Characterization Report for Vacuum Breaker 1 and Ditch East of Switchyard

Background:
Braidwood Station employs a 25,000 gpm blowdown line to return water from the Station Cooling Lake back to the Kankakee River for the purposes of reducing the dissolved mineral concentration of the lake water. This blowdown line also serves as a permitted discharge point for the Station's sewage treatment plant and the liquid radwaste system

The blowdown line is constructed of a thin steel shell, lined on the inside with concrete. The outside is covered with prestressed steel wire and concrete. The bell and spigot joints have a rubber gasket that seals the steel shells and these joints are grouted inside and out. The pipe is designed to withstand an internal pressure of 110 psig but the system normally operates below 20 psig. In addition to the vacuum breaker valve, there is a small air-release valve that allows small amounts of air to be released from the line so that the larger vacuum breaker does not cycle to relieve this air.

Since the pipe is comprised in part by concrete, the pipe is not capable of withstanding vacuum. Therefore, the pipe is fitted with 11, float-operated, 8-inch vacuum breaker valves. These valves, especially the ones nearest the plant have failed, causing water to spill from the pipe. A brief history of leaks from the 1st vacuum breaker and its associated air release valves is provided below.

Vacuum breaker 1 on the blowdown line is located about 300' east of the Station access road and 50' south of the switchyard. See CRA figure 5 (attached) for locations. Northeast of vacuum breaker 1, a gravel road forks and the southeast branch crosses the site's main drainage ditch. The ditch flows northwest at this point. The culvert that allows the ditch to cross under the road is not as deep as the ditch and therefore there is some standing water in the ditch on the southeast side of the road. This is the ditch sample that has had some low levels of tritium detected since May of 2005, ranging from 400 to 1700 pCi/L. The water in the ditch is groundwater as this water is always present but not flowing because of the culvert being higher than the bottom of the ditch. The ditch area described above is slightly east of a down gradient streamline coming from vacuum breaker 1.

Leak History for 1st Vacuum Break from Plant, 0CW058:

a. Leak Discovered 12/01/96
   The valve was inspected in June of 1995. No leakage was noted Some time during the next 17 months, the 1" pipe connecting the pilot (air release) valve to this vacuum breaker started to leaking. The leakage was discovered in Nov of 1996 and a Work Request was written. Some time between November 1996 and June 1997, the line failed completely and was repaired in June of 1997. Actual leakage was not recorded.
   1. Assuming a leak rate of 5 gals/hour (43,800 gals/yr) occurred for a minimum of 0.55 yrs and a maximum of 1.98 yrs. This component resulted in between 24,000 and 87,000 gallons of leakage.
   2. Before the leak was repaired the 1" line broke. Full flow leakage from a 1" line at 5 psig is estimated at 10 gals/min. It is assumed that this leakage occurred

D-30

for 1-3 weeks before the repair was made. This component resulted in between 100,000-300,000 gallons of leakage.

3. Total leakage was between 124,000 and 387,000 gallons.
4. Since the leakage occurred over many weeks, this leak would have included liquid radwaste release water in addition to the lake water. There is therefore, a plume of tritium in the groundwater associated with this spill.

b. Leak Discovered 11/20/00

An Operator performing his monitoring rounds discovered the vacuum breaker pit flowing water out of the manway cover and flooding the surrounding area, Nov. 20th of 2000. The valve was repaired the next day. A review of the blowdown line flow history indicates that the blowdown line was isolated Nov. 6, 2000. It is highly likely that the float was damaged by water hammer on this date.

1. Assuming a leak rate of 3000 gals/min occurred for a minimum of 1 day and a maximum of 14 days. This component resulted in between 4.3 and 60.5 million gallons of leakage. Although a range of 1 to 14 days is given, evidence indicates that it is likely 1 day.
2. This leakage was most likely the result of water hammer on the 6th, which cracked the float, eventually allowing it to sink and expose an 8" opening. The water hammer was caused by a change in the operation of the CW Blowdown line in 1997. A root cause investigation (38237) was performed in 2000 following a failure of vacuum breaker 2 addressed this problem.
3. There was a liquid release on the morning of November 19th, the vacuum breaker leak was discovered and isolated on the 20th, the next release occurred on the morning of the 23rd. Due to the proximity of this valve to the plant, it is not likely that the overflowing valve pit went undetected for more than a few hours and therefore it is unlikely that any radioactive water spilled. The low value of the range of 1 to 14 days is chosen based on the fact that this failure was easily detectable because it is located so close to the plant and the flow out of the pit made it easily identifiable. Also, there is no evidence of a tritium plume associated with this spill.

