2 Market Plaza Way, Mechanicsburg, Pennsylvania 17055

April 23, 2001

40-8907

Bill von Till
U.S. Nuclear Regulatory Commission
Fuel Cycle Licensing Branch
Mail Stop T-8A33
Washington, DC 20555

Re: **Memorandum, Change in Zone 3 Saturation, United Nuclear Church Rock Site, Gallup, New Mexico**

Dear Bill:

Enclosed is a memorandum discussing the changes in Zone 3 saturation over time and the implication of these changes on continued active remediation in Zone 3. The information presented therein lays the foundation for understanding current conditions in and for developing alternate concentration limits (ACLs) for Zone 3. This information will be enhanced by the data gathered from the new well to be installed further downgradient in the vicinity of Well EPA 11. United Nuclear, Inc. recognizes the importance of monitoring groundwater between the known seepage-impacted area and the property boundary as a means of establishing ACLs and ensuring their integration into the Long-Term Surveillance Monitoring Program.

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We look forward to further discussion on Zone 3 and encourage feedback on this topic and any others related to developing Zone 3 ACLs. Please contact Roy Blickwedel of General Electric Corporation at (610) 992-7935 or me at (570) 925-5063 if you have questions or need additional information.

Very truly yours,
Earth Tech, Inc.

Suzie du Pont

Suzie du Pont

Enclosure

cc: Roy Blickwedel, General Electric
Larry Bush, United Nuclear
Ken Hooks, Nuclear Regulatory Commission
Beiling Liu, New Mexico Environment Department
Greg Lyssy, US Environmental Protection Agency
Diana Malone, Navajo Superfund
George Padilla, Navajo Superfund
Philip Ting, Nuclear Regulatory Commission

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MEMORANDUM
CHANGE IN ZONE 3 SATURATED THICKNESS
UNITED NUCLEAR CHURCH ROCK SITE
GALLUP, NEW MEXICO

On behalf of United Nuclear Corporation, (United Nuclear), Earth Tech, Inc. (Earth Tech) has prepared this memorandum to illustrate the changes in Zone 3 saturation over time at the Church Rock site and to explain:

- The creation and evolution of saturation in Zone 3;
- The determination of the layout and staging of the remedial action system wells based on saturated thickness; and
- The limitations for continued removal of seepage-impacted water by pumping.

Development of Zone 3 Saturation

Zone 3 was not saturated in the vicinity of the tailings area prior to mining and milling. The saturation was caused by the mine discharge water that percolated into the alluvium along Pipeline Arroyo and from there into the underlying Zone 3 and Zone 1 of the Gallup Formation. The configuration of the Zone 3 saturation is determined by the location of the recharge source to the west and the geologic structure of Zone 3.

Figure 1 shows the recharge area where the mine water in the alluvium percolated into the underlying Zone 3 sandstone. The water entering Zone 3 from the alluvium flowed to the east and north, away from the higher hydraulic head in the recharge area, and downward along the northwesterly dip of the formation. The irregular outline of the eastern, updip edge of saturation is caused by folding. The effect of the folding has become more evident over time as the water has drained out of the formation and water levels have dropped. Wells located in troughs of folds maintain measurable water levels longer than wells located on or near the crests of the folds. For example, Well EPA 03 dried up very quickly while Well 501 B has continued to have measurable water levels.

The farthest eastern (updip) extent of saturation in Zone 3 is defined by Well EPA 17, which was dry when it was installed in 1985 and never had more than 2 feet of saturation. The extent is further indicated by the other wells including, from north to south, Wells EPA 1, EPA 12, EPA 18, and EPA 9, as shown on Figure 1. In 1989, before the remedial action was started, the saturated thickness at these wells was:

Well	Saturated Thickness (feet)
EPA 1	14.7
EPA 12	10.7
EPA 18	2.5
EPA 17	1.4 (Dry when installed in 1985)
EPA 9	8.1

In contrast, wells located closer to the alluvial recharge area and in the northwesterly downdip direction had a much greater saturated thickness, ranging from 40 feet to over 60 feet. For example, Figure 1 shows that the saturated thickness for Wells 708, 711, and 502 B was greater than 40 feet. Also shown on the figure is the 25-foot saturated thickness contour, which, as discussed below, is the minimum saturation needed for extraction pumping in Zone 3.

The saturated thickness in Zone 3 has changed over time in response to the mine water discharge. This change is illustrated on Figure 2, which presents saturated thickness data for Wells 420 and 504 B. These wells were selected for the illustration because they have long-term historical water level data and they are located generally outside the influence of the remedial system wells. As shown, water levels were still increasing in both wells in the early 1980s when mine water was being discharged. However, as the graphs show, water levels began to decline after 1986 when the mine water discharge ceased. Since that time, the saturated thickness in Zone 3 has declined steadily as the mine water naturally drains out of the system. Both wells now have less than 25 feet of saturation.

Zone 3 Remediation System Design and Performance

The design of the remediation system accounted for both the location of seepage impacts and the limits of the Zone 3 saturation (Canonie Environmental Services Corp. [Canonie], 1989). Figure 1 shows the location of the pumping wells and the location of the 25-foot and 0-foot saturated thickness contour lines. The approximate area of seepage impacts in 1989 is shown as diagonal hatching and is designated as the "Zone 3 Remedial Action Target Area." As shown on Figure 1, the Stage I pumping wells (Wells 701 through 703 and 705 through 713) were located at the northern boundary of the seepage-impacted area where the saturated thickness was typically greater than 25 feet.

