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POTASH ORE RESERVES IN THE PROPOSED WASTE ISOLATION PILOT PLANT AREA, EDDY COUNTY, SOUTHEASTERN NEW MEXICO

By

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This report has not been edited for conformity
with Geological Survey editorial standards or
stratigraphic nomenclature

CONTENTS

ILLUSTRATIONS

[Plates are in pocket]

TABLES

SI UNITS AND U.S. CUSTOMARY EQUIVALENTS

SI (International System of Units) is a modernized metric system of measurement. All values have been rounded to four significant digits. Use of hectare (ha) as an alternative name for square hectometer (hm^2) is restricted to measurement of land or water areas. Metric ton (t) as a name for megagram (mg) should be restricted to commercial usage, and no prefixes should be used with it.

SI Unit		U.S. Customary equivalent		
		Length		
millimeter (mm)	=	0.03937	inch	(in)
meter (m)	=	3.281	feet	(ft)
	=	1.094	yards	(yd)
kilometer (km)	=	0.6214	mile	(mi)
	=	0.5400	mile, nautical	(nmi)
		Area		
centimeter^2 (cm^2)	=	0.1550	inch^2	(in^2)
meter^2 (m^2)	=	10.76	feet^2	(ft^2)
	=	1.196	yards^2	(yd^2)
	=	0.0002471	acre	
hectare (ha)	=	2.471	acres	
	=	0.003861	section (640 acres or 1 mi^2)	
kilometer^2 (km^2)	=	0.3861	mile^2	(mi^2)
		Mass		
gram (g)	=	0.03527	ounce avoirdupois (oz avdp)	
kilogram (kg)	=	2.205	pounds avoirdupois (lb avdp)	
megagram (mg)	=	1.102	tons, short (2,000 lb)	
	=	0.9842	ton, long (2,240 lb)	

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ABSTRACT

The proposed Waste Isolation Pilot Plant (WIPP) area includes about 18,960 acres in Tps. 22 and 23 S., Rs. 30 and 31 E., New Mexico Principal Meridian, Eddy County, southeastern New Mexico. It is located within the Carlsbad Mining District about 25 miles east of Carlsbad.

The WIPP area is immediately south of the Capitan Limestone subcrop, which formed the northern margin of the Delaware basin in Permian time. During Late Permian (Ochoan) time, gypsum, anhydrite, and halite were deposited in the seas of the Delaware basin to form the Castile Formation. These deposits have a maximum thickness of about 2,000 feet and grade upward into the more argillaceous beds of the Salado Formation. The Salado Formation contains abundant sulfate minerals, notably anhydrite and polyhalite. The potash ore minerals, langbeinite and sylvite, occur in the upper part of the Salado Formation in the McNutt potash zone, a local name applied to a potassium-rich zone.

Structurally, the WIPP area is situated within a broad syncline (mapped on top of the Salado) plunging gently to the southeast. Drill holes and surface geology analyses indicate no faulting in the area; and the only structural anomalies found are a local high and a small depression located in the southwest corner and north-central part of the WIPP area, respectively.

The minimum U.S. Geological Survey standards for leasable potash ore are 4 feet of 10 percent K_2O as sylvite, 4 feet of 4 percent K_2O as langbeinite, or 4 feet of equivalent mixed ore as defined by a minimum of three data points in any one ore zone. Seven ore zones--the 10th, 9th, 8th, 5th, 4th, 3d, and 2d--maintain at least this thickness and grade in parts of the WIPP area. The WIPP area overlies an estimated 353.3 million tons (U.S. Geological Survey lease grade) of measured and indicated sylvite and langbeinite potash ore reserves. Approximately two-thirds of this ore occurs in intervals in the 10th and 4th ore zones; the rest is distributed among the five other ore zones.

INTRODUCTION

The Los Medaños area (Jones, 1973), near Carlsbad, N. Mex., is being considered for a possible site of a facility for pilot plant study of nuclear waste disposal in bedded salt. The proposed Waste Isolation Pilot Plant (WIPP) of the Energy Research and Development Administration (ERDA) project includes an area of about 18,960 acres in Tps. 22 and 23 S., Rs. 30 and 31 E., New Mexico Principal Meridian, Eddy County, southeastern New Mexico (fig. 1). The WIPP area is located within the Carlsbad Mining District about 25 miles east of Carlsbad and 15 miles east of the Pecos River.

The WIPP area has been divided areally into four zones by ERDA to support and provide data for the design criteria of the installation and to determine the future land use and mineral recovery. The zones contain the following approximate acreages: zone 1, 100; zone 2, 1,818; zone 3, 6,221; and zone 4, 10,821. Most restrictions on possible future mineral recovery would be in zone 1; the least in zone 4.

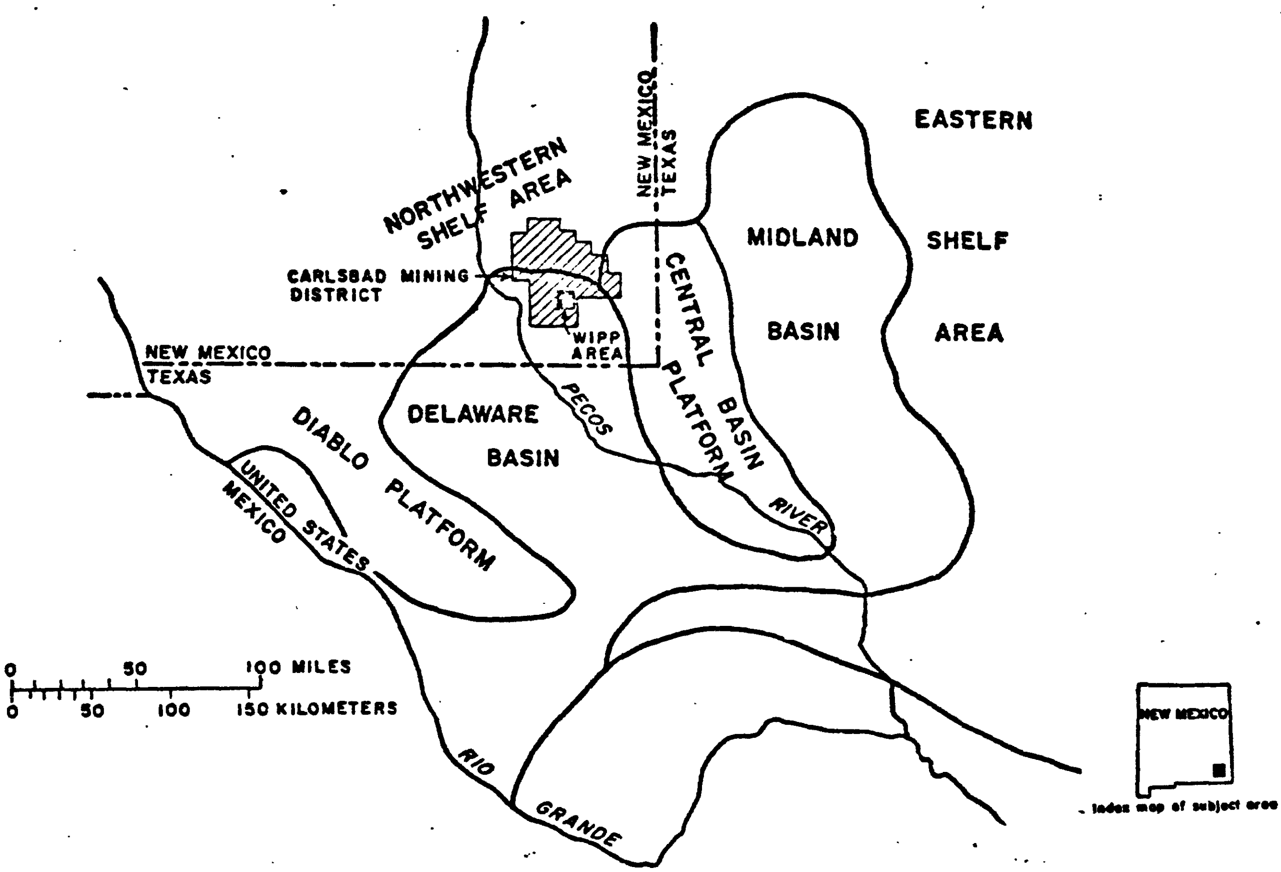


Figure 1 - Map of west Texas - southeast New Mexico showing the WIPP area within the Carlsbad Mining District and its relation to the tectonic provinces of Permian time.

Twenty-one holes were drilled in the area by ERDA from August to November 1976 in order to assess the presence of potash mineralization. In this report, the drill holes, drilling and assay procedures, and assays derived from ERDA-supported drilling and analyses are emphasized because most of the data and procedures were closely monitored by U.S. Geological Survey personnel. Information derived from other drilling and analyses is comparable and procedures, drilling methods, logging, sampling, assaying, and analyses are sufficiently similar to permit incorporation of the results in this report for the purpose of reserve estimate. Analyses of cores from these holes and other drill holes in the area provided the basic data for determining the tons of potash ore present within each of the four WIPP zones and the total tons of potash ore within the WIPP boundary.

Acknowledgments

For noteworthy and non-routine contributions to this report, appreciation is expressed to: R. J. Hite, C. L. Jones, and E. T. Sandell, Jr., for reviewing the manuscript; R. L. Fulton and J. G. Pettengill, for help in finalizing the report; and the U.S. Geological Survey, Carlsbad Mining Office, for their cooperation.

GEOLOGY

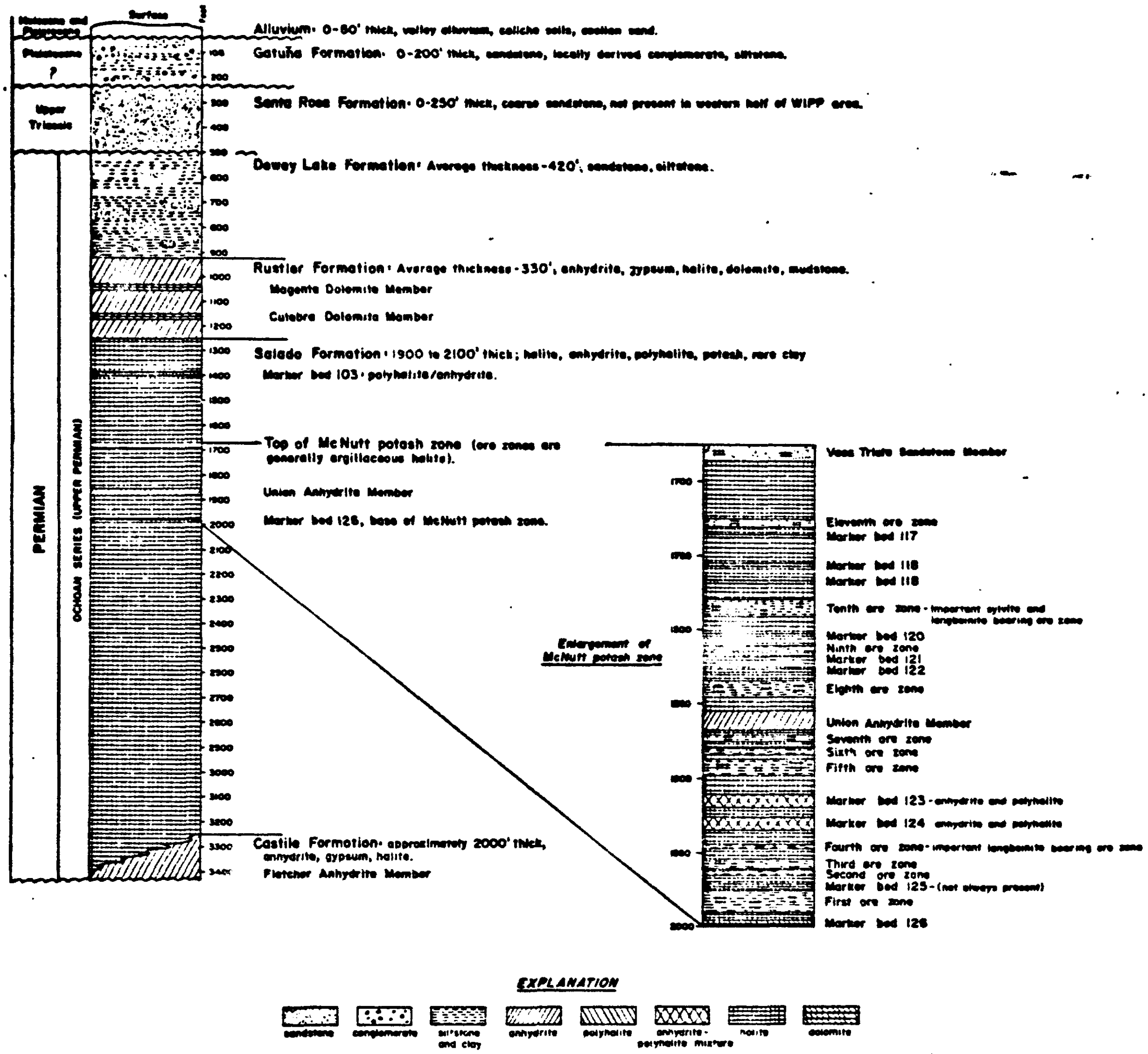
Stratigraphy

The WIPP area is south of the northern margin of the Delaware basin which was formed in Permian time (fig. 1). The basin was filled throughout Permian time with evaporite and carbonate rocks. Previous investigators have documented the regional stratigraphy and mineralogy from surface to basement (Precambrian) using potash drill holes and oil-and-gas test wells. The rocks most favored or most likely to have repositories excavated within them for radioactive waste storage are the thick halite sequences of the Upper Permian Castile and Salado Formations.

