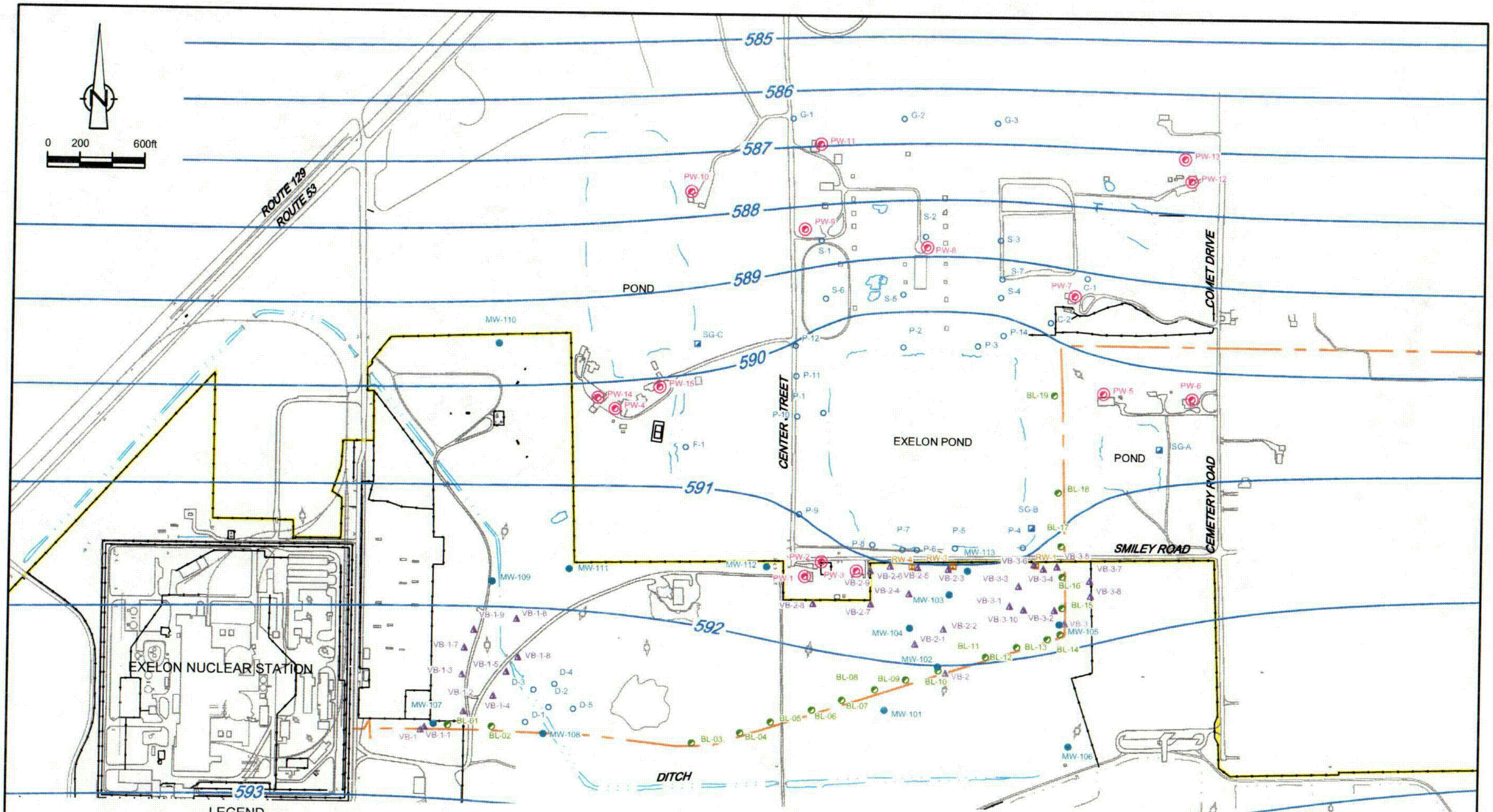

LEGEND

	EXISTING FENCE LINE
	BLOW DOWN LINE
	PLANT PROPERTY LINE
VB-3	VACUUM BREAKER LOCATION
BL-19	BLOW DOWN LINE SAMPLING LOCATION
VB-3-7	VACUUM BREAKER SAMPLING LOCATION
SG-B	STAFF GAUGE LOCATION
MW-105	MONITORING WELL LOCATION
PW-5	PRIVATE WELL LOCATION
P-11	TEMPORARY WELL LOCATION
RW-3	RECOVERY WELL LOCATION
591	MODEL SIMULATED GROUNDWATER CONTOUR