The locations of the Stage I pumping wells maximized their efficiency by placing them where they could pump the greatest water volume and, at the same time, remove the seepage-impacted water. Based on empirical data and modeling, the locations were limited to areas with greater than 25 feet of saturation. The 6 years of available empirical data from the Northeast Pump-Back Wells (Wells 600, 608, 610, 613 and 672) showed that well efficiency dropped dramatically when the saturated thickness was less than about 25 feet (personal communication, Chuck Johnson, UNC Mine Manager). The effect of the limited saturated thickness on efficiency is further exacerbated by the proximity of the unsaturated zone. The zero-saturation created a boundary effect that increased the rate and magnitude of drawdown. This effect was also demonstrated in the modeling performed for the remedial design. Data from the remediation system wells have verified this condition. As documented in the Annual Review Reports, pumping rates drop to below 1 gallon per minute (gpm) when the saturated thickness is about 25 feet or less.

The Stage II wells (Wells 714 through 720) were installed in 1991 to enhance the removal of water from the formation. As shown on Figure 1, these wells are located downgradient from the seepage-impacted area but where the saturated thickness is sufficient to provide reasonable yields. The location of these wells was based on the design modeling, which indicated the greatest water removal would occur if the wells were installed at a location downgradient from the Stage I wells and after the Stage I wells had operated for a period of 2 years (Canonie, 1989).

The remediation system wells operated as designed to speed the process of the natural draining of the water in Zone 3. The effect of this enhancement of the natural drainage is illustrated by the graph on Figure 3. The graph shows saturated thickness over time for wells located within the influence of the extraction wells. Similar to Figure 2, the saturated thickness was increasing in the early 1980s when mine water was being discharged. Water levels began to decline after 1986 when the mine water discharge ceased. Once the Stage I wells were turned on (marked by the red dashed line), the rate of decline in water levels and saturated thickness increased as indicated by the steeper trend line (black arrows). This trend continued for several years after the Stage II wells were turned on (marked by the green dashed line) until the saturated thickness for the wells was reduced to less than approximately 25 feet. After this time, the decline in saturated thickness slowed to rates representing natural drainage. The natural drainage is evident on Figures 2 and 3, which show that, since about 1996, the rate of decline in saturation for wells within the influence of the pumping wells (Figure 3) matches that evident for Wells 420 and 504B (Figure 2), which are located generally outside the influence of the extraction wells.

The effect of pumping is illustrated in plan view on Figure 4, which shows contours of saturated thickness as of the fourth quarter 2000. As shown, the eastern extent of saturation has contracted to the west so that now the boundary of saturation is approximately where the 25-foot saturated thickness contour was located in 1989 (shown on Figure 1). Also, the wells located to the west, closer to the recharge area, have lost substantial saturation. For example, Well EPA 14 had 76 feet of saturation in 1989 and now has only 41 feet.

Table 1 compares the saturated thickness data for 1989 and the fourth quarter 2000 to illustrate the change in saturation that has occurred. Values greater than 25 feet are shaded. Note that in 1989 the majority of the wells had more than 25 feet of saturated thickness. The average saturated thickness has decreased by 68 percent since 1989 and is only 15.8 feet as of the fourth quarter 2000. Also, only four of the wells monitored for water level now have saturated thicknesses greater than 25 feet.

Limitations for Future Beneficial Removal of Seepage-Impacted Water

The reduction in saturated thickness has decreased the area in Zone 3 where pumping is technically practicable. As demonstrated by the empirical data from 18 years of remedial action pumping, once the saturated thickness is reduced to about 25 feet or less, well efficiency declines and pumping rates drop below 1 gpm. As a result, all but three of the remedial action wells have met the decommissioning criterion of pumping 1 gpm or less. Figure 4 shows that these three wells, Wells 716, 717 and 718, are located in an area where the saturated thickness is at or greater than 25 feet.

Figure 5 shows the approximate extent of the seepage-impacted area together with the saturated thickness for Zone 3. This extent is based on the geochemical evaluation discussed in "Support for Shutting Off Remaining Zone 3 Pumping Wells, United Nuclear Church Rock Site" (General Electric Corporation, 2000). As shown, the majority of the seepage-impacted water is located in the portion of Zone 3 where the saturated thickness is less than 25 feet.

The only locations with sufficient saturated thickness to practicably extract Zone 3 water are downgradient from the seepage-impacted area. Extraction in these areas would not be beneficial because such extraction would increase the rate of downgradient plume migration, as discussed in the U.S. Environmental Protection Agency's (EPA's) Five-Year Review Report (EPA, 1998),

and hinder natural attenuation. This was demonstrated in the evaluation of seepage impacts at EPA 14 provided in the May 2000 letter (General Electric Corporation. Review of more recent data for Well EPA 14 confirms that seepage continues to migrate to Well EPA 14 at a faster rate than was evident before the downgradient wells were the primary pumping wells. A slower rate of migration is preferred because it allows the natural attenuation process to work more effectively to neutralize seepage impacts.