c. Leak Discovered 05/19/05

This valve was inspected in November of 2004. No leakage was noted however, some time during the next 6 months, the pilot (air release) valve seat started to leak. The leakage was discovered in May of 2005. The repair was completed in Oct. of 2005. Leakage was recorded as 20 dpm (drops per minute).

1. A leak rate of 20 dpm. Since 20 drops is approximately equal to 1 ml, the leak is estimated at 139 gals/year. The leakage occurred for a maximum of 0.98 yrs and a minimum of 0.45 yrs. Therefore, the total leakage was between 140 and 60 gals.
2. This leakage was the result of raw water debris preventing the seat from closing. Cycling of the valve during normal operation typically clears this type of leakage.
3. The Station drew a sample of the water that had pooled on the valve and found over 50,000 pCi/L tritium in the water.

Hydrology:
Hydraulic gradient lines are plotted on CRA figure 5. The ground water flow in the area of vacuum breaker 1 is northeast, turning northerly over the next 1000 feet. CRA has determined that groundwater flow on site is 50 to 100 feet per year. Water spilled at vacuum breaker 1 would be expected to flow northeast to the fork in the gravel road then follow a path roughly paralleling the east side of the western gravel road and continue north beyond monitoring well 109. From vacuum breaker 1, there is about 400 feet to the fork and an additional 600 feet to monitoring well 109. The straight-line distance from vacuum breaker 1 and the closest property line, near monitoring well 111, is about 1300 feet.

Water spilled at vacuum breaker 1 in December of 1996 has had 9 years to travel. At 50 to 100 feet per year, the plume should be centered on a streamline between 450 and 900 feet from the vacuum breaker.

Sampling for Characterization:
Again, CRA figure 5 contains sample locations. Sample wells were drilled initially to a depth of 15 feet down gradient from vacuum breaker 1. The samples and wells drilled to characterize a plume from vacuum breaker 1 were given identifiers of the form: VB1-X where X is a sequential number. The team placed wells on the expected streamline emanating from the vacuum breaker and around the ditch where tritium had been detected since May of 2005. These shallow well samples did not find the expected plume and since the ditch near staff gauge 2 (SG-2 on map) had yielded some low levels of tritium, the team postulated an active leak in the blowdown line where the line crosses the ditch since the line has several fittings to take it deep, under the ditch. Given sample names of D-X, these wells also yielded little tritium.

After discovering a strong vertical concentration gradient at remediation well #2, deeper wells were drilled at the original D-X locations. These deep wells, drilled to the clay layer also did not indicate the presence of an active leak and are designated as being deeper wells by adding a "D" to the end of the sample identifier, i.e. D-XD.

While the shallow VB1-X wells had not yield tritium concentrations as large as the ditch, these deeper wells, drilled to the underlying clay layer about 25 feet below the surface, yielded the results that the team expected for the 1996 spill. See CRA figures 1 and 2 for a graphical depiction of the shallow and deep plumes. This, and all the sample data are summarized on table 1. The plume found at depth is centered about 600 feet down gradient from vacuum breaker 1, placing it in the range of expected distance from the vacuum breaker.

The large spill that occurred in 2000 from vacuum breaker 1 did not put tritium on the ground since no significant tritium was found closer to the vacuum breaker in either shallow or deep wells. Also, the fact that this spill was due to a catastrophic leak made its detection and isolation quicker. Also as already noted, the leak was found a day after a radwaste release and immediately isolated. The team's conclusion is that there is no plume from this leak.