The salt deposits and other evaporites of the WIPP area are in the Ochoan Series of Late Permian age (fig. 2). The Ochoan is entirely of marine origin with a thick lower section of evaporites and a thin upper section of red beds. The lower section is composed of the Castile, Salado, and Rustler Formations, in ascending order, whereas the upper section is composed of the Dewey Lake Formation (Jones, 1973, p. 7).

The Castile Formation contains gypsum, anhydrite, and relatively pure halite. Adams (1969, p. 14) gives a maximum thickness of 2,000 feet for these deposits, which grade upward into the more argillaceous halite beds of the Salado Formation.

The Salado Formation is the principal salt formation of the WIPP area, and contains rock salt and potassic evaporites. This formation is 1,900 to 2,100 feet thick (Jones, 1973, p. 11) and contains all deposits of langbeinite and sylvite.



Note: Depths only for reference. Generally easterly dip puts Salado Fm top at approx. 600' deep in western part of area, approx. 1000' deep in eastern part. Polyhalite and anhydrite marker beds numbered sequentially from No 100 at approx. 50' below top of Salado Fm. down to No. 143 at approx. 100' above Castile Fm. All marker beds not shown in stratigraphic column.

Figure 2 - Generalized stratigraphic column of the ERDA Waste Isolation Pilot Plant Area
Eddy County, southeastern New Mexico

The Rustler Formation ranges in thickness from 290 to 400 feet (averaging 330 feet) and conformably overlies the Salado. A 50-foot clay bed marks the Salado-Rustler contact in the WIPP area. Halite is present locally in the Rustler Formation, but the principal lithology is anhydrite. The Rustler also contains two dolomite beds, the Magenta and Culebra Dolomite Members. The uppermost sediments of Ochoan age preserved in the WIPP area are those of the Dewey Lake Formation, which has an average thickness of 420 feet. This formation, conformable on the Rustler, is composed of red siltstone and shale that are noted for abundant gray-green spotting and mottling. In the east part of the WIPP area, the Dewey Lake Formation is unconformably overlain by the Santa Rosa Formation, a red sandstone of Triassic age. The Santa Rosa Formation, with a maximum preserved thickness of about 250 feet, is completely eroded in the vicinity of the ERDA-9 drill hole (central part of WIPP area).

The Gatuna Formation of Pleistocene(?) age, a locally derived clastic rock, overlies the Santa Rosa Formation, or the Dewey Lake Formation where the Santa Rosa has been truncated. It is overlain by a thin cover of alluvium, which consists mostly of wind-blown sand and caliche of Pleistocene and Holocene age. This alluvium has moderate relief and hummocky topography, and supports a sparse vegetation.

Structure

The WIPP area is inside, but near the margin of the Delaware basin. The basin has undergone very little deformation since subsiding to receive some 8,000 feet of sediment in Permian time. The regional structure of Permian rocks in southeastern New Mexico shows a gentle but persistent dip to the southeast, modified locally by broad synclines and anticlines.

The geologic structure within the WIPP area conforms to the regional pattern. Drill-hole data and surface geology show no faulting in the area and, locally, the structure is a broad syncline plunging gently to the southeast (pls. 1 and 2). Good stratigraphic continuity in the Salado Formation allows mapping on top of the Salado and marker bed 124, and both show the structural picture does not change radically with depth. Except for a marked thinning to the northwest, the thickness of the McNutt potash zone does not change by more than about 15 percent. A local structural high evident at both mapped horizons (pls. 1 and 2) in the southwest corner of the WIPP area, and a small depression at the top of marker bed 124 (pl. 2) in the north-central part of the area, are the only structural anomalies distinguishable with available well control. There are no known structure-related limitations to the possible mining of ore present in the WIPP area.

Potash occurrences

The potash ore minerals, langbeinite ($2MgSO_4 \cdot K_2SO_4$) and sylvite (KCl), occur in the upper part of the Salado Formation in the McNutt potash zone (fig. 2), a local name applied to a potassium-rich zone by Kroenlein (1939, p. 1691). This zone lies immediately below the Vaca Triste Sandstone Member (Adams, 1944) and above the polyhalite marker bed 126--an interval of approximately 325 feet. Within this interval there are 20 polyhalite and anhydrite marker beds, which are fairly consistent in their thicknesses and stratigraphic relationships to the 11 ore zones throughout the Carlsbad Mining District. The numbering system for both the marker beds and the ore zones was standardized by Jones, Bowles, and Disbrow (1960).

In general, an ore zone is an interval in which ore minerals are known to occur. The ore zones of the WIPP area consist of discontinuously mineralized argillaceous halite, but it is the higher clay content relative to the halite above and below that is the criterion for stratigraphic zone recognition rather than the presence of potash. These zones may vary greatly in thickness from hole to hole, and are bounded vertically by clay partings. Potash occurrences are not limited to these stratigraphic ore zones, but are often found in adjacent halite beds, leaving the stratigraphic zone partially or completely barren. For this report, a potash occurrence which is continuous across a stratigraphic zone boundary or which is located just above or below a stratigraphic zone is included in the reserves (or resources) of that ore zone. Although a given ore zone occurs between the same two polyhalite or anhydrite marker beds, it does not always occupy the same stratigraphic position in the interval. The 10th and the 4th ore zones within the WIPP area are more consistently mineralized by the economically important potassium minerals than are the other ore zones.

Potash occurrence in the Salado Formation is not generally considered to be of primary evaporitic origin. Schaller and Henderson (1932, p. 13-14) cite mineral association and microcrystalline forms as evidence of secondary mineralization by solutions rich in dissolved minerals. Adams (1969, p. 20) noted that concentrated sea brines may deposit potassium and magnesium salts, but these late-stage evaporitic deposits are subject to intense post-depositional changes. Adams (1969, p. 104), in his investigation, concluded "***a large part of the Salado Formation was derived from the dissolution, transport, and redeposition of an older evaporitic deposit." However, Jones (1954, p. 111) stated that "the variations in mineral distribution can be attributed to existing differences in chemical equilibrium throughout the seas in Late Permian time." Some of the post-depositional recrystallization, replacement, and segregation of minerals is acknowledged for all of the above theories of potash occurrence.

There are several locations within the WIPP boundary, from 0.5 to 5.0 square miles in area, that have little or no potash development (pl. 4). The reason(s) for these barren areas are not fully understood; however, the following are possible explanations: The barren areas were a result of being outside the paleogeochemical perimeter where favorable conditions existed for potash mineralization. Adams (1969, p. 113) believed that the formation of small barren areas ("salt horses") generally post-dated potash mineralization, although he also believed some of his data pointed to their formation prior to mineralization. Linn and Adams (1961, p. 68) proposed that the "salt horses" were formed by sylvite being selectively leached by upward-moving brines undersaturated with potassium chloride.

DRILLING PROCEDURES

The management of the drilling of the ERDA "P" series drill holes was contracted to Sandia Laboratories of Albuquerque, N. Mex. Fenix and Scisson Inc., of Las Vegas, Nev., were hired to supervise the technical aspects of the program. Twenty-one holes were drilled between late August and early November 1976, using truck-mounted rotary drilling rigs belonging to the Boyles Brothers Drilling Company and the Pennsylvania Drilling Company. The Boyles Brothers rigs were equipped with wire-line core retrieval equipment. The holes were drilled to 75 feet below the top of the Salado Formation where 4-inch casing was set to prevent contamination of surface and(or) subsurface waters by brine. All holes were drilled to approximately the Vaca Triste Member of the Salado Formation, which marks the top of the McNutt potash zone. Samples of the cuttings from this upper part of the hole were taken every 5 feet, and then the hole was cored to marker bed 126 using a drilling fluid saturated with potassium chloride.

As the core was removed from each hole, it was cleaned, marked for depth, and boxed in 10-foot units. The core was then described by geologists who made detailed lithologic logs, labeled marker beds and ore zones, and selected potash-bearing intervals for chemical and mineralogical assays.

Before the drill holes were plugged, three types of geophysical well logs were completed by the Water Resources Division of the U.S. Geological Survey. These were gamma-ray, gamma-gamma, and neutron logs, which served as a check on stratigraphic markers and mineralogic interpretations for the lithologic logs.

Well casing was recovered during plugging procedures and all but four holes (P-14, P-15, P-17, and P-18) were plugged and marked to comply with U.S. Geological Survey requirements. The four holes were plugged back to within 100 feet below the top of the Salado Formation, with casing cemented in place, and will be used by the Water Resources Division of the Geological Survey for hydrologic observations.

ASSAY PROCEDURES

Quartered core samples from each of the drill holes were sent to Skyline Labs, Inc., Tucson, Ariz. Four to 40 samples per hole, an average of 17, were chosen from cored intervals containing high precentages of potassium-bearing minerals according to the geophysical logs and visual estimation.

The assaying procedures were as follows:

(1) The whole sample was crushed to minus 1/4 inch and 8-100 grams was separated and pulverized in a mill to 100 or 150 mesh.

(2) Two grams of pulp were placed in a tiered crucible and dried at 80°C, weighed, then dried again at 250°C, and weighed for the plus and minus water calculation.

(3) A one-gram sample was put in a long culture tube with 50 ml of room temperature water and agitated for 30 minutes.

(4) The filtrate was put in a flask, and the residue and the filter paper were ashed, weighed, and reported as insoluble.

(5) The filtrate was taken to atomic absorption in three aliquots diluted to volume. Atomic absorption was used for Na, Mg, K, and Ca analysis.

(6) A second 50-ml aliquot was used for sulfate precipitation by means of barium chloride addition, filtering and gravimetric analysis, and the third aliquot was used for chloride measurement by means of silver nitrate titration.

STATISTICS ON ASSAYS

Basic statistical testing was performed on nine statistical samples (not rock samples) for potassium which had been commonly assayed by four laboratories. Statistical testing was not continued or greatly detailed because of the small number of assays comprising the samples available for such testing. The four laboratories whose potassium assay results make up the samples are: International Minerals and Chemical Corp. (IMC), a potash mining company located near Carlsbad, N. Mex.; Crobaugh Division of Herron Testing Laboratories of Cleveland, Ohio; Skyline Labs, Inc., of Tucson, Ariz.; and the U.S. Bureau of Mines in Salt Lake City, Utah.