References

Canonie Environmental Services Corp. 1989. *Remedial Design Report. United Nuclear Church Rock Site, Gallup, New Mexico.* April.

General Electric Corporation. 2000. *License Amendment Request, Shutdown of Remaining Zone 3 Extraction Wells, Source Materials License SUA-1475.* May 19.

U.S. Environmental Protection Agency. 1998. *Five Year Review Report, United Nuclear Corporation Groundwater Operable Unit, McKinley County, New Mexico.* September.

TABLES

TABLE 1
CHANGE IN SATURATED THICKNESS OVER TIME, ZONE 3

Well Number[1]	Saturated Thickness		Change (feet)	Change (percentage)
	3rd Quarter 1989	4th Quarter 2000		
402	--	33.2	--	--
411	62.5	--	--	--
420	56.3	22.5	-33.8	-60%
424[2]	--	35.2	--	--
446	--	11.4	--	--
501 B	20.2	0.0	-20.2	-100%
502 B[3]	48.5	20.0	-28.5	-59%
504 B	40.1	13.4	-26.7	-67%
517	42.7	14.5	-28.1	-66%
518[3]	37.2	17.4	-19.9	-53%
608[4]	--	21.0	--	--
613[5]	67.2	22.6	-44.6	-66%
EPA 01	14.7	0	-14.7	-100%
EPA 03	8.3	0	-8.3	-100%
EPA 09	8.1	4.9	-3.2	-40%
EPA 11	30.8	--	--	--
EPA 12	10.7	0	-10.7	-100%
EPA 13	24.8	11.6	-13.2	-53%
EPA 14	76.3	41.4	-34.9	-46%
EPA 15	60.8	0	-60.8	-100%
EPA 17	1.4	0	-1.4	-100%
EPA 18	2.5	0	-2.5	-100%
701	46.1	18.61	-27.5	-60%
702	24.1	11.11	-13.0	-54%
703	32.6	20.8	-11.8	-36%
705				
706	--	20.71	--	--
707	58.8	22.94	-35.9	-61%
708	49.8	--	--	--
709	56.1	--	--	--
710	45.5	17.72	-27.8	-61%
711	43.7	21.65	-22.1	-50%
712	39.1	12.08	-27.0	-69%
713	34.2	12.72	-21.5	-63%
714[6]	50.1	24.47	-25.6	-51%
715[6]	47.6	18.5	-29.1	-61%
716[6]	58.3	--	--	--
717[6]	57.6	32.64	-25.0	--
718[6]	51.1	--	--	--
719[6]	39.9	18.4	-21.5	-54%
720[6]	33.1	--	--	--
Average	37.3	15.8	-22.8	-68%

Notes:

[1] Wells 9D and 106 D were not included because they appear to be completed above the bottom of Zone 3. Measurements of saturated thickness in these wells may be less than actual conditions. Well 126 was not included because it was completed above the bottom of Zone 3. Measurements of saturated thickness in this well are less than actual conditions. Wells 600, 610 and 672 were not included because they were used solely as pumping wells, therefore no water level data are available.

[2] Well 424 water level measured on March 27, 2001. An obstruction in the well casing prevented previous measurements.

[3] Water level for Wells 502 B and 518 measured in February 2000.

[4] Well 608 was pumping in 1989, no water level available. 2000 water level measured in February.

