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TECHNICAL MEMORANDUM

TO: Permits West

FROM: M. Wasiolek

RE: Groundwater conditions near the Section 12 shaft

DATE: November 23, 2015

ISSUE: Southwest Resources, Inc. of Albuquerque has filed a Mine Permit Application and a Close Out Plan with the NM MMD for a former uranium mine located in the southwest corner of Section 12, Township 14N, Range 10W (the "Section 12 mine"), previously operated by Cobb Resources and Hydro-Nuclear. The NM MMD has requested some additional information and analyses related to shallow groundwater in the area. In particular, NM MMD requested: 1) a regional geologic map that includes alluvium on a topographic base and shows the locations of wells listed in Table 2 of the Application; 2) an evaluation of the potential for the presence of shallow groundwater conditions in the area of the mine; and 3) an assessment of the potential impact of the mine on shallow groundwater, if it is present. HAI has been asked by Permits West to provide the requested material and analyses.

In order to accomplish this task, HAI reviewed the available published and unpublished hydrogeologic reports and data for the study area and the San Juan Basin, identified wells in the OSE WATERS database located within 4,800 m (three miles) of the Section 12 shaft, and reviewed historical photography on-line resources such as GOOGLE Earth. A list of the documents and sources relied on is included at the end of this Technical Memorandum.

CONCLUSIONS:

As a result of the analyses performed, the following conclusions were arrived at regarding shallow groundwater in the vicinity of Section 12, T14N R10W:

1. There is no hydrogeologic evidence that a shallow groundwater system exists within the alluvial materials in the vicinity of the Section 12 shaft.

2. Within the San Juan Basin there is an extensive deep artesian aquifer within the Morrison Formation, which in the area of Section 12 is found between 650 and 780 feet below land surface. Groundwater in wells and mine shafts completed in this deep aquifer is under pressure and rises to within approximately 450 of the surface. Water in this aquifer is separated from surface sources of water by several hundred feet of low-permeability shales in the area of the Section 12 shaft and cannot be impacted by infiltration of surface water.

3. Previous operation of the Section 12 mine did not result in discharge of groundwater from the deep aquifer in the Morrison Formation into the Arroyo del Puerto. There will be no harm to any alluvial groundwater resources that might be located farther down the Arroyo del Puerto if future mining operations also avoid discharging into the lake, and if the berm along the western edge of Ambrosia Lake is maintained.

DISCUSSION:

1. There is no hydrogeologic evidence that a shallow groundwater system exists within the alluvial materials in the vicinity of the Section 12 shaft.

The Section 12 mine is located within 15 acres of the SW 1/4 of Section 12, Township 14N, Range 10E, NMPM, on the eastern edge of the 43 acre dry lake known as "Ambrosia Lake."

The potential for the presence of a shallow groundwater aquifer in the vicinity of Section 12 was investigated by identifying wells located within three miles of the Section 12 shaft, and determining their producing intervals and depths to water. If a shallow groundwater aquifer were to be present within the area of Section 12, it would be expected that shallow wells would be present within this radius. The OSE WATERS database was relied on, and the wells identified in that database were cross-checked with Table 1 of Stone et al (1983), Table 2 of Brod and Stone (1981), and Table 1 of Cooper and John (1968), which are reports that tabulate wells, monitor wells, and mine shafts within the San Juan Basin. Table 1 of this Technical

Memorandum lists the wells identified by this procedure. Figure 1 shows the locations of these wells and the Section 12 shaft. A legend for abbreviations in the Table and figures is provided below:

Legend for Figures 1, 2, and Table 1

Figure or Table abbreviation	Well symbol	Description
P & Tr		Permian & Triassic
Psa		Permian San Andres Formation
Jm		Jurassic Morrison Formation
Km		Cretaceous Mancos Shale
Kg		Cretaceous Gallup Sandstone
Qa		Quaternary stream alluvium
Qaf		Quaternary alluvial fan deposits
Qae		Quaternary stream alluvium subject to eolian processes
B-363		Well location & OSE water right file designation

Only one well completed in streambed alluvium was identified as potentially being present within three miles of the Section 12 shaft. This well, B-00143, was reportedly completed in 1960 to a depth of 90 feet approximately two and a half miles north-northeast of the Section 12 shaft in the streambed alluvium of an unnamed stream course that drains into Ambrosia Lake. The well appears in the OSE WATERS database, but not in any of the other well inventory report (Cooper & John, 1968, Brod and Stone, 1981, or Stone et al, 1983), which investigated the hydrogeology of the area and compiled the locations and characteristics of known groundwater wells.

