E-TR-52-II
Vol. II

MX SITING INVESTIGATION
WATER RESOURCES PROGRAM

TECHNICAL SUMMARY REPORT

VOLUME II

Ertec
The Earth Technology Corporation

E-TR-52-II

MX SITING INVESTIGATION
WATER RESOURCES PROGRAM

TECHNICAL SUMMARY REPORT

VOLUME II

Prepared for:

U.S. Department of the Air Force
Ballistic Missile Office
Norton Air Force Base, California 92409

Prepared by:

Ertec Western, Inc.
3777 Long Beach Boulevard
Long Beach, California 90807

30 November 1981

TABLE OF CONTENTS

TABLE OF CONTENTS (con't)

TABLE OF CONTENTS (con't)

TABLE OF CONTENTS (con't)

TABLE OF CONTENTS (con't)

TABLE OF CONTENTS (con't)

TABLES

APPENDICES

TABLE OF CONTENTS (con't)

Page

APPENDIX A

APPENDIX B

TABLE OF CONTENTS (con't)

Page

APPENDIX B

APPENDIX C

TABLE OF CONTENTS (con't)

Page

APPENDIX C

TABLE OF CONTENTS (con't)

Page

APPENDIX C

APPENDIX D

TABLE OF CONTENTS (con't)

Page

APPENDIX D

TABLE OF CONTENTS (con't)

TABLE OF CONTENTS (con't)

Page

APPENDIX F

TABLE OF CONTENTS (con't)

Page

APPENDIX G

1.0 INTRODUCTION

This volume contains individual hydrologic summaries for each of the 36 proposed MX deployment valleys in Nevada and Utah. These summaries are based on the results of the MX Water Resources Program. The key water-related issues summarized in Volume I are discussed for each siting valley and include:

- o General Physiography and Hydrology;
- o MX Water Requirements;
- o Water-Supply Limitations;
- o Water-Supply Alternatives; and
- o Impacts of Development.

The description of the physiography and hydrology of each valley is based upon data collected during reconnaissance field studies in each valley, interpretations of the local and regional hydrologic conditions, and previously published reports. The elements of the water budget are detailed for each valley as are local geologic conditions which control ground-water flow. The valley dimensions are based on study area boundaries defined for MX purposes which do not necessarily correspond to the topographic boundaries or hydrographic basins as defined by the states.

MX water requirements are based upon water use-estimates made by the U.S. Army Corps of Engineers (1981). Water-use estimates for the 19 valleys which will have life support camps have been revised to include water use for dependents of construction workers and for additional revegetation and landscaping.

Also included are the quantities of water requested in pending Air Force ground-water appropriation applications. In most cases, the amount requested is more than the estimated MX water use. At the time of filing, reliable water-use estimates were not available, and conservative estimates were used to ensure that supplemental appropriation applications would not have to be filed.

The exact quantities of water required for the operational phase have not been finalized but have been estimated by Ertec to be between 20 and 390 acre-ft/yr (0.02 and 0.5 hm^3/yr) in the deployment valleys. Operational water use is dependent on the number of clusters and support facilities located in each valley.

The sections on water-supply limitations address the legal and physical availability of surface and ground water in each valley. The estimates of legal water availability are derived from published perennial yield values and estimates of present water use and appropriations made by the Desert Research Institute (DRI, 1980), the Utah Water Resources Laboratory (UWRL, 1980), and Woodburn and others (1981). Assessments of the physical availability of water are based on published information and the results of hydrologic reconnaissance and exploratory drilling and aquifer testing conducted as part of the MX Water Resources Program. Water quality is assessed using Nevada and Utah Primary and Secondary Drinking Water Standards.

Water-supply alternatives considered in each valley are 1) development of the valley-fill aquifer; 2) development of the carbonate aquifer; 3) lease or purchase of existing surface- and ground-water rights; and 4) interbasin transfer of water. The only other water-supply source in the Great Basin area is surface water and this is not considered a viable alternative in MX deployment valleys.

The concluding section of each valley discussion addresses the potential impacts of the proposed MX water withdrawals. These generalized impact assessments are based on results of field testing in 20 valleys and preliminary finite-difference, numerical ground-water flow modeling in six valleys. Specific impacts which may occur will vary according to site-specific hydrologic conditions.

Appendices to this volume include basic data on ground-water levels, spring and stream discharge measurements, surface and ground-water chemistry, and a potentiometric map of each valley. The potentiometric map shows depths to water and the elevation of the potentiometric surface as well as the data collection stations used during the MX Water Resources Program. The potentiometric surfaces are based in part upon regional interpretations due to the paucity of water-level data in some valleys.

