Y/OWI/SUB-77/22328

GEOLOGIC INVESTIGATION

of the

VIRGIN RIVER VALLEY SALT DEPOSITS
CLARK COUNTY, SOUTHEASTERN NEVADA
TO INVESTIGATE THEIR SUITABILITY
FOR POSSIBLE STORAGE OF RADIOACTIVE WASTE MATERIAL

as of

SEPTEMBER, 1977

This report was prepared by
Netherland, Sewell & Associates, Inc.,
under subcontract with
Union Carbide Corporation, Nuclear Division,
under contract number W-7405-eng-26 with
the Energy Research and Development Administration.
The subcontract was administered by
the Office of Waste Isolation.

NETHERLAND, SEWELL & ASSOCIATES, INC.
CONSULTING PETROLEUM ENGINEERS AND GEOLOGISTS

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In duplicate Stauffer drill logs

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September 20, 1977

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Dr. C. D. Zerby, Director
The Office of Waste Isolation
Union Carbide Corporation, Nuclear Division
Building 9103, Post Office Box Y
Oak Ridge, Tennessee 37830

Dear Dr. Zerby:

This report sets forth the results of our geologic investigation of the Virgin River Valley salt deposits, Clark County, southeastern Nevada, to examine their suitability for further study and consideration in connection with the possible storage of radioactive waste material. This investigation was prepared for the Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, under Purchase Order Number 89Y-22328V.

The objectives of this investigation were to gather data related to and examine (1) the geologic framework and stratigraphy of the Virgin River Valley, including the structural configuration, areal extent, thickness, and lithology of the salt deposits together with the surface exposure and/or outcrops of these deposits; (2) the present structural and tectonic stability of this basin; (3) the hydrologic characteristics of the salt deposits and adjoining geologic formations; (4) the possible development of mineral resources in the area; and (5) the nature and extent of recreational activities in the area surrounding Lake Mead as it relates to the Virgin River Valley salt deposits. Another major objective of the investigation was to outline the additional information needed to more thoroughly evaluate these salt deposits in connection with the possible storage of radioactive waste material.

As shown in the SUMMARY OF FINDINGS section of this report, our findings indicate that (1) approximately one-half of the salt body underlies the Overton Arm of Lake Mead and that the dry land portion of the salt body that has a thickness of 1,000 feet or more covers an area of about four and one-half square miles; (2) current tectonic activity in the area of the salt deposits is believed to be confined to seismic events associated with crustal adjustments following the filling of Lake Mead; (3) detailed

information on the hydrology of the salt deposit area is not available at present but it is reported that a groundwater study by the U.S. Geological Survey is now in progress; (4) there is no evidence of exploitable minerals in the salt deposit area other than evaporites such as salt, gypsum, and possibly sand and gravel; (5) the salt deposit area is located inside the Lake Mead Recreation Area, outlined on the accompanying Location Plat, and several Federal, State, and Local agencies share regulatory responsibilities for the activities in the area; (6) other salt deposit areas of Arizona and Nevada, such as the Detrital Valley, Red Lake Dome, Luke Dome, the Mormon Mesa area, and several playa lake areas of central Nevada may merit further study; and (7) additional information, as outlined, is needed to more thoroughly evaluate the salt deposits of the Virgin River Valley and other areas referred to above. These items are discussed further in the following sections of this report.

We were assisted in this work by Mr. Chas. C. Bankhead, Jr., and Mr. William A. Huckaba, both of Dallas, and by Dr. Carroll F. Knutson and Mr. Charles R. Boardman, both consultants of Las Vegas, Nevada. Field trips were made to the area by Dr. Knutson and Mr. Bankhead, representing Netherland, Sewell & Associates, Inc. Mr. Boardman made a field reconnaissance of the Study Area during the week of August 7, 1977, for the purpose of examining the geologic features of the area as relates to the salt deposits.

We appreciate the opportunity of performing this investigation for you.

Very truly yours,

Clarence Netherland

CMN:LL

SUMMARY OF FINDINGS

The purpose of this investigation was (1) to examine the suitability of the Virgin River Valley salt deposits, Clark County, Nevada, for further study and consideration in connection with possible storage of radioactive waste material and (2) to outline the additional information needed to more thoroughly evaluate these salt deposits. Our findings are summarized as follows:

GEOLOGY

The Virgin River Valley is one of the numerous interior basins of the block-faulted Basin-and-Range Province of the Western United States. The relatively flat-lying Cenozoic deposits of the Valley are bounded by exposures of complexly folded and faulted pre-Cenozoic rocks in the Muddy Mountains on the west and the Virgin Mountains on the east. Principal Cenozoic exposures of the Valley are the non-marine deposits of the Muddy Creek Formation of Tertiary (Pliocene ?) age. The salt deposits of this area are part of the Muddy Creek sequence.

THE SALT DEPOSITS

The Virgin River Valley salt deposits appear to extend over an area of approximately 38 square miles along the central part of the Virgin River Valley basin. The salt is exposed at the surface in several places. In other places, it has been found in coreholes to underlie as much as 2,256 feet of overburden. Known thickness of the salt ranges from zero to more than 1,750 feet. Over one-half of the salt body underlies the water of the Overton Arm of Lake Mead to the east. It is estimated that the dry land portion of the salt body that has a thickness of 1,000 feet or more covers an area of about four and one-half square miles.

The bulk of the salt seems to be relatively pure (93 percent sodium chloride) with only sparce indications that original bedding is still preserved. There is considerable evidence of local distortion of the salt by faulting, folding, shearing, and possible diapirism. Control is lacking to determine the extent to which regional tectonic events may have disrupted the salt deposits.

TECTONIC STABILITY

Current tectonic activity in the vicinity of the salt deposits is believed to be confined to seismic events associated with crustal adjustments following the filling of Lake Mead. The area was one of major tectonic activity in the past which has diminished to a low level of activity at the present time.

Fault movement along the Las Vegas shear zone has been dated as occurring as recently as 10,000 years ago and there is evidence that the fault that bounds the west side of the Valley has been active during Recent time almost to the present.

Dissolution of salt outcrops along the shoreline of Lake Mead has caused local slumping of overburden deposits.

HYDROLOGY

Detailed information on the hydrology of the salt deposit area is not available at present but it is reported that a groundwater study by the U.S. Geological Survey is now in progress.

Permeable units in the sediments associated with the salt deposits are thin and lenticular and are unlikely to serve as passageways for significant water flow in contact with the salt. However, the numerous faults in the area could act as water conduits to the salt or might bring older formations that are porous into contact with the salt.

Where the salt crops out on the floor and along the shoreline of Lake Mead there is continuous active salt dissolution.

MINERAL RESOURCES

There is no evidence of exploitable minerals in the salt deposit area other than evaporites (salt, gypsum, etc.) and, possibly, sand and gravel. Previous leases in the salt deposit area have expired and permission to extract minerals is not likely to be granted in the future by the Bureau of Reclamation because the salt deposit is within the Lake Mead Recreation Area.

RECREATIONAL ACTIVITIES

There has been considerable development of recreational facilities along the shoreline of Lake Mead in the area of the salt deposits. Permanent facilities for water-sport activities have been constructed and these attract numerous visitors, particularly during the warmer months.

The National Park Service which administers the Lake Mead Recreation Area has a policy that no facility that would pose a "visual intrusion" shall be located within the area. The Bureau of Reclamation requires ample assurances that there will be no unacceptable environmental effects from projects within areas of its responsibility.

OTHER SALT DEPOSIT AREAS

In the process of investigating the salt deposits of the Virgin River Valley area, information was obtained on other salt deposits in Nevada and Arizona. Locations of these areas are shown on Exhibit 1 with brief descriptions of the areas summarized in an accompanying section of this report.

The salt deposits of the Detrital Valley of northwestern Mohave County, Arizona, are of particular interest because of the thick beds of salt found at shallow depths. The salt beds in the Detrital Valley are indicated to be 500 feet to 700 feet thick, found at depths of 420 feet to 600 feet and extend over several square miles (Pierce and Rich, 1962).

There are several other salt deposits in northern Arizona and in the southern and central portion of Nevada which may merit further consideration in connection with the possible storage of radioactive waste material. These include Red Lake Dome in the Hualpai Valley of Arizona, Luke Dome in Maricopa County, Arizona, together with a number of playa lakes in central Nevada, as shown on Exhibit 1, which are known to contain salt deposits. Also, it appears that geologic conditions are favorable for the existence of thick salt deposits in the Mormon Mesa area of Clark County, Nevada, immediately north of the Virgin River Valley Study Area.

ADDITIONAL INFORMATION NEEDED

The additional information needed to more thoroughly evaluate the Virgin River Valley salt deposits may be summarized as follows:

I. To define the configuration, composition, and internal structure of the Virgin River Valley salt deposits -

(1) Corehole data - A series of additional coreholes, carefully located and supervised, drilled into and through the salt deposits for more precise measurement of the depth, areal extent, thickness, and configuration of the salt deposits. Full sized cores obtained from such corehole drilling to provide data on the composition and internal structure of the salt deposits.

(2) Geophysical surveys - A combination of gravity and/or seismic surveys and a lesser number of coreholes may satisfactorily define the size and internal characteristics of the salt deposits; however, extensive corehole drilling in the area of interest probably would provide more high quality data than a program based on a limited number of coreholes combined with gravity and/or seismic surveys.

II. To evaluate more thoroughly the salt dissolution or hydrologic stability of the salt deposits -

It is reported that a groundwater study of the area is now being conducted by the U.S. Geological Survey. The results of this study should be obtained and analyzed to determine the nature and extent of additional information (such as the drilling of shallow water wells and/or coreholes, studies of surface and subsurface water flow and salinity patterns, effect of faulting on the transmissivity of water in the area, etc.) which may be needed to evaluate the hydrologic stability of the salt deposits and associated strata.

III. To evaluate the tectonic stability of the salt deposits and the immediately surrounding area -

A more detailed study of recent faults in the area, aided by data obtained during corehole drilling in the area as outlined above. Also, on-site monitoring of the area of the salt deposits for detection of seismic activity.

IV. To evaluate the effect of the salt deposits being located inside the Lake Mead Recreation Area -

The Virgin River Valley salt deposits are located underneath the western shore of the Overton Arm of Lake Mead between Echo Bay and Overton Beach; this area is within the Lake Mead Recreation Area. Therefore, several Federal, State, and Local agencies share regulatory responsibilities for the activities in the area. These agencies include the National Park Service, the Bureau of Reclamation, the Corps of Engineers, the U.S. Geological Survey, various Water Resource Boards (including the City of Las Vegas), various Environmental Protection Agencies, and other agencies concerned with recreational and/or environmental activities in the area.

Of high priority in studying the suitability of the Virgin River Valley salt deposits for possible storage of radioactive waste material is the determination of whether or not approval can be obtained from these regulatory agencies for such use of these salt deposits.

V. To evaluate other salt deposits in the general region of southern Nevada and northern Arizona -

A number of coreholes, together with further geologic studies, are needed to evaluate the other salt deposits in southern Nevada and northern Arizona. Of particular interest may be (1) the Detrital Valley salt deposits located in Mohave County, Arizona, approximately eight miles south of Lake Mead where several hundred feet of bedded salt is found at depths of 400 feet to 600 feet and extending over an area of several square miles, and (2) the Mormon Mesa area located in Clark County, Nevada, immediately north of the Virgin River Valley Study Area where it appears that geologic conditions are favorable for the existence of thick salt deposits. Other areas of potential interest located in Nevada and Arizona are disucssed in this report.

REGIONAL GEOLOGY

SOUTHEASTERN NEVADA AND VICINITY

as affects

THE VIRGIN RIVER VALLEY SALT DEPOSITS, CLARK COUNTY, NEVADA

The Virgin River Valley Study Area, Clark County, Nevada, is situated near the margins of several geographic and geologic provinces (Exhibit 1). The Study Area is part of the Great Basin, a physiographic province of ridges and valleys that lies between the Sierra Nevada Range on the west and the Wasatch Range and Colorado Plateau on the east. To the south, the Great Basin merges with the Mojave Desert and the Colorado River valley. The entire region has a long, complex history of sedimentary, erosional, igneous, and tectonic events. The stratigraphy of the region as it relates to the Study Area is summarized on Exhibit 2.

During most of the Paleozoic Era, geosynclinal marine basins occupied Nevada (Eardley, 1949). The Study Area was situated on the eastern shelf of the basin environment.

In early Mesozoic time, the basin in eastern Nevada shrank in size and its axis shifted to the east near the Study Area (Clark, 1957). By Early Jurassic time, sedimentation in the Study Area was dominantly non-marine and only a shallow sea covered portions of the Great Basin area to the north (Stanley, et al., 1971). Osmond and Elias (1971, p. 417) describe later Mesozoic events as follows: "During Late Jurassic and Early Cretaceous time, granitic masses related to the Sierra Nevada batholith were intruded in great numbers into western Nevada and as a few scattered, smaller bodies in eastern Nevada. This intrusive episode caused general uplift of the Great Basin area, and the additions of material produced crustal stress leading to the development of large folds and overthrusts both eastward and westward in many parts of the Great Basin. The largest of these is the Sevier orogenic belt of western Utah."

The eastern edge of the Sevier orogenic belt crosses the northwest portion of the Study Area. Harris (1959) has extensively described and illustrated the history of the "Sevier Arch." He divided development into the following stages: (I) deposition of Triassic and Jurassic sediments, (II) uplift and folding of the Arch during the Jurassic (?) and Cretaceous

from west-central Utah into southern Nevada, (III) Late Cretaceous regional thrusting, (IV) erosion to mild topographic relief during Late Cretaceous and early Tertiary, (V) deposition of an extensive sheet of early Tertiary (Oligocene ?) volcanics, and (VI) late Tertiary Basin-and-Range type faulting and folding. In the Study Area, Cretaceous sediments (Willow Tank Formation, Baseline sandstone) were deposited during Stage II; Cretaceous (?) (Overton Formation) fanglomerate deposition accompanied Stage III; Cretaceous (?)-Tertiary sediments (Horse Springs Formation) were deposited during Stage IV; Tertiary volcanics were laid down during Stage V; and late Tertiary valley fill (Muddy Creek Formation) followed the Stage VI deformation.

Van Houten (1956) gives considerable information about Cenozoic events in Nevada. He considers the Muddy Creek Formation (which contains the salt deposits of the Study Area) to be younger than the "Stage V" Tertiary (Oligocene ?) volcanics (page 2810) and to be the equivalent of Miocene-Pliocene non-marine sediments and volcanics to the north and west (page 2818). He infers the region of the Study Area to be different from the rest of Nevada in that (1) the Muddy Creek Formation in southern Nevada is the only sequence in these correlative units to contain evaporites (page 1818) and (2) post-Muddy Creek tectonic activity has been minor compared to later disturbances to the north and west (page 2823).

Salt deposits similar to the Virgin River Valley deposit occur in the Muddy Creek Formation a short distance south of the Study Area at Detrital Valley and Hualpai Valley, Arizona. Farther south, salt deposits, that may be similar in age and origin to the Virgin River Valley salt, occur in the Phoenix Basin at the Luke Dome and Picacho Reservoir (Eaton, 1972). Some of the Tertiary evaporites of the Death Valley and Mojave Desert regions of California (Van Houten, 1956; Lindgren, 1928) were deposited at about the same time and in a similar manner as the Virgin River Valley salt.

Post-Tertiary right-lateral movement of the Las Vegas fault zone, located west of the Study Area, has displaced Paleozoic deposits 25 to 30 miles (Lane, 1965; Rich, 1971; Ross, 1964). This fault zone may continue into the southwest portion of the Study Area. The Las Vegas fault is probably related to the right-lateral shear zones of Death Valley and the Garlock fault where post-Tertiary and Recent movements have occurred (Stevens, C. H., 1973; Wright and Troxel, 1966). Left-lateral fault displacements have occurred during or since the Tertiary to the south and west of the Study Area (Anderson, 1973; Stevens, 1973) and cut across the southeast portion of the Area.

Either by coincidence or because of some fundamental condition, the salt deposit portion of Virgin River Valley Study Area appears to have been a relatively stable locality since Precambrian time. During the Paleozoic and early Mesozoic, it was on the geosynclinal shelf; later Mesozoic orogeny was confined to the west portion of the Area, Cenozoic basin-and-range tectonic activity was not as prolonged in the Area, and recent lateral shearing in the Area appears to be confined to the south and southeast.

NETHERLAND, SEWELL & ASSOCIATES, INC.

SALT DEPOSITS STUDY AREA

VIRGIN RIVER VALLEY, CLARK COUNTY, NEVADA

SALT DEPOSITS STUDY AREA

VIRGIN RIVER VALLEY, CLARK COUNTY, NEVADA

INTRODUCTION

The salt deposits of the Virgin River Valley are located in eastern Clark County, Nevada, about 45 miles east of the City of Las Vegas. The Virgin River Valley lies between the Virgin Mountains to the east and the Muddy Mountains to the west, and its central portion is now covered by the Overton Arm of Lake Mead (Exhibit 3).

Prior to the construction of Hoover (Boulder) Dam, completed in 1936, the Virgin River Valley was a desert area of sparce population with small farms and cattle ranches along the major stream beds. Since the filling of Lake Mead behind the dam, the Valley has become part of the Lake Mead National Recreation Area and is now a popular resort for sight-seeing, camping, fishing, swimming, and water-skiing. There are several marinas with permanent dwellings and other structures in the area.

Detailed geological mapping of the Virgin River Valley is not available except for a portion of the Black Mountains immediately south of the salt deposit area which has been mapped by R. E. Anderson (1973). In order to determine the suitability of the salt deposits for further study in connection with possible storage of radioactive waste material, personnel of C.K. GeoEnergy Corporation, Las Vegas, were retained to assist with this investigation because of their intimate personal knowledge of the area and access to records of previous investigations. Dr. Carroll F. Knutson supervised the work and Mr. Charles R. Boardman assisted with surface and subsurface investigations. Field trips were made to the area by Dr. Knutson and Mr. Charles C. Bankhead, Jr., representing Netherland, Sewell & Associates, Inc. Mr. Boardman made a field study of the area during the week of August 7, 1977. The results of this work is reported in the following sections of this report.

