MASTER

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UPDATED EVALUATION OF

HYDROCARBON POTENTIAL

ORNL STUDY AREA, SOUTHEAST NEW MEXICO

Netherland, Sewell & Associates

May, 1975

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OFFICE OF WASTE ISOLATION
OAK RIDGE, TENNESSEE

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June 6, 1975

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Dear Dr. McClain:

This is an update report, based on our geological and engineering studies to May, 1975, setting forth our current evaluation of the hydrocarbon potential of the three-square-mile ORNL "Study Area" of Southeast New Mexico as outlined in detail in our original report dated June 11, 1974. The purpose of this current study was to analyze the available data obtained during the past year from the drilling of 16 wells within the area of interest surrounding the ORNL Study Area and to review the field production and reservoir performance of the surrounding fields to determine if these data altered our geologic interpretation and conclusions as set forth in our earlier report. This current study was prepared for the Holifield (Oak Ridge) National Laboratory operated by Union Carbide Corporation, Nuclear Division, for the Energy Research and Development Administration, under Purchase Order Number 78X-70344V of Union Carbide Corporation, dated February 27, 1975.

This current review of drilling activity in the area of interest since our report of May, 1974, together with our review of the field production and reservoir performance of the fields in the area, confirms our geologic interpretations and conclusions, as set out in our earlier report, that no economically recoverable oil and gas exists within the limits of the ORNL Study Area or under the acreage immediately adjoining the Study Area. Our current findings further confirm (1) that three prominent structural highs cross the central portion of the area of investigation, as shown on Exhibit 2; (2) that these structural highs carry through from shallow Permian beds to the deeper Siluro-Devonian beds; (3) that hydrocarbon production, when found, is limited to the porous zones on the crests of the structural highs; and (4) that no oil or gas production in any formation has been found in the synclinal troughs such as the one traversing the central portion of the area (Exhibit 2) in which the ORNL Study Area is located.

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Our current investigation reveals no significant leasing activity in the area of interest surrounding the ORNL Study Area at this time; the nearest leasing activity of which we became aware was in the Brinninstool Field area approximately 12 miles southeast of the Study Area where some lease sales or trades were made at prices in the range of \$125 per acre. We believe that the current value of minerals, as they pertain to oil and gas rights, in the area of interest is no higher than the \$100 per acre stated in our earlier report; in fact, we believe there has been a modest decrease in the value of the minerals in this area during the past year.

We appreciate the opportunity of updating this study for you.

Very truly yours,

A handwritten signature in cursive script that reads "Clarence Netherland". The signature is written in dark ink and is positioned below the typed name "Clarence Netherland".

- ELLENBURGER FIELDS
- DEVONIAN-FUSSELMAN FIELDS
- MORROW-ATOKA (PENN.) FIELDS
- DELAWARE (PERMIAN) FIELDS

PRODUCING ZONE MAP

DELAWARE BASIN

WEST TEXAS-SOUTHEAST NEW MEXICO

PRODUCING ZONE BY FIELD

SCALE IN MILES

10 0 10 20 30 40 50

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DALLAS, TEXAS UPDATED TO MAY, 1975

GENERAL DISCUSSION

We have studied the available data obtained from the drilling of 16 wells within the area of interest surrounding the ORNL "Study Area" of Southeast New Mexico to determine if the data from these wells altered our geologic interpretations and conclusions as set forth in our report of May, 1974. We also reviewed the field production and reservoir performance data for those fields located in the northern portion of the Delaware Basin of Southeast New Mexico surrounding the ORNL Study Area. The purpose of this updated study was to review our summary conclusions concerning the hydrocarbon potential of the ORNL Study Area as set forth in our earlier report.

In our current study, a determination was made of all drilling activity since May of 1974 in approximately eleven townships surrounding the ORNL Study Area. Thirteen Morrow tests, two Upper Permian (Yates) tests and one Cherry Canyon (Middle Permian) test, were drilled during this period. The data obtained from these wells are set forth in detail in the accompanying GEOLOGICAL DISCUSSION section of this report. The manner in which these data tie into the data outlined in our earlier report is also discussed, together with the minor effect which these data had on our original geologic interpretation. The accompanying exhibits have been revised to show the slight changes in interpretation to honor the new data available from the additional drilling to May of 1975.