WR File Nbr	Owner	Use	Source	q64	q16	q4	Sec	Tws	Rng	X	Y	Distance	Finish Date	Depth Well	Depth Water	Aquifer
B 00366 *	Rio Algom Mining	MIN	Artesian		1	4	24	14N	10W	241563	3924043	3070	12/31/1955	760		Jm
B 00372	Sabre-Pinon Corp.	MIN			4	1	23	14N	10W	239552	3924525	3105	09/12/1956	796		Jm
B 00994 S5	Rio Algom Mining	MIN	Shallow	4	1	3	17	14N	09W	244128	3925430	3295	04/05/1959	1094		Jm
B 00994 S4	Rio Algom Mining		Shallow	1	1	4	19	14N	09W	243086	3924087	3510	03/16/1970	779		Jm
B 00994	Rio Algom Mining	MIN	Shallow	3	4	3	24	14N	10W	241046	3923554	3555	09/18/1958	857		Jm
B 00373	Rio Algom Mining	MIN	Artesian	4	1	2	22	14N	10W	238453	3924864	3610	12/31/1956	1003		Jm
B 00994 S6	Rio Algom Mining	MIN	Shallow	4	1	2	22	14N	10W	238453	3924864	3610	01/02/1958	827		Jm
B 00363	Rio Algom Mining	MIN	Artesian	2	2	4	22	14N	10W	238835	3924236	3771	04/30/1956	745		Jm
B 01881	Jerry Elkins	STK	Shallow	1	1	1	10	14N	10W	237674	3928251	3792	12/14/2014	1060	800	Jm
B 00143	Andrews	DOM	Shallow	4	3	1	35	15N	10W	239462	3930833	4154	07/18/1960	90	60	Qa
B 00362	Rio Algom Mining	MIN	Artesian	4	1	4	22	14N	10W	238435	3924036	4186	11/30/1956	3093		P & Tr
B 00371	Sabre-Pinon Corp.	MIN			3	1	25	14N	10W	240716	3922861	4278	08/25/1956	752		Jm
B 00364	Anderson Development Corp.	MIN	Artesian	1	2	2	30	14N	09W	243460	3923276	4399	08/31/1956	735		Jm
B 00365	Anderson Development Corp.	MIN	Artesian		2	3	20	14N	09W	244399	3923952	4427	01/31/1956	793		Jm
B 00994 S	Rio Algom Mining	MIN	Shallow	4	3	1	30	14N	09W	242425	3922703	4542	03/23/1968	810		Jm
B 00522 *	UNC-Homestake Ptnrs	MON		2	2	4	25	14N	10W	242009	3922518	4639	02/07/1978	70		Psa

* The location of B 00552 was projected by the OSE from a sub-division lot and appears to be incorrect. According to the well log, the well is completed in Psa, which is not present at the location projected by the OSE.

* WR File Nbrs in red were listed in Table 2 of the first permit Application.

Table 1. Wells in NM OSE Database Located Within 4,800 m of Section 12 Mine Shaft