STUDY AREA GEOLOGY

Structural Framework and Stratigraphic Characteristics

There are a number of major structural elements in the vicinity of the Virgin River Valley Study Area (Exhibit 3). The Las Vegas shear zone trend curves into the area from the west. This is a late Tertiary right-

lateral fault system with a horizontal offset of at least 30 miles (Steward, 1970). The shear zone seems to break up under the Study Area in a complex interaction with the Sevier fault zone that trends into the area from the northeast.

Adjustment along the Las Vegas shear zone seems to have continued into recent times. The compaction fault scarps of the Las Vegas Valley bend into and terminate along the shear zone and are probably related to the shear system. The faulting has been dated as occurring within the last 10,000 to 15,000 years (Mindling, 1974).

The Hamblin Bay fault trends into the Echo Bay area from the southwest. This fault is a left-lateral feature with an estimated displacement of 40 miles. The Hamblin Bay fault transects a late Miocene stratovolcano (the Hamblin-Cleopatra feature) that has been wrenched into three segments which are displaced as much as 12 miles along the northeast trending strike-slip and oblique-slip zone (Anderson, 1973).

The salt in the Study Area occurs in the Muddy Creek Formation of Pliocene (?) age (Exhibit 4). The Muddy Creek consists of thick nonmarine clastic material and evaporites that were deposited in the faulted graben valleys of southeastern Nevada and the adjacent sections of Utah and Arizona. Genetically, the Muddy Creek Formation originated largely as lake, playa, and fluviatile material. The source of some of these deposits was clastic material eroded from the nearby highlands as well as volcanic rock and landslide material. However, the bulk of the material probably was eroded or dissolved from rocks located to the northeast in the drainage area of the streams flowing into the valley complex. The principal source of the halite found in the Muddy Creek was probably the Pennsylvanian evaporite beds, with lesser contributions from the disseminated sodium chloride found in the Permian, Triassic, and Jurassic rocks of the Colorado Plateau (Krumbein, 1951; Hardy, 1952).

The clastic material probably was largely trapped in "upstream" basins; and the salt-rich water flowed into, and was evaporated from, the basin in the Study Area as well as other lower basins, e.g., Detrital Valley, Red Lake Valley, etc.

The stratigraphy of the area is summarized in Exhibit 2.

The rocks exposed include igneous, metamorphic, and sedimentary types ranging in age from Precambrian to Recent. The Precambrian rocks consist predominantly of quartz-mica schist, chloritic schists, amphibolites, and quartzose gneisses, which were apparently derived by

the metamorphism of an older sedimentary sequence. They are intruded by coarse-grained granitic rocks and pegmatite, aplite, and related dikes, of Precambrian and later age.

Sedimentary rocks of the Paleozoic Era, with an aggregate thickness of about 2,000 feet, are exposed in the ranges adjacent to the Study Area. Limestone and dolomite form 75 to 80 percent of the Paleozoic strata; quartzite, sandstone, and shale, largely within the Cambrian and Permian systems, form the remainder. Minor facies changes occur in an east-west direction across the area, but major changes in the Ordovician through Mississippian section take place in a northwest direction, toward the axis of the Cordilleran geosyncline. A thick section of red sandstone and shale, previously correlated with the Supai Formation, occurs adjacent to the Study Area; this unit is designated the Permian red beds, its age being fixed by its stratigraphic position between fossiliferous Permian carbonate rocks.

A major erosional unconformity separates the Paleozoic and Mesozoic rocks. The Triassic and Jurassic section ranges in thickness from 4,300 to about 6,500 feet; it is predominantly sandstone and shale, with 500 to 700 feet of limestone of the Moenkopi Formation near the base. This part of the section is similar to the section farther east, on the Colorado Plateau. Volcanic materials in the Triassic units indicate the initiation of volcanic activity nearby.

In Cretaceous time, the earlier rocks were folded and faulted and underwent a period of erosion. Several great thrust faults and numerous minor faults were formed which involved all the sedimentary rocks. During the epoch of thrusting, and locally as late as Miocene time, intrusive activity began and the granitic plutons south of the Study Area were emplaced. Many of the metallic mineral deposits adjacent to the Study Area are related to this period of thrust faulting and intrusive activity. In Late Cretaceous and early Tertiary (?) time, as much as 4,000 feet of clastic material, much of it very coarse, was deposited penecontemporaneously with deformation. Three Upper Cretaceous (?) to Tertiary clastic units, widely distributed south of the Study Area, are designated the Gale Hills Formation; this includes the Horse Spring Formation, mapped separately in this Area. Beds of tuff in the Cretaceous rocks give evidence of volcanism in the general region.

During Tertiary time, 2,000 to 6,000 (?) feet of fresh-water clastic and chemical sediments were deposited unconformably on Paleozoic and Cretaceous strata in the north section of the Study Area. The beds, Miocene (and older ?), were then tilted, eroded, and locally succeeded

by the more than 2,500-plus feet of Pliocene (?) lacustrine and stream deposits, containing some intercalated olivine basalt flows, comprising the Muddy Creek Formation.

The Muddy Creek Formation was deposited in basins that corresponded to a considerable extent to present valleys except that, for a long time, the intervening highlands were lower and some of the basins were more extensive than now. These highlands are composed of a variety of sedimentary, metamorphic, and igneous rocks varying in age from Precambrian to Recent. Uplift and wedging of the marginal rock mass against the basins, deformed much of the Muddy Creek Formation both during and after its deposition. In many places, the subsurface slope of the basin sides doubtless resembled that of the present mountain fronts in that the increase in depth of fill toward the valleys is rapid. Locally, flat-lying Muddy Creek beds rest with depositional contact on older rocks; elsewhere the beds are in fault contact and are tilted more-or-less sharply.

The small scale structural features within the area of interest are typified by broad synclines and adjacent, sharper anticlines that are frequently transected by faults (Exhibit 5). The faulting may be part of a major trend, such as the Rogers Spring fault, or it may be a more restricted feature. A critical aspect of the small scale faults is whether they are part of a system of integrated faults (as pictured by Anderson, 1973, in his Thin Skin Distension Model) or are isolated, discontinuous features (as pictured by Mannion, 1963).

The dip of the Muddy Creek beds in the Study Area ranges from a few degrees to more than 40 degrees along the flanks of some of the anticlines.

A secondary contorted bedding in the Overton Beach and Echo Bay areas is impressed on the broader structural features. This contortion is probably related to the solution of near surface gypsum and salt layers. The degree of contortion is a function of the near surface volume of gypsum and salt and the amount dissolved.

Exposures of younger floodplain and lake deposits, the Las Vegas Formation, are distributed around Overton Beach. Vertebrate and invertebrate fossils found therein indicate a humid climate, and radio-active analyses of charcoal found in these beds indicate dates ranging from several thousand to more than forty thousand years ago.

Lithologic Characteristics

The salt deposit is enclosed by an envelope of Muddy Creek siltstones, sandstones, claystones, and shales. The salt is generally surrounded by a layer of mixed evaporitic material in a silty matrix. The upper layer is from 100 to 200 feet thick, and glauberite ($Na_2SO_4 \cdot CaSO_4$) and anhydrite ($CaSO_4$) are the principal evaporitic minerals. The lower marginal layer exhibits thicknesses up to 500 feet; and halite, glauberite, anhydrite, and gypsum are the evaporitic minerals in the clayey, siltstone, and sandstone matrix (Mannion, 1963).

Mannion (1963) describes the composition of the salt deposit as follows: "Within the salt body the halite is coarsely crystalline, generally brownish or gray, and contains only sparse indications of bedding. Salt crystals mostly range from one-quarter to one-half inch in diameter. Layers of glauberite, clay, and tuff are the principal evidence of stratification. Some layers show distortion and a few are completely disrupted, evidently through recrystallization of the salt. The overall quality below the upper 400 feet of salt is about 93 percent sodium chloride. Impurities consist mostly of grains, blebs, and interstitial masses of light brown, fine sand, silt, and glauberite between and within salt crystals. Locally, masses of exceptionally pure, recrystallized salt occur in which cleavage surfaces more than three inches across have been seen. The shape and orientation of these recrystallized masses are not known but they can hardly be bedded."

"Glauberite is an abundant and ubiquitous constituent of the evaporite body probably averaging more than three percent of the total deposit. It occurs as saccharoidal to coarsely crystalline beds and as euhedral crystals of plowshare habit up to two inches long dispersed or interlocked in salt and siltstone. The euhedral crystals are randomly oriented although near vertical attitudes are perhaps most common. Fine intermixtures of silt and glauberite present a speckled brown and white appearance. The mineral exhibits some interesting physical and optical characteristics including the property of dissolving incongruently, leaving a calcium sulfate residue which recrystallizes in the laboratory to the fibrous variety of gypsum. This gives rise to the possibility that some of the gypsum found in the Muddy Creek formation was derived from weathering and solution of glauberite beds. Near the salt outcrops, selenitic gypsum, apparently pseudomorphous after glauberite, is abundant both as beds and dispersed crystals in shale. A large outcrop of glauberite was reported by Longwell (1928, p. 24) prior to the filling of Lake Mead. Glauberite has a markedly lower solubility in fully saturated sodium chloride brine than in that which is only a few percent below saturation. It seems

likely, therefore, that glauberite would tend to crystallize along with halite which, indeed, is the association in the deposit."

The frequent presence of the unhealed deformational features within the salt found in the Study Area indicates either that it has been subjected to relatively recent faulting, which may have either cut out or repeated some of the salt section, or that the salt may be continuing to intrude the overlying portion of the Muddy Creek. In both cases, the internal salt structures will be more complicated than the original layering.

Surface Exposure of Salt Deposits

Salt is exposed on the surface near the northern end of the Salt Cove anticline (Exhibit 5). Two old mines were located in this area, the Salvation Salt Mine and the Big Cliff Mine. The salt outcrops in the vicinity of these mines occur as a series of sharp bulges on top of the anticline. Some of the structures in the vicinity of the salt outcrop resulted from regional tectonic forces, some from flowage and intrusive movement of salt and, most recently, others were caused by solution collapse along the lake margin.

A number of mines along the course of the Virgin River east of the Study Area are now covered by Lake Mead.

The outcrops along the river have been known for a long time. They were used as a source of salt by the Indians, and later by the early settlers. These outcrops were described by Longwell (1935). In length, the area of the salt outcrops extends from Overton Beach south for approximately 40 miles.

Corehole Data of Salt Area

Subsurface data for a portion of the area of salt deposits were available from six holes drilled for Stauffer Chemical Company in the early 1960's. Dr. L. E. Mannion of Stauffer Chemical Company provided C.K. GeoEnergy Corporation with core and cuttings descriptions from these six holes drilled in the area between Echo Bay and Overton Beach. Their locations are shown on Exhibit 6. Detailed locations of these core holes and descriptions of the cuttings and cores are presented in the corehole data section of this report.

Based upon the assessment of the Stauffer geologists, only two of the holes (SCB-1 and SCB-2 located in the southern half of the Study Area) completely penetrated the Muddy Creek (salt-bearing) Formation.

Two coreholes (SCB-2 and SSC-3) completely penetrated the halite zone. Hole SCB-1 (which was not cored) did not encounter halite.

Apparent thicknesses of the salt zone and its overburden along with locations of the Muddy Creek basalt marker bed and other mineral occurrences are shown in Table I. As indicated in the table, at the Stauffer corehole locations, the thickness of the salt zone overburden varies between 864 feet and 2,256 feet and the salt zone apparent thickness ranges from zero to 1,757-plus feet. These relationships are shown graphically on correlation section A-A' (Exhibit 7). The plan orientation of this section, as shown on Exhibit 6, begins at corehole SCB-2 in the south and ends with corehole SSC-3 in the north.

Dips of beds within the halite zone were determined from the cores from all five of the holes that were cored while dips of the overburden were determined from cores from SSC-1, SSC-2, and SSC-3. These measurements are summarized in Table II. As indicated in this table, (1) the dips of the halite zone in each corehole are fairly consistent with those of the overburden, (2) dips within the halite zone vary considerably at SSC-1 and SCB-2 corehole locations, and (3) maximum dip was 45° as shown in coreholes SSC-4 and SCB-2. It is concluded that considerable folding of the halite beds has occurred and that not all the beds in a given section have been folded uniformly.

Indications of relatively recent deformation of the halite were found in corehole SSC-2 in the form of shattered salt. This phenomenon was observed at various depths over a 474-foot interval between 2,446 feet and 2,920 feet. Halite cores from SSC-1 exhibited shearing parallel to the bedding at a depth of 2,241 feet, diagonal fracturing and slickensides with a 30° dip at a depth of 2,908 feet, and shattered salt in the interval 2,968 feet to 2,997 feet. Shattered salt was also observed in the core from SSC-4 between 1,032 feet and 1,297 feet. No indications of fault deformation were recorded for SSC-3 and SCB-2.

Areal Extent of Salt Area

The full areal extent of the salt deposits has not been determined since it has not been extensively cored. The approximate limit drawn on Exhibit 5 was revised after that of Mannion (1962) and represents the best available estimate at this time.

The regional gravity map (Joesting, 1964) shows a broad low in the Study Area that conforms to the valley fill. Since no local low is indicated in the area of thick salt deposits south of Overton Beach, the sensi-

TABLE I

STAUFFER CHEMICAL CORPORATION COREHOLE DATA

VIRGIN RIVER VALLEY SALT DEPOSIT AREA, CLARK COUNTY, NEVADA

Depth and Estimated Thickness of Halite Zone

and Presence of Other Mineral Zones

	SSC-1	SSC-2	SSC-3	SSC-4	SCB-1	SCB-2
HALITE ZONE						
Depth (Feet)	2,070	1,877	864	1,000	-	2,256
Apparent Thickness (Feet)	988+	1,757+	1,166	338+	0	260
True Thickness * (Feet)	963+	1,750+	1,010	277+	0	255
OTHER MINERAL ZONES (Feet Above Halite Zone)						
Basalt Marker	1,420	1,397	Not Encountered	Not Encountered	-	Not Encountered
Glauberite Zone	506	47	92	180	-	Not Noted

*Determined using estimated average dips from Table II.

TABLE II

STAUFFER CHEMICAL CORPORATION COREHOLE DATA

VIRGIN RIVER VALLEY SALT DEPOSIT AREA, CLARK COUNTY, NEVADA

Summary of Dip Measurements on Cores

	SSC-1	SSC-2	SSC-3	SSC-4	SCB-1	SCB-2
MEASURED DIPS (Degrees)						
Halite Zone Overburden	0° - 20°	5°	10° - 38°	None Recorded	-	None Recorded
Halite Zone	0° - 30°	0° - 9°	30°	25° - 45°	-	0° - 45°
ESTIMATED AVERAGE DIP (Degrees)						
Halite Zone	13°	5°	30°	35°	-	11°

tivity of the survey does not appear to be high enough to help outline the salt body. However, the lack of a gravity low extending across the Rogers Spring Fault indicates that the older rock is at a shallow depth west of the fault. Thus, there is little chance of thick salt deposits west of the fault.

The salt extends to the east under the present Overton Arm of Lake Mead. Outcroppings of salt were reported there by Longwell (1935) in his survey of the Future Lake Bottom. Old salt mines and prospects are also reported from the area now covered by the lake.

There are probably a series of salt deposits along the course of the old Virgin River Valley system. Old mines are reported in the area now covered by the lake south of the Overton Islands; and similar, though thinner deposits have been reported at Detrital Valley and Red Lake (Hualpai Valley) to the south of Lake Mead in Arizona (Eaton, 1972).

Thickness of Salt Deposits

The amount of information available allows only rough approximations of the thickness of the salt in the Study Area.

The thickest salt section is south of Overton Beach, where corehole SSC-2 encountered over 1,700 feet of halite. Corehole SCB-2 near Echo Bay found the salt section to be only 260 feet thick, and corehole SCB-1 between Overton Beach and Echo Bay did not find the salt. Thus, the thickness appears to be quite variable and somewhat intermittent.

An isopachous map of the salt deposit is presented as Exhibit 6. The location of the zero thickness contour of this map corresponds to the salt limit shown on Exhibit 5. Estimated true thicknesses of the halite zone shown on the map are taken from the data in Table I. Based upon this map, the area of the salt zone with thickness greater than 1,500 feet is estimated to be about four square miles with less than two square miles underlying dry land. The area of the salt zone with thickness greater than 1,000 feet is estimated to be about nine square miles, with about four and one-half square miles underlying dry land.

Surface Geology - Field Reconnaissance

During the week of August 7, 1977, Mr. Charles R. Boardman made a field reconnaissance of the Study Area for the purpose of examining the geologic features of the area as relates to the salt deposits. As part of this reconnaissance, he examined the outcrops of the Muddy Creek Formation along the Lake Mead shoreline as well as along roads authorized

for vehicular traffic between Echo Bay and Overton Beach. Indications of severe deformation (including faulting) were observed at a number of locations. One of the more spectacular examples is in the Valley of Fire Wash, approximately one mile due west of SSC-1. At this location, steeply dipping Muddy Creek clay beds are bounded abruptly on the east and west by relatively flat-lying clay beds.

A steeply dipping fault with less than 10 feet of displacement was observed less than one-half mile east of SSC-1.

The outcrop of the halite zone was observed on the shore of the lake at Salt Cove, approximately one mile east-southeast of SSC-3. This outcrop appears to be the top of the halite zone since an approximately 10-foot interval of clay overlies the halite at this location. A large salt block with overlying clay is exposed in the outcrops. A rather obvious vertical fracture transects the salt block. Deformation at this location has been extremely severe and appears to be recent as evidenced by a dry wash bed which has been dammed up by slumping blocks with no evidence of silting against the natural block dam. Another nearby dry wash bed was similarly dammed up but contained a 4- to 5-foot thick section of sediments against the dam. Extensive open fissures have developed in the rock through which lake water is free to move. Superimposed upon the regional dip of the beds are many localized flexures with a multiplicity of attitudes, which suggests that extensive solution of the salt has occurred, resulting in subsidence of the overlying rock. Substantial displacement of beds (several hundred feet) is suspected because of the close proximity (several hundred feet) of the marker basalt bed to the halite. (In coreholes SSC-1 and SSC-2, the basalt bed is more than 1,000 feet above the halite zone.) Other open fissures were observed elsewhere along the lake shore south of Salt Cove.