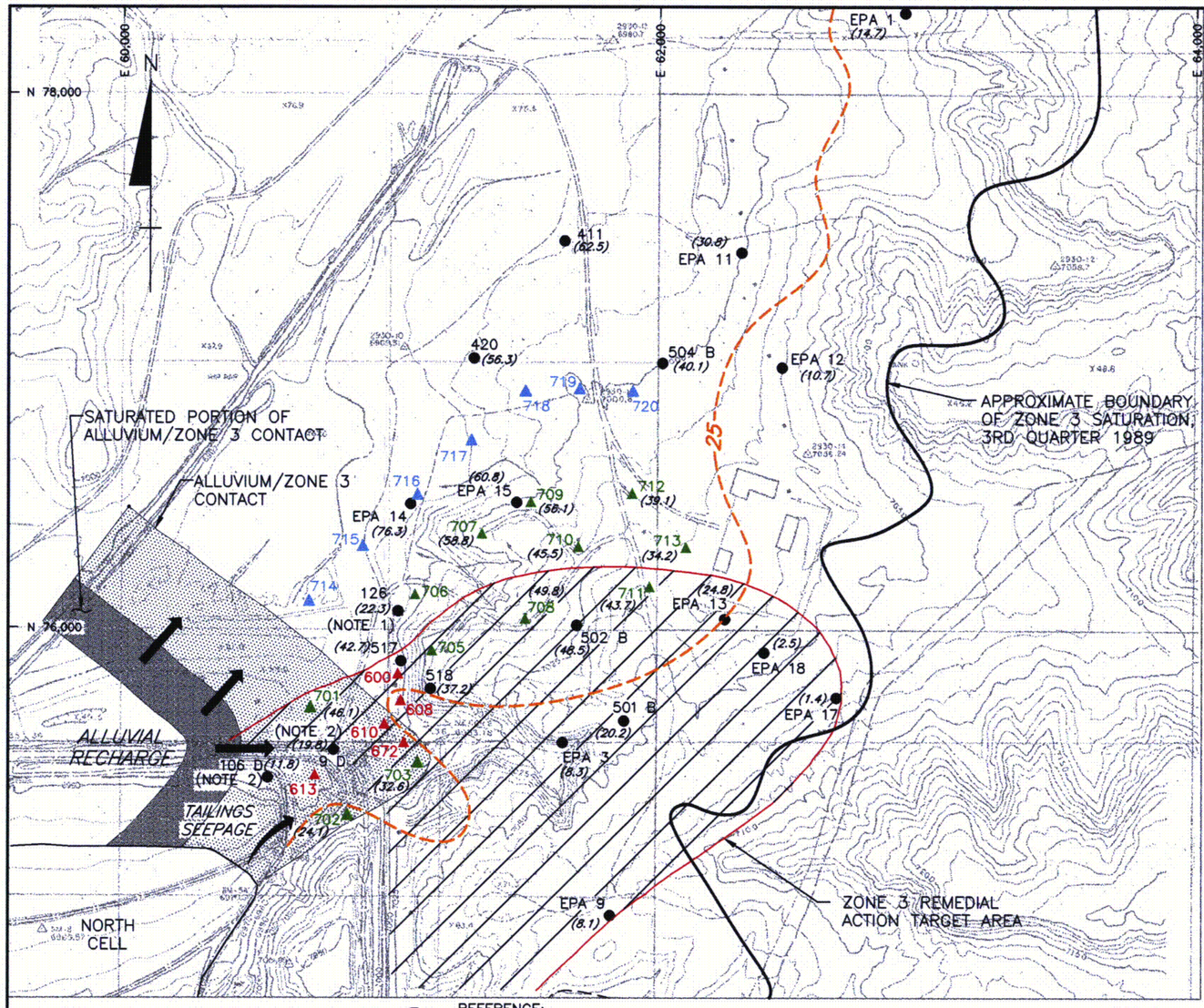
[5] Water level for Well 613 measured in 1983 before pumping started. Water level data for 1989 are not available because the well was pumping.

[6] Water levels for the Stage II wells were measured June 1991 when well installed. Not included in 1989 average saturated thickness calculation.

Shading indicates saturated thickness greater than 25 feet.

"--" indicates that no data is available.

FIGURES



LEGEND:

608▲	NORTHEAST PUMP–BACK WELL LOCATION AND DESIGNATION
708▲	ZONE 3–STAGE I EXTRACTION WELL LOCATION AND DESIGNATION
714▲	ZONE 3–STAGE II EXTRACTION WELL LOCATION AND DESIGNATION (NOTE 4)
420●	ZONE 3 MONITORING WELL LOCATION AND DESIGNATION
(36.2)	SATURATED THICKNESS, FEET 3RD QUARTER 1989
—25—	SATURATED THICKNESS OF ZONE 3 3RD QUARTER 1989 (DASHED WHERE INFERRED)

NOTES:

1. MONITORING WELL 126 WAS COMPLETED ABOVE THE BOTTOM OF ZONE 3. CONSEQUENTLY MEASUREMENTS OF SATURATED THICKNESS IN THIS WELL ARE LESS THAN ACTUAL CONDITIONS.
2. MONITORING WELLS 9 D AND 106 D APPEAR TO BE COMPLETED ABOVE THE BOTTOM OF ZONE 3. MEASUREMENTS OF SATURATED THICKNESS IN THESE WELLS MAY BE LESS THAN ACTUAL CONDITIONS.
3. NORTHEAST PUMP–BACK WELLS WERE PUMPING AT THIS TIME. WATER LEVEL DATA NOT AVAILABLE.
4. NO WATER LEVEL DATA AVAILABLE IN 1989, STAGE II WELLS WERE INSTALLED IN 1991.

C-1

FIGURE 1

ZONE 3 REMEDIAL ACTION TARGET AREA vs SATURATED THICKNESS 1989

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UNC MINING AND MILLING
GALLUP, NEW MEXICO