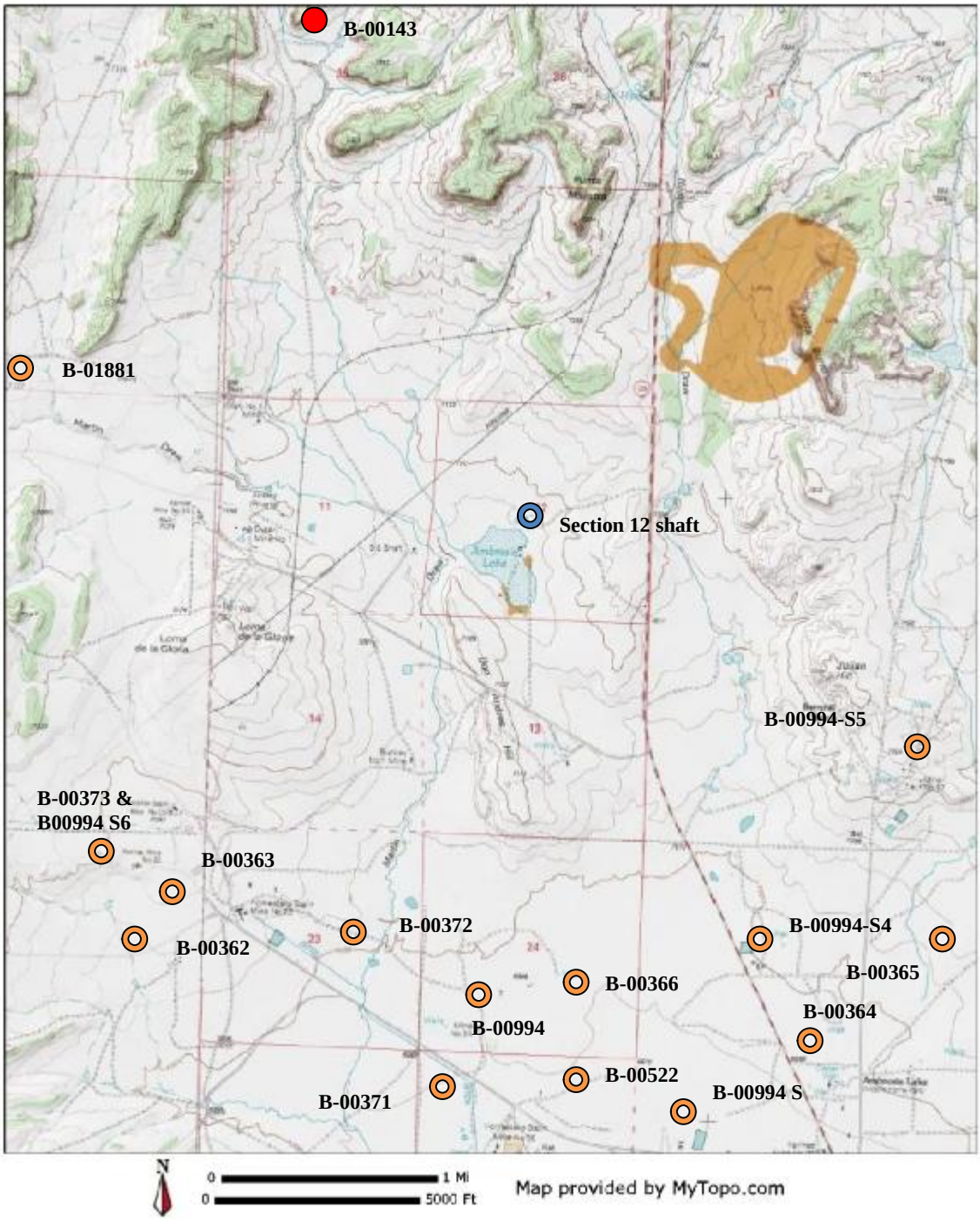

Figure 1. Location of Wells in OSE WATERS Database within 4,800 m of Section 12 Shaft.