Mr. John Bezy, a geologist with the National Park Service, stationed at Echo Bay, stated that he has observed a fault scarp in the alluvium near Rogers Spring, located 1.3 miles north of SCB-1 and 2 1/2 miles due west of Stewarts Point on the lake shore.

TECTONIC STABILITY OF AREA

Tectonic Activity

The Virgin River Valley, Clark County, Nevada, is not classified as tectonically active. However, a number of earthquakes were reported in the area during the time Lake Mead was being filled.

Mannion (1963) reported after his study of the area, that the movement on the Rogers Spring Fault probably started before or during early Muddy Creek time and has persisted almost to the present. Further, near surface deformation of the beds, associated with dissolution of salt by Lake Mead and tributary waters, is taking place at the present time.

Thus, the area was one of major tectonic activity in the past which has diminished to a low level of activity at the present time.

Seismicity

Historical Lake Mead earthquakes with magnitude equal to or greater than Richter 4.0 (or modified Mercalli Intensity equal to or greater than V) were tabulated by Rogers and Lee (1976). Their record started in 1936 and includes 30 earthquakes; the first occurring on September 7, 1936, and the last on September 23, 1964. With only four exceptions, the epicenters were located at or near latitude 36.0 degrees North, longitude 114.8 degrees West in the vicinity of Hoover Dam. The highest magnitude recorded was 5.0 and the highest intensity was VI.

HYDROLOGIC STABILITY OF SALT DEPOSITS

Detailed hydrologic evaluations have not been carried out in the Virgin River Valley Study Area (personal communications from Desert Research Institute at Las Vegas and Bureau of Reclamation at Boulder City). However, it is reported that the U.S. Geological Survey is now conducting a study of the groundwater hydrology of the area for the National Park Service.

Core drilling in the salt body itself indicated that the salt was dry (Mannion, 1963).

Some of the stratigraphic units above and below the salt body are relatively coarse clastics which would be expected to have appreciable transmissivity. However, Longwell (1935) reported that most of these units were lenticular and could be traced only a few hundred yards. Hence, we would not expect to find a major integrated aquifer system.

There are a number of faults in the area that could act as fluid conduits and charge the permeable elements with water from nearby Lake Mead. This may cause water problems in the drilling of shafts and in other access holes to an underground working.

MINERAL RESOURCES IN THE AREA

There are no mines or prospects in the area of the Virgin River Valley salt deposits that are not related to the evaporites, such as gypsum and halite.

Mineralization of the older rocks is widespread in the general area. However, the trend seems to run southwest from the Virgin Mountains, through the El Dorado Mountains located south of Hoover Dam, and on south through the Searchlight district (Longwell, 1965), and not under the valley fill rocks of the Study Area. The valley fill deposits range from one-half to one mile in thickness and probably preclude mineral exploration in the underlying deposits.

Oil and gas prospects in the area are not considered favorable because of the pervasive fracturing of the older rocks and the resulting problem for trapping of oil and gas (Osmond and Elias, 1971).

The salt deposits are located within the Lake Mead Recreation Area. Mineral exploration and exploitation in the salt deposit area are inhibited by restrictions on such activities within the Recreation Area.

OTHER SALT DEPOSIT AREAS

Other salt deposit areas in northern Arizona and southern and central Nevada are shown on Exhibit 1 and are briefly described below.

Mormon Mesa

Mormon Mesa is located in Clark County, Nevada, immediately north of the Virgin River Valley Study Area. It is considered to be a potential salt deposit area inasmuch as it appears to contain a thick section of Muddy Creek sediments and the northern extent of the salt in the Muddy Creek at Virgin River Valley has not been established.

Detrital Valley

Detrital Valley is located in northwestern Mohave County, Arizona, about seven and one-half miles south of Lake Mead. Muddy Creek deposits in the Valley contain 500 feet to 700 feet of bedded salt, at depths of 420 feet to 600 feet, extending over several square miles (Pierce and Rich, 1962). Core descriptions indicate that impurities in the salt, including anhydrite and clay, range from less than five percent to more than 40 percent.

Several groups have considered this deposit as a source of salt for chlorine production and minimal pilot work has been done. A solution mining/solar evaporation salt recovery program has been approved but the project has funding problems.

Red Lake Dome

Red Lake Dome is in the Hualpai Valley of northern Mohave County, Arizona. The salt is thought to occur in the Muddy Creek Formation and has a maximum thickness in excess of 4,000 feet. Three coreholes have encountered the top of the salt between the depths of 1,200 feet and 1,800 feet.

Luke Dome

Luke Dome is located in Maricopa County, Arizona, 15 miles west-northwest of Phoenix. Eaton, et al. (1972) have published the results of a detailed study of this salt feature. Geophysical data indicate the salt to be as shallow as 500 feet and suggest that the base of the salt body is at a depth of at least 6,900 feet. Salt from the dome is produced and sold by Southwest Salt Company.

Picacho Reservoir

Salt has been encountered at 1,936 feet in a drill hole located near Picacho Reservoir in Pinal County, Arizona, near the southeast end of the Phoenix Basin (Luke Dome is near the northwest end of this basin). Thickness and extent of this salt deposit are unknown.

Holbrook Basin

Holbrook Basin, also known as Supai Basin, is located in Navajo and Apache Counties, eastern Arizona.

A detailed description of the salt deposits in this Basin has been published by Mytton (1973). The salt beds are part of a clastic and evaporite sequence of Permian age that underlies an area of approximately 2,300 square miles and ranges in depth from 600 feet to 2,500 feet. The salt occurs as thin (10 feet to 20 feet), discontinuous units within an evaporite-bearing interval that is 450 feet to 1,300 feet thick.

Pima Area

Salt has been penetrated between the depths of 2,329 feet and 2,339 feet by a test boring located near the town of Pima, Graham County, southeastern Arizona.

Northern and Central Nevada

Numerous playa lakes in northern and central Nevada are known to contain deposits of salt. These include:

Occurrence	Location
Charleston	Northern Elko County
Buffalo Springs	South-Central Washoe County
Carson Sink Area*	Northwestern Churchill County
Dixie (Humbolt) Salt Marsh	Northeastern Churchill County
Diamond Range	East-Central Eureka County
Wabuska	Central Lyon County
Sand Springs	Southwestern Churchill County
Teel's Marsh	Southern Mineral County
Rhodes Marsh	Southeastern Mineral County
Butterfield Marsh	Eastern Nye County
Columbus Marsh	Northwestern Esmeralda County
Silver Peak Marsh	Central Esmeralda County

* Includes Carson Sink, Eagle Salt Marsh, White Plains (Humbolt Sink), and Parran.

Some of the deposits appear to be thin, surface accumulations but exploration has not been adequate to determine their actual size.

A number of core holes, together with further geologic studies, would be required to determine the suitability of the above named salt deposit areas for further consideration for possible storage of radioactive waste material.

EXHIBITS

GEOLOGIC INVESTIGATION

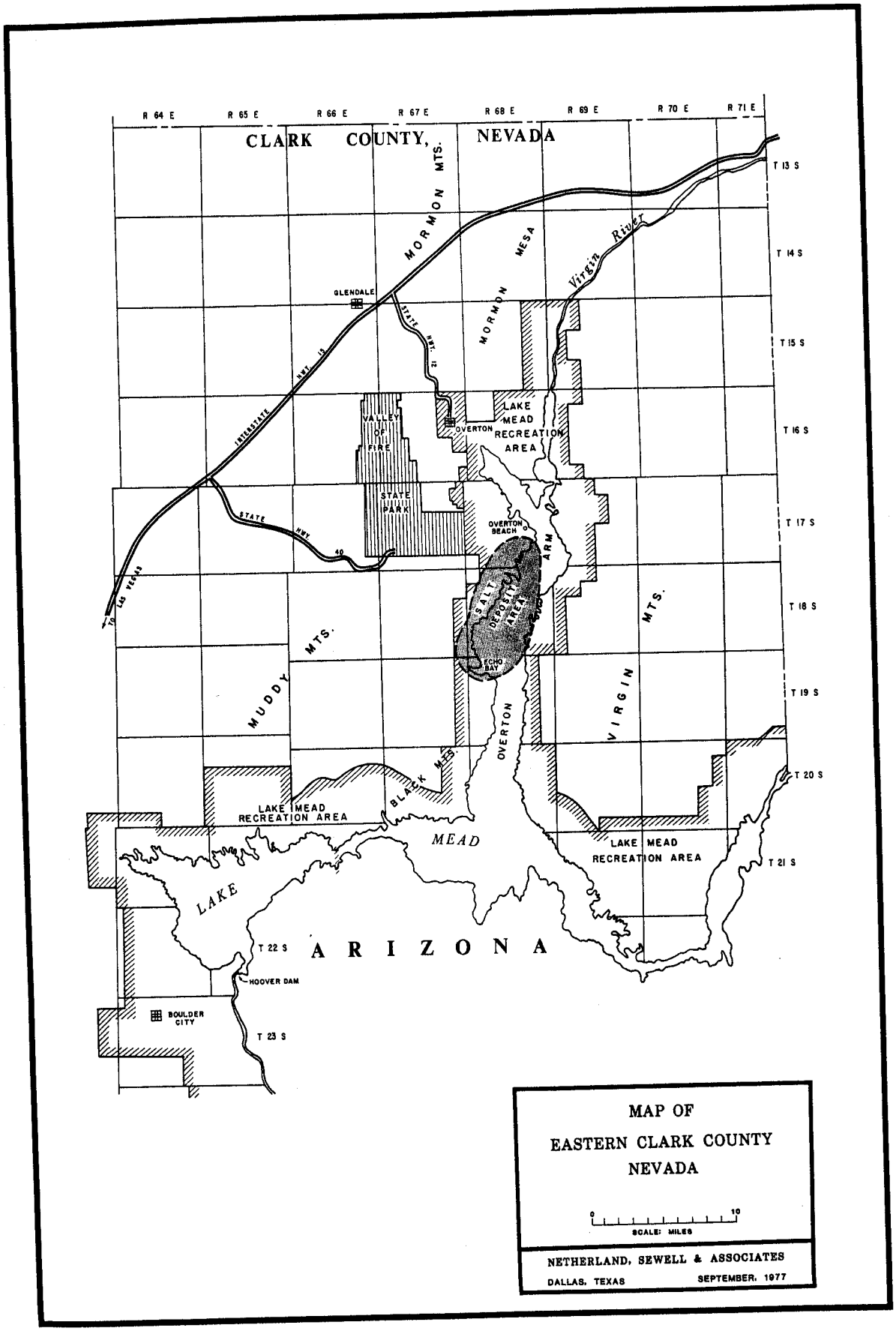
of the

VIRGIN RIVER VALLEY SALT DEPOSITS

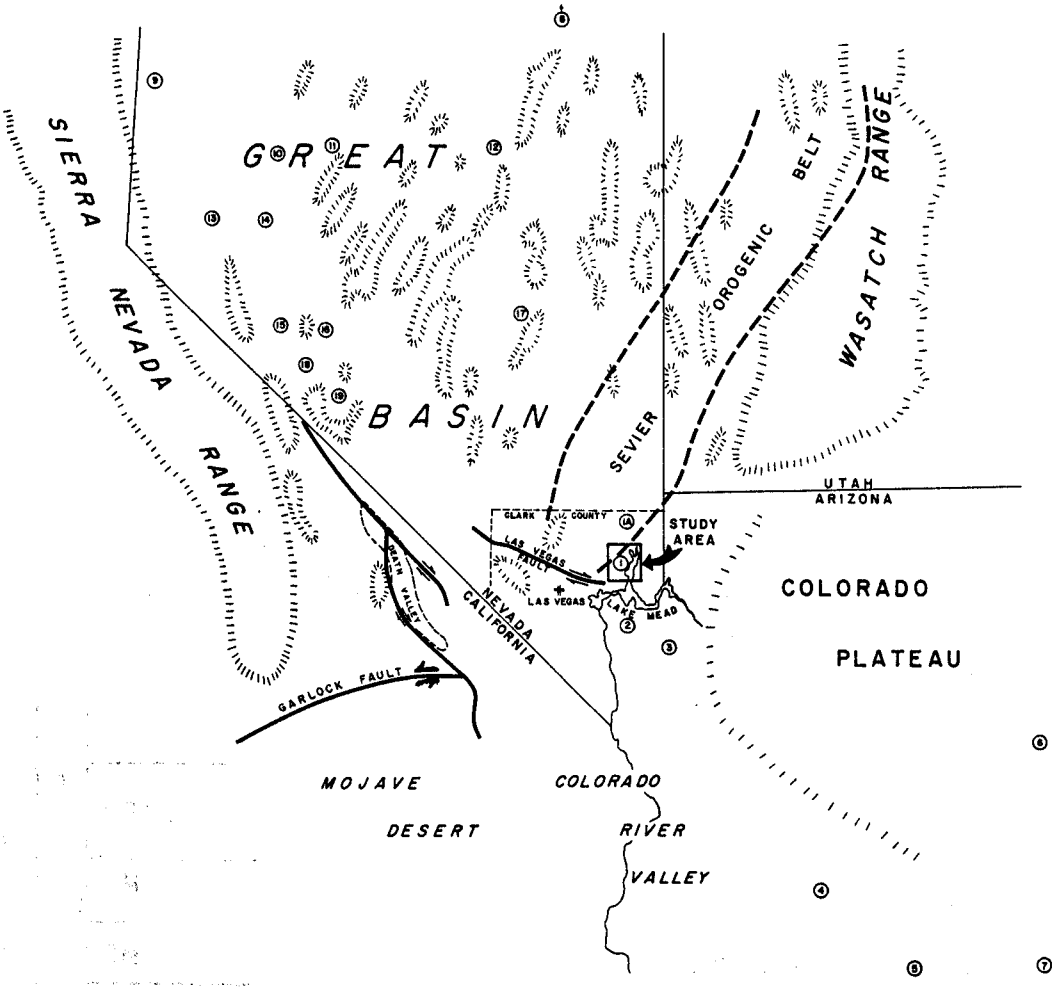
CLARK COUNTY, SOUTHEASTERN NEVADA

as of

SEPTEMBER, 1977



Location Plat



SALT DEPOSITS

CLARK CO., NEVADA

(1) VIRGIN RIVER VALLEY AND
(1A) POSSIBLE MORMON MESA EXTENSION

ARIZONA

(2) DETRITAL VALLEY
(3) RED LAKE DOME (HUALPAI VALLEY)
(4) LUKE DOME
(5) PICACHO RESERVOIR
(6) HOLBROOK BASIN
(7) PIMA (SAFFORD VALLEY)

NEVADA

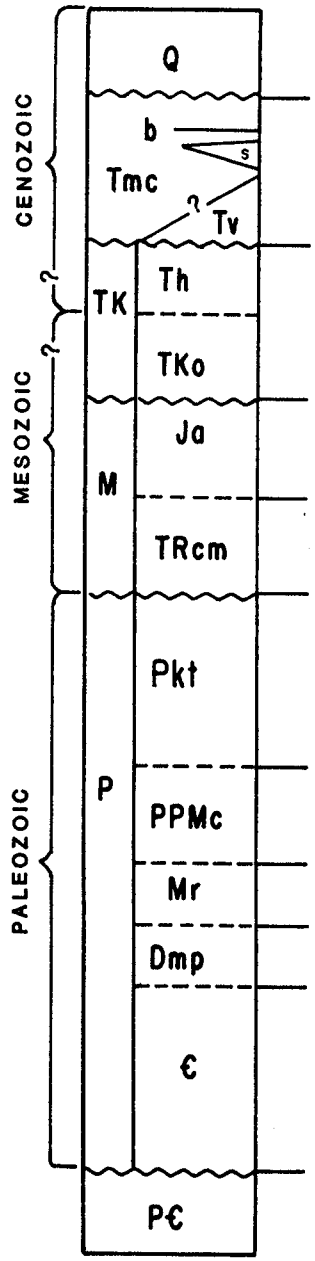
(8) CHARLESTON (30 MILES NORTH OF MAP)
(9) BUFFALO SPRINGS
(10) CARSON SINK
(11) DIXIE (HUMBOLT) SALT MARSH
(12) DIAMOND RANGE
(13) WABUSKA
(14) SAND SPRINGS
(15) TEEL'S MARSH
(16) RHODES MARSH
(17) BUTTERFIELD MARSH
(18) COLUMBUS MARSH
(19) SILVER PEAK MARSH

LOCATION MAP
VIRGIN RIVER VALLEY
STUDY AREA
CLARK COUNTY, NEVADA

SCALE IN MILES
40 0 40 80 120

NETHERLAND, SEWELL & ASSOCIATES, INC.
DALLAS, TEXAS SEPTEMBER, 1977

Exhibit 1



Recent Alluvium and Terrace Deposits.

Tertiary, Muddy Creek Formation - Shale, sandstone, evaporites - 2,500 feet. b - basalt flow, s - salt. Tertiary volcanics (Tv) south of area may in part be as young as or younger than Muddy Creek.

Tertiary (?) - Cretaceous (?) deposits - 4,000 feet. Gale Hill Formation including Horse Spring Formation (Th) and Overton Fanglomerate (TKo).

Jurassic, Aztec sandstone - 2,000 to 2,500 feet maximum.

Triassic, undivided. Includes Chinle Formation (1,000 feet), Shinarump Conglomerate (10 to 250 feet), and Moenkopi Formation (2,300 feet).

Permian, undivided. Includes Toroweap and Kiabab Limestones (600 feet), Coconino Sandstone (100 feet), and Queantoweap-Supai-Hermit Red Beds (1,100 feet).

Permian, Pennsylvanian, and Mississippian - Callville Limestone - 1,500 feet.

Mississippian, Rogers Spring Limestone - 800 feet.

Devonian, Muddy Peak Dolomite - 500 feet.

Cambrian - Upper Cambrian (and Ordovician?)(800 feet), Peasley Limestone (800 feet), Chisholm shale (70 feet), Lyndon Limestone (100 feet), Pioche shale (300 feet), and Prospect Mountain Quartzite (Tapeats Sandstone) (225 feet).

Precambrian Gneiss, Schist, and Granite.