EARTH TECH

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
1	8/23/99	ISSUED FOR ZONE 3 SATURATED THICKNESS MEMO	SAB		

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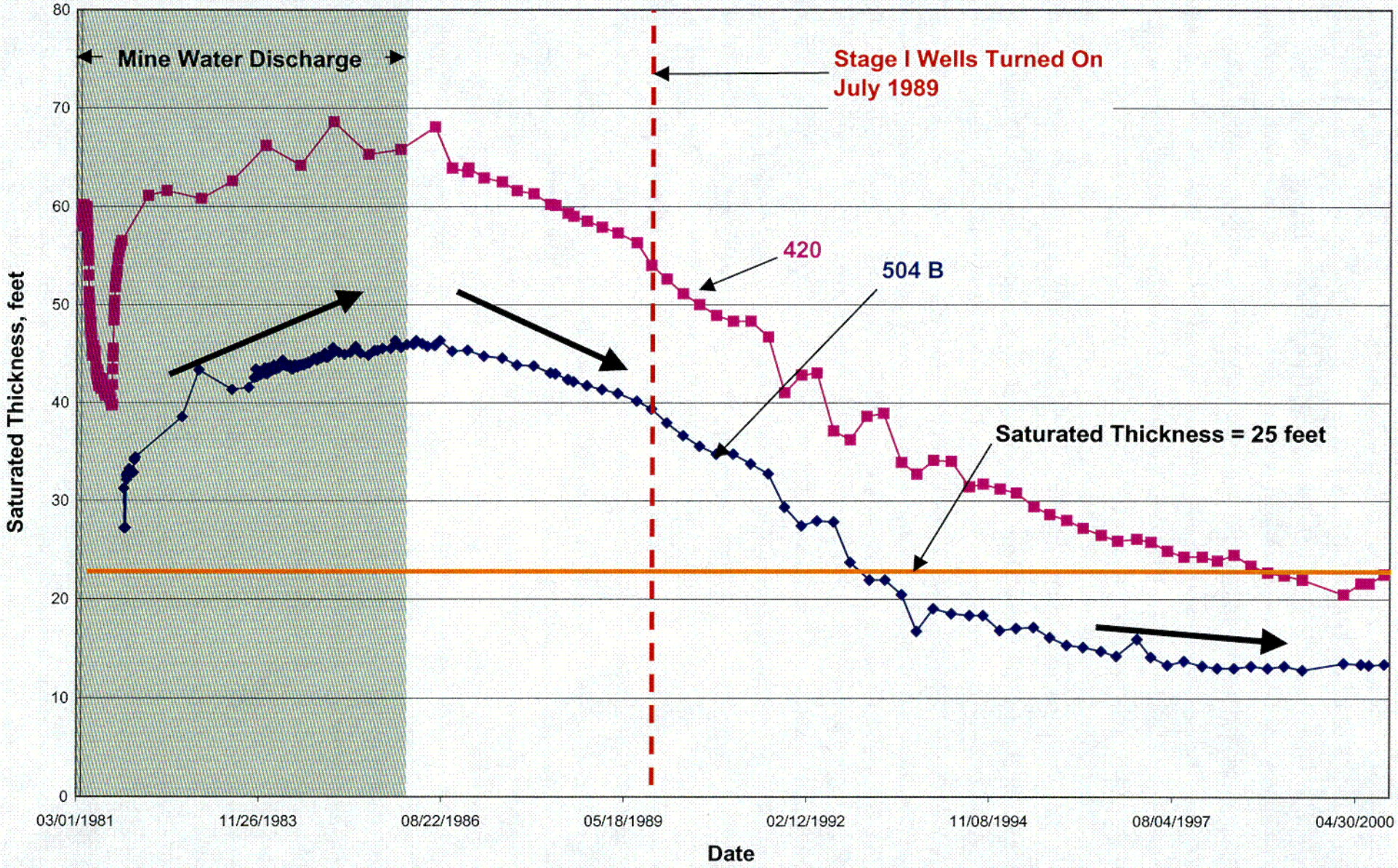
REFERENCE:
TOPOGRAPHIC MAP OF SEC. 2, T16N, R16W N.M.P.M. & VICINITY PROVIDED BY UNITED NUCLEAR CORPORATION, GALLUP, N.M. DATED: 8–1–96. SCALE: 1" = 400'.