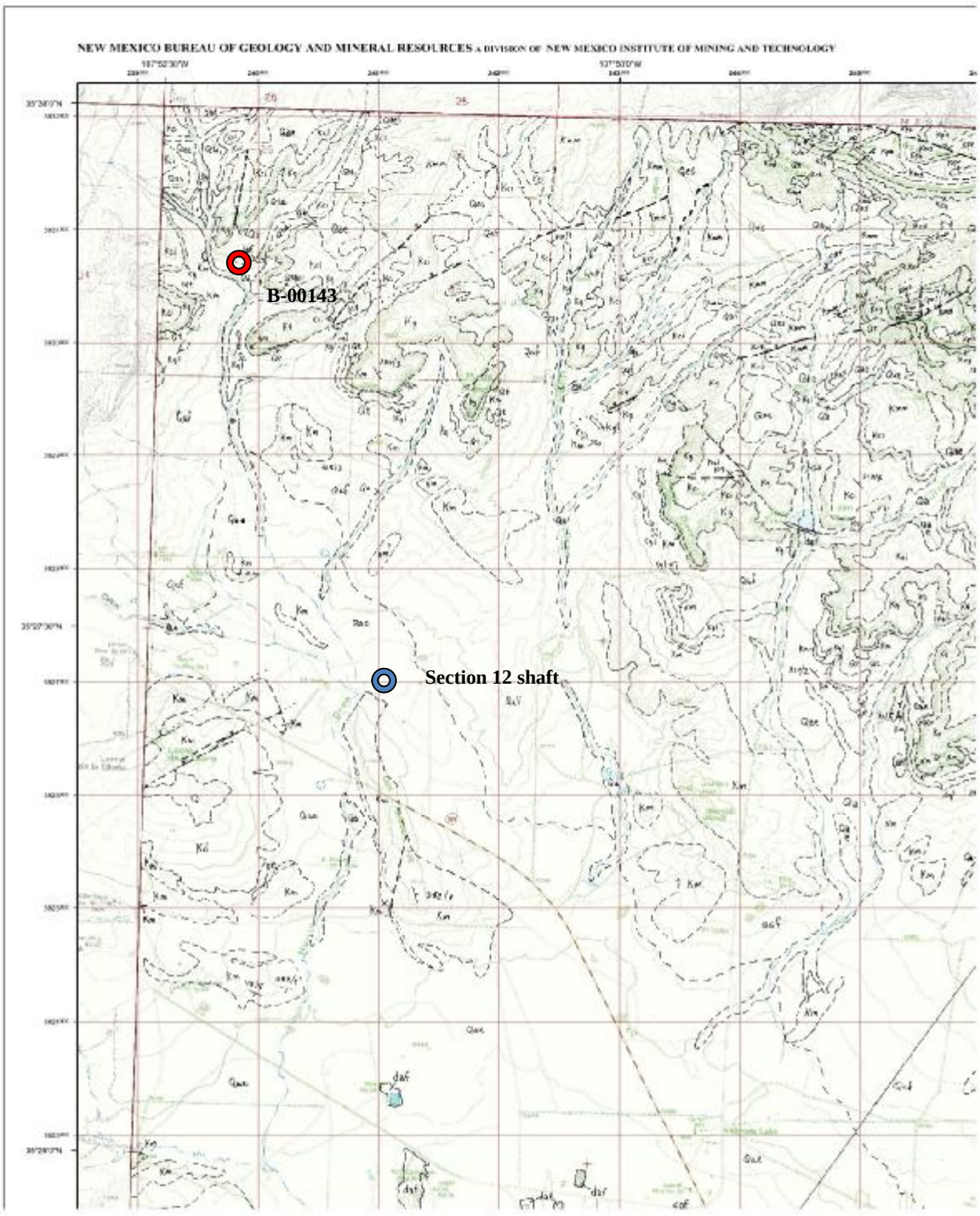

Figure 2. Geologic Map of the Area around the Section 12 Shaft. (modified from Ferguson & McCraw, 2010)

The well log for B-00143 describes the aquifer as "sand and gravel, red shale." Recent geologic mapping by Ferguson and McCraw (2010) identifies the aquifer in the area of the well as stream bed alluvium (Qa), as can be seen on Figure 2. They describe Qa as "Stream alluvium (Quaternary)-Gravel, sand and silty sand in stream channels." Qa is confined on their map to the immediate area of a stream drainage, and is not the same geologic unit as is mapped in the vicinity of Section 12. Outside of stream channels, the Quaternary alluvial deposits are designated as either alluvial fan deposits (Qaf), or as alluvium which has been subjected to eolian processes; ie, windblown sands and silts (Qae). Qae is present in the area of Ambrosia Lake and the Section 12 shaft; it is described by Ferguson and McCraw (2010) as "Primarily stream alluvium subject to eolian processes (Quaternary)- Sand, and silty sand occupying low-lying flat areas, often showing areas of deflation and eolian deposition on lee sides of bedrock hills and structures. Occasional gravel lag deposits." These are different materials than those purportedly tapped by well B-00143.