This review of drilling activity since our report of May, 1974, essentially confirms the geologic interpretations as set out in our earlier report that three prominent structural highs cross the central portion of the area of investigation, as shown on Exhibit 2. The structural highs shown on this exhibit are: the South Salt Lake Trend in the northeast, the Cabin Lake-Zonne Trend south of the ORNL Study Area, and the Sand Dunes Trend in the southern part of the area. These structural highs carry through from shallow Permian beds to the deeper Siluro-Devonian beds. The three-square-mile ORNL Study Area is located in a synclinal trough on the north flank of the Cabin Lake-Zonne Trend. No oil or gas production in any formation has been found in the synclinal troughs such as the one traversing the central portion of the area (Exhibit 2) in which the ORNL Study Area is located; instead, hydrocarbon production, when found, is limited to the Delaware, Strawn, Atoka, and Morrow formations where porosity exists on the crests of the structural highs.

To review the field production and reservoir performance of the fields in the area of interest, we obtained updated reports of oil and gas production filed with the New Mexico Oil and Gas Conservation Commission and spotted this production on our graphs on which the earlier production

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had been plotted. Examples of these updated production plots are shown as Exhibits E-1, E-2 and E-3 in this report; these plots are for fields nearby and pertinent to the ORNL Study Area. These plots indicate that, after an initial "flush" high producing rate, the Morrow and Atoka wells decline rather sharply in producing capacity as shown for the Cabin Lake (Morrow) Field, Exhibit E-1, and for the Hat Mesa (Morrow) Field, Exhibit E-2. The higher production shown for the South Salt Lake (Morrow) Field has been maintained by the drilling of additional wells as indicated by the number of producing wells having increased from two to eight during the past 12 to 18 months (the five producing wells shown for the Hat Mesa Morrow Field are included by us in the South Salt Lake Field based on our geologic interpretation).

The review of the field production and reservoir performance of the fields in the area surrounding the ORNL Study Area leads us to the same conclusions as set out in our earlier report that the fields which produce gas from the Morrow, Atoka, and Strawn formations in the vicinity of the ORNL Study Area are small in size and disappointing in producing rates, pressure performance, and resulting recoverable reserves. We believe this results from the nature of the geologic formations from which the gas is produced in which thin and erratic lenses of porosity are scattered through thick gross sections, suggesting that the producing reservoirs are small and probably not connected.

Our current investigation indicates that the Morrow, Atoka, and Strawn are the only zones that continue to be of any significant interest to oil and gas operators in the areas surrounding the ORNL Study Area. Also, our investigation reveals no significant leasing activity in this area of interest surrounding the ORNL Study Area at this time; the nearest leasing activity of which we became aware was in the Brinninstool Field area located approximately 12 miles southeast of the Study Area where some lease sales or trades were made at prices in the range of \$125 per acre.

Therefore, we believe that the current value of minerals, as they pertain to oil and gas rights in the area surrounding the ORNL Study Area is no higher than the \$100 per acre which we stated in our earlier report; in fact, we believe there has been a modest decrease in the value of the minerals in this area during the past year.

INTRODUCTION

This report updates to May, 1975, our earlier investigation to determine the probability of finding commercially productive hydrocarbons under the three-square-mile ORNL Study Area of southeastern New Mexico described in the accompanying cover letter. The results of our earlier investigation of May, 1974, were set forth in our report dated June 11, 1974, and addressed to Dr. William C. McClain, Director of the Geologic Disposal Evaluations Project.

In our current updated study, a determination was made of all drilling activity since May of 1974 in approximately eleven townships surrounding the subject Study Area.

Thirteen Morrow tests, two Upper Permian (Yates) tests, and one Cherry Canyon (Middle Permian) test were drilled. Geological data afforded by these wells essentially substantiated the subsurface interpretations depicted in the May, 1974, report.