Table 1 shows the potassium assay data on the nine samples which are solved and the standard statistics derived therefrom. Although the coefficient of variation shown for each sample in table 1 is not strictly applicable because replicate assays are not involved, it is shown to give the reader a numerical measure of precision among assays. Each coefficient of variation (c) should be judged in conjunction with its own sample mean ($\bar{x}$).

Table 1.--Input data for Student's t test on nine statistical samples for potassium from ERDA's Proposed Waste Isolation Pilot Plant site.

[X_b, U.S. Bureau of Mines assay; X_c, Crobaugh assay; X_i, International Minerals and Chemical Corp. assay; X_s, Skyline Labs assay; s, standard deviation; $\bar{x}$, Mean; $\frac{s}{\sqrt{n}}$, standard deviation divided by square root of number of assays of potassium]

Hole No.	Sample No.	POTASSIUM ASSAYS (Weight percent)							Coefficient of variation (percent)
		X_i	X_c	X_s	X_b	$\bar{x}$	s	$\frac{s}{\sqrt{n}}$	$c = \frac{100s}{\bar{x}}$
P-2	15	8.37	9.62	8.90	8.78	8.92	0.52	0.26	5.83
P-12	21	18.97	18.99	20.50	18.80	19.32	0.79	0.40	4.09
P-13	32	12.76	12.50	10.60	10.60	11.62	1.18	0.59	10.15
P-14	4	12.79	12.37	10.80	11.10	11.77	0.96	0.48	8.16
P-14	20	7.72	8.37	8.00	7.69	7.95	0.32	0.16	4.03
P-16	6	7.50	7.18	6.50	6.30	6.87	0.56	0.28	8.15
P-16	10	9.41	13.00	11.00	11.80	11.30	1.51	0.75	13.36
P-17	4	9.14	9.87	9.50	8.96	9.37	0.40	0.20	4.27
P-17	8	9.55	9.87	8.60	8.62	9.16	0.65	0.32	7.10

To measure confidence in the statistics for potassium at hand, the Student's t distribution (Snedecor, 1956) was used to avoid error in the use of the sample standard deviations as the best unbiased estimator of the population deviation (σ) where $\underline{\sigma}$ is not known. Table 2 shows the confidence intervals at two limits for the potassium assays used. The confidence interval becomes less as the limits decrease. For example, the assay value for potassium content of sample number 15 (drill-hole P-2) can be expected to fall between about 8.1 and 9.8 weight percent 95 percent of the time; or, on the basis of the data used, there are only 5 chances in 100 that the potassium content will actually exceed the limits shown.

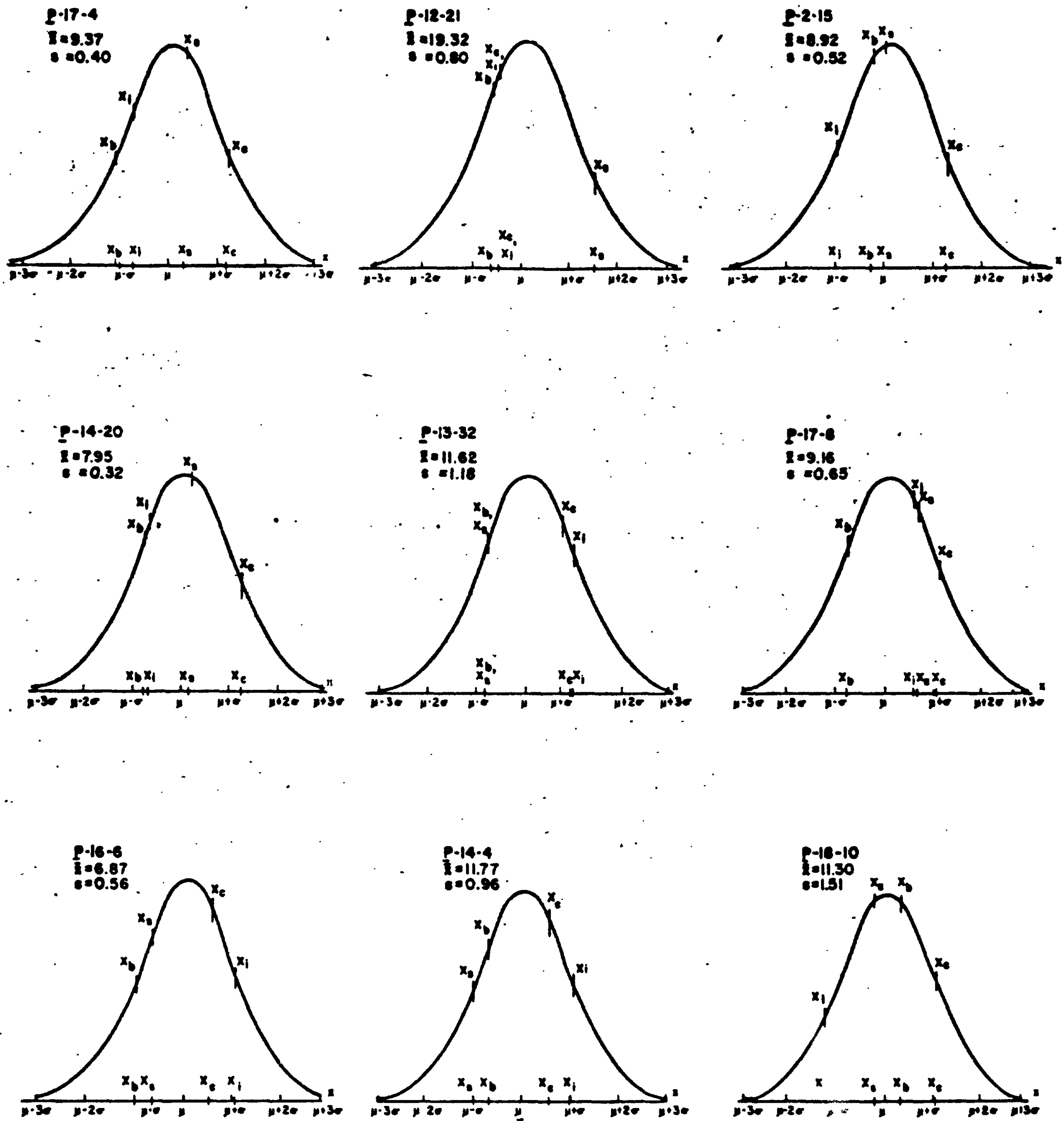
In figure 3, values of potassium assays fall within two standard deviations of the means; this is natural because with an assumed normal distribution, $\underline{\bar{x}}$ and $\underline{u}$ become identical. A pattern exists wherein Crobaugh assays (X_c) tend to be the highest five out of nine times, Skyline assays (X_s) are closer to the means five out of nine times, and the U.S. Bureau of Mines assays (X_b) are the lowest six out of nine times. The samples may be random even though the sample size (of four assayers) is small. The populations may have been the most assayed samples, however, because they all meet ore-grade potassium content. All nine of the intervals most assayed contain ore-grade materials; that is, these sample intervals met the criteria of 10 percent K_2O as sylvite or 4.0 percent K_2O as langbeinite with the exception of P-13-32, which makes mixed ore.

Table 2.--Confidence intervals for population means derived from Student's t test on nine potassium samples from ERDA's proposed Waste Isolation Pilot Plant site [1]

Hole No.	Sample No.	0.025 or 95 percent confidence interval			0.075 or 85 percent confidence interval		
		Lower Value $\bar{x} - 3.182 \frac{s}{\sqrt{n}}$	Population Mean u	Upper Value $\bar{x} + 3.182 \frac{s}{\sqrt{n}}$	Lower Value $x - 1.955 \frac{s}{\sqrt{n}}$	Population Mean u	Upper Value $x + 1.955 \frac{s}{\sqrt{n}}$
P-2	15	8.093	8.92	9.747	8.412	8.92	9.428
P-12	21	18.047	19.32	20.593	18.538	19.32	20.102
P-13	32	9.743	11.62	13.497	10.467	11.62	12.773
P-14	4	10.243	11.77	13.297	10.832	11.77	12.708
P-14	20	7.441	7.95	8.459	7.637	7.95	8.263
P-16	6	5.979	6.87	7.761	6.323	6.87	7.183
P-16	10	8.914	11.30	13.687	9.835	11.30	12.766
P-17	4	8.734	9.37	10.006	8.979	9.37	9.761
P-17	8	8.142	9.16	10.178	8.535	9.16	9.785

[1]Formula used: $t = \frac{\bar{x}-u}{s/\sqrt{n}}$; $u = \bar{x} \pm \frac{ts}{\sqrt{n}}$; solved for u

Where - t = Student's t statistic, $\bar{x}$ = sample mean, u = population mean, s = standard deviation,
n = number of assays for potassium



EXPLANATION

X_b	U. S. Bureau of Mines Assay	μ	Population mean
X_c	Crobaugh Assay	σ	Population standard deviation
X_i	IMC Assay	s	Standard deviation
X_s	Skyline Labs Assay	$\bar{x}$	Sample mean
P-17-4	ERDA core hole with assay number		

Figure 3.—Standard normal curves of the nine assays with sample means and standard deviations.

Preliminary analysis of variance, although marginal, indicates that there is no reason to assume significant differences among potassium assays owing to either laboratory or method of analysis, at least for selected groups of assays which likely received careful attention. Preliminary indications for larger groups of assays which likely underwent standard procedures and methods point up the possibility that significant differences may exist among assays as a result of assays in different laboratories.

ASSAY DIFFERENCES

Differences among assays, detectable to some extent by statistical testing, can be attributed to differences in analytical procedures. The analysis for potassium was deemed most critical because potassium is the element most sought for use as plant fertilizer and because the most complete data sets relate to potassium. However, no element (ion or complexed ion) can be simply separated from all others and insoluble residue for purposes of consideration of mineral species present in the sample. S. J. Lambert of Sandia Laboratories (written commun., 1977) remarked on some differences in procedure and inherent behavior of mineral phases which can cause differences in assay returns, even among assays from the same laboratory. For example, some ions may have been minimized in assay because samples were not heated, thereby allowing some less soluble mineral species to remain with the insoluble residue (largely clays). One laboratory agitated samples in solute at room temperature for one-half hour while another heated the mixture and allowed it to soak overnight, thus possibly allowing more complete solution of less soluble salts. One laboratory added lanthanum nitrate ($La(NO_3)_3$) to solutions t inhibit potassium and quell an interference source in atomic absorption spectrophotometry, while another used a nitrous-oxide flame to reduce interference.

One laboratory reported that some samples formed precipitate upon dilution after dissolution. This precipitation was possibly the result of the incongruent dissolution of polyhalite which forms leonite constituents and anhydrite or gypsum in aqueous solution. Any reduction of ions in solution by precipitation of calcium-sulfate species would enrich the assay in the components of potassium minerals other than polyhalite.

Assaying of selected samples in more than one laboratory provided control of assays and encouraged re-assay of troublesome samples. Assay returns were expected to differ and did so, but differences are thought to be within acceptable tolerances and assays sufficiently accurate to allow calculation of mineral species within reasonable limits.

POTASH RESERVES

Leasing standards

The U.S. Geological Survey minimum standards for leasable potash ore are 4 feet of 10 percent K_2O as sylvite, 4 feet of 4 percent K_2O as langbeinite, or 4 feet of equivalent mixed ore as defined by a minimum of three data points in any one ore zone (Aguilar and others, 1976). The minimum thickness standard of 4 feet is constant and only the ore grade is varied to establish ore cutoffs. In this report, leasing standard and lease grade are used interchangeably. Seven ore zones--the 10th, 9th, 8th, 5th, 4th, 3d, and 2d--maintain at least this thickness and grade in parts of the WIPP area. Tonnages of potassium-bearing rock using two additional cutoffs, a lower one at 4 feet of 3 percent K_2O as langbeinite (potash resource) or 4 feet of 8 percent K_2O as sylvite (potash resource) and a higher one at 4 feet of 8 percent K_2O as langbeinite (potash reserve) or 4 feet of 14 percent K_2O as sylvite (potash reserve), were compiled in order to allow for estimates of the effects of possible fluctuations in the market price of potash. Where a bed of potash-bearing rock is less than 4 feet thick, the percent K_2O is diluted by adding enough theoretically barren halite to that bed to make up the minimum 4-foot mining face. If the percent fell below the given standards after dilution, that bed was considered to be non ore-bearing. The barren halite added to the mining face produced conservative percent K_2O estimates in places because minor amounts of potash-bearing minerals were commonly present in these poorly mineralized intervals.