Other indications that shallow aquifers might be present would be the presence of springs or a groundwater-fed lake. Neither are present in the vicinity of Section 12. Review of topographic maps and previous investigations of the area do not reveal any reports of springs, seeps, or shallow groundwater. Ambrosia Lake itself is a shallow, closed depression which occasionally holds water, but is often dry for years at a time, a condition which has been commented on by various observers for at least the past fifty years. For example, according to Cooper and John, "Ambrosia Lake, Casamero Lake and Smith Lake are natural depressions that are normally dry and contain water only after heavy rains" (Cooper & John, 1968, p. 11). Twenty years later in 1989 Chenoweth described Ambrosia Lake as "a small, ephemeral lake situated in the SW1/4 sec. 12, T14N, R10W. It is now dry and is the site of Cobb Nuclear's Section 12 shaft" (Chenoweth, 1989, p. 297). The eastern part of the lake reportedly held some water during part of 2014, but HAI personnel have observed it to be dry on various occasions during the last 10 years. If the lake were fed by a shallow groundwater aquifer, it would hold water permanently. Its ephemeral nature indicates that it is not fed by groundwater inflow from a shallow aquifer. It is, rather, an ephemeral, playa lake unconnected to a groundwater aquifer. Such features typically form in low areas in the southwest, developing beds of fine silt and clay which impede

downward movement of water during precipitation events and hold it temporarily before it is evaporated.

2. Within the San Juan Basin there is an extensive deep artesian aquifer within the Morrison Formation, which in the area of Section 12, is found between 650 and 780 feet below land surface. Groundwater in wells and mine shafts completed in this deep aquifer is under pressure and rises to within approximately 425 feet of the surface. Water in this aquifer is separated from surface sources of water by several hundred feet of low-permeability shales in the area of the Section 12 shaft and cannot be impacted by infiltration of surface water.

Records for all other wells within three miles of the Section 12 shaft indicate that they pump from the Morrision Formation, usually from the Westwater Canyon Member, or the lower Mancos Shale from a depth of 400 to 650 feet below land surface. In addition to wells listed in Table 1 from OSE WATERS data base, Table 1 of Stone et al (1983) and Table 1 of Cooper and John (1968) list the depths and water levels in a number of additional mine monitor wells and mine shafts within 14N 10W sections 23, 24, 25, and 14N 9W, section 30. These wells and mines are approximately 700 feet in depth, and have depths to water of 425 feet or more below land surface. Granger (1982) reports water levels and mine depths for the nearby Section 23 mine that are comparable.

Between the Westwater Canyon Member and land surface are hundreds of feet of Mancos Shale, a low-permeability geologic unit (Stone et al, 1983). The presence of an artesian head in the Westwater Canyon aquifer is indication that the shale is an effective barrier to vertical movement of groundwater. Groundwater in this deeper aquifer cannot be impacted by activities on the land surface above.

3. Previous operation of the Section 12 mine did not result in discharge of groundwater from the deep aquifer in the Morrison Formation into the Arroyo del Puerto. There will be no harm to any alluvial groundwater resources that might be located farther down the Arroyo del Puerto if future mining operations also avoid discharging into the lake, and if the berm along the western edge of Ambrosia Lake is maintained.

NMED records indicate that records indicate that none of the mines in the area of Section 12 discharged water into the lake or Arroyo del Puerto. Table 1 of *Water quality data for discharges from uranium mines and mills in New Mexico*, compiled by Perkins of the NMED (1980), lists the Section 12 mine as "dry." No discharge from this mine was noted in this report or in any other contemporaneous investigation such as the USEPA's *Water quality impacts of uranium mining and milling activities in the Grants mineral belt*, (1975), or Table 5 of Brod and Stone (1981).

Ambrosia Lake is located in a closed basin, and although ephemeral stream courses empty into it, none flow out. The upper Arroyo del Puerto (also called "Martin Draw" on some maps) swings near the western side of the lakebed, but an earthen berm prevents any occasional flow from that stream course from entering the lakebed, and any water from leaving. Activities within the lake basin at the Section 12 mine would not affect an alluvial aquifer in the Arroyo del Puerto, if one exists in this area, which is doubtful. Prior to discharge of mine water into the Arroyo del Puerto by mines located several miles downstream of Section 12, the alluvial fill of the stream course was reportedly dry (Ganus, 1980). That at the present Arroyo del Puerto contains some sub-surface water from about three miles downstream of Section 12 is due to seepage from mine ponds and discharge of mine dewatering water into the arroyor from uranium mills, particularly Kerr-McGee and United Nuclear Homestake Partners mills, during the 1960-1983 period (Kaufman et al, 1975; NMED, 2010, 2012). Mine and mill reclamation activities and lack of natural recharge will eventually decrease the amount of groundwater in the streambed to an insignificant level.

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