Two Morrow gas wells were completed in the South Salt Lake Field (Wells A and B, shown on accompanying exhibits), one is awaiting completion (Well BB) and a southwest stepout (Well C) was dry as predicted. A new Morrow gas discovery (Well F) was found in the South Salt Lake Trend southeast of the field. This appears to represent another accumulation southeast of the established field limits. This discovery and a Morrow dry hole (Well E) approximately three miles to the north are outside of the original investigation area. Two shallow dry Upper Permian (Yates) wells (Wells I and II) were drilled in the vicinity of Well F and have no bearing on the potential productivity of the Study Area.

One Morrow confirmation gas well (Well D) and one dry hole (Well G) were drilled in the Cabin Lake Field. One Morrow well is testing in the Los Medanos Field (Well H). One Morrow well is testing in the Sand Dunes Field (Well I) and one Cherry Canyon well (Well III) was completed as a small oil and salt water producer. A north stepout in the Zonne (Red Tank) Field (Well J) is testing the Morrow and a southeast stepout (Well K) is drilling. A north stepout in the Brinninstool Deep Unit (Well L) is testing.

Complete data on some of the foregoing wells are not yet available but it appears that all information will conform basically to the geological interpretation presented in our report of May, 1974. However, the configuration of the Morrow Structure Map (G-10) was revised slightly to incorporate the new data and the Morrow Sand Analysis Map (G-20) was also brought up to date. The production from the new Morrow wells was incorporated on the hydrocarbon distribution map (Exhibit 2) and the overall

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relationship of the hydrocarbon accumulations to the ORNL Study Area was investigated to form the basis for our conclusions.

HYDROCARBON DISTRIBUTION MAP AND OVERLAY

Exhibit 2 with overlay has been updated and depicts all of the hydrocarbon producing wells in the area of investigation and the estimated present limits of such production. It will be noted that practically all of the production is on the axes of structural anticlines with the Morrow gas accumulations being the most outstanding. Some isolated wells have produced off of the structural highs, but their production thus far has been insignificant.

A new Morrow gas discovery was made southeast of the South Salt Lake Trend (Well F) which represents a different gas accumulation from the South Salt Lake Field. This discovery and a Morrow dry hole (Well E) approximately three miles to the north are outside of our Study Area but conform to our regional geologic interpretation.

A new potential Morrow gas discovery is testing (Well L) north of the Brinninstool Deep Unit which is located at the eastern end of the Sand Dunes Trend several miles southeast of the ORNL Study Area, as shown on Exhibit 2.

The ORNL Study Area lies on the south flank of a synclinal trough 3.2 miles south of the South Salt Lake Field, 4.1 miles east of the Cabin Lake Field, and 1.8 miles northwest of the Zonne pool. It is less than two miles northeast of a deep dry hole designated 15 SW1 located in T22S-R31E, and less than three miles southwest of a recent dry Morrow test (C-Dry Hole) in Section 21 of T21S-R32E. Both of these wells failed to find commercial hydrocarbon production in any formation. Additionally, Well J is testing the Morrow in the Zonne area. This well is some two miles southeast of the subject Study Area and, as of May 1, 1975, it had tested less than one million cubic feet of gas per day with approximately 180 barrels of salt water per day.

Based on the results of drilling and testing to date, the only commercial production in the area of investigation has been found along the anticlinal trends as depicted on Exhibit 2.

SUMMARY OF DELAWARE BASIN GEOLOGY

Reference is made to the summary discussion of the Delaware Basin geology on page G-4 of our original report of May, 1974. The discussion contained in our earlier report remains unchanged.

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AREA OF INVESTIGATION

Exhibit G-1 is the Key Well Map showing the essential wells which formed the basis for preparing our report of May, 1974. Additionally, the recent wells completed during the past year, to May of 1975, are shown on this exhibit.

Each key well has a symbol designation as set out in the legend, showing whether it is a producing oil or gas well, abandoned oil or gas well, testing well, drilling well, or a dry hole. These wells are also listed in the Tabulation of Key Wells shown on pages G-8 through G-9 of this report.

Cross-sections A-A' and B-B' traverse the ORNL Study Area and are shown in detail on Exhibits G-17 and G-18.