STRATIGRAPHIC COLUMN

VIRGIN RIVER VALLEY, NEVADA

DALLAS, TEXAS NETHERLAND, SEWELL & ASSOCIATES, INC. SEPTEMBER, 1977

Exhibit 2

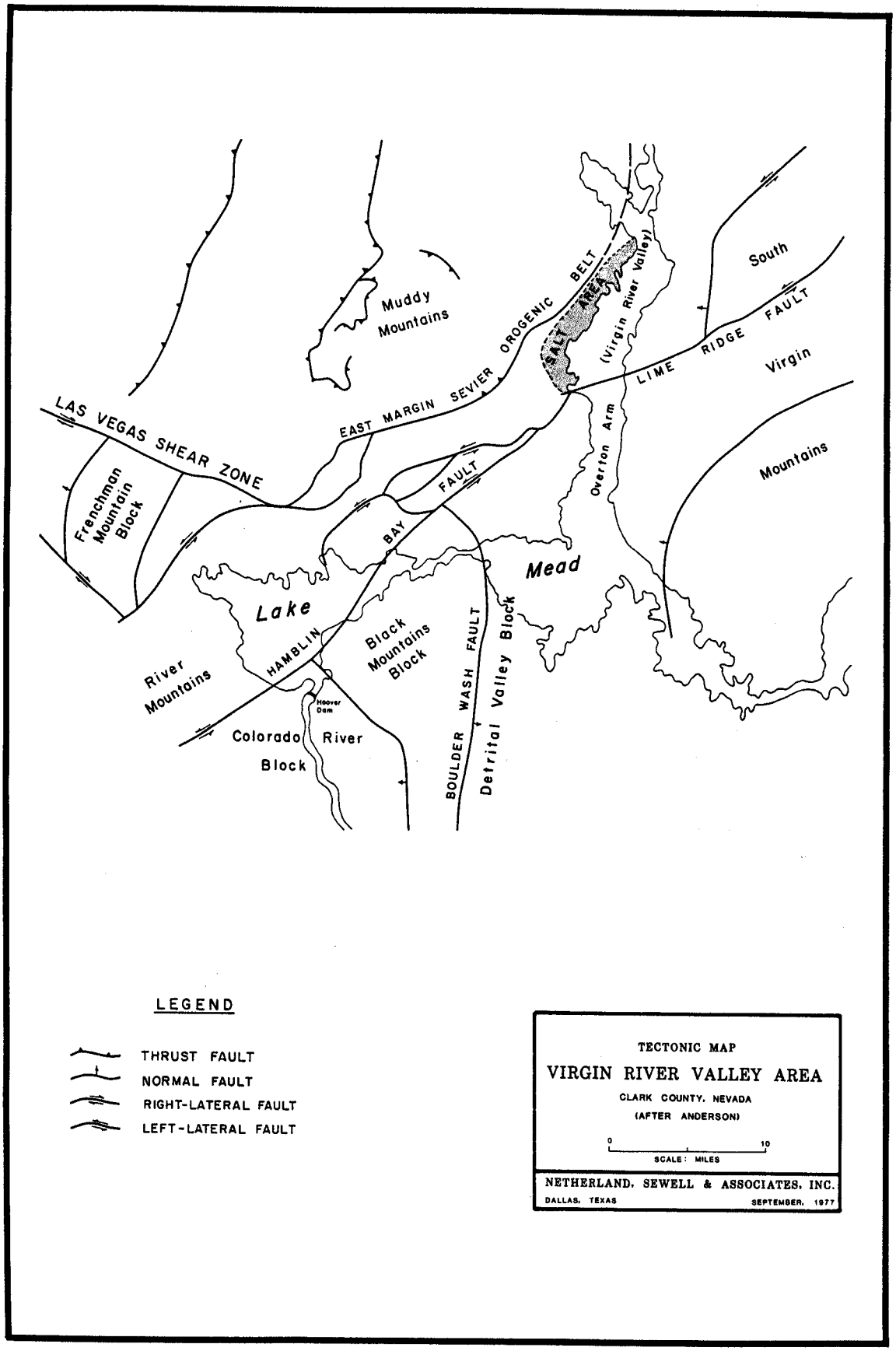

Muddy Mountains
SALT AREA
(Virgin River Valley)
South
LIME RIDGE FAULT
Virgin
Mountains
EAST MARGIN SEVIER OROGENIC BELT
LAS VEGAS SHEAR ZONE
Frenchman Mountain Block
FAULT
Overton Arm
BAY
Mead
Lake
HAMBLIN
Black Mountains Block
River Mountains
Hoover Dam
Colorado River Block
BOULDER WASH FAULT
Detrital Valley Block
LEGEND
THRUST FAULT
NORMAL FAULT
RIGHT-LATERAL FAULT
LEFT-LATERAL FAULT
TECTONIC MAP
VIRGIN RIVER VALLEY AREA
CLARK COUNTY, NEVADA
(AFTER ANDERSON)
0
10
SCALE: MILES
NETHERLAND, SEWELL & ASSOCIATES, INC.
DALLAS, TEXAS
SEPTEMBER, 1977

Exhibit 3

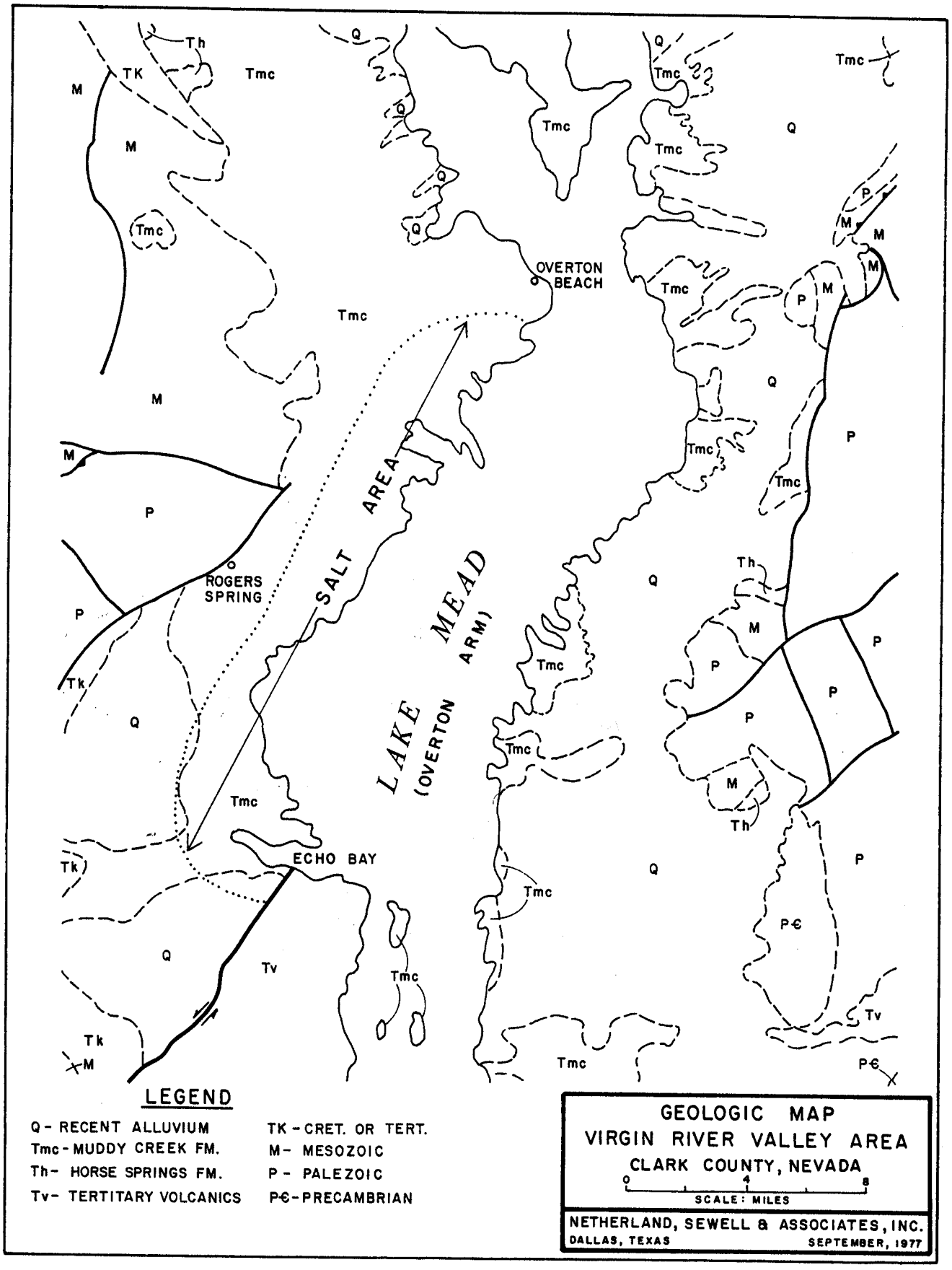

OVERTON BEACH
ROGERS SPRING
SALT AREA
LAKE MEAD (OVERTON ARM)
ECHO BAY
Th
TK
Tmc
M
Q
P
Tk
Tv
P€
LEGEND
Q - RECENT ALLUVIUM
Tmc - MUDDY CREEK FM.
Th - HORSE SPRINGS FM.
Tv - TERTITARY VOLCANICS
TK - CRET. OR TERT.
M - MESOZOIC
P - PALEZOIC
P€ - PRECAMBRIAN
GEOLOGIC MAP
VIRGIN RIVER VALLEY AREA
CLARK COUNTY, NEVADA
0 4 8
SCALE: MILES
NETHERLAND, SEWELL & ASSOCIATES, INC.
DALLAS, TEXAS
SEPTEMBER, 1977

Exhibit 4

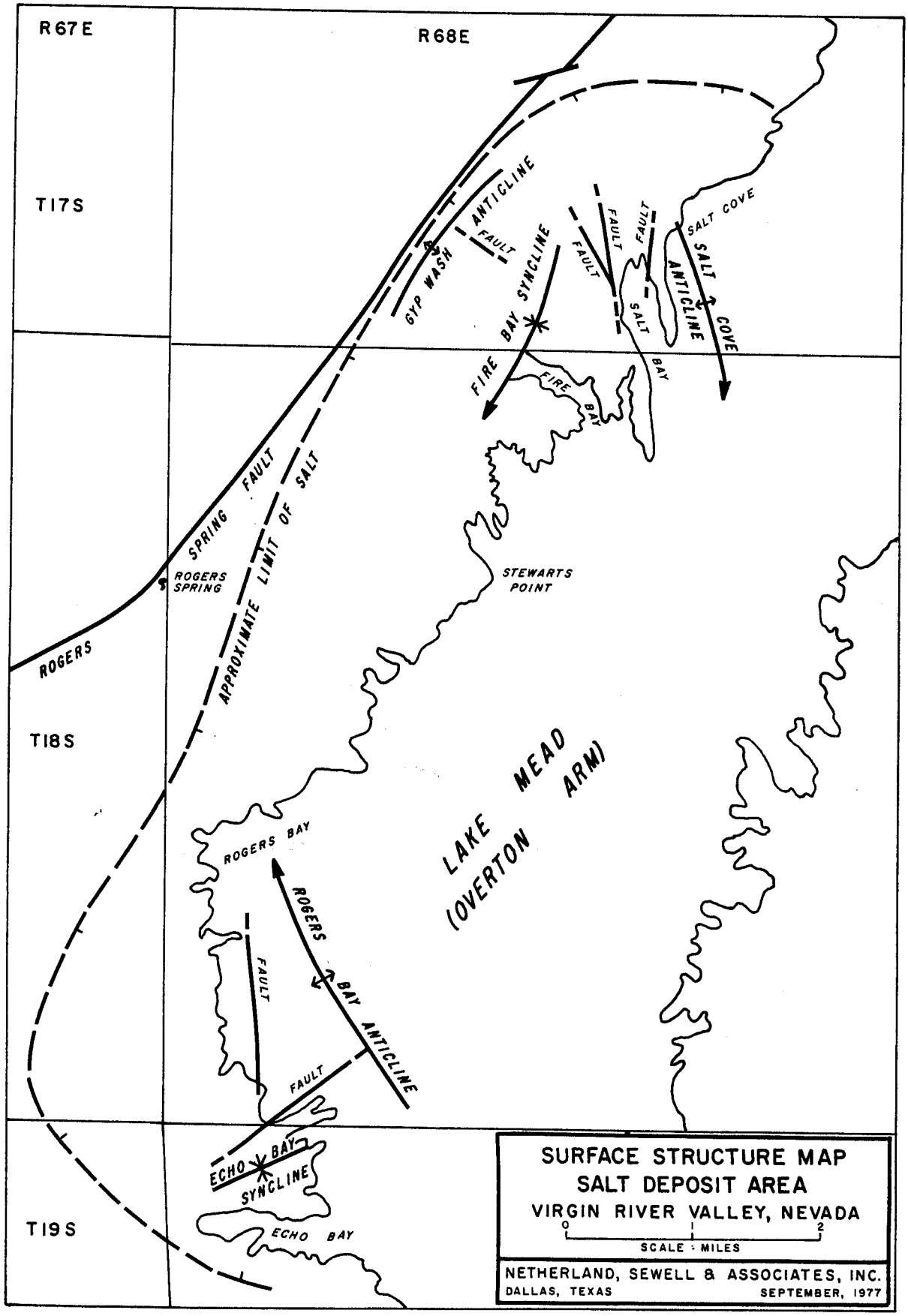

R67E
R68E
T17S
T18S
T19S
GYP WASH ANTICLINE
FAULT
FIRE BAY SYNCLINE
FAULT
FAULT
SALT COVE ANTICLINE
SALT COVE
FIRE BAY
FIRE BAY
SPRING FAULT
APPROXIMATE LIMIT OF SALT
ROGERS SPRING
ROGERS
STEWARTS POINT
LAKE MEAD (OVERTON ARM)
ROGERS BAY
ROGERS BAY ANTICLINE
FAULT
FAULT
ECHO BAY SYNCLINE
ECHO BAY
SURFACE STRUCTURE MAP
SALT DEPOSIT AREA
VIRGIN RIVER VALLEY, NEVADA
0
2
SCALE : MILES
NETHERLAND, SEWELL & ASSOCIATES, INC.
DALLAS, TEXAS
SEPTEMBER, 1977

Exhibit 5

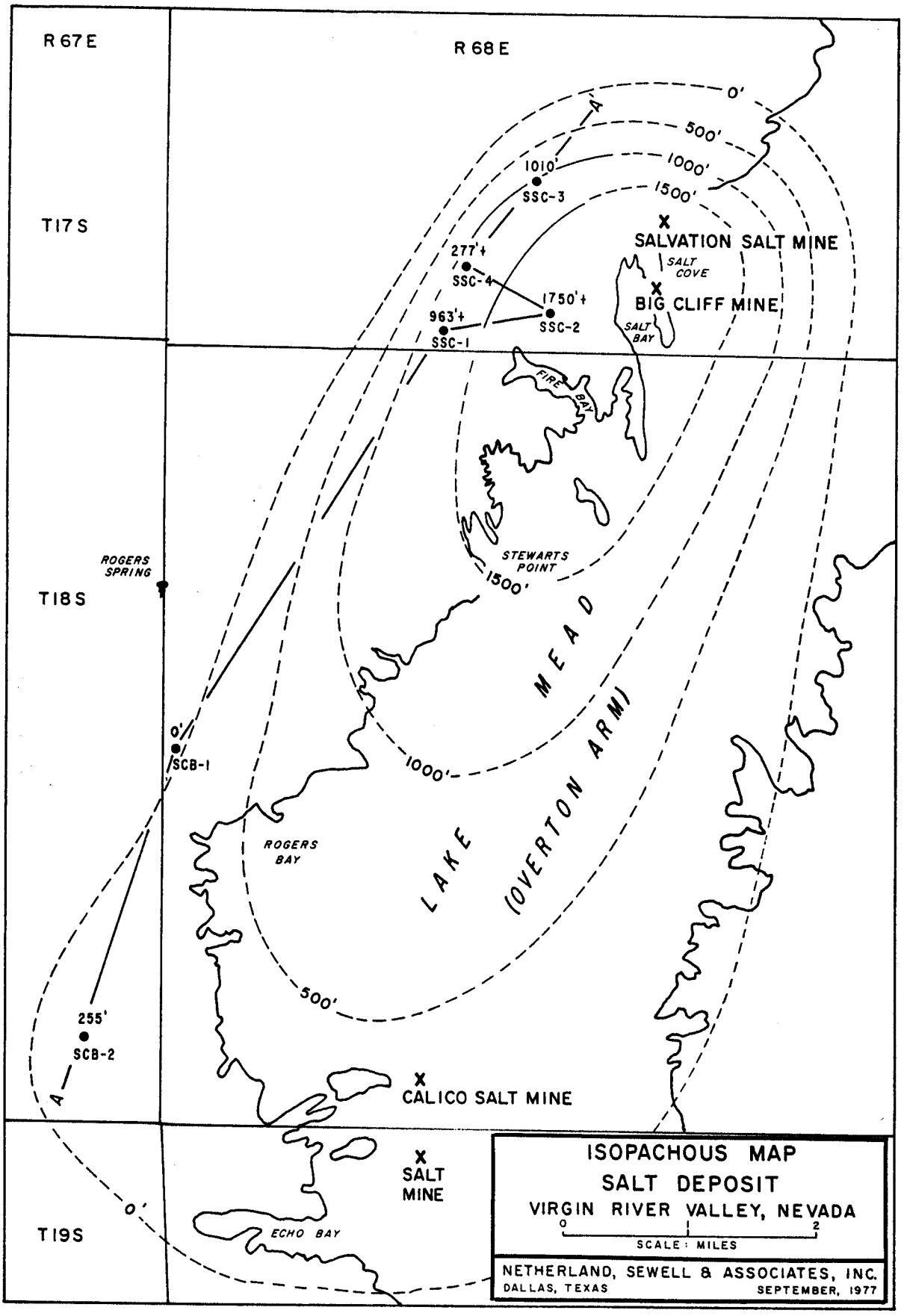
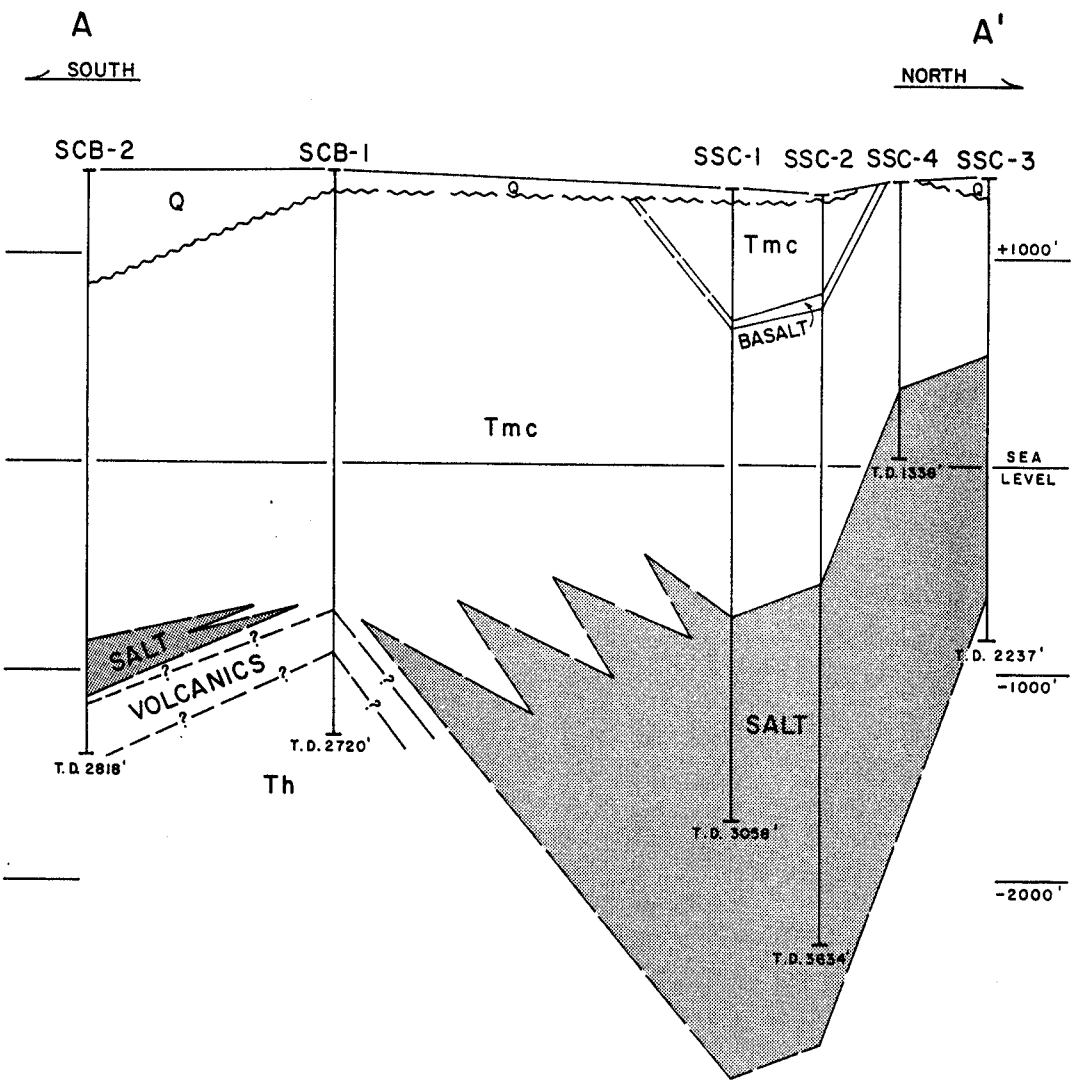