Regarding the 2005 leak, there is a very small plume near vacuum breaker 1 which is expected to decay to background before reaching the property line. Estimating that 100

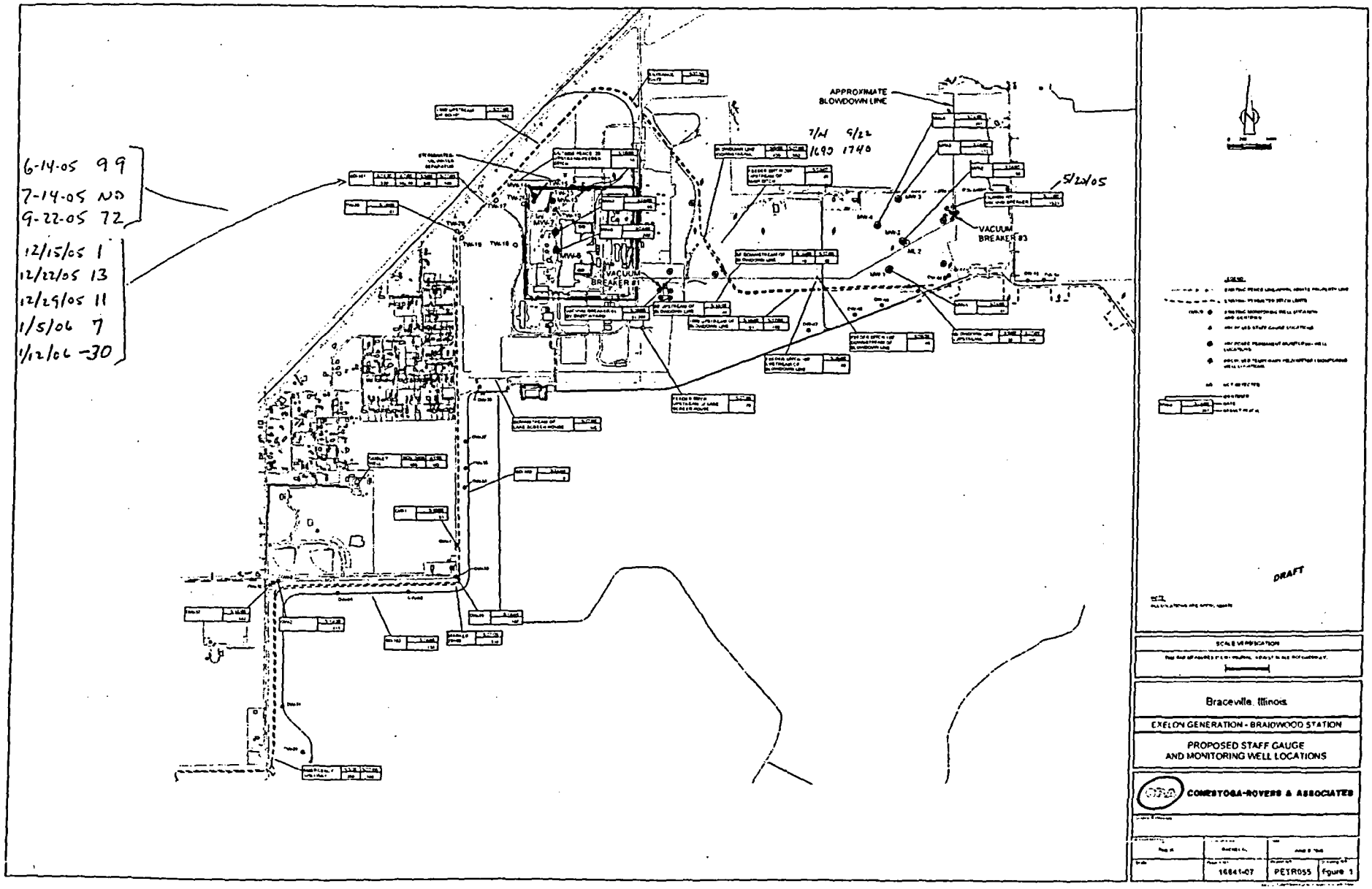
gallons was spilled, the soil is 20% water, and the plume is 2 feet deep and 4 feet wide, the plume would be about 8 to 10 feet long traveling with ground water.