NOTE:
STAFF GAUGE ELEVATIONS TAKEN ON JANUARY 25, 2006.
MONITORING WELL DATA TAKEN JANUARY 3, 2006 TO JANUARY 5, 2006.

figure 3

MODEL 2 SIMULATED GROUNDWATER LEVELS
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

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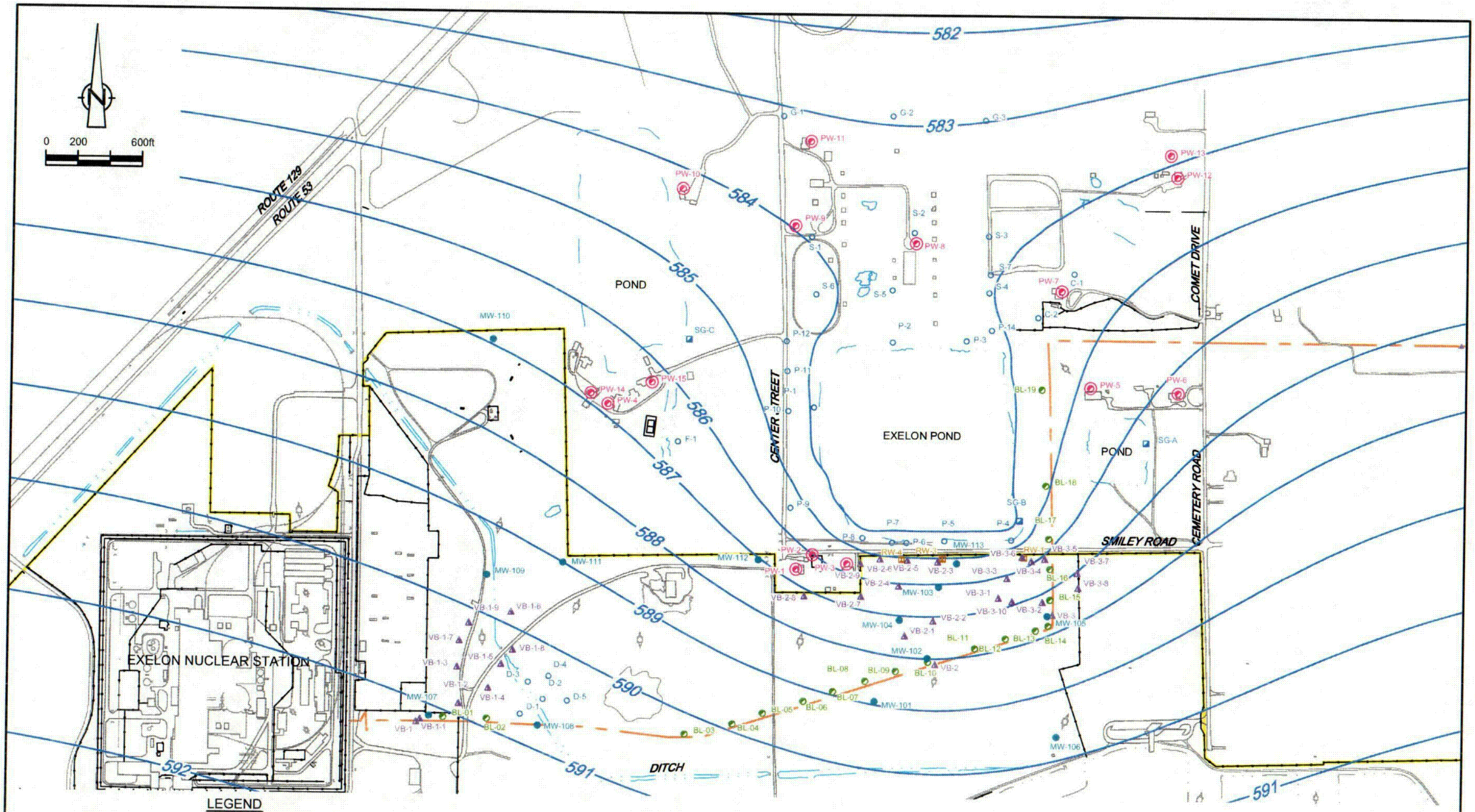
C11