In compiling the potash resources of the Carlsbad Mining District, the following criteria quoted below (Aguilar and others, 1976) were used for the definition of measured and indicated ore, barren areas, and unevaluated areas:

> Measured potash reserves - Resources for which tonnage is computed from dimensions revealed in workings and drill holes. The grade is computed from the results of detailed sampling. A minimum of three data points in any one ore zone meeting quality and thickness standards, no more than 1½ miles (2.4 km) apart, have been used to delineate measured reserves.
>
> Indicated potash reserves - Resources for which tonnage and grade are computed partly from specific measurements, samples, or production data and partly from projection for a reasonable distance on geolgic evidence. The sites available for inspection, measurement, and sampling are too widely, or otherwise inappropriately, spaced to permit the mineral bodies to be outlined completely or the grade established throughout.
>
> Unevaluated potash areas - Contain resources for which tonnage and grade have not been computed due to low-density drilling and sampling, but are surrounded by measured and(or) indicated reserves.
>
> Barren and(or) minor potash mineralization areas - Composed of subeconomic resources that would require a substantially higher market value or a major cost-reducing technology for economical production. Subeconomic resources also include other bittern minerals not presently being recovered.

The above classification criteria were used for the potash distribution maps (pls. 3, 4, and 5). However, the terminology in the explanation and the title of plate 3 reads differently because potash-bearing material below lease grade cutoff comprises only resources, not reserves. The standards and criteria given above are consistent and in accordance with the definition of resources and reserves defined in U.S. Geological Survey Bulletin 1450-A (1976).

Plates 3, 4, and 5 show the distribution of measured and indicated potash ore in the WIPP area. These maps are composites for all seven ore zones, for the one lease grade cutoff and two cutoffs for potassium-bearing rock of higher and lower grade. These composite maps give a planimetric view of all the ore zones, where the ore zone with the most extensive boundary in any given direction is taken as the composite boundary of the potash ore.

Although the potash ore is not as high a grade, nor are its thicknesses and continuity as great as some of the ore currently being mined in the Carlsbad Mining District, at U.S. Geological Survey lease grade, an estimated 353.3 million tons of ore (315.7 million tons of measured and 37.6 million tons of indicated ore) is present within the WIPP area. Preliminary estimates of reserves in the Carlsbad Mining District, made prior to the drilling of core holes in the WIPP area, showed about 5 billion tons of ore.

Reserve calculation method

Approximately 57 drill holes (including 21 ERDA drill holes) in the WIPP area provided the basic assay data for calculating the mineral content of selected samples (table 3). These mineral-content data were used in the reserve calculation estimate method that is briefly discussed as follows: The weighted-volume estimate method (Forrester, 1946, p. 560-562) was used for calculating potash ore reserves. Triangular networks among drill holes were constructed for each ore zone, and ore grade; types and thicknesses were posted at the apices of the triangles and(or) cutoff points. The weighted-average grade and average thickness were determined for each triangle and these and other data were entered into an electronic graphics calculator. Then, the perimeter of the triangle was scaled by the calculator cursor and the tons of potash ore electronically calculated.

Major reserves

The 4th ore zone (at lease grade) contains the greatest estimated tonnage of reserves in the WIPP area and is currently being mined nearby; the closest mine, Duval's Nash Draw Mine, is about 5 miles to the west. Within the WIPP area, the 4th ore zone contains 107.5 million tons of measured langbeinite ore and an additional 7.9 million tons of indicated langbeinite ore, totaling about 115.4 million tons.

The other major ore zone is the 10th, which contains langbeinite and sylvite. The 10th ore zone (at lease grade) contains an estimated 97.2 million tons of measured potash ore of both ore types and 5.9 million tons of indicated ore, totaling 103.1 million tons of potash ore. Approximately 52 percent of this ore is sylvite and 48 percent langbeinite. There is a minor amount of overlap between the sylvite and langbeinite lobes of the 10th ore zone. When reporting total tons of K_2O for the entire WIPP area, total tons sylvite and total tons langbeinite were added, but that portion where they overlapped was subtracted from the sylvite area. Thus, for total tonnages, the overlap area was taken to be solely langbeinite, and was not counted twice. Tables 4, 5, and 6 summarize the tons of ore present in all ore zones, giving subtotals by WIPP zone, measured ore, and indicated ore for low grade, lease grade, and high grade cutoffs.

Lesser reserves

There are five ore zones in addition to the 10th and 4th that contain potash ore which meets or exceeds current U.S. Geological Survey leasing standards. The ore in these zones tends to be localized in relatively small, and sometimes isolated, lobate deposits.

The 9th and 8th ore zones, containing principally sylvite potash ore, contain, at lease grade, an estimated 6.0 million tons (all indicated) and 28.8 million measured tons of ore, respectively. The 5th, 3d, and 2d, containing langbeinite ore, have respective totals (at lease grade) of 24.2 million tons (20.2 measured and 4.0 indicated), 25.6 million tons (all measured), and 50.2 million tons (36.4 measured and 13.8 indicated) of ore. As indicated by table 4, there is less ore at the higher cutoff grade and more ore at the lower cutoff grade.

Weighted-average ore grades

Weighted-average ore grades were calculated for the sylvite and langbeinite measured reserves for each ore zone, at lease grade. The considered reserves included all seven ore zones and the four WIPP zones. This was done by summing the proportional grades of all the ore increments of the triangular networks. The following shows the percent K_2O as sylvite and langbeinite by ore zone:

ORE ZONE	SYLVITE	LANGBEINITE
10	12.1	5.2
9	No measured ore	No measured ore
8	11.4	---
5	---	5.3
4	---	7.0
3	---	5.1
2	---	5.8

Table 3 - Calculated mineral content of selected samples from potassium-bearing intervals with summation of percent K_2O as ore mineral*

[Drill-hole no.: Drill-hole designations: P, Energy Research and Development Administration; FC, Farm Chemical Res. Dev. Corp; IMC, International Minerals and Chemical Corp. NFU, Farmers Edu. and Coop. Union of America. D, Duval Sulphur and Potash Co., U, U.S. Potash Co., Inc. Arc, arcanite; Ba, bischofite; Bl, bloedite; C, carnallite; Gl, glaserite, Gu, glauberite; Ka, kainite, Ki, kieserite; L, langbeinite; Le, leonite; Lo, loewite; S, sylvite, Va, vanthoffite.]

Drill-hole no.	Ore zone	Sample no.	Depths of interval (feet)	Thickness (feet)	Calculated minerals present (weight percent)					K_2O as ore minerals (percent)*	Weighted average K_2O as ore mineral for all intervals in ore zone (feet and percent)
					Polyhalite	Halite	Sylvite	Langbeinite	Other minerals		
P-1	5	9	1440.47-1441.35	0.88	8	76	---	15.0	Tr/Ka[1]	3.4/L	
	5	10	1441.35-1442.30	0.95	9	86	---	4.4		1.0/L	
	5	11	1442.30-1443.50	1.20	---	79	---	---	14.0/Ka Tr/Bl[1]	---	
	5	12	1443.50-1444.35	0.85	---	95	---	2.34	---	0.53/L	
	5	13	1444.35-1445.30	0.95	1	79	---	17.07	---	3.87/L	4.83-1.67/L
P-2	10	14	1627.15-1628.35	1.20	1	39	---	39.9	1.9/Ka 5.0/Le	9.05/L	
	10	15	1628.35-1629.52	1.17	1	46	---	43.1	2.6/Ka 0.5/Le	9.78/L	2.37-9.41/L
	4	5	1802.70-1804.00	1.30	1	39	---	38.0	12.9/Ka	8.6/L	
	4	6	1804.00-1805.00	1.00	6	80	---	---	---	---	
	4	7	1805.00-1805.85	0.85	5	89	---	---	---	---	
	4	8	1805.85-1806.30	0.45	6	60	---	20.0	4.0/Ka 3.7/Le	4.54/L	3.60-3.67/L
	2	1	1833.08-1834.00	0.92	2	79	---	4.4	1.9/Ka	3.14/L	
	2	2	1834.00-1834.50	0.50	---	38	---	52.9	0.5/Ka	12.0/L	1.42-6.26/L
P-3	4	3	1596.30-1597.60	1.30	2	72	---	24.7	0.5/Ka	5.6/L	
	4	4	1597.60-1598.70	1.10	2	62	---	18.6	0.5/Ka	4.22/L	
	4	5	1598.70-1599.53	0.83	34	38	---	23.4	---	5.31/L	3.23-5.06/L
P-4	10	2	1572.60-1574.97	2.37	1	56	46.0	---	---	29.40/S	
	10	3	1574.97-1576.17	1.20	4	64	27.6	---	---	17.48/S	
	10	4	1576.17-1577.77	1.60	3	86	7.0	---	---	4.32/S	
	10	5	1577.77-1578.69	0.92	4	64	28.0	---	---	17.46/S	6.09-18.66 /S
P-5	10	6	1546.69-1548.65	1.96	6	65	28.0	---	---	18.28/S	
	10	7	1548.65-1549.66	1.01	4	76	13.3	---	---	8.42/S	
	10	8	1549.66-1551.40	1.74	3	60	21.0	---	---	13.41/S	
	10	9	1551.40-1552.75	1.35	2	65	14.5	---	---	9.14/S	6.06-13.2/S
P-6	4	12	1476.00-1477.45	1.45	6	74	---	22.0	1.0/Ki	5.01/L	
	4	13	1477.45-1478.37	0.92	1	83	2.0	8.0	6.0/Ki	1.90/L 1.26/S	
	4	14	1478.37-1480.00	1.63	3	84	---	12.0	---	2.78/L	4.00-3.39/L
	2	18	1510.50-1511.32	0.82	1	37	2.0	54.0	6.0/Ki	12.31/L	
	2	19	1511.32-1512.10	0.78	---	53	---	42.0	---	9.65/L	
	2	20	1512.10-1513.05	0.95	7	79	3.0	1.0	8.6/Ka	0.19/L	2.55-6.98/L
P-7	4	2	1479.73-1481.20	1.47	2	65	1.0	29.0	---	6.53/L	
	4	3	1481.20-1483.00	1.80	---	89	2.0	3.0[4]	---	0.75/L[4]	
	4	4	1483.00-1483.48	0.48	3	69	2.0	3.8	5.7/Ka 1.0/Le 1.0/Bl	3.8/L	3:75-3.41/L
P-8	10	2	1363.70-1365.00	1.30	---	52	29.0	25.0	---	18.45/S 5.62/L	
	10	3	1365.00-1366.72	1.72	1	46	3.0	45.0	4.0/Ka 2.0/Le	10.3/L 1.65/S	
	10	4	1366.72-1368.05	1.33	1	86	---	14.0	---	9.23/L	4.35-6.74/L 4.35-6.17/S mixed ore equivalent: 4.35-9.2/L

Table 3 - Calculated mineral content of selected samples from potassium-bearing intervals with summation of percent K_2O as ore mineral--continued