SCALE
400 0 400 FEET

1

Change in Saturated Thickness Over Time

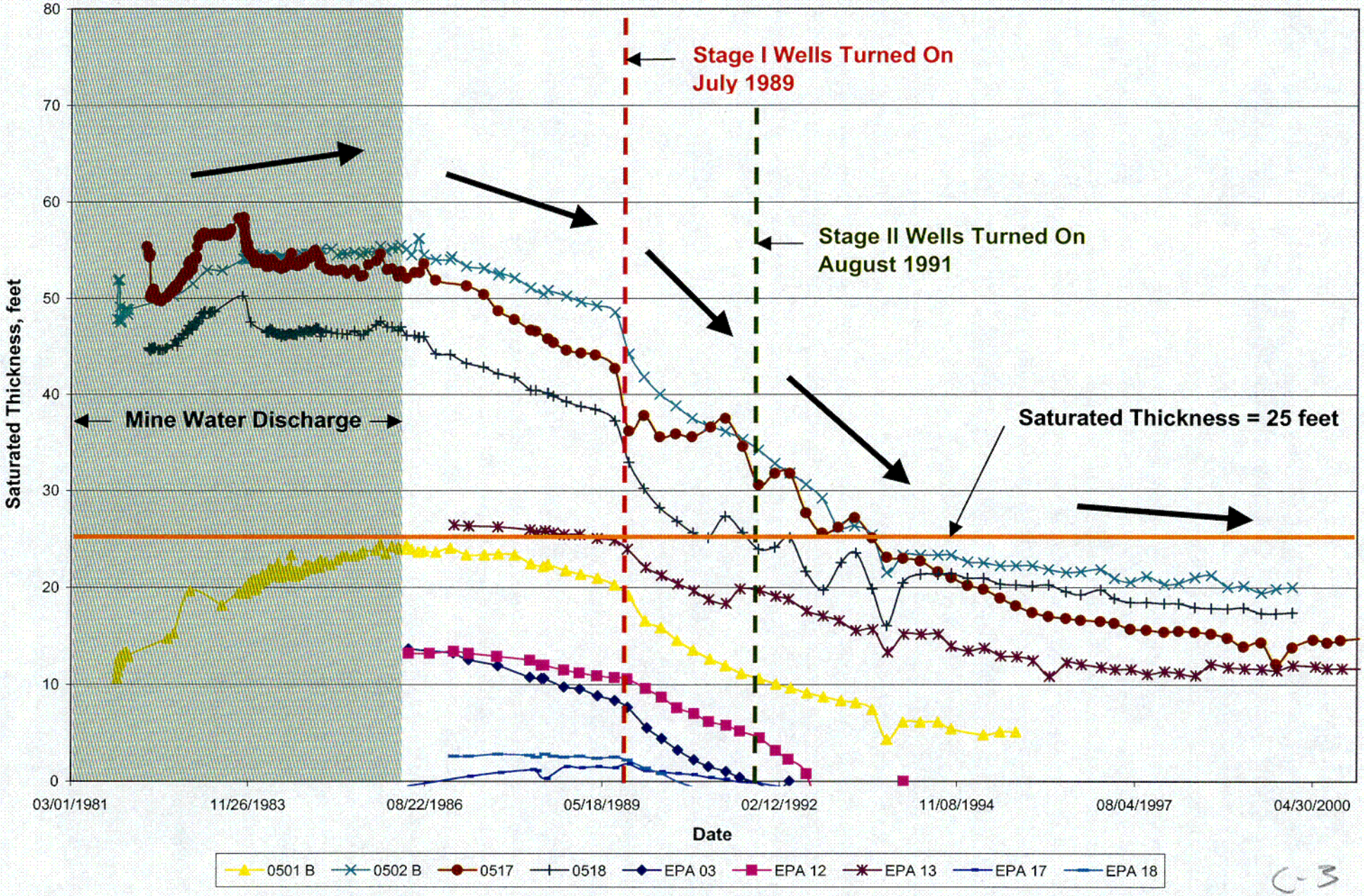


L:\Work\32114\Work\Product\Submittals\Final Sat Thick Memo\Sat Thick Figure Chart 1\Sat Thick Figure Chart 1

FIGURE 2

1-2

Effect of Pumping to Enhance Natural Drainage in Zone 3



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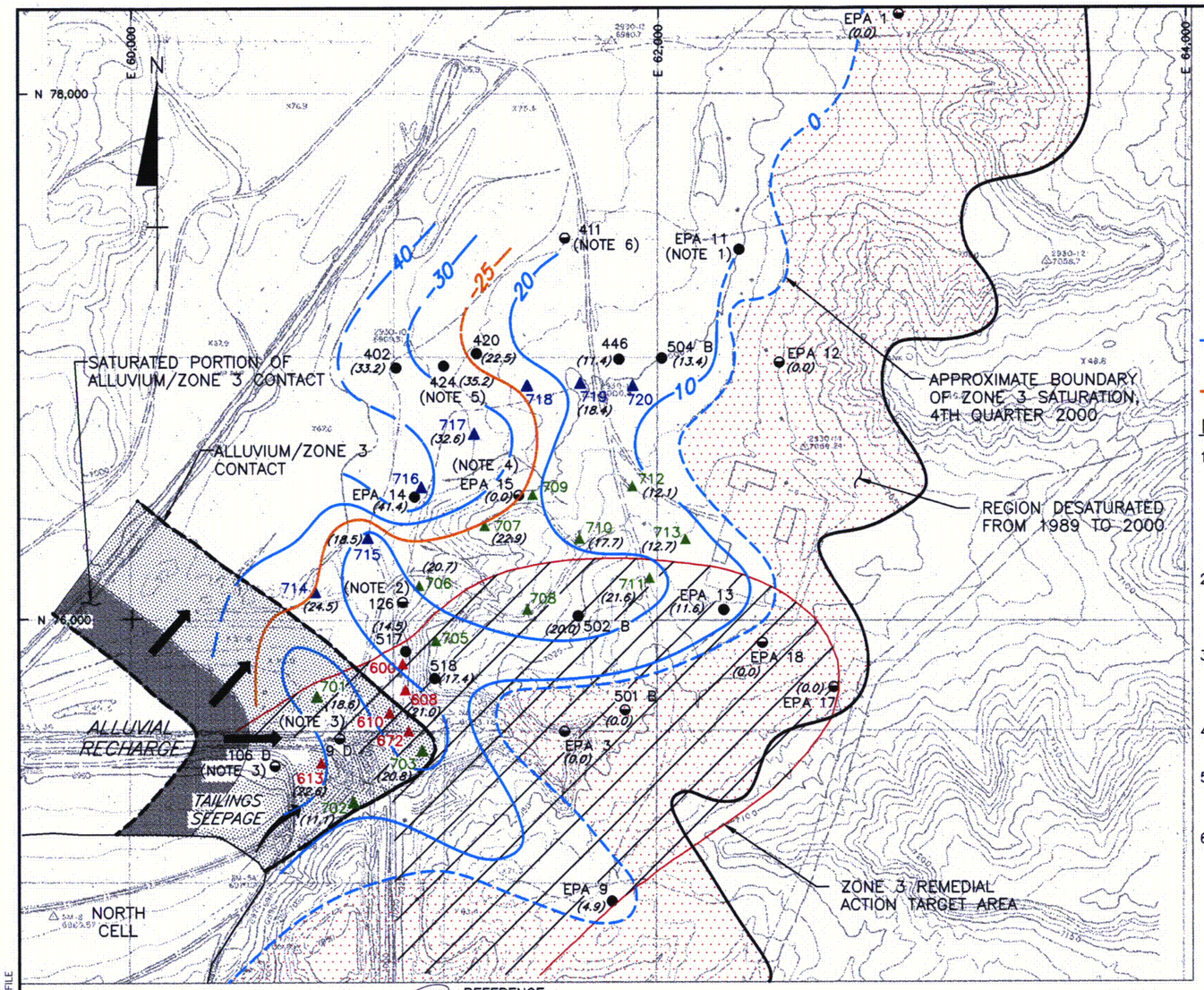
L:\Work\32114\Work\Product\Submittals\Final Sat Thick Memo\Effect of Pumping Figure Chart 2\Effect of Pumping Figure Chart 2