LEGEND

	EXISTING FENCE LINE
	BLOW DOWN LINE
	PLANT PROPERTY LINE
VB-3	VACUUM BREAKER LOCATION
BL-19	BLOW DOWN LINE SAMPLING LOCATION
VB-3-7	VACUUM BREAKER SAMPLING LOCATION
SG-B	STAFF GAUGE LOCATION
MW-105	MONITORING WELL LOCATION
PW-5	PRIVATE WELL LOCATION
P-11	TEMPORARY WELL LOCATION
RW-3	RECOVERY WELL LOCATION
591	MODEL SIMULATED GROUNDWATER CONTOUR

NOTE:
STAFF GAUGE ELEVATIONS TAKEN ON JANUARY 25, 2006.
MONITORING WELL DATA TAKEN JANUARY 3, 2006 TO JANUARY 5, 2006.

figure 4

MODEL 1 SIMULATED GROUNDWATER LEVELS WHEN PUMPING FROM THE EXELON POND
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

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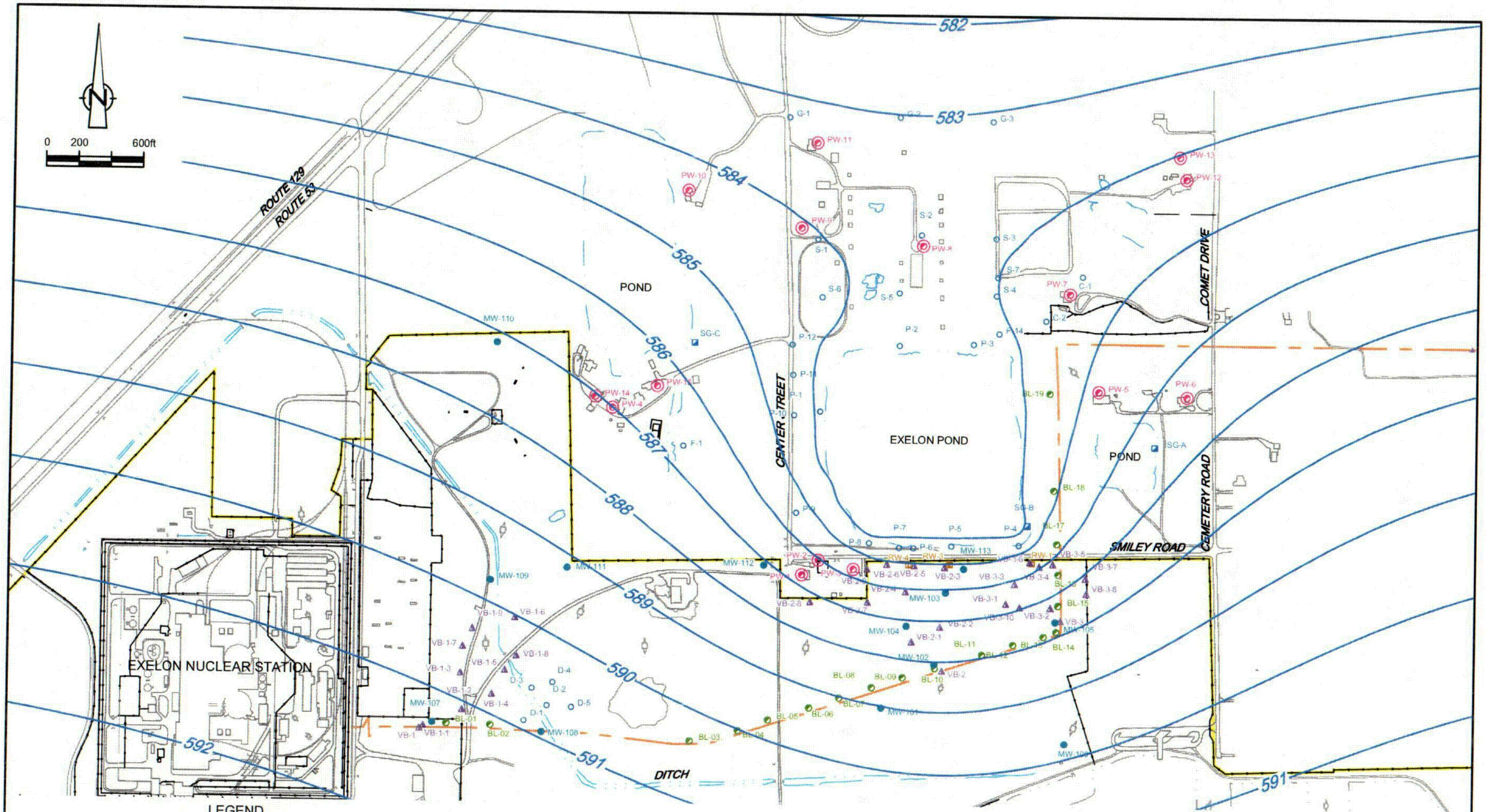