Drill-hole no.	Ore zone	Sample no.	Depths of intervals (feet)	Thickness (feet)	Calculated minerals present (weight percent)					K_2O as ore minerals (percent)	Weighted average K_2O as ore mineral for all intervals in ore zone (feet and percent)
					Polyhalite	Halite	Sylvite	Langbeinite	Other minerals		
P-9	10	8	1522.56-1523.41	0.85	1	42	7.0	48.0	0.67/Ka	4.73/S 10.8/L	
	10	9	1523.41-1524.07	0.66	1	93	2.0	---	3.0/Ki	0.96/S	
	10	10	1524.07-1524.70	0.63	2	17	7.0	63.37	---	4.42/S 14.37/L	
	10	11	1524.70-1526.04	1.34	3	95	---	1.10	---	0.24/L	
	10	12	1526.04-1526.74	0.70	2	65	---	31.31	---	7.1/L	4.18-5.63/L 2.14-3.48/S mixed ore equivalent: 4.18-6.34/L
	4	17	1703.65-1705.23	1.58	2	70	---	28.70	---	6.51/L	
	4	18	1705.23-1705.65	0.42	1	89	---	6.80	3.0/Ka	1.55/L	2.00-5.47/L
P-10	11	1	1650.38-1651.22	0.84	6	89	1.8	---	1.0/Ka	1.13/S	
	11	2	1651.22-1652.03	0.81	7	81	6.1	---	2.0/Ki	3.83/S	
	11	3	1652.03-1653.83	1.80	5	85	7.7	---	1.0/Ki	4.85/S	3.45-3.70/S
	11	4	1653.83-1654.58	0.75	6	94	---	---	---	---	
P-11	11	2	1601.90-1603.56	1.66	---	56	5.0	---	3.60/Ki 1.0/C	3.34/S	
	11	3	1603.56-1604.64	1.08	3	61	2.0	---	31.0/Ka 3.0/C	1.48/S	
	11	4	1604.64-1605.38	0.74	4	84	3.0	---	7.0/Ka 2.0/C	2.20/S	3.48-2.52/S
	10	7	1670.70-1671.84	1.14	1	71	19.0	8.0	1.0/Ki	12.0/S 1.82/L	
	10	8	1671.84-1673.42	1.58	2	66	10.0	18.0	1.0/Ki	6.32/S 3.96/L	
	10	9	1673.42-1674.70	1.28	3	71	16.7	---	1.0/Ki	10.53/S	4.00-9.29/S 2.72-3.07/L mixed ore equivalent: 4.00-14.51/S
	9	14	1688.72-1689.60	0.88	3	76	22.0	---	---	13.74/S	
	9	15	1689.60-1690.89	1.29	1	64	36.9	---	---	23.30/S	
	9	16	1690.89-1691.95	1.06	1	71	21.3	---	2.0/C	13.43/S	
	9	17	1691.95-1693.28	1.33	2	92	2.0	---	1.0/C	1.24/S	4.56-12.73/S
	4	19	1840.60-1842.35	1.75	1	58	---	40.0	5.0/Ki	9.14/L	
	4	20	1842.35-1843.40	1.05	4	76	5.0	4.9	---	1.11/L 2.98/S	2.80-6.0/L
	2	22	1868.67-1870.28	1.61	1	38	2.0	60.0	2.0/Ki	13.65/L	
	2	23	1870.28-1871.10	0.82	---	54	5.0	45.0	1.0/Ki	13.53/L	
	2	24	1871.10-1872.30	1.20	---	27	---	58.3	8.0/Ka Tr/Bl&Lo[1]	13.24/L	3.63-13.49/L

Table 3 - Calculated mineral content of selected samples from potassium-bearing intervals with summation of percent K_2O as ore mineral--continued

Drill-hole no.	Ore zone	Sample no.	Depths of interval (feet)	Thickness (feet)	Calculated minerals present (weight percent)					K_2O as ore minerals (percent)	Weighted average K_2O as ore mineral for all intervals in ore zona (feet and percent)
					Polyhalite	Halite	Sylvite	Langbeinite	Other minerals		
P-12	10	2a[4]	1344.97-1345.27	0.3	4	36	62.3	---	1.0/Ki	39.38/S	
	10	2b	1345.27-1345.90	0.63	---	10	24.0[2]	---	59.0/Ki	15.08/S	
	10	3	1345.90-1346.95	1.05	1	59	18.0	---	18.0/Ki	11.39/S	
	10	4	1346.95-1348.90	1.95	3	64	18.0	---	19.0/Ki	11.36/S	
	10	5	1348.90-1349.91	1.01	7	44	20.0	---	8.6/Ki		
									8.7/Ka	12.63/S	
	10	6	1349.91-1350.80	0.89	3	67	16.0[3]	---	2.0/Ka	10.42/S	5.83-13.29/S
	8	14	1390.19-1390.97	0.78	4	80	15.5	---	---	9.77/S	
	8	15	1390.97-1392.66	1.69	7	88	7.0	---	---	4.12/S	
	8	16	1392.66-1394.29	1.63	4	88	10.3	---	---	6.47/S	
	8	17	1394.29-1394.90	0.61	8	51	35.5	---	---	22.42/S	4.71-8.24/S
	4	21	1520.00-1521.55	1.55	1	22	23.0	45.0	9.0/Ki	14.47/S	
										10.13/L	2.39-7.08/L
	4	22	1521.55-1522.39	0.84	10	48	7.0	6.0	16.0/Ka	1.44/L	2.39-10.94/S
									10.0/Le	4.42/S	mixed ore equivelent: 4.00-8.23/L
	3	26	1533.50-1535.05	1.55	---	40	11.0	49.0	---	7.0/S	
										8.59/L	
	3	27	1535.05-1535.59	0.54	34	86	1.0	8.0	1.0/Ki	1.80/L	
										0.62/S	3.51-5.98/L
	3	28	1535.59-1537.01	1.42	2	47	10.0	21.0	---	4.72/L	3.51-[illegible]74/S
										6.32/S	mixed ore equivelent: 3.51-8.27/L
	2	34	1549.79-1550.65	0.86	3.	85	---[4]	11.0	2.42/L	0.54/L	
	2	35a	1550.65-1551.29	0.64	---	20	5.0	70.0	1.0/Ka[1]		
									Tr/Le	15.93/L	
	2	35b	1551.29-1551.61	0.32	---	21	5.0	30.0	18.0/Ka		
									19.0/Le		
									17.0/Bl	12.48/L	1.82-8.05/L
P-13	10	29	1318.02-1319.00	0.98	1	46	49.5	---	---	31.32/S	
	10	30	1319.00-1320.22	1.22	1	62	17.0	2.0	15.0/Ki	10.92/S	
	10	31[4]	1320.22-1320.88	0.66	3	97	---	---	---	---	
	10	32	1320.88-1321.87	0.99	1	30	20.0	10.0	30.0/Ki	12.6/S	3.85-14.67/S
									10.0/Ka	2.27/L	
	9	36	1334.82-1336.38	1.56	2	94	2.0	---	---	1.12/S	
	9	37	1336.38-1337.32	0.94	2	62	34.8	---	---	21.99/S	
	9	38	1337.32-1338.64	1.32	---	90	3.8	---	---	2.41/S	3.82-6.7/S
	8	21	1359.65-[illegible].63	0.98	2	67	30.2	---	---	19.13/S	
	8	22	1360.63-1[illegible]1.70	1.07	8	80	9.14	---	---	4.97/S	2.05-11.74/S
	4	2	1480.20-1481.73	1.53	2	82	2.0	9.0	3.0/Ki	2.03/L	
	4	3	148[illegible]-1482.78	1.05	1	63	---	33.2	0.4/Le	7.53/L	3.53-4.06/L
	4	4	148[illegible]8-1483.73	0.95	1	64	---	7.0	7.0/Bl	1.59/L	

Table 3 - Calculated mineral content of selected samples from potassium-bearing intervals with summation of percent K_2O as ore mineral--continued

Drill-hole no.	Ore zone	Sample no.	Depths of interval (feet)	Thickness (feet)	Calculated minerals present (weight percent)					K_2O as ore minerals (percent)	Weighted average K_2O as ore mineral for all intervals in ore zone (feet and percent)
					Polyhalite	Halite	Sylvite	Langbeinite	Other minerals		
	3	8	1493.23-1493.88	0.65	2	86	---	7.0	---	1.59/L	
	3	9	1493.88-1494.58	0.70	---	15	---	53.0	---	12.06/L	
	3	10	1494.58-1495.50	0.92	3	86	---	10.0	---	2.21/L	2.27-5.07/L 4.00-2.88/L[5]
P-14	10	2	1255.24-1255.64	0.40	---	41	57.0	---	---	36.03/S	
	10	3	1255.64-1257.56	1.92	---	41	57.0	---	---	36.06/S 8.84/S	
	10	4	1257.56-1259.07	1.51	3	64	14.0	18.0	Tr/Ka[1]	3.99/L	
	10	5	1259.07-1260.15	1.08	4	74	7.0	22.0	---	4.36/S 4.88/L	
	10	6	1260.15-1261.05	0.90	2	55	12.0[6]	---	16.0/Ka	6.21/S	5.81-18.47/S 2.59-4.36/L mixed ore equivalent: 5.81-23.33/S
	5	10	1364.44-1366.11	1.67	5	74	5.0	15.0	1.0/Ka	3.35/L 3.00/S	
	5	11	1366.11-1367.86	1.75	3	83	---	19.0	Tr/Ka[1]	4.3/L	
	5	12[6]	1367.86-1369.26	1.40	1	80	---	13.0	Tr/Ka[1]	3.03/L	4.82-3.60/L 1.67-3.0/S mixed ore equivalent: 4.82-4.02/L
	4	18	1440.79-1441.98	1.19	4	46	6.0	38.5	---	8.74/L 3.99/S	
	4	19	1441.98-1442.84	0.86	5	95	---	---	---	---	
	4	20	1442.84-1443.98	1.14	16	56	4.0	23.0	Tr/Le 2.0/Ka	5.22/L 2.53/S	
	4	21	1443.98-1444.61	0.63	3	88	---	11.0	---	2.50/L	3.82-4.69/L 3.19-2.39/S
P-15	4	7	1371.94-1372.81	0.87	6	76	---	25.0	---	5.59/L	
	4	8	1372.81-1374.77	1.96	8	89	---	4.0	---	1.00/L	
	4	9	1374.77-1375.80	1.03	9	64	---	28.0	---	6.30/L	3.86-3.45/L
	2	13	1399.66-1400.38	0.72	3	64	---	32.0	4.0/Ka	7.18/L	
	2	14	1400.38-1401.51	1.13	---	78	---	17.0	3.0/Ka 3.0/Le	4.28/L	1.85-5.41/L
P-16	10	4	1301.94-1302.57	0.63	3	93	0.7	4.0	---	0.47/S 0.89/L	
	10	5	1302.57-1303.91	1.34	3	79	---	21.0	---	4.77/L	
	10	6	1303.91-1304.39	0.48	---	61	---	34.0	8.1/Ka 8.0/Le Tr/Ki[1]	7.77/L	2.45-4.63/L
	4	10	1476.76-1478.40	1.64	---	36	2.0	53.0	Tr/Ka&Le[1]	12.01/L 1.26/S	
	4	11	1478.40-1478.95	0.55	2	86	---	8.7	---	1.98/L	2.19-9.49/L
	4	12	1490.12-1491.00	0.88	1	83	1.0	14.1	---	4.94/L	
	4	13	1491.00-1491.56	0.56	0	39	7.0	19.7[7]	---	4.40/L 4.12/S	
	4	14	1491.56-1492.64	1.08	7	79	---	12.0	---	2.75/L	
	4	15	1492.64-1493.89	1.25	2	56	3.0	31.0	6.0/Le 2.0/Ka	7.05/L 2.09/S	3.77-4.93/L

Table 3 - Calculated mineral content of selected samples from potassium-bearing intervals with summation of percent K_2O as ore mineral--continued