2.0 VALLEY DESCRIPTIONS

2.1 ANTELOPE VALLEY

2.1.1 General Physiography and Hydrology

Antelope Valley is a north-trending basin in Eureka and northern Nye counties, Nevada. The valley is open to Kobeh Valley to the north and is separated from other valleys by north-trending mountain ranges. The valley is 34 miles (55 km) long, 21 miles (34 km) across at its widest point, and encompasses 444 mi^2 (1150 km^2). The average elevation of the valley floor is 6200 feet (1890 m). Antelope Valley is bounded by the Monitor Range on the west, the Antelope Range on the southeast, and the Fish Creek Range and Mahogany Hills on the east. The highest peaks occur to the west of the valley in the Monitor Range where average elevations range from 7000 to 10,000 feet (2134 to 3048 m).

Numerous streams originate in the mountainous areas, generally flowing in response to snowmelt and high intensity, short duration rainfall. Streams on the valley floor are generally ephemeral, but a few mountain streams are perennial for a portion of their length. Runoff from the streams is rapidly lost by infiltration on the valley floor. Small springs in the valley, principally Klobe Springs and those at Kitchen Meadow, discharge approximately 1000 acre-ft/yr (1.2 hm^3/yr). In September 1980, five springs and one stream were measured by Ertec. Flows from the springs ranged from less than 1 gpm to 8 gpm (0.1 to 0.5 l/s). The streamflow was estimated to be 990 gpm (62 l/s).

Precipitation in the drainage area accounts for the approximately 4100 acre-ft/yr (5.1 hm^3/yr) of average annual groundwater recharge (Rush and Everett, 1964). In the northern part of Antelope Valley, east-trending faults form barriers which impede the flow of ground water out of the valley (Rush and Everett, 1964). The northward flow of ground water, restricted by these fault barriers, results in the water table being near or, in the case of springs, above land surface south of the faulted area. Discharge of ground water by evapotranspiration, which would otherwise flow to Kobeh Valley to the north, occurs in this area. Evapotranspiration losses in Antelope Valley are estimated to be 4200 acre-feet (5.2 hm^3) annually (Rush and Everett, 1964).

The depth to water in the northern and central portions of the valley is generally less than 50 feet (15 m), increasing to over 150 feet (46 m) along the valley margins (Appendix Figure B1-1). The hydraulic gradient in the valley-fill aquifer is northward toward Kobeh Valley at an average of 10 feet/mile (2 m/km) along the axis of the valley.

The valley-fill aquifer consists of older alluvium of late Tertiary to Quaternary age and younger alluvium of Quaternary age. The older alluvium is composed of low to moderately permeable mixtures of silt, sand, and gravel. The younger alluvium, although generally finer grained, is less consolidated and thus more permeable than the older alluvium. Underlying these sediments are thick sequences of carbonate rocks ranging from Cambrian to Permian in age. These consolidated carbonate rock formations occur at depths of more than 700 feet (213 m) along the valley axis (Rush and Everett, 1964).

Carbonate rocks of Paleozoic age are the dominant rock types found in the mountain ranges to the south and east of the valley. Most of the mountains to the west and north are comprised chiefly of lava flows and volcanic tuffs of Tertiary and Cretaceous age.

2.1.2 MX Water Requirements

MX construction is projected to begin in Antelope Valley in 1985 and continue to 1990. The peak annual demand for water during MX construction is estimated to be 1969 acre-feet (2.4 hm^3) in 1989. The Air Force has requested 3805 acre-ft/yr (4.7 hm^3/yr) of ground-water appropriations in Antelope Valley.

2.1.3 Water-Supply Limitations

2.1.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Antelope Valley is estimated to be 4000 acre-ft/yr (4.9 hm^3/yr) (Nevada State Engineer, 1971). This estimate is based on the assumption that all the losses due to evapotranspiration can be recovered. The figure differs from the estimates of recharge and discharge by Rush and Everett (1964) due to numerical rounding of the actual estimate. Current demands on the ground-water reservoir are estimated to be 437 acre-ft/yr (0.5 hm^3/yr) for irrigation of small fields and livestock watering at scattered ranches in the valley (DRI, 1980). Certificated rights for ground water total 1832 acre-ft/yr (2.3 hm^3/yr) (Woodburn and others, 1981).

Surface-water appropriations include 1519 acre-ft/yr (1.9 hm^3/yr) of certificates and proofs and 52 acre-ft/yr (0.1 hm^3/yr) in permits and applications (DRI, 1980).