STRATIGRAPHY

The May, 1974, report covered the rocks in the area of investigation which ranged in age from Precambrian to Quaternary. However, the report was concerned only with those sedimentary deposits which occur below the base of the Castile evaporites of Late Permian age in the central and southern portions of the area and below the Capitan Reef of Late Permian age in the northern portion of the area. Exhibit G-2 shows the stratigraphic column for the area.

Available data from the thirteen Morrow tests drilled since the May, 1974, report confirm our earlier statements regarding the rocks penetrated by these wells through the Pennsylvanian System.

STRUCTURE

The thirteen Morrow wells investigated in this updated report confirmed, with only slight variation, our earlier structural interpretations. Slight revisions were necessary in the South Salt Lake and Zonne Trends. No revisions were necessary in the Cabin Lake, Los Medanos, and Sand Dunes Trends. One well (Well L) north of Brinninstool Deep Unit reasonably confirmed the regional geology.

South Salt Lake Field

Three wells (Wells A, B and BB) were drilled in the South Salt Lake Field, and the two released logs of Wells A and B indicated the top of the Morrow formation was within a few feet of the anticipated

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depths as set out in Exhibit G-10. Well C encountered the top of the Morrow within 25 feet of our prediction on Exhibit G-10 and, after a year of costly drilling and testing (the well commenced drilling February 2, 1974, and was abandoned as a dry hole February 16, 1975), confirmed our interpretation (Exhibit G-20) that it was drilled downdip and outside of the hydrocarbon limits of the South Salt Lake Field.

Cabin Lake Field

Two wells (Wells D and G) were drilled in the Cabin Lake Field. Well D was completed as an excellent gas well and, although the log is not yet released, the top of porosity based on the perforated interval confirms our previous interpretation. Thus, the Morrow top should be approximately as mapped. The log of Well G has not been released but the well tested salt water in the Morrow, substantiating our estimate of the gas-water contact for the field accumulation.

Los Medanos Trend

Well H encountered the top of the Morrow as predicted and is waiting on a completion unit to perforate the Morrow.

Sand Dunes Trend

Well I encountered the top of the Morrow as predicted and currently is testing the Lower Morrow.

Zonne Trend

One well (Well J) was drilled north of the Zonne discovery (Well 20 NE1) and found the top of the Morrow some 50 feet higher than anticipated. It currently is testing as discussed under Hydrocarbon Analysis (Page G- 6). Well K is testing along trend to the southeast and this log has not been released. Additional discussion will be found under the Hydrocarbon Analysis section of this report.

Brinninstool Deep Unit Area

A north stepout (Well L) found the top of the Morrow some 78 feet lower than expected and, as of May, 1975, the well is testing the Morrow.

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HYDROCARBON ANALYSIS

Morrow Sand Analysis Map, Exhibit G-20

Exhibit G-20 was changed slightly to incorporate the data available from the thirteen tests drilled during the past year.

South Salt Lake Field

Wells A and B were completed as gas wells and the top of the Morrow porosity checked within a few feet of that predicted in our earlier report. The log has not been released on Well BB and it awaits a completion unit. It should be a successful Morrow gas well. Well C commenced drilling February 2, 1974, and, after a year of costly drilling and testing, it was abandoned as a dry hole on February 16, 1975. It encountered the top of the Morrow within 27 feet of our prediction and was outside of the limits of the hydrocarbon accumulations of the South Salt Lake Field as indicated in our May, 1974, report.

South Salt Lake Field Trend

Well F was drilled along trend southeast of the South Salt Lake Field and has been completed as a successful Morrow gas well. The log of this well has not been released but the accumulation appears to represent a new structural high outside of our mapped area of investigation. Well E was completed as a dry hole north of Well F and southeast of the South Salt Lake Field. It is also outside of our area of investigation.

Cabin Lake Field

Well D was completed as a successful Morrow gas well after testing gas in the Strawn. The log has not been released but the top of the Morrow porosity came in as expected. Well G confirmed our estimated southeastern limits of production and was abandoned as a dry hole after swabbing salt water from the Morrow.