Drill-hole no.	Ore zone	Sample no.	Depths of interval (feet)	Thickness (feet)	Calculated minerals present (weight percent)					K_2O as ore minerals (percent)	Weighted average K_2O as ore mineral for all intervals in ore zone (feet and percent)
					Polyhalite	Halite	Sylvite	Langbeinite	Other minerals		
P-16	2	19	1526.90-1528.00	1.10	1	51	1.0	42.0	2.0/Ka	9.05/L	1.10-9.60/L
P-17	10	2	1365.60-1367.20	1.6	1	27	---	68.8	---	15.61/L	
	10	3	1367.20-1368.45	1.25	3	76	---	12.6	2.0/Ka	2.87/L	
	10	4	1368.45-1369.70	1.25	3	44	---	6.64	30.0/Le 9.0/Ka	1.51/L	4.10-7.43/L
	4	8	1542.90-1543.68	0.78	---	48	---	38.0	13.0/Le Tr/Ka[1]	8.62/L	
	4	9	1543.68-1544.46	0.78	---	43	---	53.0	3.0/Le	12.03/L	1.56-10.33/L
	2	18	1591.39-1592.71	1.32	1	44	---	46.0	1.0/Ka	10.46/L	
	2	19	1592.71-1594.21	1.50	4	83	---	2.4	2.0/Ka	0.53/L	2.82-5.18/L
P-18	10	3	1728.40-1728.78	0.38	1	41	33.0	35.0	---	22.83/S 7.94/L	
	10	4	1728.78-1730.45	1.67	3	86	9.0	---	---	5.61/S	
	10	5	1730.45-1731.49	1.04	6	80	0.72	---	---	0.45/S	
	10	6	1731.49-1732.29	0.80	4	74	0.81	---	---	0.51/S	3.89-4.86/S 0.38-7.94/L mixed ore equivalent: 3.89-6.8/S
P-19	10	7	1741.80-1742.35	0.55	1	55	6.70	36.0	---	4.23/S 8.24/L	
	10	8	1742.35-1743.72	1.37	1	26	2.0	59.0	---	1.20/S 13.39/L	
	10	9	1743.72-1745.09	1.37	4	81	1.0	15.0	---	0.62/S 3.40/L	
	10	10	1745.09-1746.00	0.91	2	53	---	30.0	8.4/Le 2.0/Ka	9.21/L	4.20-8.03/L
	4	21	1925.20-1925.90	0.70	1	74	---	11.0	12.0/Ki	2.50/L	
	4	22	1925.90-1926.70	0.80	1	27	---	57.0	2.0/Ka 9.0/Ki	12.93/L	
	4	23	1926.70-1927.94	1.24	2	62	---	3.6	5.0/Ka Tr/Le[1]	0.82/L	2.74-4.79/L
	2	26	1956.40-1957.36	0.96	6	64	1.0	16.0	15.0/Ki	3.74/L	
	2	27	1957.36-1958.71	1.35	1	29	---	65.0	Tr/Ka[1]	14.83/L	
	2	28	1958.71-1959.21	0.50	0.5	61	---	25.0	Tr/Ka[1]	5.72/L	2.81-9.42/L
P-20	10	2	1725.00-1726.15	1.15	2	72	21.2	Tr/L[4]	---	13.43/S	
	10	3	1726.15-1728.10	1.95	4	64	7.0	35.0	---	4.42/S 8.01/L	
	10	4	1728.10-1729.62	1.52	3	60	28.0[6]	---	6.0/Ka	17.69/S	1.95-8.01/L
	10	5	1729.62-1731.48	1.86	3	60	34.0	---	---	21.48/S	6.51-14.03/S mixed ore equivelent: 6.51-20.03/S
	4	10	1898.80-1900.45	1.65	5	53	1.0	37.0	5.0/Ka	8.35/L	
	4	11	1900.45-1901.77	1.32	16	85	---	1.3	---	0.30/L	
	4	12	1901.77-1903.35	1.58	10	74	---	17.7	---	4.0/L	4.55-4.5/L

Table 3 - Calculated mineral content of selected samples from potassium-bearing intervals with summation of percent K_2O as ore mineral--continued

Drill-hole no.	Ore zone	Sample no.	Depths of interval (feet)	Thickness (feet)	Calculated minerals present (weight percent)					K_2O as ore minerals (percent)	Weighted average K_2O as ore mineral for all intervals in ore zone (feet and percent)
					Polyhalite	Halite	Sylvite	Langbeinite	Other minerals		
P-20	2	14[4]	1925.08-1926.30	1.22	3	95	---	0.88	---	0.2/L	
	2	15	1926.30-1927.75	1.45	1	61	---	35.5	---	8.05/L	2.67-4.46/L
P-21	10	2	1644.03-1644.84	0.81	4	80	17.0	---	---	10.82/S	
	10	3	1644.84-1646.00	1.16	4	81	11.8	---	2.0/Ki	7.46/S	
	10	4	1646.00-1646.33	0.33	1	28	20.2[6]	---	42.0/Ki	12.76/S	
	10	5	1646.33-1647.20	0.87	1	41	25.5[6]	---	18.0/Ki	16.14/S	
	10	6	1647.20-1648.22	1.02	1	62	29.5[2]	---	1.0/Ki	18.66/S	
	10	7	1648.22-1649.23	1.01	3	64	31.3	---	---	19.81/8	5.20-14.37/8
	8	15	1685.17-1686.48	1.31	0	55	45.0	---	---	28.4/S	
	8	16	1686.48-1687.20	0.72	4	83	6.0[6]	---	---	3.72/S	
	8	17	1687.20-1688.24	1.04	5	92	3.0	---	---	1.95/S	
	8	18	1688.24-1688.77	0.53	4	95	0.8	---	---	0.52/S	
	8	19	1688.77-1690.19	1.42	6	86	9.9	---	---	6.24/S	
	8	20	1690.19-1691.26	1.07	8	90	1.0	---	---	0.75/S	
	8	21	1691.26-1692.40	1.14	3	65	33.0	---	---	21.16/S	
	8	22	1692.40-1693.34	0.94	5	65	13.0	---	---	8.18/S	8.17-10.24/S
	4	24	1809.90-1811.50	1.60	0	31	3.0	64.0	2.5/Ka 3.9/Le	14.60/L	1.92-14.69/L
	4	25	1811.50-1811.82	0.32	0	18	5.0[2]	54.66	9.0/Ka 10.60/Le	15.12/L	4.00-7.05/L[5]
	4	30	1815.51-1816.10	0.59	11	51	5	27.0	9.0/Ki	6.08/L	
	4	31	1816.10-1817.25	1.15	3	42	5	44.0	8.0/Ka	9.95/L	1.74-8.64/L 4.00-3/76/L[5]
AEC-8	10	10	1589.10-1589.70	0.60	1	85	5	---	5/Ki 2/An	2.97/S	
	10	11	1589.70-1591.70	2.00	---	43	16	---	40/Ki	10.32/S	
	10	12[6]	1591.70-1592.20	0.50	---	37	24	---	6/C 30/Ki 0.1/An	15.16/S	
	10	13[6]	1592.20-1594.50	2.30	---	49	32	---	7/C 9/Ka 0.8/An	20.31/S	
	10	14	1594.50-1594.70	0.20	---	38	4	---	51/C 9/Ka 1/Ki 0.1/An	2.34/8	
	10	15[6]	1594.70-1595.50	0.80	2	85	3	---	4/C 2/Ki 9/Ka 0.9/An	2.18/S	6.4-12.33/S
	4	2	1752.70-1753.40	0.70	---	95	---	4	---	0.86/L	
	4	3	1753.40-1754.00	0.60	1	69	2	33	3/Ka	7.39/L	
	4	4	1754.00-1755.00	1.00	---	33	2	68	2/Ka	13.90/L	
	4	5	1755.00-1756.70	1.70	---	24	---	69	3/Le	15.38/L	4-11.27/L

Table 3 - Calculated mineral content of selected samples from potassium-bearing intervals with summation of percent K_2O as ore mineral--continued

Drill-hole no.	Ore zone	Sample no.	Depths of interval (feet)	Thickness (feet)	Calculated minerals present (weight percent): Polyhalite	Halite	Sylvite	Langbeinite	Other minerals	K_2O as ore minerals (percent)	Weighted average K_2O as ore mineral for all intervals in ore zone (feet and percent)
FC-70	10	2	1377.67-1379.00	1.33	2	65	11.2	---	20.0/Ki	7.11/S	
	10	3	1379.00-1381.00	2.00	2	51	39.1[6]	---	1.0/Ki	24.72/S	
	10	4	1381.00-1382.00	1.00	2	64	19.4[6]	---	3.0/C	12.29/S	4.33-16.44/S
									3.0/Ki		
	9	6	1391.50-1393.00	1.50	1	53	28.00	---	---	17.74	1.5-17.74/S
	8	7	1415.08-1415.75	0.67	2	70	25	---	Tr/Ki[1]	16.10/S	
	8	8	1415.75-1416.50	0.75	5	89	2	---	Tr/Ki[1]	1.35/S	
	8	9	1416.50-1418.00	1.50	2	97	1	---	1.0/Ka		
									Tr/Ki[1]	0.57/S	
	8	10	1418.00-1419.50	1.50	3	91	3	---	---	1.62/S	
	8	11	1419.50-1420.42	0.92	2	80	16	---	1.0/Ka		
									Tr/Ki[1]	10.04/S	
	8	12	1420.42-1421.50	1.08	1	71	16	---	1.0/Ka	10.21/S	6.42-5.5/S
	5	16	1466.00-1467.58	1.58	---	72	---	19.6	---	4.43/L	
	5	17	1467.58-1469.00	1.42	1	53	---	40.7	---	9.22/L	
	5	18	1469.00-1469.67	0.67	1	70	---	24.2	---	5.49/L	3.67-6.48/L
	4	19	1529.92-1531.42	1.50	1	36	---	52.6	---	11.93/L	
	4	20	1531.42-1532.42	1.00	---	45	---	33.0[6]	---	7.42/L	2.5-10.13/L
FC-81	8	7	1564.17-1564.92[8]	0.75	2	58	36.6	---	2.0/C	23.16/S	
	8	8	1564.92-1566.13	1.21	2	79	15.3	---	4.0/C	9.71/S	
	8	9	1566.13-1567.38	1.25	5	66	8.9	6.1	10.0/C	5.62/S	3.21-11.26/S
										1.38/L	3.21-0.54/L
											mixed ore equivalent:
											3.21-12.61/S
	4	10	1687.00-1688.21	1.21	---	20	---	74.0	4.0/Ka	16.71/L	
									Tr/Va[1]		
	4	11	1688.21-1689.46	1.25	1	25	---	67.0	Tr/Va[1]	15.31/L	2.46-16.0/L
	2	15	1712.88-1714.46	1.58	1	40	---	56.0	2.2/Le	12.7/L	
	2	16	1714.46-1715.46	1.00	---	65	---	30.3	3.0/Ka	6.9/L	
									Tr/Le[1]		
	2	17	1715.46-1716.00	0.54	4	45	---	42.8	Tr/Le[1]	9.71/L	3.12-10.4/L
FC-82	5	1	1541.42-1541.79	0.37	---	17	---	72.2	2.0/Le		
									6.0/C	16.34/L	
	5	2	1541.79-1542.29	0.50	---	85	7.0	7.2	---	1.63/L	
	5	3	1542.29-1543.96	1.67	2	5	---	49.8	4.0/Lo	11.3/L	
									20.9/C		
	5	4	1543.96-1544.50	0.54	1	59	5.0	20.0	Tr/Le[1]	4.54/L	3.08-9.37/L
	4	5	1613.42-1615.08	1.66	---	17	---	63.0	9.3/Ki		
									Tr/Lo[1]	14.3/L	
	4	6	1615.08-1615.92	0.84	1	48	0.7	12.8	17.7/Le	2.9/L	
									12.0/Ki		2.5-10.52/L

Table 3 - Calculated mineral content of selected samples from potassium-bearing intervals with summation of percent K_2O as ore mineral--continued