R 67 E
R 68 E
T 17 S
T 18 S
T 19 S
0'
500'
1000'
1500'
A
A'
1010'
SSC-3
277'+
SSC-4
1750'+
SSC-2
963'+
SSC-1
SALVATION SALT MINE
SALT COVE
BIG CLIFF MINE
SALT BAY
FIRE BAY
STEWARTS POINT
ROGERS SPRING
LAKE MEAD (OVERTON ARM)
ROGERS BAY
0'
SCB-1
1000'
500'
255'
SCB-2
A'
CALICO SALT MINE
SALT MINE
ECHO BAY
0'
ISOPACHOUS MAP
SALT DEPOSIT
VIRGIN RIVER VALLEY, NEVADA
0
2
SCALE : MILES
NETHERLAND, SEWELL & ASSOCIATES, INC.
DALLAS, TEXAS
SEPTEMBER, 1977

Exhibit 6



LEGEND

Q - RECENT ALLUVIUM

Tmc - MUDDY CREEK FORMATION (INCLUDES BASALT MEMBER AND SALT)

VOLCANICS - PART OF HORSE SPRING ?

Th - HORSE SPRINGS FORMATION

COREHOLE
CORRELATION SECTION
A - A
VIRGIN RIVER VALLEY AREA
CLARK COUNTY, NEVADA

0 1 2 3
HORIZONTAL SCALE: MILES

NETHERLAND, SEWELL & ASSOCIATES, INC.
DALLAS, TEXAS SEPTEMBER, 1977

Exhibit 7

Corehole data shown in this section of the report were obtained from Dr. L. E. Mannion of Stauffer Chemical Company. These data were obtained from six core holes drilled for Stauffer Chemical Company in the early 1960's in the area between Echo Bay and Overton Beach now included in the Virgin River Valley Study Area.

The locations of these core holes are shown on Exhibit 6.

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN 4/13/60 FINISHED 4/22/60 LOGGED BY L.E.M. DRILLED BY Armstrong Fowler Co. DRILL HOLE SSC-1
ELEV. 1340 TOTAL DEPTH 3058 LOCATION 778' N. & 401' E of S.W. cor. sec. 33, T 17S, R6E ORE Salt 2070 (-) to 3058(+)

FOOTAGE FROM	TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
0	65	65	Cuttings	Alluvium	Gravels with local caliche beds up to 8' thick			17' of 16" casing cemented into top of hole. Samples lost, flooded by drilling mud.
65	90	35	"	Muddy Creek	Clay, buff to light buff			
90	100	10	"	" "	Clay, light greenish tan, sticky.			* All depths measured from kelly bushing 9.8' above ground level.
100	150	50	"	" "	Clay, light greenish gray, sticky.			
150	330	180	"	" "	Clay, light brown, locally greenish or grayish brown, sparse gypsum. Grades downward into more greenish brown clay; contact arbitrary.			
330	500	170	"	" "	Clay, sparse silt, slightly greenish brown, locally greenish gray. Grades into less green clay below, contact arbitrary.			
500	650	150	"	" "	Clay, local silt, light brown, with somewhat darker brown, sparse greenish brown; becomes somewhat more compact downward.			
650	679	29	"	" "	Basalt, very dark gray to black, fine grained.			Sample from 650.' to 660' shows mostly clay, but there is a 10' lag in receiving cuttings at top of hole.
679	810	130	"	" "	Clay and local silt, clay is greenish brown, silt is light brown, becoming more compact than above.			

STAUFFER CHEMICAL COMPANY DRILL LOG

page 2

BEGUN____ FINISHED____ LOGGED BY____ DRILLED BY____ DRILL HOLE SSC-1
ELEV.____ TOTAL DEPTH____ LOCATION____ ORE

FOOTAGE FROM	TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
810	1150	340	Cuttings	Muddy Creek	Clay and fine silt, greenish brown tending toward brown downward, scarce light brown silt. Much is approaching soft shale in compactness; like 679' to 810'.			
1150	1170	20	"	" "	Same as above, but with trace gray sand stone.			Trace of gypsum (anhydrite) at 1270' ±
1170	1200	30	"	" "	Clay and silt, brown, local greenish brown, with trace gray sandstone and trace (local) gypsum			
1200	1310	110	"	" "	Clay and silt, greenish brown to brown, local trace gypsum, sparse fine tanish gray sandstone.			
1310	1360	50	"	" "	Clay and silt, brown to greenish brown; 1% to 5% anhydrite, scattered.			
1360	1420	60	"	" "	Clay and silt, brown, local greenish brown, bare trace selenitic gypsum.			
1420	1520	100	"	" "	Clay and siltstone, brown to greenish brown, some selenite and anhydrite locally.			
1520	1560	40	"	" "	Clay and siltstone, brown to greenish brown, trace greenish gray, some selenite and anhydrite locally.			
1560	1573	15	"	" "	Anhydrite, gray to white impure with about 10% green shale; anhydrite is fine to coarsely crystalline.			

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SSC-1

ELEV. G.L._____ DEPTH_____ LOCATION_____ PAGE 3

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
1564	1573	9	Core	Muddy Creek	Shale, brown, so..ft clayey with crystals and thin layers of anhydrite (?) or glauberite (?)			Core quite plastic when wet; difficult to core, much appears jammed into barrel Drag bit used. Slow penetration, up to 35 min per foot.
1573	1655	82	Cuttings	" "	Clay and siltstone, both shaly appearing locally, brown, locally greenish brown.			
1655	1705	50	"	" "	Clay and silt, brown, locally green brown and sparsely gray green; 10% to 30% anhydrite (?) and gypsum (?). Moderate efflorescence on cuttings after drying.			
1705	1730	25	"	" "	Same, but only 5% to 10% anhydrite (?)			
1730	1750	20	Core 7'	" "	Clay shale, brown, soft to locally firm, 0.1' of brownish gray saccharoidal anhydrite (?) at top.			Bedding horizontal
1750	1770	20	Cuttings	" "	Clay shale and siltstone, brown to light brown, local gray, sparse glauberite, slight efflorescence			
1770	1800	30	"	" "	Clay shale and glauberite, brown-gray brown shale, light gray to white, hydrated glauberite			

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SSC-1

ELEV. G.L._____ DEPTH_____ LOCATION_____ PAGE 4

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
1800	1850	50	Cuttings	Muddy Creek	Shale and local clay, brown, light brown, and about 10% gray shale. Much less clay, becoming fairly lithified in part; sparse glauberite.			
1850	1920	70	"	" "	Shale and siltstone, brown, local gray brown, local light gray; 5% to 20% glauberite (?); sparse, soft, round particles of unknown saline, possibly partly dissolved glauberite.			
1920	1976	56	"	" "	Shale and local siltstone, brown; locally considerable light gray and gray brown; sparse to local glauberite. Local slight efflorescence.			
1976	1986	10	Core 9'	" "	Glauberite, light to medium gray, impure, contains brown siltstone layers 25%; bedding is wavy.			Bedding wavy but nearly horizontal
1977.4	1986	8.6	7.6	" "	Interbedded shale, siltstone, sandstone, and glauberite; shale is clayey, brown and gray green; sandstone is light brownish gray; glauberite is gray. Dried core contains salty tasting efflorescence.			Bedding generally horizontal but dip of 20° appears on anhydrite layering 8" from bottom.
1986	2030	44	Cuttings	" "	Shale and clay, brown to gray brown, locally gray, trace of gypsum increasing downward, trace efflorescence at top increasing to moderate at bottom.			

STAUFFER CHEMICAL COMPANY DRILL LOG

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FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
2030	2070	40	Cuttings	Muddy Creek	Shale, clay, and gypsum or anhydrite, brown to light brown and buff to white; gypsum or anhydrite makes 20% to 40% of rock; heavy efflorescence; chloride content of drilling mud increasing.			
2070	2100	30	"	" "	Shale, clay, and anhydrite or gypsum, light brown to brown and buff to white; anhydrite or gypsum makes up 30% to 50% of rock; strong efflorescence to 2090, moderate to 2100'.			Possible salt 2070 to 2100
2100	2110	10	"	" "	Shale and clay, brown, some anhydrite or gypsum; heavy efflorescence on dry cuttings. Unknown hard rhombohedral (?) mineral (glauberite?)			
2110	2119				No sample			
2119	2148.7	29.7	29.5	Muddy Creek	Halite 90%, light gray to brownish, because of occluded clay; contains irregular blebs and small masses of gray, fine sandstone irregularly distributed through core; some euhedral crystals of glauberite			Core Number 1
2148.7	2154	5.3	5.3	" "	Halite, light gray, 80%; irregularly distributed, irregular masses of fine sandstone impregnated with salt; saccharoidal, anhydrite and sparse anhydrite(?) or glauberite (?) crystals, gray, brown and white.			

STAUFFER CHEMICAL COMPANY DRILL LOG

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FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
2154	2176.1	22.1	20.	Muddy Creek	Glauberite, light gray to white, coarsely crystalline, 85% with only sparse beds of fine brownish gray siltstone 10%. Less than 5% halite in thin beds, most abundant toward bottom.			Dips horizontal up to 20 degrees.
2176.1	2185.4	9.3	8.5		Glauberite, very light gray, coarsely crystalline to very coarsely crystalline 65%; halite, coarsely crystalline 35%; 0.3' brown siltstone from 2180.1' to 2180.4'.			
2185.4	2191.4	6	6		Halite, very light gray to white, coarsely crystalline, 75% to 80%; glauberite, coarse crystals, white, irregularly distributed; 20%; tuff, light gray, fine grained, bedded, 0.7' from 2190.7' to 2191.4'.		70% to 80%	Dips horizontal to 15 degrees.
2191.4	2215.5	24.1	17.4		Halite, light gray, locally white, fairly pure in top 4.4', remainder contains 35% to 40% medium coarse to coarsely crystalline glauberite, some enclosed in fine sandstone in irregular masses and beds.		4.4'-95% 19.7'-30% to 40%	Dips up to 15 degrees Mostly rather flat dips. From 2213.9 to 2215.0 is fine, gray. brown sandstone with only a few glauberite crystals and trace of salts.
2215.5	2229	13.5	13.5		Halite, white to light gray, 95% plus		95%	
2229	2237.3	8.3	8.3		Halite, 75% gray to light gray; glauberite in medium coarse crystals and masses.		75%	
2237.3	2244.3	7	7	Muddy Creek	Halite, light gray, coarsely crystalline 95%.		95%	

STAUFFER CHEMICAL COMPANY DRILL LOG

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ELEV. G.L._____ DEPTH_____ LOCATION_____ PAGE 7

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
2244.3	2250.5	6.2	4.7	Muddy Creek	Halite 45%, glauberite (?), coarsely crystalline, euhedral 55%.		45%	3 feet of core were lost from bottom of core #9, 1.5 feet of which is assigned to the glauberite bearing section
2250.5	2257.9	7.4	7.4	"	Halite, coarsely crystalline 90%		90%	
2257.9	2261.6	3.7	3.7		Halite, 50%; fine and coarse, euhedral glauberite and fine gray brown silty sandstone.		50%	
2261.6	2301	40.6	40		Halite, white to brownish gray 90% to 95%, local blebs and interstitial fillings of fine, impure, sandstone, 5%.		94%	"Ice cream salt" from 2267.5' - 2272.5'.
2301	2326	25	4	Muddy Creek	Halite, poor recovery, probably mostly halite 90% as above and below		88%	A 2" light greenish buff tuff at 2326.5(?) Location not certain because core box also has core labelled 2243' in it.
2326	2338	14	14	"	Halite, white to light gray 90%		90%	
2338	2347	9	9	"	Halite, light gray to light gray brown 60%; fine to coarse glauberite and light gray brown, fine silty sandstone interstitial to salt crystals; a fine sandstone bed at 2342.65' to 2342.5'		60%	Dips up to 15 degrees
2347	2368	21	18		Halite 85%; silty, brown sandstone, irregularily distributed as irregular masses containing medium fine to medium coarse glauberite.			

STAUFFER CHEMICAL COMPANY DRILL LOG

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FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
2368	2393	25	4.5		Halite 75% in core recovered; glauberite, white, coarse and fine in irregularly distributed crystals and masses and in 3 or 4 thin layers.		75%	Dips flat to 10°
2393	2567.4	174	174		Halite, white, very light gray and brownish, coarsely crystalline, contains finely disseminated brown silt and clay and also blebs and small masses irregularly distributed through some parts. Purity ranges up to almost 100%, probably average is 93 to 95%. Conspicuous impure zones; from 2479' to 2480.5' coarse glauberite (?) crystals; 85%; from 2470' to 2472.25' fine, saccharoidal, light brown sandstone 75%. Pure white milky salt from 2559' to 2567.4' with 0.6' of massive glauberite at top; milky salt also at 2549' to 2553.		90%-95%	Sheared salt, sheared parallel to bedding from 2441-2444.5.
2567.4	2577	9.6	4.3	Muddy Creek	Halite, brownish gray, with irregular seams and blebs of sandstone in top 2.7'; bottom 1.5' is gray brown, saccharoidal glauberite and sandstone with some halite		85% 15%	Core #23
2577	2585.4	8.4	8.4		Halite, light gray, 75%, with irregular masses of brown siltstone with glauberite 25%.		70%	Core #24
2585.4	2647	61.6	48.3		Halite, coarsely crystalline, gray brown to light gray; fine blebs and films of interstitial clay and silty sand; local small masses of silt.		92%	Cores #24,25, and 26 Recov.# 24-25 of 25 " #25-20 of 20 " #26-11.70 of 25

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FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
2647	2672	25	9		Halite, very light gray to gray brown, coarsely crystalline; conspicuous efflorescence on core		90%	Core #27-9' of 25' Core badly ground especially at top.
2672	2687	15	14		Halite, light gray to gray brown, with fine to medium blebs and films of siltstone; 1.1' of very light greenish gray, salt impregnated tuff from 2673.5' to 2674.6'(+).		88%	Core #28 18.9' of 21'
2687	2693.8	6.8	5.5		Halite, light brown to light gray, has mosaic appearance with intersitial brown clay and glauberite.		60%	
2693.8	2739	45.2	42.6		Halite, very light gray to gray brown, with irregularly distributed blebs and interstitial films of silt and clay.		90%	Core #29-21.9' of 23' Core #30-23.5' of 25'
2739	2763	45.2	4.6	Muddy Creek	Same as above probably for the entire run although only a few rounded pieces were recovered.		90%	Used rock bit Core #31 - 4' of 24'
2763	2773	10	1	"	Probably same as above, only fragments and rounded pieces recovered.		90%	Used tungsten carbide solid ring bit Core #32 - 1' of 10'
2773	2793	20	20		Halite, white to gray brown, coarsely crystalline with small to medium blebs of shale and films on crystal boundaries.		91%	Core #33-20' of 20'
2793	2818	25	7.4		Halite, gray brown to brown, coarsely crystalline, irregularly distributed blebs of siltstone and clay.			Core #34 - 7.4' of 25'
2818	2837	19	18.4		Halite, white to gray brown, contains several intervals of heavily silt - and clay- contaminated salt, 2829' to 2832.5' and 2836.5' to 2837'; some glauberite		88%	Core #35 - 18.6 of 19