Los Medanos Field

Well H found the top of the Morrow formation as predicted and is currently shut in awaiting a completion unit to perforate the Morrow.

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Sand Dunes Field

Well I encountered the top of the Morrow as predicted. Testing of the interval at 14,595 feet (11,089 feet subsea) is now in progress and the results to date have been disappointing. The gas is less than one million cubic feet per day and it has been associated with varying amounts of salt water.

Zonne Field

A north stepout (Well J) to the Zonne discovery (Well 20 NE1) encountered the Morrow formation higher than expected and found an Upper Morrow sand above the production interval in the discovery well. The sand appears to be wet and testing of both zones, when open simultaneously, has resulted in less than one million cubic feet of gas per day along with some 180 barrels of salt water. Currently the well is shut in. The Upper Morrow sand in Well J from 14,375 to 14,420 feet (10,674 to 10,719 feet subsea) is clean and well developed but appears to contain salt water rather than gas. It was not present in the discovery well (20 NE1). The gas zone in this well was encountered some 72 feet higher in Well J, necessitating a minor revision in the Morrow Sand Analysis Map (Exhibit G-20).

Well J in the Zonne Field is some 10,500 feet or approximately two miles from the Study Area and the northwest limits of the gas accumulation in the Lower Morrow zone of this field still extends no closer than approximately 1.8 miles from the Study Area, as shown in our May, 1974, report (Exhibit G-20). The significance of the well developed but wet Upper Morrow sand cannot accurately be evaluated at this time. However, it is postulated that the sand is limited in area, not associated with any gas accumulation and does not change our earlier views regarding the areal extent of the Zonne Field.

CONCLUSIONS

The review of drilling activity since our May, 1974, report essentially confirms the geological interpretations as set out in this earlier report.

Three Morrow gas wells were drilled in the South Salt Lake Field, one in the Cabin Lake Field, one awaits testing the Morrow in the Los Medanos Field, one is testing the Morrow in the Sand Dunes Field,

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another is testing Morrow gas and salt water in the Zonne Field, and a new Morrow discovery was made southeast of the South Salt Lake Field. Additionally, a Morrow dry hole was drilled southeast of South Salt Lake Field, a Morrow dry hole was drilled on the southern extremity of the Cabin Lake Field, another Morrow well awaits testing in the Sand Dunes Field, a north stepout in the Zonne Field is testing Morrow gas and salt water, a Zonne Trend well is testing the Morrow southeast of the discovery, a north stepout from the Brinninstool Deep Unit is testing the Morrow, and a Morrow dry hole was drilled on the north end of the South Salt Lake Trend.

Additionally, two dry Shallow Yates (Upper Permian) tests were drilled to the east and outside of the area covered in the May, 1974, report, and one Cherry Canyon (Middle Permian) well was completed in the Sand Dunes Field.

Based upon the foregoing drilling activity, we are pleased to reconfirm our earlier conclusions as stated below.

Three prominent structural highs cross the central portion of the area of investigation: the South Salt Lake Trend in the northeast, the Cabin Lake-Zonne Trend south of the ORNL Study Area, and the Sand Dunes Trend in the southern part of the area. These structural highs carry through from shallow Permian beds to the deeper Siluro-Devonian beds.

The three-square-mile ORNL Study Area, shaded on all maps, is located in a synclinal trough on the north flank of the Cabin Lake-Zonne Trend.

Hydrocarbon production near the central portion of the area of investigation is limited to the Delaware, Strawn, Atoka, and Morrow formations where porosity exists on the crests of the structural highs. No production in any formation has been found in the synclinal troughs, such as the one traversing the central portion of the area (Exhibit 2).

This updated study indicates that no hydrocarbon accumulations of significance can be expected in the trough area under the lands comprising the ORNL Study Area in any formation from the Permian to the Precambrian.

Respectfully submitted,

Chas. C. Bankhead, Jr.