Interaction with the Ditch:
The ditch is being fed by deep water because the ditch is dug below the surface of the groundwater. The ditch, a partially penetrating trench, locally lowers the groundwater surface. The depression is greater when recharge (precipitation) falling on the surrounding ground raises the water table and pushes water into the ditch. When the water table rises above the culvert water flows in the drainage ditch, taking groundwater with it. The localized low pressure in the ground water causes water under the ditch to flow upward since it sees a lower pressure above it than to the sides. This explains why the shallow wells near the ditch failed to produce and tritium but the ditch does. The ditch is actually intercepting some of the nearby plume.

This site drainage ditch flows around the site to the north then turns west and then south along our western property line. The ditch passes the town of Godley. The Station has been monitoring the ditch water where it passes under the Division Street entrance road (A gate) and finding low and varying levels. While this monitoring point is not exactly indicative of water that may pass Godley, it does indicate that when the ditch is flowing, it is picking up tritium from the ditch culvert east of the switchyard and moving it down stream. Some tritium must be passing the town of Godley when the ditch is flowing. This sampling point is not however, a reliable indicator of the actual condition of the ditch at Godley since large precipitation events will flush the ditch to low, possible undetectable levels while a light rain will not dilute as much but can move the tritium possibly only a short distance. To remedy this situation, the source should be eliminated by filling in or lining the ditch east of the switchyard so that it is no longer a partially penetrating trench. This will keep groundwater out of the ditch. AND IT WILL GO WHERE ?

Projection:
The plume from the 1996 leak will continue to travel northward. While the center of the plume will likely stay west of the property line, the periphery (above background) of the plume will hit the property line in about 10 years. In 10 years, the center should have decayed and dispersed to about half its current concentration. Beyond 10 years, the plume will be drawn to the Fatlan residence pond since this pond is being artificially lowered by a man-made culvert. This will draw the plume toward and through the 5 residential properties on the south end of the pond. This plume therefore, should be monitored closely and potentially remediated to prevent contamination of these residential areas.

The small plume caused by the 2005 spill is too small to be of concern. Numerical modeling performed on a continuous 1 gpm leak at 90,000 pCi/L showed that background levels were reached in 985 feet from the source. This model very conservatively bounds the 100 gallon spill at vacuum breaker 1 in 2005.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12/29/05 11
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APPROXIMATE BLOWDOWN LINE
7/1 9/22
1690 1740
5/24/05
VACUUM BREAKER #3
VACUUM BREAKER #1
MW-6
DRAFT
Braceville, Illinois
EXELON GENERATION - BRAIDWOOD STATION
PROPOSED STAFF GAUGE AND MONITORING WELL LOCATIONS
CONESTOGA-ROVERS & ASSOCIATES
16841-07
PETR055
figure 1

Characterization Report for Vacuum Breaker 7

Background:
Braidwood Station employs a 25,000 gpm blowdown line to return water from the Station Cooling Lake back to the Kankakee River for the purposes of reducing the dissolved mineral concentration of the lake water. This blowdown line also serves as a permitted discharge point for the Station's sewage treatment plant and the liquid radwaste system

The blowdown line is constructed of a thin steel shell, lined on the inside with concrete. The outside is covered with prestressed steel wire and concrete. The bell and spigot joints have a rubber gasket that seals the steel shells and these joints are grouted inside and out. The pipe is designed to withstand an internal pressure of 110 psig but the system normally operates below 20 psig. In addition to the vacuum breaker valve, there is a small air-release valve that allows small amounts of air to be released from the line so that the larger vacuum breaker does not cycle to relieve this air.

Since the pipe is comprised in part by concrete, the pipe is not capable of withstanding vacuum. Therefore, the pipe is fitted with 11, float-operated, 8-inch vacuum breaker valves. These valves, especially the ones nearest the plant have failed, causing water to spill from the pipe. A search of work history for leaks from the 7th vacuum breaker and its associated air release valve however, determined that there have been no valve failures.

Vacuum breaker 7 on the blowdown line is located about 875 yards east of Essex road and 450 yards north of Smiley road on transmission tower right-of-way. This land is leased to a local resident for agriculture. Directly north of the right-of-way is property owned by the Will County Forrest Preserve District.