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FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
2837	2858	21	20.5		Halite, gray brown to very light gray, contains fine to locally medium, blebs and films of clay.		91%	Core #36 - 24.6' of 25'
2858	2862	4.1	4.1		Halite, white, pure, coarsely crystalline.		100%	
2862	2895.8	33.8	27.5		Halite, white, to gray brown, irregularly distributed, sparse clay and siltstone blebs.		92%	
2895.8	2908	12.2	12		Halite, gray brown, irregularly distributed, large and small blebs and films of clay and glauberite		88% 91%	
2908	2933.5	25.5	25		Halite, white to gray and gray brown, small to medium blebs and films of shale.		91%	Shows diagonal fracturing and local slickensides w/30 degree dip.
2933.5	2954.25	20.75	19		Halite, white to gray and brown mosaic structure, irregularly distributed silt and silty sandstone in locally considerable amounts probably mixed with glauberite; from 2938.5' to 2939' glauberite impregnated silt, from 2952.75' to 2953.25' is 90% clay.			
2954.25	2957.25	3	3		Halite, white clear		100%	
2957.25	2968	10.75	9½		Halite, gray and white and tan, mosaic structure, sandy siltstone, red brown, 2958' to 2958.75'		80%	
2968	2997	29	21		Halite, gray and white and tan, considerable interstitial clay, coarsely crystalline, but shattered		90%	

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FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
					generally; some coarse granular appearing salt; tends to break up into small, eroded pieces of core with rubbly, granular appearance			
2997	3028	31	24.0		Halite, clear to gray and gray brown; local blebs of siltstone.		94%	
3028	3037	9	2		Sandy siltstone 40%, brown medium soft; halite, gray brown 60%.		60%	
3037	3058	21	19		Halite, white to gray and gray brown, coarsely crystalline		91%	Total depth 3058'

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN 5/6/60 FINISHED 5/17/60 LOGGED BY Jefferson DRILLED BY Armstrong Fowler Company DRILL HOLE SSC-2
ELEV. G.L. 1318 DEPTH 3634 LOCATION 1258'N. & 398'W. of S.E. cor.sec. 33,T17S,R.68E.Ore Salt 1878-3634 PAGE 1

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
0	40	40	Cuttings	Alluvium	Clay, buff to light reddish brown, and limestone fragments, sand, and gravel.			All depths measured from kelly bushing 9.8' above ground level.
40	180	140	"	Muddy Creek	Clay to very soft shale, reddish brown to buff; trace of gypsum.			18" of 6" casing projects from hole; 6" casing has 2-2" ports with plugs. 6" casing contains a 3" tubi projecting 4" above top of 6" annulus and 3" tubing have welded caps.
180	480	300	"		Shale, reddish brown to buff, some brick red, trace light greenish gray, all very soft; slightly silty; probably thin silty and sandy beds at irregular intervals; silty material becomes more common downward, may be as high as 20% in some samples; trace gypsum as fragments of large clay filled crystals.			
480	500	20	"		Basalt, black, very fine grained, amygdaloidal 85%, amygdules are very fine grained, white, in radiating clusters, probably a zeolite; shale, brown to light reddish brown, very soft 15%.			Black Point basalt member
500	520	20	"		As above, basalt 50%; shale 50%			"
520	560	40			Basalt, black, very fine grained, no amygdules 80%; shale as above 20%.			"
560	580	20	"		Shale, brick red, very soft, almost a clay 80%; basalt, as above 15%; tuff, white, very fine grained, hard, with small biotite flakes 5%.			
580	700	20	"		Clay, greenish brown, with a trace of silty material; trace of gypsum.			

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ELEV. G.L. DEPTH LOCATION PAGE 2

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
700	960	260	Cuttings		Shale, reddish brown to buff, some brick red, soft to medium soft, color changing to greenish brown at depth; trace silty material; 5% gypsum from 840' to 920'.			Slight efflorescence on cuttings beginning at 920'.
960	1180	220	"		Shale, greenish brown, soft to medium soft, some brick red, medium soft, all somewhat harder than above, trace gypsum; some silty material; 5% gypsum from 1120' to 1180'.			
1180	1200	20	"		Shale, brown to greenish brown, soft, 70% shale, light grayish green to gray, medium soft 20%; gypsum 10%.			
1200	1320	120	"	Muddy Creek	As above, shale, brown to greenish brown 85%; light grayish green to light gray shale 10%; gypsum 5%.			
1320	1540	220	"		As above, shale, brown to greenish brown 60%; shale, light grayish green to light gray 30%; gypsum 10%; from 1460' to 1500' gypsum reaches 30%.			
1540	1780	240	"		Shale, grayish green to light gray 50%; shale, greenish brown to brown 40%; gypsum 10%; both shales are soft to medium soft; from 1580' to 1620' gypsum reaches 30%; percentage of grayish green shale increases with depth to 70% at 1780'.			
1780	1800	20	"		No sample.			
1800	1820	20	"		Shale, gray green 50%; shale, light gray 20%; both soft; gypsum 30%.			

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ELEV. G.L._____ DEPTH_____ LOCATION_____ PAGE 3

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
1820	1830				No sample			
1830	1835.45	5.45	5.45	Muddy Creek Top of Core	Glauberite, white, coarsely to very coarsely crystalline, with shale, light greenish gray, medium hard, as partings and laminations. Shale about 15%; shale becoming somewhat sandy toward base, stringly gypsiferous.			
1835.45	1843.3	7.85	7.85		Glauberite, white, coarsely to very coarsely crystalline as bands and euhedral crystals 60%; siltstone brown to very light reddish brown, almost a sandstone in places, poorly cemented 20%; 100% glauberite 1839' to 1840.4'.			At 1839 5°dip.
1843.3	1857.5	14.2	14.2		Glauberite, white, as masses of interlocking euhedral crystals and as bands 85%; shale, brown to light reddish brown and grayish green, somewhat silty in places, as partings 15%; local tuffaceous, fine, tan to brown sandstone; some clay.			
1857.5	1865.4	7.9	1.2		Core consists of fragments of very soft brown shale and fine sandstone.			
1865.4	1877.0	11.6	11.6	Muddy Creek	Glauberite, white, as euhedral crystals, interlocking masses of same, and as bands 90% with a matrix of brown very soft siltstone and shale (in places medium soft).			
1877	1878.5	1.5	1.5		Shale, light grayish brown, soft to very soft with 30% glauberite (?) as	Halite	5% NaCl	Dips 0°to 5° Top of salt

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SSC-2
ELEV. G.L._____ DEPTH_____ LOCATION_____ PAGE 4

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
					euhedral crystals; glauberite increasing toward base and small bands and partings of halite appearing; transition is gradational from shale through glauberite to halite - glauberite.			
1878.5	1880	1.5	1.5		Halite, coarsely crystalline, transparent, with glauberite and brown, very soft shale; halite increasing from 15% to 90% +.		50% NaCl	
1880	1805	5.0	5.0		Halite, transparent, medium to very coarsely crystalline with partings and laminations of grayish green to brown shale and associated with euhedral glauberite crystals.		85-90% NaCl	
1885	1890	5.0	0.0	Muddy Creek	No recovery.			
1890	1904	14.0	14.0		Halite, transparent, with thin partings of brown, soft, tuffaceous siltstone and white glauberite; glauberite 30% in bottom .8'.		90% NaCl	
1904	1920	16	0.0		No recovery			
1920	1942.9	22.9			Glauberite, white to light gray, as interlocking masses of very coarse to coarse, euhedral crystals and as bands; sparse, interstitial blebs, whisps, and partings of shale, grayish brown, soft; halite irregularly distributed as bands and interstitial filling.		NaCl 50%	Bedding dips 0°-9° Somewhat wavy

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ELEV. G.L._____ DEPTH _____ LOCATION _____ PAGE 5

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
1942.9	1976.5	33.6	33.6		Halite, transparent, coarsely crystalline to very coarsely crystalline with scattered coarse to very coarse, euhedral crystals and local beds of glauberite; local thin partings of fine grained, light gray and light brown, fine sandstone and clay.		85-90%	Dip about 5°.
1976.5	1977.5	1.5	1.5		Glauberite, as interlocking very coarse euhedral crystals with light gray clay and some halite.		10% NaCl	
1977.5	1980	2.5	0.0	Muddy Creek	No recovery.			
1980	1987.4	7.4	7.4		Halite, transparent, with local euhedral crystals of white glauberite; blebs and bits of light gray to light brown, very fine sandstone and siltstone.		90%+NaCl	
1987.4	1992.4	5.0	5.0		As above		80%NaCl	
1992.4	1998.5	6.1	6.1		As above		90%NaCl	
1998.5	2010	11.5	0.0		No recovery.			
2010	2018.2	8.2	8.2		Halite, coarsely crystalline with shaly, sandy appearing anhydrite (?).		80% NaCl	Core badly ground.
2018.2	2036.4	18.2	18.2		As above.		90%+NaCl	
2036.4	2040	3.6	0.0		No recovery.			
2040	2041.1	1.1	1.1		Tuff (?), fine grained, light gray with halite.		40%NaCl	Tuffaceous appearing but very soft and at least in part, gypsiferous.

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BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SSC-2

ELEV. G.L._____ DEPTH _____ LOCATION _____ PAGE 6

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
2041.1	2070	28.9	4.8		Halite, transparent, very coarsely crystalline, with very thin partings and laminations of reddish brown, sandstone.		95%NaCl	An additional three feet of mixed gray to brown, very soft shale and halite recovered, 25% NaCl.
2070	2100	30.0	10.5	Muddy Creek	As above.		90%NaCl	
2100	2102	2.0	2.0		Halite, transparent, very coarsely crystalline, with thin partings and laminations of light greenish gray shale, with associated white, very coarse, euhedral crystals of glauberite.		60%NaCl	At 2099.5 to 2100 2" & 3" to 4" of burf to greenish tuff.
2102	2148	46	46		Halite, transparent, very coarsely crystalline, with thin partings and laminations of reddish brown siltstone and very fine sandstone with associated white euhedral crystals of glauberite, locally coarse.		85%NaCl	Dips less than 10°.
2148	2180	32	0.0		No recovery.			
2180	2190	10	10		As above.		80%+NaCl	
2190	2220	30	27.0		As above.		75%+NaCl	
2220	2288.9	60.9	60.1		As above .		90%+NaCl	8.0' correction made (2280' to 2288').
2288.9	2313.4	24.5	24.5		As above.		90%+NaCl	
2313.4	2318	4.6	0		No recovery.			
2318	2339	21.0	21.0		Halite, transparent, coarsely crystalline, somewhat shattered, with thin partings of reddish brown, fine		90%NaCl	70% NaCl, 2331.7'-2333'

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BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SSC-2

ELEV. G.L._____ DEPTH_____ LOCATION_____ PAGE 7

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
					sandstone, and reddish brown, very soft clay; sparse, scattered, euhedral crystals of white glauberite.			
2339	2379.5	40.5	40.5		As above.		95%+NaCl	
2379.5	2417	37.5	36.4		As above; 0.45' greenish gray, tuffaceous, very soft clay, at 2416.4'.		90%NaCl	2399' to 2401' is 5" of very light gray, salt saturated tuff with some biotite plus 19" of brown silty fine sandstone with glauberite crystals in lower 1/3 grading to medium crystalline glauberite in bottom 3 inches. Glauberite salt contact at bottom is sharp; flat dips.
2417	2438	21	0		No recovery.			
2438	2444	6	6		As above.		90%NaCl	At 2414 wavy dip of less than 5°.
2444	2450	6	6		As above.		85%NaCl	2446-2454 locally shattered salt.
2450	2465	15	15		As above.		95%NaCl	
2465	2505.3	40.3	37.6		As above.		85%-90%NaCl	
2505.3	2535	29.7	0		No recovery.			
2535	2542	7.0	7.0		As above; .2' reddish brown clay @ base.		90%NaCl	
2542	2565	23	0		No recovery.			
2565	2571	6	6		As above; .2' ground halite and		90%NaCl	Locally shattered salt

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SSC-2

ELEV. G.L._____ DEPTH_____ LOCATION_____ PAGE 8

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
					glauberite at top and .7' ground clay, glauberite and halite @ base.		90%NaCl	Locally shattered sal
2571	2595	24	0		No recovery.			
2595	2640.2	55.2	53.4		As above; 1.4', 60% NaCl, 2603.6'-2604'; remainder sandy appearing, reddish brown fine sandstone.		90%NaCl	
2640.2	2660	19.8	0		No recovery.			
2660	2689	29	29		Halite, transparent, coarsely granular, (in places, has texture of ice cream salt), with glauberite (?) as sparse white crystals and as reddish brown, sandy appearing zones; some reddish clay as partings and laminations.		95%NaCl	
2689	2703	14	14		As above; .5' sandy glauberite(?), 2691'-2691.5'; .3' 2695'-2695.3'		85%NaCl	
2703	2746	43	43		As above; .5' fine sandstone at base		90%NaCl	
2746	2773	27	6.10		As above		90%NaCl	Salt at least locally shattered
2773	2793	20	7.0		As above		90%NaCl	
2793	2800	7	Cuttings		No sample			Returned to drilling because of poor core recovery.
2800	2820	20	"		Shales, probably all from up the hole.			
2820	2900	80	"		Halite, but not showing in cuttings until 2860'.			
2900	2920	20	13.1		Halite, transparent, with some		90%+NaCl	Salt in part shattered and rubbly.

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SSC-2

ELEV. G.L._____ DEPTH _____ LOCATION _____ PAGE 9

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
					glauberite, as sandy appearing, reddish brown material, and as large white euhedral crystals, some reddish brown clay as partings.			
2920	2940	20	1.0		As above.		90%+NaCl	
2940	2980	40	Cuttings		Shale 60%, decreasing to 40%; halite 40-60%.			Shale from mostly fr up the hole; percenta in cuttings not in- dicative of quality of salt.
2980	3020	40	"		Halite 60% - 70%; shale 30%-40%.			
3020	3040	20	"		Shale 60¢; shale, mostly brown to greenish brown; halite, 40%.			
3040	3080	40	"		Halite, 70%; shale, 30%.			
3080	3420	340	"		Halite, 80% - 90%; shale, 10% -20%.			
3420	3440	40	"		Halite, 70%-80%; shale, 20% - 30%			
3440	3634	194	"		Halite, 80% - 90%; shale, 10% - 20%			Total depth 3634'.

STAUFFER CHEMICAL COMPANY DRILL LOG

Page 1

BEGUN 5/19/60 FINISHED 5/23/60 LOGGED BY Jefferson DRILLED BY Armstrong Fowler Company DRILL HOLE SSC-3
ELEV. 1408 TOTAL DEPTH 2237 LOCATION 1436'N. & 1257'W. of S.E. cor. sec. 28, T17S, R.68E ORE

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
0	60	60	Cuttings		No sample.			All depths measured from kelly bushing 9.8' above ground level.
60	100	40	"	Alluvium	Clay and gravel.			
100	160	60	"	Muddy Creek	Clay, light reddish brown			
160	220	60	"		Clay to very soft shale, light reddish brown 60%; shale, light greenish gray, very soft 40%; trace gypsum.			
220	260	40	"		Shale, very soft, light reddish brown, 50%; shale, soft, greenish brown 50%; trace to 5% gypsum.			
260	440	180	"		As above; reddish shale decreasing to 30%; brownish increasing to 65%; gypsum 5%; from 340' to 400', gypsum 10%; from 400' to 440', gypsum, 15% to 20%.			Slight efflorescence beginning at 360'.
440	460	20	"		Shale, soft, greenish brown, 50%; shale, soft to very soft, light reddish brown, 20%; sandstone, soft, light gray to gray, 15%; gypsum, 15%.			
460	650	190	"		Shale, soft, greenish brown, 65%; shale, soft, light reddish brown, 20%; gypsum 15%; from 620'to 650', gypsum 30%.			
650	660	10	"		No sample.			
660	753	93	41		Shale, brown, soft,medium bedded to laminated; anhydrite as bands of fine grained material, local silty to (Con't)			Bedding dip: 10° to 36°, average 22°.