Drill-hole no.	Ore zone	Sample no.	Depths of interval (feet)	Thickness (feet)	Calculated minerals present (weight percent)					K_2O as ore minerals (percent)	Weighted average K_2O as ore mineral for all intervals in ore zone (feet and percent)
					Polyhalite	Halite	Sylvite	Langbeinite	Other minerals		
FC-82	3	7	1624.33-1625.58	1.25	2	57	---	31.1	3.5/Bl 3.7/Ka	7.06/L	
	3	8	1625.58-1627.00	1.42	2	67	---	29.9	0.6/C[1]	6.78/L	
	3	9	1627.00-1627.75	0.75	1	28	---	62.2	Tr/Bl[1] 5.0/Gl	14.11/L	3.42-8.49/L
FC-91	4	34	1712.25-1712.66	0.42	1	18	---	50.0	11.0/Ka 7.5/Le 6.0/Ki	11.35/L	
	4	35	1712.66-1713.08	0.42	---	62	---	---	5.0/Ka 3.4/Ki	---	
	4	36	1713.08-1714.17	1.08	1	25	---	64.6	5.0/Ki	14.66/L	
	4	37	1714.17-1714.75	0.58	2	32	---	58.7	5.0/Ka 1.3/Ki	13.32	
	4	38	1715.75-1715.75	1.00	20	38	---	47.0	5.0/Ka[1] Tr/Gu	10.66	
	4	39	1715.75-1716.33	0.58	6	31	---	54.0	6.2/Ka 4.0/Gl 1.2/Ki	12.25/L	4.08-11.3/L
	4	40	1718.66-1719.42	0.75	3	81	---	8.0	3.0/Ka 9.0/Bs	1.82/L	
	4	41	1719.42-1720.75	1.33	2	37	---	59.5	---	13.5/L	
	4	42	1720.75-1722.00	1.25	---	60	---	37.08	Tr/Gu 3.4/Bs	8.41/L	
	4	43	1722.00-1722.58	0.58	---	71	---	13.5	0.4/Ka 6.0/Bs[1] Tr/Gu	3.06/L	3.91-8.08/L
	2	44	1742.75-1743.25	0.50	---	15	---	62.0	8.8/Ka[2] Tr/Va	14.07/L	
	2	45	1743.25-1744.25	1.00	---	47	---	30.5	10.0/Ki 10.0/Va	6.92/L	
	2	46	1744.25-1745.00	0.75	---	61	---	1.0	3.2/Ka 10.1/Ki 24.0/Va[1] Tr/Gu	0.73/L	2.25-6.44/L
FC-92[9]	8	5	1604.92-1606.04	1.12	1	51	47	Tr[1]	Tr/C[1]	29.0/S	
	8	6	1606.04-1606.50	0.46	---	50	49	Tr[1]	Tr/C[1]	31.0/S	
	8	7	1606.50-1606.75	0.25	---	60	29	1	5.7/C	18.5/S	1.83-28/S
	4	57	1740.66-1741.58	0.92	1	51	---	46.7	---	10.6/L	
	4	58	1741.58-1742.25	0.66	1	36	---	61.0	---	13.85/L	
	4	59	1742.25-1743.25	1.00	1	36	---	61.2	0.1/Ki	13.89/L	
	4	60	1743.25-1744.08	0.83	1	34	---	61.3	---	13.91/L	
	4	61	1744.08-1745.00	0.92	2	38	---	48.8	1.8/Ki	11.07/L	4.33-12.6/L
	2	62	1769.42-1770.08	0.66	1	42	---	55.4	3.0/Va	12.57/L	
	2	63	1770.08-1771.42	1.33	1	51	---	45.7	2.0/Va 1.0/Arc	10.37/L	
	2	64	1777.42-1772.08	0.66	---	39	---	33.0	17.0/Va 8.0/Ki 1.0/Gu	7.49/L	
	2	65	1772.08-1772.38	0.5	---	73	---	1.5	14.0/Va 1.0/Gu	0.34/L	3.16-8.64/L

Table 3 - Calculated mineral content of selected samples from potassium-bearing intervals with summation of percent K_2O as ore mineral--continued

Drill-hole no.	Ore zone	Sample no.	Depths of interval (feet)	Thickness (feet)	Calculated minerals present (weight percent)					K_2O as ore minerals (percent)	Weighted average K_2O as ore mineral for all intervals in ore zone (feet and percent)
					Polyhalite	Halite	Sylvite	Langbeinite	Other minerals		
IMC-374	4	8	1430.70-1432.10	1.40	6	86	0.7	2.0	0.7/Ki 0.3/Ka	0.46/L 0.44/S	
	4	9	1432.10-1433.10	1.00	13	68	1.0	6.4	1.35/Le	1.46/L 0.63/S	2.4-0.88/L 2.4-0.51/S
IMC-375	4	7	1627.90-1629.00	1.10	2	78	---	6.6	2.0/Ka	1.50/L	
	4	8	1629.00-1630.50	1.50	4	70	2.0	13.2	2.0/Le 1.0/Ka	3.0/L 1.3/S	2.5-2.46/L 1.5-1.3/S
IMC-376	10	2	1427.00-1427.70	0.7	---	60	38.4	---	---	24.3/S	
	10	3	1427.70-1428.30	0.6	---	98	0.2	---	---	0.1/S	
	10	4	1428.30-1429.20	0.9	1	96	0.4	---	---	0.26/S	
	10	5	1429.20-1431.00	1.8	2	86	11.2	---	---	7.1/S	4.0-7.52/S
	5	13	1528.00-1528.90	0.9	2	89	1.0	2.8	---	0.63/L	
	5	14	1528.90-1530.90	2.0	0	45	---	51.3	1.0/Le	11.65/L	3.7-6.5/L
	5	15	1530.90-1531.70	0.8	2	93	1.0	1.05	---	0.25/L	(4.0-6.03/L)[5]
NFU-1[10]	8		1536.25-1540.17	3.92	---	---	---	---	---	19.67/S	3.92-19.67/S
	4		1646.75-1649.08	2.33	---	---	---	---	---	11.96/L	2.33-11.96/L
NFU[10]	10		1441.08-1445.17	4.08	---	---	---	---	---	0.8/S	4.08-0.8/S
	8		1479.80-1483.80	4.00	---	---	---	---	---	9.1/S	4.0-9.1/S
	4		1598.50-1602.70	4.20	---	---	---	---	---	13.1/L	4.2-13.1/L
D-120[10]	10		1248.30-1249.80	1.50	---	---	---	---	---	31.63/S	
	10		1249.80-1251.10	1.30	---	---	---	---	---	10.4/S	
	10		1251.10-1252.50	1.40	---	---	---	---	---	7.34/S	4.2-15.3/S
	4		1419.60-1421.30	1.70	---	---	---	---	---	13.8/S	2.2-10.7/S
	4		1421.30-1421.80	0.50	---	---	---	---	---	0.5/S	2.2-7.5/L mixed ore equivelent: 2.2-29.45/S
D-48[10]	10		1236.60-1240.60	4.00	---	---	---	---	---	---	4.0-11/S 4.0-2.1/L (visual estimate)
	8		1280.52-1289.78	9.26	---	---	---	---	---	---	9.26-17.37/S
	4		1414.20-1416.20	2.00	---	---	---	---	---	---	2.0-8.8/L (visual estimate)

Table 3 - Calculated mineral content of selected samples from potassium-bearing intervals with summation of percent K_2O as ore mineral--continued

Drill-hole no.	Ore zone	Sample no.	Depths of interval (feet)	Thickness (feet)	Calculated minerals present (weight percent)					K_2O as ore minerals (percent)	Weighted average K_2O as ore mineral for all intervals in ore zone (feet and percent)
					Polyhalite	Halite	Sylvite	Langbeinite	Other minerals		
D-207	10	24	1358.60-1359.60	1.00	4	87	5	---	2/Ka	3.34/S	
	10	25	1359.60-1360.20	0.60	4	89	5	1	2/Ka	3.34/S 0.25/L	
	10	26[4]	1360.20-1360.60	0.40	1	75	4	1	6/Ka	0.31/L	
	10	27	1360.60-1361.20	0.60	1	47	6	16	5/Ka	3.79/S 3.70/L	
	10	28	1361.20-1361.80	0.60	2	69	2	9	2/Ka	2.04/L	
	10	29	1361.80-1362.30	0.50	7	62	5	10	7/Ka	3.34/S 2.31/L	
	10	30	1362.30-1363.10	0.80	6	83	4	---	1/C 3/Ka	2.66/S	4.5-2.54/S 2.7-1.8/L mixed ore equivalent: 4.5-5.24/S
	4	33	1533.10-1533.50	0.40	2	53	36	7	---	1.51/L 22.74/S	
	4	34	1533.50-1533.80	0.30	4	86	2	11	---	2.43/L	
	4	35	1533.80-1534.40	0.60	2	85	1	2	---	0.50/L	
	4	36	1534.40-1534.70	0.30	3	95	---	4	---	0.85/L	
	4	37	1534.70-1535.00	0.30	2	74	4	1	3.0/Ki	0.14/L	
	4	38	1535.00-1539.80	4.80	6	87	2	4	---	0.85/L	6.7-0.90/L 0.4-22.74/S mixed ore equivalent: 6.7-1.44/L
	3	44	1545.90-1546.30	0.40	1	66	---	32.0	0.74/Le	7.2/L	
	3	45	1546.30-1546.66	0.30	1	11	---	73.2	9.0/Ki	16.6/L	
	3	46	1546.66-1548.00	1.40	2	62	---	30.3	3.8/Le	6.89/L	
	3	47	1548.00-1548.60	0.60	1	43	---	54.7	---	12.4/L	2.7-9.24/L
	2	52	1552.20-1553.00	0.80	11	83	---	5.0	---	1.05/L	
	2	53	1553.00-1553.20	0.20	11	45	---	41.5	2.0/Le	9.41/L	
	2	54	1553.20-1553.60	0.40	4	81	---	15.8	---	3.59/L	
	2	55	1553.60-1554.00	0.40	1	47	---	49.4	1.32/Le	11.19/L	
	2	56	1554.00-1554.80	0.80	18	86	1.4	8.8	---	2.0/L 0.9/S	2.6-3.94/L Tr/S[4]
D-104[10]	10		1340.40-1341.70	1.30	---	---	---	---	---	---	
	10		1341.70-1343.20	1.50	---	---	---	---	---	---	
	10		1343.20-1344.00	0.80	---	---	---	---	---	---	
	10		1344.00-1344.70	0.70	---	---	---	---	---	---	6.0-5.5/S
	10		1344.70-1346.40	1.70	---	---	---	---	---	---	3.2-4.71/L mixed ore equivalent: 6.0-11.78/S
	8		1391.10-1392.00	0.90	---	---	---	---	---	---	
	8		1392.00-1395.30	3.30	---	---	---	---	---	---	
	8		1395.30-1396.30	1.00	---	---	---	---	---	---	5.2-10.8/S
	4		1519.90-1522.80	2.90	---	---	---	---	---	---	2.9-9.4/L

Table 3 - Calculated mineral content of selected samples from potassium-bearing intervals with summation of percent K_2O as ore mineral--continued

Drill-hole no.	Ore zone	Sample no.	Depths of interval (feet)	Thickness (feet)	Calculated minerals present (weight percent)					K_2O as ore minerals (percent)	Weighted average K_2O as ore mineral for all intervals in ore zone (feet and percent)
					Polyhalite	Halite	Sylvite	Langbeinite	Other minerals		
D-104[10]	3		1527.50-1528.90	1.40	---	---	---	---	---	---	1.4-5.0/L
	3		1528.90-1530.50	1.60		---	---	---	---	---	2.9-11.4/S mixed ore equivelent: 2.9-6.66/L
	2		1539.50-1540.20	1.20	---	---	---	---	---	---	1.2-15.0/L
U-134[10]	10		1319.58-1321.25	1.69	3	---	6.0	---	2.0/Ka 0.7/C	3.79/S	
			1321.25-1322.83	1.58	2	---	---	---	12.5/Ka	17.22/S	3.27-10.28/S
	8		1361.10-1362.17	1.08	---	---	---	---	---	---	
	8		1362.17-1364.50	2.33	---	---	---	---	---	---	
	8		1364.50-1366.50	2.00	---	---	---	---	---	---	6.33-7.89/S
	8		1366.50-1367.42	0.92	---	---	---	---	---	---	(4.0-12.5/S)[5]
	5		1406.75-1409.42	2.66	---	---	---	---	---	14.44/L	
	5		1409.42-1410.00	0.58	---	---	---	---	---	8.03/L	
	5		1410.00-1411.66	1.66	---	---	---	---	---	7.05/L	4.9-11.2/L
	4		1471.66-1474.00	2.33	---	---	---	---	---	8.54/L	2.33-8.54/L
	3		1484.91-1487.33	2.42	---	---	---	---	---	3.6/L	
	3		1487.33-1490.25	2.92	---	---	---	---	---	1.86/L	
	3		1490.25-1491.33	1.08	---	---	---	---	---	8.7/L	6.42-3.7/L[3]

*Values in table for percent mineral and K_2O equivalent are not consistent owing to independent rounding of essays and conversion factors by numerous authors and investigators.