LEGEND

- EXISTING FENCE LINE
- BLOW DOWN LINE
- PLANT PROPERTY LINE
- VB-3 VACUUM BREAKER LOCATION
- BL-19 BLOW DOWN LINE SAMPLING LOCATION
- VB-3-7 VACUUM BREAKER SAMPLING LOCATION
- SG-B STAFF GAUGE LOCATION
- MW-105 MONITORING WELL LOCATION
- PW-5 PRIVATE WELL LOCATION
- P-11 TEMPORARY WELL LOCATION
- RW-3 RECOVERY WELL LOCATION
- 591 MODEL SIMULATED GROUNDWATER CONTOUR

NOTE:
STAFF GAUGE ELEVATIONS TAKEN ON JANUARY 25, 2006.
MONITORING WELL DATA TAKEN JANUARY 3, 2006 TO JANUARY 5, 2006.

figure 5

MODEL 2 SIMULATED GROUNDWATER LEVELS
WHEN PUMPING FROM THE EXELON POND
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

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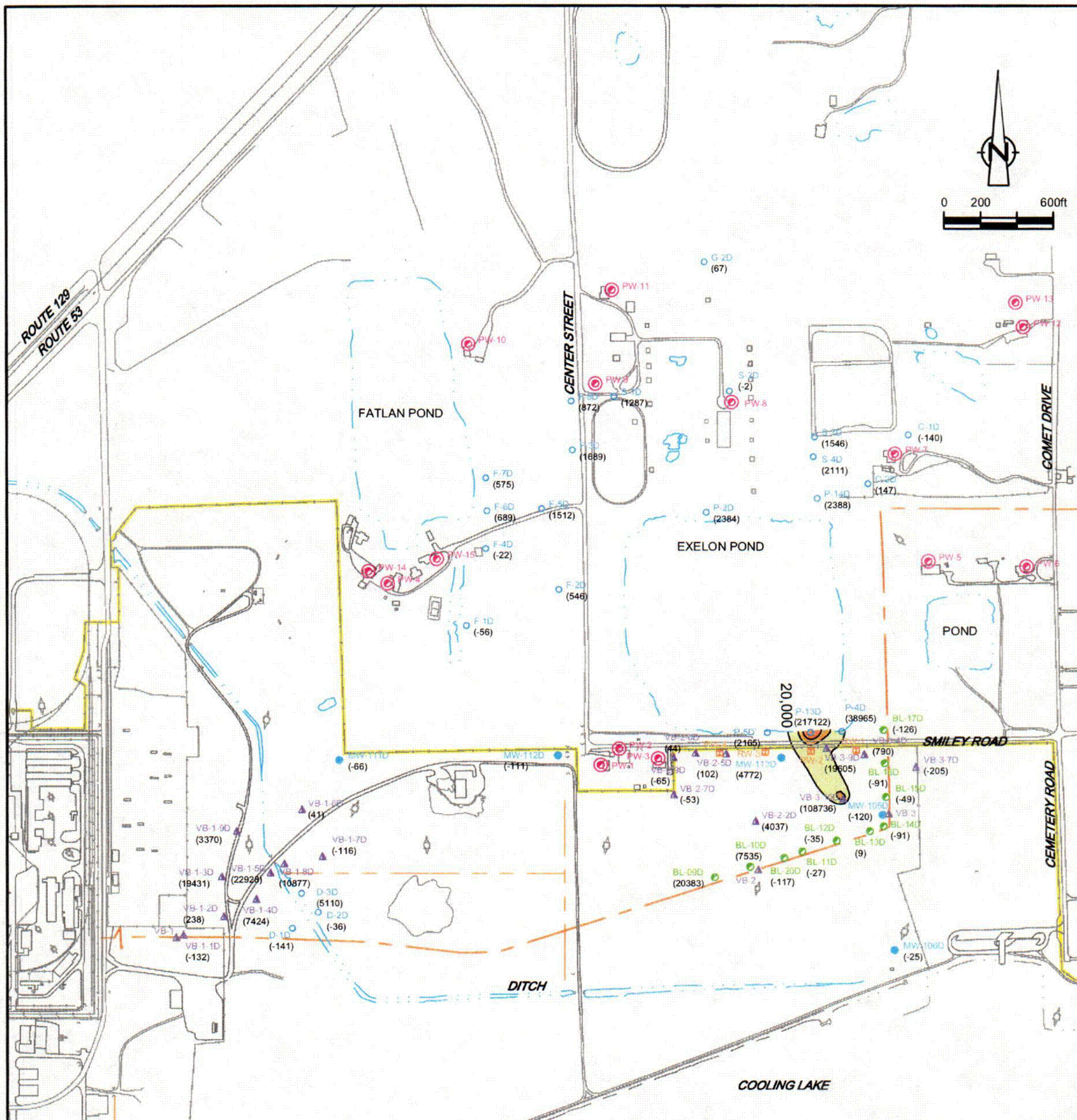

LEGEND:

EXISTING FENCE LINE
EXISTING PERIMETER DITCH LIMITS
FEEDER DITCH
BLOW DOWN LINE
PLANT PROPERTY LINE
BL-17D DEEP BLOW DOWN LINE SAMPLING LOCATION