STAUFFER CHEMICAL COMPANY DRILL LOG

Page 2

BEGUN____ FINISHED____ LOGGED BY____ DRILLED BY____ DRILL HOLE SSC-3
ELEV.____ TOTAL DEPTH____ LOCATION____ ORE____

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
					sandy material, anhydrite about 5%.			
753	772	19	17		Shale, brown, soft, medium bedded, in places sandy to silty; anhydrite as bands and laminations of fine grained massive material; from 759.0' to 760.1' is massive anhydrite.			Beddings dip: 20° to 35°, average 27°.
772	843	71	40		Anhydrite(?), mostly massive,coarsely crystalline, in part euhedral crystals, very coarsely crystalline, probably includes some glauberite; grayish brown to brown shale as thin bands, partings, and laminations, and in part as a matrix for mesh of glauberite (?) or anhydrite (?) crystals.			
843	863.5	20.5	18.7		Shale, brown to green, medium hard, thin bedded to laminated, with partings and thin beds of fine grained anhydrite, also considerable glauberite (?) as coarse euhedral crystals; glauberite (?)and anhydrite increasing from 15% to 80% at base.			Bedding dip: 25° to 38°, average 34°.
863.5	873	9.5	8.0	Muddy Creek	Glauberite (?), coarsely to very coarsely crystalline as a mesh of euhedral crystals with the interstices filled with shale, green to brown to light gray, medium hard. Halite occurs to minor extent in interstices; halite from 864.9' to 865.5' is a layer, transparent, very coarsely crystalline.	Halite	10% NaCl	

STAUFFER CHEMICAL COMPANY DRILL LOG

Page 3

BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SSC-3

ELEV._____ TOTAL DEPTH_____ LOCATION_____ ORE_____

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
873	888	15	15		Halite, transparent, very coarsely crystalline with euhedral crystals of glauberite (?) minor shale, brown to light gray to green; halite increasing toward base.		50% NaCl	
888	909	21	21		As above.		90%+ NaCl	
909	933	24	24		Anhydrite (?), and glauberite (?), massive, fine grained, and as very coarse euhedral crystals with a matrix of halite, and greenish to brownish shale; massive anhydrite (?) as distinct bands.		20% NaCl	
933	963	3.0	3.0		Halite, transparent, coarsely crystalline with some fragments of greenish shale.		90%+ NaCl	Dip 30°.
963	987	24	24		Halite, transparent, very coarsely crystalline with anhydrite as scattered sparse euhedral crystals and as bands of same, associated with grayish green shale.		85% NaCl	
987	1012	25	25		As above.		95% NaCl	
1012	1023	11	0		No recovery.			
1023	1032	9	9		As above.		70% NaCl	
1032	1047	15	15		As above.		90%+ NaCl	
1047	1052.5	5.5	5.5		As above.		70% NaCl	

STAUFFER CHEMICAL COMPANY DRILL LOG

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BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SSC-3

ELEV._____ TOTAL DEPTH_____ LOCATION_____ ORE_____

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
1052.5	1053	0.5	0.5		Shale, gray green.		0% NaCl	Nil halite.
1053	1059	6.0	6.0		Halite and shale as above.		80% NaCl	
1059	1074	15	15		Halite and shale as above.		85%+ NaCl	
1074	1124	50	42.8		As above; zone of high shale and anhydrite (?), (less than 50% NaCl) at 1086.3 to 1087.3'.		90%+ NaCl	
1124	1128	4	4		As above; .5' silty grayish green shale at 1126'.		80%+ NaCl	
1128	1263	135	121		As above.		90%+ NaCl	
1263	1280	20	Cuttings	Muddy Cmek	Halite, 60%; shale, light greenish gray to reddish brown, 40%.			
1280	1300	20	"		As above, halite 80% to 85%.			All samples have considerable shale as large fragments, probably sloughing from up the hole.
1300	1320	20	"		As above.			
1320	1340	20	"		As above.			
1340	1360	20	"		As above.			
1360	1380	20	"		As above.			
1380	1400	20	"		As above.			
1400	1420	20	"		As above.			
1420	1430	10	"		No sample.			

STAUFFER CHEMICAL COMPANY DRILL LOG

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BEGUN _____ FINISHED _____ LOGGED BY _____ DRILLED BY _____ DRILL HOLE SSC-3

ELEV. _____ TOTAL DEPTH _____ LOCATION _____ ORE _____

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
1430	1459	29	Cuttings		Halite, transparent, coarsely to very coarsely crystalline, granular in places with sparse glauberite (?) as euhedral crystals, some reddish brown silty shale as thin bands.		90%+ NaCl	
1459	1480	21	"		Halite 35%; light greenish gray to light reddish brown shale 65%.			Shale in part is slough.
1480	1500	20	"		As above, halite 85% to 90%.			
1500	1520	20	"		As above, halite 85% to 90%.			
1520	1540	20	"		As above, halite 85% to 90%.			
1540	1560	20	"		As above, halite 85% to 90%.			
1560	1580	20	"		Halite 60% to 70%; shale 30% to 40%.			
1580	1600	20	"		Halite 85% to 90%.			
1600	1614	14	"		No sample.			
1614	1616	2	2		Anhydrite (?), massive with some shale, greenish gray, and halite.		20% NaCl	
1616	1629.4	13.4	13.4		Halite, transparent, very coarsely crystalline with scattered bands of massive anhydrite.		85%+ NaCl	
1629.4	1636	6.6	6.6		As above.		70% NaCl	
1636	1644	8	8		No recovery.			

STAUFFER CHEMICAL COMPANY DRILL LOG

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BEGUN _____ FINISHED _____ LOGGED BY _____ DRILLED BY _____ DRILL HOLE SSC-3

ELEV. _____ TOTAL DEPTH _____ LOCATION _____ ORE _____

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
1644	1680	36	Cuttings		Shale, greenish gray to brown with 10% halite and anhydrite and glauberite (?).			
1680	1800	120	"		As above, halite and glauberite (?) anhydrite, 30% to 40%.			
1800	1830	30	13.0		Interbedded anhydrite, massive, in part coarse euhedral crystals of glauberite (?) and shale, medium hard, brown.		0% NaCl	
1830	1910	80	Cuttings		Shale, green to light gray to light reddish brown; halite 30% to 40%; the two materials are interbedded with halite to 10' in thickness			
1910	1924	14	"		Not recorded, probably same as 1830' to 1910'.			
1924	1933.5	9.5	9.5		Anhydrite and glauberite (?), mostly massive, in part euhedral crystals with sparse shale, brown, medium hard as bands and matrix; .3' black carbonaceous shale at 1927'; halite as scattered matrix with anhydrite (?) crystals.		10% Halite	
1933.5	1939	5.5	5.5		Halite, transparent, very coarsely crystalline with scattered crystals of glauberite (?), and anhydrite and bands and partings of shale, brown, medium hard.		70% NaCl	

STAUFFER CHEMICAL COMPANY DRILL LOG

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BEGUN _____ FINISHED _____ LOGGED BY _____ DRILLED BY _____ DRILL HOLE SSC-3

ELEV. _____ TOTAL DEPTH _____ LOCATION _____ ORE _____

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
1939	1953	14	13.5		Anhydrite (?), massive, with sparse bands and partings of shale, gray, medium hard.			
1953	2000	47	Cuttings	Muddy Creek	Shale, light greenish gray to green to light reddish brown with 10% anhydrite.			
2000	2010	10	"		As above; anhydrite and gypsum, 25% to 30%.			
2010	2030	20	"		As above; with halite, 60%.			
2030	2070	40	"		Shale, mostly green to light grayish green with some light reddish brown; anhydrite and gypsum, 10% to 20%.			
2070	2180	110	"		Shale, dark reddish brown with 5% to 10% anhydrite.			Shale very soft.
2180	2230	50	"		As above, with anhydrite increasing toward base to 40%.			Total depth 2230'.

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN 8/29/62 FINISHED 9/14/62 LOGGED BY L.E.M. DRILLED BY Boyles Brothers Drilling Co. DRILL HOLE SSC-4
ELEV. G.L. 1379 DEPTH 1338 LOCATION 3828'North & 823' East of SW Cor.Sec.33.T.17S.R.68E MDM 338 Salt PAGE 1

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
0	60	60	None	Muddy Crk.	No sample			
60	120			" "	Clay shale and clayey siltstone, light brown, soft, disintegrates in water quite rapidly after drying.			Samples taken at intervals shown
140				" "	Clay shale and clayey siltstone light brown 70%; gray brown 30%			Two days lost by pump trouble 8/29 and 8/30.
162				" "	Clay shale, light brown, 40%; sandstone, very light gray, 30%; clay shale, gray, soft 30%.			All samples after drying disintegrate readily in water.
182				" "	Clay shale, light brown 80%; clay shale, gray 20%; trace fine gypsum (?).			
185				" "	Clay shale, light brown, 60%; gypsum, buff, fine grained, firm, 40%			(Check for composition of gypsum)
200				" "	Clay shale, gray, 40%; gypsum, fine grained, buff, firm, with caused selenite 60%.			
210				" "	Clay shale, light brown 10%; clay shale, gray 20%; gypsum selenitic, white to colorless, 70%.			
220				" "	Clay shale, light, to slightly reddish brown, soft, 70%; siltstone, light brown 10%; gypsum, selenitic, 20%.			
240				" "	Clay shale, light brown, soft disintegrates readily in water, 80%; gypsum, buff, fine grained, firm, may be in part tuffaceous, 20%.			
260				" "	Clay shale, light brown, trace fine grained gypsum.			
280				" "	Clay shale and silty clay shale, very light to light brown, silty particles do not disintegrate as readily as clay shale			

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN 8/29/62 FINISHED 9/14/62 LOGGED BY L.E.M. DRILLED BY Boyles Brothers Drilling Co. DRILL HOLE SSC-4
ELEV. G.L. 1379 DEPTH 1338 LOCATION 3828'North & 823'East of SW Cor.Sec.33.T.17S.R.68E MDM 338 Salt PAGE 2

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
300				Muddy Crk.	Silty clay shale, light gray to light brownish gray 60%; clay shale, light brown 20%; gypsum selenitic and fibrous, 20%;			Disintegration observed after sample are dried. Damp samples do not disintegrate noticeably in water.
320				" "	Clay shale, light brown and very light brown; 50-50%; the very light brown is softer and disintegrates more readily in water; trace fine gypsum.			
340				" "	Clay shale, light brown, does not disintergate, 90%; clay shale, brownish gray, 10%. Trace fine gypsum.			
360				" "	Clay shale, light brown 30%; brownish gray 50%; both soft and disintegrate readily in water, the light brown more readily; gypsum selenitic 20%.			
380	420			" "	Same but proportions 70%; 25%; 5%.			
440					Same, but proportions 50%, 45%; 5%.			
460				" "	Clay shale, light brown 40%; gray brown and brownish gray 50%; tuff, gray, locally greenish, fine grained, very finely speckled with black, soft, 10%; Both shales, soft, disintegrate readily in water.			Is equivalent to 440-460 in SSC-3(?)
480				" "	Clay shale, light brown 40%; gray and brownish gray 60%; light brown more readily disintegrates; trace gypsum selenitic.			
500				" "	Clay shale, light brown 30%; gray and brownish gray 70%; trace selenitic, gypsum.			

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN _____ FINISHED _____ LOGGED BY L.E.M. DRILLED BY Boyles Brothers Drilling Co. DRILL HOLE SSC-4

ELEV. G.L. _____ DEPTH _____ LOCATION _____ PAGE 3

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
520					Clay shale; light brown, 30%;gray brown to gray 70%.			
540					Clay shale, light brown 20%;gray brown to light gray, 80%.			
560	580				Clay shale, light brown 10%; light gray to brownish gray 90%; trace blue gray clay shale and selenitic gypsum.			
600					Clay shale, tan to gray brown to light brown, 90%; blue gray 10%; trace selenitic gypsum.			
620					Clay shale, brown, locally grayish, and greenish brown,85%; light brown 10%; selenitic gypsum 5%.			
640					Sample lost.			
660	730				Clay shale, mostly grayish brown to brown; trace selenitic gypsum; trace light brown shale.			
740					Clay shale, brown to gray brown 70%; light brown 30%.			
750					Clay shale,light brown 60%; gray brown 40%.			
760					Clay shale,light brown 50%;gray brown 50%; trace selenitic gypsum.			
770					Same but 60%-40%; trace gypsum.			
780					Clay shale, brownish gray to gray brown, trace gypsum.			Samples are here about 10' behind (shallower) than footage indicated.
790					Clay shale, gray brown 80%; light brown 20%; trace selenitic.			
800	810				Clay shale, gray brown to brownish gray 70%; light brown 30%; trace selenite.			
820					Clay shale, gray brown to brown 90%; light brown 10%; trace gray; trace selenite;rare trace partly dissolved glauberite			Topmost glauberite(?)

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN _____ FINISHED _____ LOGGED BY L.E.M. DRILLED BY Boyles Brothers Drilling Co. DRILL HOLE SSC-4

ELEV. G.L. _____ DEPTH _____ LOCATION _____ PAGE 4

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
830					Clay shale, brown to gray brown 80%;light brown 20%; 1% white soft particles of partly dissolved glauberite.			
840					Clay shale, brownish gray to gray brown and brown 80%; light brown 20%, trace selenite; trace disseminated. glauberite (?)			
850	860				Clay shale, brown to gray brown to greenish brown, 95%;gypsum after glauberited (?) 5%; trace selenite.			Glauberite dissolves partially leaving a calcium sulfate residue.
870					Clay shale, same 90%; gypsum after glauberite 10%.		Efflorescence	Washed cuttings " "
880					Same but 95%-5%			" "
890					Same but 90-10%			" "
900					Same but 80-20%			" "
910					Clay shale, brownish gray 70%. light brown 10%; gypsum after glauberite 20%.			
920	940				Clay shale, brownish gray to gray brown 70%; light brown 5%; greenish gray trace to 5%; gypsum after glauberite 20%.			

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN_____ FINISHED_____ LOGGED BY L.E.M. DRILLED BY Boyles Brothers Drilling Co. DRILL HOLE SSC-4

ELEV. G.L._____ DEPTH_____ LOCATION_____ PAGE 5

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY ESTIM.	REMARKS
950	960				Clay shale, gray brown 95% trace greenish brown; gypsum after glauberite 5%.			Samples are about 15' behind (shallower) than footage indicate
970	980				Clay shale, gray brown to brown 85%; light brown 10%; gypsum after glauberite 5%.			All samples show efflorescence even though they were washed.
990					Same but gypsum after glauberite 10%.			
1000					Clay shale gray brown to brown 90%; light brown 5%; gypsum after glauberite 5%; trace light greenish gray shale.			Small amount of cuttings in return 1000-1020. Salt probably first encountered in quantity at about 1000 feet.
1010					Clay shale, gray brown 80%; gypsum after glauberite 20%; trace light greenish gray shale.			
1020					Same but w/5% light brown shale			
1022 # 1	1028	6	6	Muddy Crk.	Chiefly glauberite, glassy, fine to very coarse (up to 1" long) crystals, generally massive appearing with some bedding noticeable, 70%; light greenish gray silt or clay (?) interstitial to glauberite; halite, medium crystalline, gray 20%.	Halite Glaub.	20%NaCl	30° dip @ 1028'

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN_____ FINISHED_____ LOGGED BY L.E.M. DRILLED BY Boyles Brothers Drilling Co. DRILL HOLE SSC-4

ELEV. G.L._____ DEPTH_____ LOCATION_____ PAGE 6

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY ESTIM.	REMARKS
1028 # 1	1032	4	4	Muddy Crk	Halite, gray to colorless, medium coarse 65%; glauberite, medium to coarse, dispersed and irregular patches in halite.		65%NaCl	
1032 # 2	1040	8	8	" "	Halite, colorless to gray, medium to medium coarse grained, 90%; glauberite, fine to coarse, as irregularly distributed crystals and patches, local greenish gray clay or silt interstitial to glauberite 10%.		90%NaCl	Halite is strongly shattered and crushed but healed solid.
1040 #	1052 2 & 3	12	11	" "	Halite, colorless, medium coarse to coarse 95%; sparse scattered glauberite..		95%+NaCl	" "
1052 #	1062 4	10	1	" "	Halite, colorless, 80%, gray brown saliterous clay lower 2"; sparse glauberite.		80%?	Halite Run is probably good salt; immediately above and below is good salt. Core is washed.
1062 #	1065 5	3	3	" "	Halite, clear, cut by numerous fractures perpendicular to core axis, 95%; sparse glauberite toward bottom.		95% H.	
1065	1072	7	2/1/2		Halite, gray, 50%; glauberite and light greenish gray clay in fine mixture, rather soft, irregular patches 40%.		60% H	Core lost, washed badly
1072	1081	9	1		Halite clear, 85%; glauberite and clay as above in upper 3".		85% H.	

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN_____ FINISHED_____ LOGGED BY L.E.M. DRILLED BY Boyles Brothers Drilling Co. DRILL HOLE SSC-4
ELEV. G.L._____ DEPTH_____ LOCATION _____ PAGE 7

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY ESTIM.	REMARKS
1081	1085	4	4		Halite, greenish to brownish gray, dark, with much included clayey material; some fine glauberite, considerable shattering noticeable.		80% H.	
1085	1091	6	6		Halite, colorless to gray, strongly shattered 97%; nil glauberite; clay and silt 3%.		97% H.	Strongly shattered
1091	1102	11	2-1/2		Halite, 90% in upper 1-1/2', 50% in lower 1' which is much washed and broken; lower 1' contains 50% glauberite and mixed silt and glauberite.		80% H.	
1102	1108	6	1		Halite, colorless to light gray, sparse glauberite crystals.		90% H.	Core washed and lost.
1108	1118	10	10		Halite, brownish, locally colorless, 85-90%; considerable blebs and intergranular films of silt and clay, brown; sparse, fine glauberite.			Shattered locally
1118	1126.25	8.25	8.25		Halite, gray brown to locally colorless, disseminated and blebby brown silt; sparse scattered glauberite crystals and fine glauberite in clay.		95% H.	Somewhat shattered
1126.25	1133	6.75	7.25		Halite, colorless to gray 85%, impure with irregularly distributed glauberite crystals and fine grained, irregular stringers of glauberite.		85% H.	Dip 25-30° Locally shattered

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN_____ FINISHED_____ LOGGED BY L.E.M. DRILLED BY Boyles Brothers Drilling Co. DRILL HOLE SSC-4
ELEV. G.L._____ DEPTH_____ LOCATION _____ PAGE 8

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY ESTIM.	REMARKS
1133	1140.25	7.25	7.25		Halite, brownish 87.90%; disseminated and blebby brown siltstone & clay; sparse glauberite crystals, some disseminated in clay blebs; Lower 1.5', 80% glauberite, medium to fine crystalline with interstitial gray green clay.		87% H.	Shattered
1140.25	1145.75	5.5	5.5		Halite, clear to gray, 95%+; trace glauberite and silt.		95% H.	Shattered
1145.75	1148.5	2.75	2.75		Halite, brownish, containing sparse glauberite and some silt and clay, brown as blebs and interstitial films.		85-90%H	
1148.5	1151.5	3	3		Glauberite, fine to coarse; abundant irregular masses 60%; halite clear to gray 40%.		40% H.	Dip 45° @ 1151
1151.5	1167.25	15.75	15.75		Halite, brownish to gray, shattered 90%, local silty glauberitic zones Glauberite less than 3%.		90% H.	
1167.75	1170	2.25	2.25		Halite, gray brown 70%; glauberite, medium grained, locally silty 30%.		70% H.	Dip 35-40°
1170	1188	18	18		Halite, clear to gray brown, locally somewhat impure 90%; very sparse glauberite		95%+H	
1188	1198	10	10		Halite like above but with muddy spots; very sparse glauberite except in bottom 2' where 15% glauberite is present.		90%H	

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN_____ FINISHED_____ LOGGED BY L.E.M. DRILLED BY Boyles Brothers Drilling Co. DRILL HOLE SSC-4

ELEV. G.L._____ DEPTH_____ LOCATION_____ PAGE 9

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY ESTIM.	REMARKS
1198	1212.75	14.75	14.75		Halite, gray, to brownish and locally colorless, 93%, sparse glauberite 2-3%.		93% H.	
1212.75	1221	9.75	8.75		Halite, grayish to brownish, 80-85%; glauberite, fine to medium fine as very irregular masses, blebs and stringers 15%; minor clay with glauberite.		80% H.	
1221	1223	2	2		Tuff, very light gray, in middle is bedded, upper and lower parts are disturbed and intruded by halite, lower foot is 50% halite.		35% H.	
1223	1228	5	5		Halite, brownish to light grayish 90% +; local muddy, fine glauberite.		90%+H.	
1228	1230	2	2		Halite, gray to brown, 75%; glauberite, fine and medium coarse, irregularly distributed, locally muddy; 2" muddy glauberite at 1229', 15-20% glauberite.		75% H.	
1230	1259.25	29.25	29.25		Halite, gray to brown 90%+, irregularly distributed blebs, masses, and films of silt, shale, and silty glauberite, local sparse glauberite crystals; glauberite 3%.		90%+H.	Locally highly shat.
1259.25	1261.75	2.5	2.5		Halite, brown, 70%; glauberite, irregularly distributed, medium fine to coarse glauberite crystals, 20% some silt.		70% H.	