FIGURE 3



LEGEND:

608 ▲	NORTHEAST PUMP-BACK WELL LOCATION AND DESIGNATION
708 ▲	ZONE 3-STAGE I EXTRACTION WELL LOCATION AND DESIGNATION
714 ▲	ZONE 3-STAGE II EXTRACTION WELL LOCATION AND DESIGNATION
420 ●	ZONE 3 MONITORING WELL LOCATION AND DESIGNATION (CONTAINS WATER)
EPA 17 ◒	ZONE 3 MONITORING WELL LOCATION AND DESIGNATION (DRY OR CONTAINS INSUFFICIENT WATER FOR SAMPLE COLLECTION)
(36.2)	SATURATED THICKNESS, FEET 4TH QUARTER 2000
—30—	SATURATED THICKNESS OF ZONE 3, 4TH QUARTER 2000 (DASHED WHERE INFERRED)
—25—	MINIMUM SATURATED THICKNESS REQUIRED FOR GROUNDWATER EXTRACTION

NOTES:

1. MONITORING WELL EPA-11 WAS NOT USABLE AS OF THIRD QUARTER 1990. THE WATER LEVEL DROPPED BELOW THE PUMP INTAKE. THE PUMP COULD NOT BE LOWERED BECAUSE IT IS CEMENTED IN THE WELL. THE NRC AND EPA WERE NOTIFIED OF THIS PROBLEM IN TELEPHONE CONVERSATIONS ON JULY 18 AND SEPTEMBER 5, 1990.
2. MONITORING WELL 126 WAS COMPLETED ABOVE THE BOTTOM OF ZONE 3. CONSEQUENTLY MEASUREMENTS OF SATURATED THICKNESS IN THIS WELL ARE LESS THAN ACTUAL CONDITIONS.
3. MONITORING WELLS 9 D AND 106 D APPEAR TO BE COMPLETED ABOVE THE BOTTOM OF ZONE 3. MEASUREMENTS OF SATURATED THICKNESS IN THESE WELLS MAY BE LESS THAN ACTUAL CONDITIONS.
4. THE BOTTOM OF MONITORING WELL EPA 15 IS COMPLETED IN A SHALE LAYER WHICH CONTAINS NO WATER.
5. WELL 424 WATER LEVEL MEASURED MARCH 2001. OBSTRUCTION IN THE WELL CASING PREVENTED EARLIER MEASUREMENTS.
6. WELL 411 FILLED WITH OIL AS OF SECOND QUARTER 1998.

FIGURE 4

ZONE 3 SATURATED THICKNESS 4TH QUARTER 2000

PREPARED FOR:

UNC MINING AND MILLING GALLUP, NEW MEXICO

EARTH TECH

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
1	04/23/01	ISSUED FOR ZONE 3 SATURATED THICKNESS MEMO	SAB		

REFERENCE:
TOPOGRAPHIC MAP OF SEC. 2, T16N, R16W N.M.P.M. & VICINITY PROVIDED BY UNITED NUCLEAR CORPORATION, GALLUP, N.M. DATED: 8-1-96. SCALE: 1" = 400'.