VB-3 VACUUM BREAKER LOCATION
VB 3-7D DEEP VACUUM BREAKER SAMPLING LOCATION
MW-113D DEEP MONITORING WELL LOCATION
PW-5 PRIVATE WELL LOCATION
P-4D DEEP TEMPORARY WELL LOCATION
PW 6P POND SAMPLING LOCATION
RW-2 DEEP RECOVERY WELL LOCATION
(2,484) TRITIUM RESULT IN GROUNDWATER (pCi/L)
200 TRITIUM CONTOUR

TRITIUM RESULTS 200,000 TO 250,000 (PICOCURRIES/LITER)
TRITIUM RESULTS 100,000 TO 200,000
TRITIUM RESULTS 60,000 TO 100,000
TRITIUM RESULTS 20,000 TO 60,000

NOTE:
BACKGROUND TRITIUM CONCENTRATION: 200 pCi/L
DRINKING WATER STANDARD FOR TRITIUM: 20,000 pCi/L
TRITIUM DATA FOR SAMPLES COLLECTED THROUGH JANUARY 30, 2006. CONTOURS WERE GENERATED USING LOG VALUES.

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figure 6

ESTIMATED TRITIUM PLUME
DEEP GROUNDWATER ZONE
EXELON GENERATION BRAIDWOOD STATION
Braceville, Illinois

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