AAPG Certified Petroleum Geologist 257

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TABULATION OF KEY WELLS

AREA OF GEOLOGICAL INVESTIGATION FOR UPDATED ORNL STUDY
AS OF MAY, 1975
DELAWARE BASIN, EDDY AND LEA COUNTIES, NEW MEXICO

<u>MAP KEY</u>	<u>Operator</u>		<u>Lease</u>	<u>Production</u>
<u>T20S-R33E</u>				
A	Belco Petroleum Corporation	#2	Bass-Federal Section 30	Morrow Gas Well
<u>T21S-R32E</u>				
B	Phillips Petroleum Company	#1	Hat Mesa Section 2	Morrow Gas Well
BB	Phillips Petroleum Company	#2	Hat Mesa Section 11	Probable Morrow Gas Well. Waiting on completion unit.
C	Skelly Oil Company	#1	Salt Lake South Unit Section 21	Dry Hole
<u>T22S-R30E</u>				
D	Troporo Oil & Gas Company	#1	Cabana Section 1	Morrow Gas Well
<u>T21S-R33E</u>				
E	Getty Oil Company	#1	Stock Unit Section 15	Dry Hole
F	Brunson & McKnight	#1	Leggett Section 33	Morrow Gas Well
<u>T22S-R31E</u>				
G	Byron McKnight	#1	Campana Section 6	Dry Hole
<u>T23S-R31E</u>				
H	Continental Oil Company	#7	James Ranch Unit Section 6	Waiting to Perforate Morrow
I	Skelly Oil Company	#1-a	Todd 25 Federal Section 25	Testing
<u>T22S-R32E</u>				
J	Cleary Petroleum Corporation	#1	Federal 17 Section 17	Testing
K	Gulf Oil Corporation	#1	Covington "A" Federal Section 25	Testing

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TABULATION OF KEY WELLS

AREA OF GEOLOGICAL INVESTIGATION FOR UPDATED ORNL STUDY
AS OF MAY, 1975
DELAWARE BASIN, EDDY AND LEA COUNTIES, NEW MEXICO

<u>MAP KEY</u>	<u>Operator</u>	<u>Lease</u>	<u>Production</u>
<u>T23S-R33E</u>			
L	American Quasar	#1 Brinninstool Section 20	Testing
<u>T21S-R33E</u>			
I	Brunson & McKnight	#1 Leggett "A" Section 34	Shallow Dry Hole
<u>T22S-R33E</u>			
II	Robert N. Enfield	#1 Cotter Federal Section 1	Shallow Dry Hole
<u>T23S-R31E</u>			
III	Texas American	#7 Todd Federal Section 26	Cherry Canyon Oil and Water Well

NORTHERN DELAWARE BASIN

PALEOZOIC STRATIGRAPHIC COLUMN

SYSTEM	EPOCH	ROCK UNITS
PERMIAN	OCHOAN	RUSTLER ANHYDRITE SALADO SALT CASTILE EVAPORITES TANSIL
	GUADALUPIAN	DELAWARE GROUP BELL CANYON CAPITAN REEF BELL CANYON CLASTICS CHERRY CANYON BRUSHY CANYON
	LEONARDIAN	BONE SPRINGS FORMATION
	WOLFCAMPIAN	WOLFCAMP FORMATION

SYSTEM	EPOCH	ROCK UNITS
PENNSYLVANIAN	MISSOURIAN AND VIRGILIAN	CISCO CANYON FORMATION
	DESMOINESIAN	STRAWN FORMATION
	DERRIAN	ATOKA FORMATION
	MORROWAN	MORROW FORMATION
MISSISSIPPIAN	CHESTER-MERAMEC	BARNETT SHALE
	OSAGE-KENDERHOOK	MISSISSIPPI LIME
SILURO-DEVONIAN		WOODFORD SHALE SILURO-DEVONIAN LIME
ORDOVICIAN		MONTOKA SIMPSON ELLENBURGER
PRECAMBRIAN	BASEMENT	

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EDDY AND LEA COUNTIES, NEW MEXICO

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CROSS SECTION A-A'

HORIZONTAL SCALE: 1" = 10,000' FEET
 VERTICAL EXAGGERATION: 8X

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CROSS SECTION B-B'

HORIZONTAL SCALE IN FEET
5000 0 5000 10,000 15,000 20,000 25,000
VERTICAL EXAGGERATION: 8X

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