Interviews with engineers who managed the Circulating Water System revealed that this vacuum breaker operated full open during normal operation until flow in the blowdown line was increased in September of 2003. The line did not contain enough flow to keep the pipe full and therefore, there was little chance of spilling water. Following the installation of the blowdown booster pump in 2003, flow in the line increased. The increased flow raised the water level in the pipe at this vacuum breaker to the point where the valve would occasionally cycle to relieve air. Each time that a vacuum breaker cycles, it releases a small amount of water. Engineers estimated that this valve cycled every 5 minutes, releasing about 8 ounces of water each time. This is equivalent to a 0.013 gpm leak. Since the vacuum breaker cycled periodically, it approximates a composite sampler during the 2-year period. The attached spreadsheet calculates the composite tritium concentration for the period and the total curies released. Based on the estimates provided by the engineering staff and actual release data for the period, approximately 2,486,000,000 pCi of tritium were released at vacuum breaker 7. The average concentration of all water spilled during this time period from the vacuum breaker is 48,600 pCi/L

Hydrology:
Hydraulic gradient lines are plotted on CRA figure Z. The ground water flow in the area of vacuum breaker 7 is northeast. CRA has determined that groundwater flow on site is 50 to 100 feet per year. Assuming this to be the same at vacuum breaker 7, water spilled at vacuum breaker 7 would be expected to flow northeast.

Water spilled at vacuum breaker 7 in September of 2003 has had 2.4 years to travel. The groundwater gradients at vacuum breaker 7 are relatively flat so the flow rate is on the low end of this range. At 50 feet per year, the plume's leading edge should be about 120 feet from the vacuum breaker.

Sampling for Characterization:

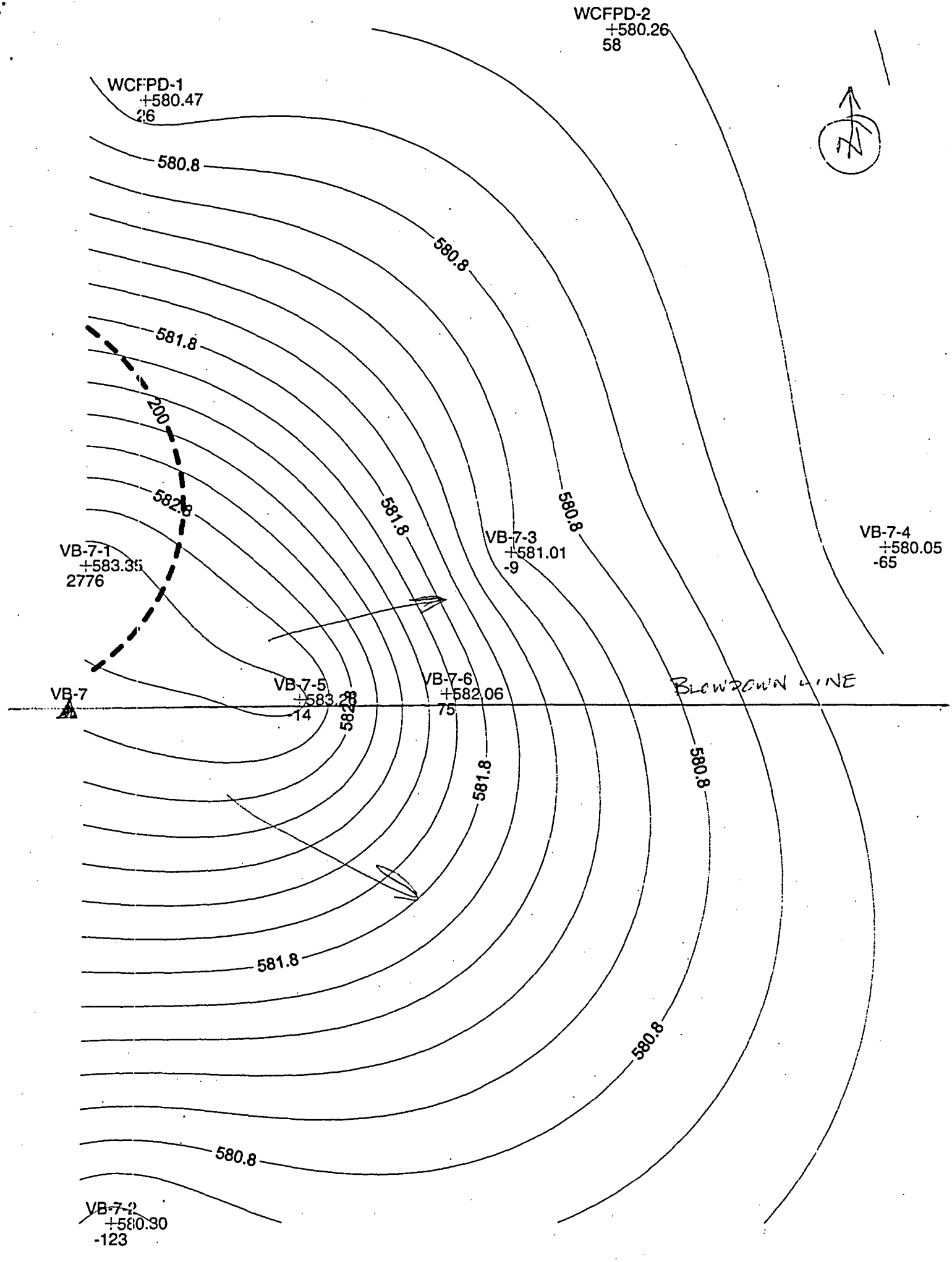
Again, CRA figure Z contains sample locations. Sample wells were drilled either to a depth of 15 feet or 25 feet in the down gradient direction from vacuum breaker 7. Additional sample wells were drilled to determine the extent of the expected plume. The samples and wells drilled to characterize a plume from vacuum breaker 7 were given identifiers of the form: VB7-X where X is a sequential number. The team placed wells on the expected streamline emanating from the vacuum breaker. Only one of these wells, a shallow one drilled 40' directly north of the vacuum breaker, yielded any significant tritium concentration. Well VB7-1 has about 2500 pCi/L.