1 Trace amount; equals 0 to 2.0 percent
2 Incomplete dissolution of sample
3 5.9 percent insolubles, by weight
4 Incomplete or unreliable assay
5 Grade adjusted to 4-foot interval
6 High insoluble content
7 7.1 percent potassium assay used
8 Outside of the ERDA area by 300 feet, included due to influence
9 Raw data unavailable; these are company figures
10 Company interval data; raw data unavailable; no sample numbers assigned

Table 4.--Estimated potash ore reserves and resources in the proposed Waste Isolation Pilot Plant (WIPP) area, Carlsbad Mining District, Eddy County, New Mexico

[Reserves and resources expressed in millions of short tons. Numbers in brackets in the 10th ore zone show totals minus langbeinite ore zone overlap. ---, no data]

A. Low-grade resources[1]

WIPP zone	Measured	Indicated	Total measured and indicated
10th ore zone			
I	0.8 (S)	---	0.8 (S)
II	3.7 (S)	1.6 (S) [1.4]	5.3 (S) [5.1]
	3.2 (L)	---	3.2 (L)
III	21.3 (S)	9.4 (S) [3.2]	30.7 (S) [24.5]
	21.8 (L)	---	21.8 (L)
IV	48.2 (S) [44.4]	---	48.2 (S) [44.4]
	26.4 (L)	4.2 (L)	30.6 (S)
Total	125.4 (L+S) [121.6]	15.2 (L+S) [8.8]	140.6 (L+S) [130.4]
9th ore zone			
III	---	3.7 (S)	3.7 (S)
IV	---	6.6 (S)	6.6 (S)
Total	---	10.3 (S)	10.3 (S)
8th ore zone			
III	5.0 (S)	---	5.0 (S)
IV	43.1 (S)	---	43.1 (S)
Total	48.1 (S)	---	48.1 (S)
5th ore zone			
II	0.8 (L)	---	0.8 (L)
III	10.8 (L)	---	10.8 (L)
IV	10.3 (L)	4.3 (L)	14.6 (L)
Total	21.9 (L)	4.3 (L)	26.2 (L)
4th ore zone			
I	0.6 (L)	---	0.6 (L)
II	3.5 (L)	6.2 (L)	9.7 (L)
III	32.8 (L)	3.4 (L)	36.2 (L)
IV	109.3 (L)	5.2 (L)	114.5 (L)
Total	146.2 (L)	14.8 (L)	161.0 (L)
3d ore zone			
I	---	0.4 (L)	0.4 (L)
III	8.6 (L)	5.6 (L)	14.2 (L)
IV	19.9 (L)	---	19.9 (L)
Total	28.5 (L)	6.0 (L)	34.5 (L)
2d ore zone			
I	0.4 (L)	---	0.4 (L)
II	0.4 (L)	---	0.4 (L)
III	23.4 (L)	---	23.4 (L)
IV	42.1 (L)	7.4 (L)	49.5 (L)
Total	66.3 (L)	7.4 (L)	73.7 (L)
Summary of resources in all ore zones			
I	0.8 (S)	---	0.8 (S)
	1.0 (L)	0.4 (L)	1.4 (L)
II	3.7 (S)	1.4 (S)	5.1 (S)
	7.9 (L)	6.2 (L)	14.1 (L)
III	26.3 (S)	6.9 (S)	33.2 (S)
	97.4 (L)	9.0 (L)	106.4 (L)
IV	87.5 (S)	6.6 (S)	94.1 (S)
	208.0 (L)	21.1 (L)	229.1 (L)
Total	432.6 (L+S)	51.6 (L+S)	484.2 (L+S)

[1]4.0 ft of 8 percent K_2O as sylvite (S) and 4.0 ft of 3 percent K_2O as langbeinite (L).

Table 4.--Estimated potash ore reserves and resources in the proposed Waste Isolation Pilot Plant (WIPP) area, Carlsbad Mining District, Eddy County, New Mexico--continued

B. Lease-grade reserves[2]

WIPP zone	Measured	Indicated	Total measured and indicated
	10th ore zone		
I	0.6 (S)	------	0.6 (S)
II	3.4 (S)	1.4 (S)	4.8 (S) [4.6]
	2.7 (L)	------	2.7 (L)
III	8.2 (S)	7.8 (S) [3.1]	16.0 (S) [11.3]
	21.9 (L)	------	21.9 (L)
IV	38.2 (S) [37.2]	------	38.2 (S) [37.2]
	23.2 (L)	1.6 (L)	24.8 (L)
Total	98.2 (L+S) [97.2]	10.8 (L) [5.9]	109.0 (L+S) [103.1]
	9th ore zone		
III	------	1.2 (S)	1.2 (S)
IV	------	4.8 (S)	4.8 (S)
Total	------	6.0 (S)	6.0 (S)
	8th ore zone		
III	1.0 (S)	------	1.0 (S)
IV	27.8 (S)	------	27.8 (S)
Total	28.8 (S)	------	28.8 (S)
	5th ore zone		
II	0.7 (L)	------	0.7 (L)
III	10.2 (L)	------	10.2 (L)
IV	9.3 (L)	4.0 (L)	13.3 (L)
Total	20.2 (L)	4.0 (L)	24.2 (L)
	4th ore zone		
I	0.6 (L)	------	0.6 (L)
II	0.7 (L)	0.7 (L)	1.4 (L)
III	20.1 (L)	1.9 (L)	22.0 (L)
IV	86.1 (L)	5.3 (L)	91.4 (L)
Total	107.5 (L)	7.9 (L)	115.4 (L)
	3d ore zone		
I	------	------	------
III	9.6 (L)	------	9.6 (L)
IV	16.0 (L)	------	16.0 (L)
Total	25.6 (L)	------	25.6 (L)
	2d ore zone		
I	------	------	------
II	------	------	------
III	15.5 (L)	3.2 (L)	18.7 (L)
IV	20.9 (L)	10.6 (L)	31.5 (L)
Total	36.4 (L)	13.8 (L)	50.2 (L)
	Summary of reserves in all ore zones		
I	1.2 (S)	------	1.2 (S)
	------	------	------
II	3.4 (S)	1.2 (S)	4.6 (S)
	4.1 (L)	0.7 (L)	4.8 (L)
III	9.2 (S)	4.3 (S)	13.5 (S)
	77.3 (L)	5.1 (L)	82.4 (L)
IV	65.0 (S)	4.8 (S)	69.8 (S)
	155.5 (L)	21.5 (L)	177.0 (L)
Total	315.7 (L+S)	37.6 (L+S)	353.3 (L+S)

[2] 4.0 ft of 10 percent K_2O as sylvite (S) and 4.0 ft of 4 percent K_2O as langbeinite (L).

Table 4.--Estimated potash ore reserves and resources in the proposed Waste Isolation Pilot Plant (WIPP) area, Carlsbad Mining District, Eddy County, New Mexico--continued

C. High-grade reserves [3]

WIPP zone	Measured	Indicated	Total measured and indicated
	10th ore zone		
I	--	--	--
II	2.5 (S)	0.9 (S) [0.8]	3.4 (S) [3.3]
III	4.0 (S)	6.4 (S) [2.5]	10.4 (S) [6.5]
	7.9 (L)	--	7.9 (L)
IV	30.0 (S) [28.9]	--	30.0 (S) [28.9]
	0.9 (L)	--	0.9 (L)
Total	45.3 (L+S) [44.2]	7.3 (S) [3.3]	52.6 (L+S) [47.5]
	9th ore zone		
III	--	--	--
IV	--	0.7 (S)	0.7 (S)
Total	--	0.7 (S)	0.7 (S)
	8th ore zone		
III	--	--	--
IV	13.7 (S)	--	13.7 (S)
Total	13.7 (S)	--	13.7 (S)
	5th ore zone		
II	--	--	--
III	--	--	--
IV	1.6 (L)	--	1.6 (L)
Total	1.6 (L)	--	1.6 (L)
	4th ore zone		
I	--	--	--
II	--	--	--
III	14.6 (L)	--	14.6 (L)
IV	44.1 (L)	0.3 (L)	44.4 (L)
Total	58.7 (L)	0.3 (L)	59.0 (L)
	3d ore zone		
I	--	--	--
III	--	--	--
IV	--	--	--
Total	--	--	--
	2d ore zone		
I	--	--	--
II	--	--	--
III	1.9 (L)	--	1.9 (L)
IV	7.5 (L)	0.4 (L)	7.9 (L)
Total	9.4 (L)	0.4 (L)	9.8 (L)
	Summary of reserves in all ore zones		
I	--	--	--
	--	--	--
II	2.5 (S)	0.8 (S)	3.3 (S)
	--	--	--
III	4.0 (S)	2.5 (S)	6.5 (S)
	24.4 (L)	--	24.4 (L)
IV	43.5 (S)	0.7 (S)	44.2 (S)
	52.5 (L)	0.7 (L)	53.2 (L)
Total	126.9 (L+S)	4.7 (L+S)	131.6 (L+S)

[3]4.0 ft of 14 percent K_2O as sylvite (S) and 4.0 ft of 8 percent K_2O as langbeinite (L).

CONCLUSIONS

Within the WIPP area there are seven ore zones which meet or exceed the current U.S. Geological Survey leasing grade standards of 4 feet of 4 percent K_2O as langbeinite or 10 percent K_2O as sylvite. These ore zones (at lease grade) contain an estimated 353.3 million tons of potash ore, which is broken down into 315.7 million tons of measured ore and 37.6 million tons of indicated ore. The most important zones are the 4th and 10th, which (at lease grade) contain a combined total of 218.5 million tons of potash ore. The 4th ore zone contains the greatest estimated tonnage of potash reserves in the WIPP area: 10[illegible].5 million tons of measured langbeinite ore and an additional 7.9 million tons of indicated langbeinite ore, totaling about 115.4 million tons. The other major ore zone, the 10th, contains langbeinite and sylvite. The 10th ore zone (at lease grade) contains an estimated 97.2 million tons of measured potash ore of both ore types and 5.9 million tons of indicated ore for a total of 103.1 million tons of potash ore

Potash ore reserves and potash resources were calculated at a higher and lower cutoff grade to anticipate possible fluctuations in the market price of potash. The lower cutoff, 4 feet of 3 percent K_2O as langbeinite or 8 percent K_2O as sylvite, yielded resources for the 7 ore zones of 484.2 million tons of mineralized material (432.6 million tons of measured and 51.6 million tons of indicated). The higher cut-off, 4 feet of 8 percent K_2O as langbeinite or 14 percent K_2O as sylvite, yielded reserves of 131.6 million tons of potash ore (126.9 million tons of measured and 4.7 million tons of indicated ore).

The estimated 353.3 million tons (at lease grade) of potash ore reserves in the WIPP area constitutes about 7 percent of the estimated 5.4 billion tons of potash ore reserves in the Carlsbad Mining District.

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