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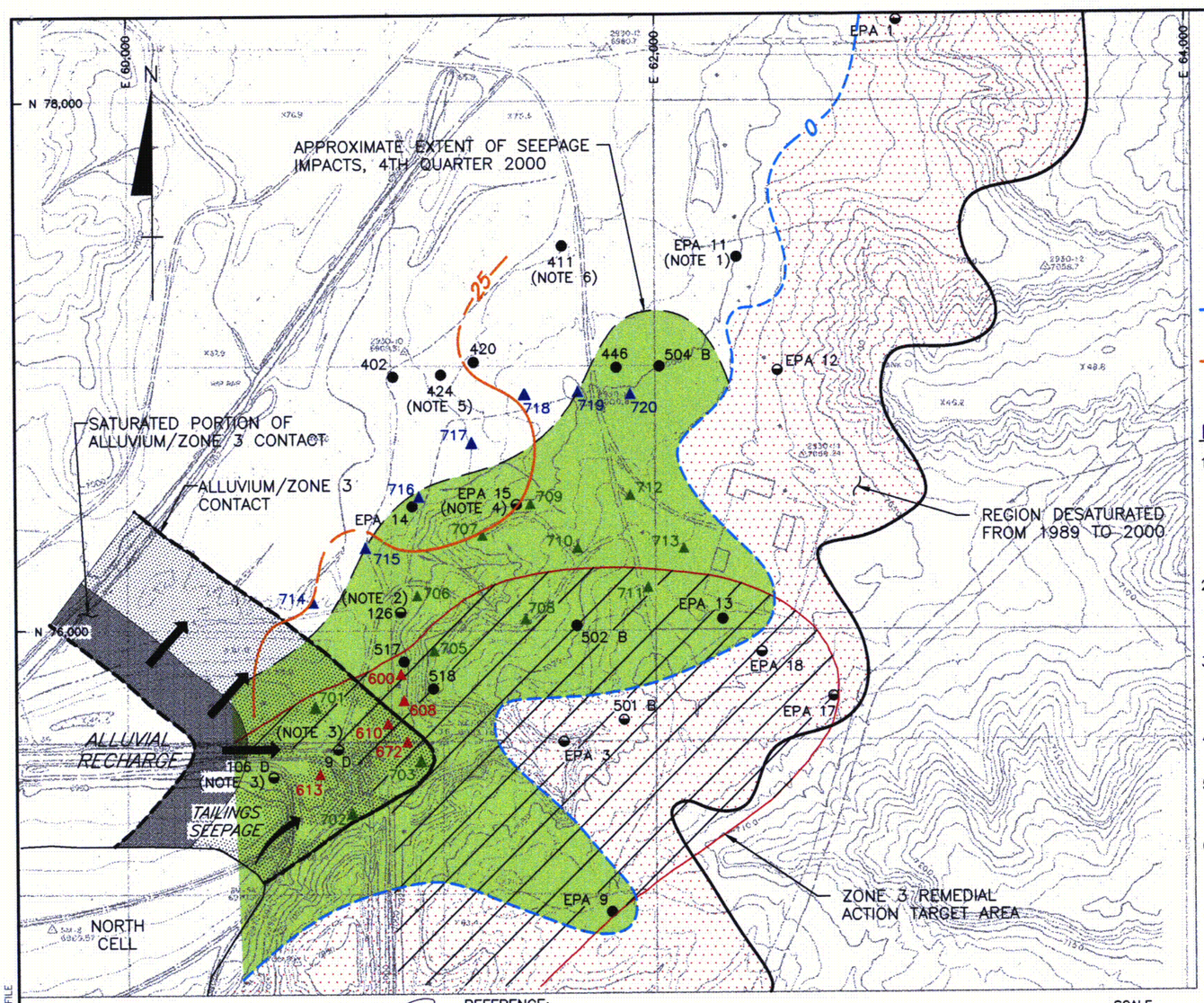

LEGEND:

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714 ▲	ZONE 3–STAGE II EXTRACTION WELL LOCATION AND DESIGNATION
420 ●	ZONE 3 MONITORING WELL LOCATION AND DESIGNATION (CONTAINS WATER)
EPA 17 ◒	ZONE 3 MONITORING WELL LOCATION AND DESIGNATION (DRY OR CONTAINS INSUFFICIENT WATER FOR SAMPLE COLLECTION)
— 0 —	SATURATED THICKNESS OF ZONE 3, 4TH QUARTER 2000 (DASHED WHERE INFERRED)
—25—	MINIMUM SATURATED THICKNESS REQUIRED FOR GROUNDWATER EXTRACTION

NOTES:

1. MONITORING WELL EPA–11 WAS NOT USABLE AS OF THIRD QUARTER 1990. THE WATER LEVEL DROPPED BELOW THE PUMP INTAKE. THE PUMP COULD NOT BE LOWERED BECAUSE IT IS CEMENTED IN THE WELL. THE NRC AND EPA WERE NOTIFIED OF THIS PROBLEM IN TELEPHONE CONVERSATIONS ON JULY 18 AND SEPTEMBER 5, 1990.
2. MONITORING WELL 126 WAS COMPLETED ABOVE THE BOTTOM OF ZONE 3. CONSEQUENTLY MEASUREMENTS OF SATURATED THICKNESS IN THIS WELL ARE LESS THAN ACTUAL CONDITIONS.
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4. THE BOTTOM OF MONITORING WELL EPA 15 IS COMPLETED IN A SHALE LAYER WHICH CONTAINS NO WATER.
5. WELL 424 WATER LEVEL MEASURED MARCH 2001. OBSTRUCTION IN THE WELL CASING PREVENTED EARLIER MEASUREMENTS.
6. WELL 411 FILLED WITH OIL AS OF SECOND QUARTER 1998.

FIGURE 5

ZONE 3 SEEPAGE-IMPACTED AREA vs 4TH QUARTER 2000 SATURATED THICKNESS

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UNC MINING AND MILLING GALLUP, NEW MEXICO

EARTH TECH

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
1	04/23/01	ISSUED FOR ZONE 3 SATURATED THICKNESS MEMO	SAB		

REFERENCE:
TOPOGRAPHIC MAP OF SEC. 2, T16N, R16W N.M.P.M. & VICINITY PROVIDED BY UNITED NUCLEAR CORPORATION, GALLUP, N.M. DATED: 8–1–96. SCALE: 1" = 400'.

SCALE
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1