Characterizing the plume with one data point presents a challenge to the accuracy. Since none of the deep wells had elevated tritium, the plume seems confined to the shallow groundwater. Also, there was no elevated tritium detected at VB7-3 which is located about 130' east of VB7-1 nor was there any tritium at WCFP-1, located 150' north of VB7-1. Therefore, it is reasonable to estimate the plume as being 120' long, 10'wide at the vacuum breaker, spreading to and remaining 50' wide at the property line, and 4' deep. The average concentration of plume is estimated at 1/3 the difference between the composite concentration of 41,600 and the concentration (2500) at the property line. For the part of the plume north of the property line, it is estimated at 1/3 the value (2500 pCi/L) at the property line. For sandy soils, the soil is estimated to contain 20% water. This yields a total tritium inventory of 2,682,000,000 pico-curies.

The characterization above compares favorably with the estimate of tritium released from the valve from September 13 2003 to November 23, 2005 using actual release data and the estimated spill rate.

Projection:

The plume from the periodic spills will continue to travel. The plume is a low concentration plume traveling slowly northeast. The closest resident is over 1000 yards down-gradient. At 50 feet/year, the water in the plume would not be expected to reach this residence for another 58 years (60 years from 2003) and by that time the tritium will decay and disperse below 200 pCi/L. This analysis is based on (and bounded by) a plume model provided by CRA where a 90,000 pCi/L, 1 gpm leak dissipated to background in less than 1000' and 26 years.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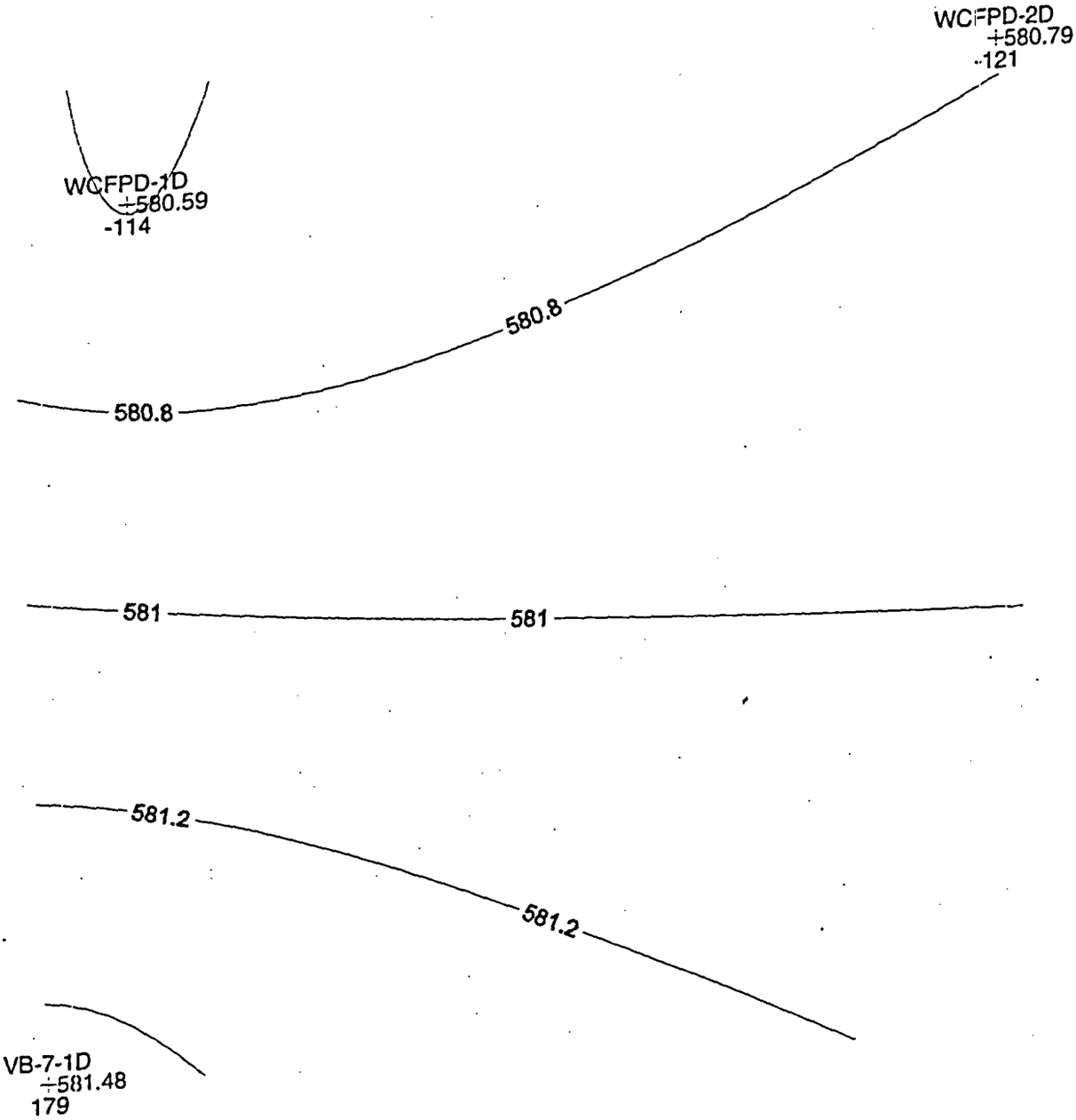
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580.8
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581.2
VB-7-1D
+581.48
179

0 50 100ft

LEGEND

	EXISTING FENCE LINE/APPROXIMATE PROPERTY LINE
	BLOW DOWN LINE
VB-3 ▲	VACUUM BREAKER LOCATION
VB-3-7 ▲	VACUUM BREAKER SAMPLING LOCATION
P-11 ○	SHALLOW TEMPORARY WELL LOCATION
P-40 ○	DEEP TEMPORARY WELL LOCATION

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

BRAIDWOOD STATION
BRACEVILLE, ILLINOIS

BASEMAP OF VB-7

CONESTOGA-ROVERS & ASSOCIATES

Source Reference

Project Manager:	Reviewed By:	Date:	
P. HARVEY	N. SMITH	JANUARY 2006	
Scale	Project Nº.	Report Nº:	Drawing Nº:
1"=300'	16841-13	014	2

16841-13(014)GN-WA002 JAN 18/2006