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN_____ FINISHED_____ LOGGED BY L.E.M. DRILLED BY Boyles Brothers Drilling Co. DRILL HOLE SSC-4

ELEV. G.L._____ DEPTH_____ LOCATION_____ PAGE 10

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY ESTIM.	REMARKS
1261.75	1262.85	1.1	1.1		Glauberite, coarse, massive, very muddy in lower 2", 90%; halite 10%		10% H.	
1262.85	1268.	5.15	5.15		Halite, clear to brownish to gray & somewhat muddy in upper 2', 90%; nil glauberite.		90% H.	
1268	1271	3	3		Halite, brownish, 85%; glauberite, coarse, scattered crystals 8%.		85% H.	
1271	1296.6	25.5	25.5		Halite, brownish, locally shattered, local gray, 90%; scattered patches of medium to medium coarse glauberite crystals, 2-3%.		90% H.	
1296.6	1297.5	1.1	1.1		Silt, probably tuffaceous, brown, saline.		10% H.	
1297.5	1302.5	5	5		Halite, gray brownish, 90%.		90% H.	
1302.5	1308.25	5.75	5.75		Halite, clear to gray brown; pure and very muddy halite intermixed, probably average 85% halite.		85% H.	
1308.25	1316.5	8.25	8.25		Halite, brown, silty and clayey, locally colorless, 85-90%.		85% H.	
1316.5	1320.25	3.75	3.75		Halite, brownish to grayish 80%, patches and masses of glauberite, medium fine to medium coarse, 20%.		80% H.	
1320.25	1325.75	5.5	5.5		Halite, gray brown 85-90%, irregular patches of medium grained glauberite, also patches of silty fine grained glauberite, brown.		85% H -90% H.	

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN _____ FINISHED _____ LOGGED BY L.E.M. DRILLED BY Boyles Brothers Drilling Co. DRILL HOLE SSC-4

ELEV. G.L. _____ DEPTH _____ LOCATION _____ PAGE 11

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY ESTIM.	REMARKS
1325.75	1327	1.25	1.25		Tuff, light gray, slightly, greenish, soft.			
1327	1336½	9½	9½		Halite, gray to gray brown, 85-90%, irregular patches & scattered crystals of fine to medium fine glauberite, commonly silty.		85-90%	H.
1336½	1337.5	0.75	0.75		Silt, glauberitic, saline, brown.			Core ground up.
1337.5	1338	0.5	0.5		Halite, gray brown, silty		80%	Total Depth 1338 feet.

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN 4/24/60 FINISHED 4/26/60 LOGGED BY G. Jefferson DRILLED BY Armstrong and Fowler DRILL HOLE SCB-1
ELEV. 1411 TOTAL DEPTH 2720 LOCATION 702'S and 105'E. of N. W. cor. sec. 19, T.18S, R.68E CORE

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
0	100	100	Cuttings		Not logged, mostly alluvial material.			All depths measured from kelly bushing 9.8' above ground level
100	180	80	80	Muddy Creek	Clay, reddish brown to buff, very soft at top becoming more indurated toward base, contains 30% limestone pebbles at top, pebbles decreasing to 10% at base.			Limestone pebbles present as trace in virtually all samples but 10% or less below 180'
180	400	220	220	"	Shale, reddish brown to buff, very soft and clayey with some gypsum as very small particles, cleavable masses forming 10%+ from 380' to 400'; shale, thin to medium bedded.			Gypsum(?) commonly present as hydrated white pulpy blebs and occlusions in larger cleavable fragments.
400	480	80	80	"	Shale, reddish brown to buff, very soft 80% increasing to 100% at base; shale, gray to greenish gray, very soft 20% decreasing to 0 % at base; trace gypsum.			
480	540	60	60	"	Shale, reddish brown to buff, very soft, with trace gypsum and shale, light gray, thin bedded, very soft.			
540	600	50	50	"	Shale, reddish brown to buff, very soft, 80% to 100% increasing downward; shale, gray to greenish gray, 20% to 0 % decreasing downward; trace of gypsum.			

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN FINISHED LOGGED BY DRILLED BY DRILL HOLE SCB-1
ELEV. TOTAL DEPTH LOCATION CORE

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
600	1980	1380	1380	Muddy Cr.	Shale, reddish brown to buff, very soft, 65% to 85%; shale, gray, greenish gray to light gray, very soft, 15% to 35%; trace gypsum; anhydrite as trace of black to brown, hard fragments from 1600' downward.			
1980	2040	60	60	"	Shale, reddish brown to buff, very soft 55%; shale, gray to greenish gray, very soft 20%; gypsum, as blebs and cleavable fragments 20%; anhydrite, dark gray to black 5%.			
2040	2120	80	80	Hams Sp.(?)	Shale, reddish brown to buff, very soft 70%; shale, gray to greenish gray, very soft 20%; gypsum as blebs and cleavable fragments 10%.			
2120	2140	20	20	"	Basalt, black 15%; shale, reddish brown to buff, very soft 50%; shale, gray to greenish gray, very soft 20%; gypsum and anhydrite 15%.			Top basalt
2140	2240	100	100	"	Basalt, black 45%; shale, reddish brown to buff, very soft 40%; shale, gray to greenish gray, very soft 10%; gypsum and anhydrite 5%.			
2240	2260	20	20	"	Basalt, black 10%; shale, reddish brown to buff, very soft 70%; shale, gray to greenish gray, very soft 15%; gypsum and anhydrite 5%.			

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN _____ FINISHED _____ LOGGED BY _____ DRILLED BY _____ DRILL HOLE SCB-1

ELEV. _____ TOTAL DEPTH _____ LOCATION _____ ORE _____

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
2260	2320	60	60	Hasc Sp(1)	Shale, reddish brown to buff 70%; shale, gray to greenish gray 20%; basalt 10%, decreasing downward.			
2320	2340	20	20	"	Gypsum, (anhydrite) light reddish brown to brown, fine grained 70%; shale, reddish brown and gray to greenish gray 30%.			
2340	2420	80	80	"	Shale, reddish brown to buff 85%; shale, gray to greenish gray 10%; gypsum and anhydrite 5%.			
2420	2440	20	20	"	Gypsum, (anhydrite) light reddish brown to brown, fine grained 75%; shale, reddish brown and gray to greenish gray 25%.			
2440	2560	120	120	"	Shale, reddish brown to buff 50%; shale, light gray 40%; shale, gray to greenish gray 10%; trace gypsum.			Light gray shale somewhat silty.
2560	2720	160	160	"	Shale, light gray, somewhat silty 40%; shale, reddish brown to buff 20%; shale, bright reddish brown 20%; somewhat silty, shale, gray to greenish gray to grayish green 10%; gypsum and anhydrite, reddish brown to brown, fine grained 10%.			
2720	2725	5	5	"	Not logged, lost in part.			Total Depth 2725' Lost circulation intermittantly 2720' to 2725' cuttings contaminated with lost circulation material not logged

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN 4/28/60 FINISHED 5/3/60 LOGGED BY Gene Jeffers DRILLED BY Armstrong and Fowler DRILL HOLE SCB-2
ELEV. G.L. 1404 DEPTH 2818' LOCATION 148'N.& 1849'E. of W 1/4 cor. sec. 36, T.18s., R.67E. PAGE 1

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
0	40	40	Cuttings	Alluvium	Sand, limestone, gray, coarse to very coarse.			All depths measured from kelly bushing 9.8' above ground level.
40	180	140	140	"	Gravel limestone, gray, with some clay 5% to 10% reddish brown.			Fragments of black to a light gray limestone common and in some samples abundant.
180	380	200	200	"	Clay, reddish brown, with 20% gravel and sand, little gravel or sand at 260' to 280'.			Closely resembles interval 380' to 540'.
380	540	160	160	"	Sand and gravel becoming progressively more sandy toward base, fragments of gray limestone.			
540	900	360	360	Muddy creek	Clay and very soft, shale, reddish brown to greenish brown with trace brick red, trace gypsum.			
900	980	80	80	"	Clay to shale, reddish brown, greenish brown, very soft 95%; gypsum and anhydrite, white to light gray 5%.			
980	1000	20	20	"	As above.			
1000	1460	460	460	"	Shale, reddish brown to greenish brown, trace of brick red, very soft; gypsum and anhydrite, trace except where noted. From 1090' 1120' gypsum 10% to 15%; from 1080' to 1300' gypsum 10% to 15%.			Tuff, white, very fine grained 5% to 10% from 1140' to 1180'; tuff in part is clay, blue gray to gray; hard material probably contains some very fine biotite.

STAUFFER CHEMICAL COMPANY DRILL LOG

BEGUN _____ FINISHED _____ LOGGED BY _____ DRILLED BY _____ DRILL HOLE SCB-2
ELEV. G.L. _____ DEPTH _____ LOCATION _____ PAGE 2

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	MINERALS	ASSAY	REMARKS
1460	1580	120	120	Muddy Cr.	Shale, reddish brown to greenish brown, trace brick red, very soft; gypsum and anhydrite 5% to 10%.			
1580	1740	160	160	"	Shale, reddish brown, with trace greenish brown, very soft 75% to 80%; gypsum and anhydrite, white to light gray 20% to 25%.		% Halite	
1740	2260	520	"	"	Shale, reddish brown with trace greenish brown, very soft, trace to several percent gypsum and anhydrite.			Some efflorescence from 2160' to 2240'; strong efflorescence on cuttings from 2240' to 2260'.
2256	2265	9	Core	"	Halite, white to transparent, very coarsely crystalline with partings and bands to .1' of reddish brown, fine grained anhydrite, somewhat sandy in appearance, and scattered crystals of glauberite to .2' in length (mostly associated with larger bands of anhydrite).		90% +	Halite bedding 45 degrees to core axis.
2265	2269.3	4.3	4.3	"	As above		20%	
2269.3	2276	6.7	4.9	"	As above		65%	
2276	2277	1	1	"	Anhydrite, reddish brown to brown, fine grained, has a sandy appearance.		0%	
2277	2289.2	12.2	12.2	"	Halite, transparent, very coarsely crystalline with partings and laminae of reddish brown, fine grained anhydrite, containing some large white crystals of glauberite, to (0.1').		90%	

STAUFFER CHEMICAL COMPANY DRILL LOG

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BEGUN _____ FINISHED _____ LOGGED BY _____ DRILLED BY _____ DRILL HOLE SCB-2

ELEV. _____ TOTAL DEPTH _____ LOCATION _____ ORE _____

FOOTAGE FROM	TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
2289.3	2303.4	14.2	14.2	Muddy Creek	As above		85% Halite	
2303.4	2309.3	5.9	5.9	"	As above		90% +	
2309.3	2315	5.7	5.7	"	As above		80 to 85%	
2315	2321.7	6.7	6.7	"	As above but contains several thin zones of medium crystalline halite		90% +	
2321.7	2327.5	5.8	5.8	"	As above		70%	
2327.5	2328.3	.8	.8	"	Anhydrite, reddish brown, fine grained, sandy, with coarsely crystalline white glauberite (?)		0%	Bedding 0 to 30 degree dip.
2328.3	2335.3	7.0	7.0	"	Halite, transparent, very coarsely crystalline with occasional zones medium crystalline anhydrite, reddish brown, fine grained with some coarse crystals of white glauberite (?) as laminations and partings. 4' band from 2333.6' to 2334.0'.			
2335.3	2342.8	7.5	7.5	"	Halite, very coarsely to medium crystalline, transparent, with laminae and partings of anhydrite, reddish brown, local light gray, sandy appearing, with scattered euhedral crystals of white glauberite(?) up to 0.1' long.		90%	
2342.8	2346.3	3.5	3.5	"	As above		75.%	

STAUFFER CHEMICAL COMPANY DRILL LOG

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BEGUN _____ FINISHED _____ LOGGED BY _____ DRILLED BY _____ DRILL HOLE SCB-2

ELEV. _____ TOTAL DEPTH _____ LOCATION _____ ORE _____

FOOTAGE FROM	TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
2346.3	2348.7	2.4	2.4	Muddy Cr.	As above		85% to 90%	
2348.7	2351.8	3.1	3.1	"	As above		80%	
2351.8	2366	14.2	11.2	"	As above		90%	
2366	2366.9	0.9	0.9	"	As above		30%	
2366.9	2377.3	10.4	10.4	"	As above		90%	Bedding 0 degree dip
2377.3	2387.8	10.5	10.5	"	As above		95% +	
2387.8	2391	3.2	3.2	"	As above		90%	Bedding 0 degree dip
2391	2396	5	2	"	As above		5%	
2396	2406.2	10.2	10.2	"	As above		70%	Contains .8' band anhydrite at base.
2406.2	2412.3	6.1	6.1	"	As above		90%	
2412.3	2434.5	22.2	22.2	"	As above		85.%	
2434.5	2444.3	9.8	9.8	"	Anhydrite, reddish brown to brown, fine grained and somewhat sandy appearing with scattered sparse crystals of white glauberite(?) up to .2' long; also contains sparse halite.			

STAUFFER CHEMICAL COMPANY DRILL LOG

page 5.

BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SCB-2

ELEV._____ TOTAL DEPTH_____ LOCATION_____ ORE_____

FOOTAGE FROM	TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
2444.3	2445.8	1.5	1.5	Muddy Creek	As above		50%	
2445.8	2447.3	1.5	1.5	"	Anhydrite, light gray with some light brown, all sandy appearing, light gray strongly salt and pepper texture; also contains sparse coarse crystals of white glauberite(?) and some halite.		30% Halite	bedding 0 degree dip
2447.3	2516.2	68.9	68.9	✓	Halite, medium to very coarsely crystalline, transparent, some portions from 2471' to 2477' and 2510' to 2516' ice-like in appearance; anhydrite present as very fine laminations and bands to .2'; associated sparse white crystals of glauberite(?) to.1'.		90% + Halite	
2516.2	2532.4	16.2	16.2	[redacted] Spring ?	Anhydrite, fine grained with interbedded shale and tuff; in part is a volcanic breccia containing fragments of vesicular basalt; anhydrite in part is brown fine grained and also as small transparent crystals to .05'; shale is medium soft reddish brown; bedding medium to fine.			Bedding 5 to 8 degree dip.
2532.4	2533.7	1.3	1.3	"	Shale, greenish gray, laminated.			
2533.7	2536.8	3.1	3.1	"	Sandstone, fine grained, salt and pepper texture with thin partings of reddish brown shale and .3' of same at top; sandstone probably 30% to 40% anhydrite and strongly tuffaceous medium bedded.			

STAUFFER CHEMICAL COMPANY DRILL LOG

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BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SCB-2

ELEV._____ TOTAL DEPTH_____ LOCATION_____ ORE_____

FOOTAGE FROM	TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
2536.8	2544.7	5.9	4.7	[redacted] Spring ?	Anhydrite, white to transparent finely crystalline with thin partings of reddish brown shale (to .05')			Footage corrected at 2538' to 2540'
2544.7	2549.7	5.0	5.0	"	Sandstone, dark gray to greenish gray, fine to medium grained with several shaly bands to .6' near top, also contains sparce clear crystals of anhydrite to .05'; sandstone, entirely of volcanic (basaltic) materials, medium bedded.			17.3' lost at base of run Bedding 0 to 7 degree dip.
2549.7	2567				Missing.			
2567	2582.2	15.2	15.2	"	Pyroclastics, poorly bedded, basaltic fragments to .3' mostly ash to lapilli in size, color grades from greenish gray at top to brick red at base.			
2582.2	2587	4.8	4.8	"	Basalt, amygdaloidal, very few phenocrysts of feldspars; amygdules of clear finely crystalline zeolite and also as a fracture filling; basalt appears to be highly weathered.	✓		
2590	2620	30	Cuttings	"	Shale, reddish brown to brown, with some greenish gray, very soft 70%; basalt, black and reddish brown 20%; anhydrite and gypsum, reddish brown and white 10%.			

STAUFFER CHEMICAL COMPANY DRILL LOG

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BEGUN_____ FINISHED_____ LOGGED BY_____ DRILLED BY_____ DRILL HOLE SCB-2

ELEV._____ TOTAL DEPTH_____ LOCATION_____ ORE_____

FOOTAGE FROM	FOOTAGE TO	THICKNESS	RECOVERY	FORMATION	LITHOLOGY	ORE MINERALS	ASSAY	REMARKS
2620	2640	20	Cuttings	Horse Spring?	Shale, brown, some reddish brown, medium hard to soft 50%; basalt black and reddish brown, some fragments of greenish amygdules 50%; some gypsum.			
2640	2670	30	"	"	As above basalt 70%; shale 30%.			
2670	2750	80	"	"	As above, basalt 40%; shale 60%.			
2750	2780	30	"	"	As above basalt 15%; shale 85%.			
2780	2818	38	"	"	Shale, reddish brown, distinctly redder than typical Muddy Creek shales, medium hard, 95%; basalt 5%; decreasing to a trace of depth.			Samples were taken at 2818' of intervals of 0, 10 minutes and 20 minutes following cessation of drilling. samples showed no essential change in lithology. Total Depth 2818'

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