The quantity of ground water available from the valley-fill aquifer for MX use is 3563 acre-ft/yr (4.4 hm^3/yr) when considering the perennial yield (4000 acre-ft/yr [4.9 hm^3/yr]) and existing use (437 acre-ft/yr [0.5 hm^3/yr]). When comparing the perennial yield to certificated ground-water rights of 1832 acre-ft/yr (2.3 hm^3/yr), the amount of water available for MX use is 2168 acre-ft/yr (2.7 hm^3/yr). Both amounts are more than peak annual MX requirements.

2.1.3.2 Source Capabilities

Surface water in Antelope Valley is not considered a dependable source of water for the MX project. Surface-water flows from springs in the valley are fully appropriated and not of sufficient quantity throughout the year to be a reliable source of water.

Although no aquifer tests have been conducted in this valley to date, existing data on the valley fill aquifer in Antelope Valley indicate that it can be considered a reliable source of water that is economically recoverable in most areas of the valley.

The carbonate aquifer is considered to have a low potential for development in Antelope Valley. This assessment is based primarily on the lack of significant thicknesses of known water bearing hydrostratigraphic units at economically drillable depths.

2.1.3.3 Water Quality

Water samples were collected from two wells and two springs in the valley for chemical analyses (Appendix F1-1) by Ertec. These analyses indicate that for the constituents analyzed, the quality of the waters sampled are within acceptable limits for construction (Appendix E1-1). The analyses also indicate that, for the constituents analyzed, all but one well (18N/51E-10b) meet Primary and Secondary Drinking Water Standards for the State of Nevada (Appendix E1-2). That well, located in the north-central part of the valley, has a cadmium concentration of 0.02 mg/l which exceeds the recommended level of 0.01 mg/l. Based on these analyses and others cited in Appendix F1-1, it is expected that the ground water in Antelope Valley would be suitable for both construction and drinking water use.

2.1.4 Water-Supply Alternatives

2.1.4.1 Lease or Purchase of Existing Water Rights

It should not be necessary to obtain MX water supplies through lease or purchase of existing rights in Antelope Valley because of the substantial amount (2168 acre-ft/yr [2.7 hm^3/yr]) of unappropriated ground water available. However, sufficient surface-and ground-water rights exist to make lease/purchase a viable supply option.

2.1.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for MX requirements for construction and operation. Aquifer tests have not been performed in the valley-fill sediments of Antelope Valley. Lithologic logs of existing well borings indicate that moderate to highly permeable sediments exist throughout much of the valley. Available water-quality data suggest that it will not be a limiting factor.

2.1.4.3 Carbonate Aquifer

The carbonate aquifer in Antelope Valley is characterized as having a low potential for ground-water development. It should be considered only as an alternative source of water.

2.1.4.4 Interbasin Transfer

Interbasin transfer of water from adjoining valleys such as Monitor or Kobeh valleys is feasible since these valleys have abundant water to meet current demands. Interbasin transfer should not be considered unless the valley-fill aquifer in Antelope Valley is not capable of meeting MX requirements.

2.1.5 Impacts of Development

2.1.5.1 Intrabasin Effects

Ground-water drawdown impacts due to withdrawals for the MX project should be minimal at existing wells because MX wells will be located at least 1 mile (2 km) from existing wells and because the aquifer transmissivity is expected to be moderate to high. Three wells pumping at the anticipated well yield of 450 gpm (28 l/s) will be required to meet the MX peak-year water requirement for construction. Future aquifer tests and computer modeling of the valley will provide a means for quantitatively predicting the probable drawdown due to MX pumping.

There will be no effect on springs located in the mountains at elevations above the valley-fill aquifer. Water from springs on the valley floor at the north end of the valley which is currently lost to evapotranspiration may be salvaged by a short-term decline in the ground-water table with no effect on phreatophyte growth during the short duration of peak withdrawals.

2.1.5.2 Interbasin Effects

There should be no effect on adjacent valleys due to MX withdrawals from the valley-fill aquifer in Antelope Valley. A fault forms a ground-water barrier in the valley fill at the north end of the valley and significantly reduces flow to Kobeh Valley. Underflow to other valleys is negligible and should not be affected by MX withdrawals.

construction phase of the MX project is within the perennial yield of the valley.

2.2.3.2 Source Capabilities

The only perennial sources of surface water in Big Sand Springs Valley are the small springs which issue from the bedrock-alluvial boundary. These springs are presently developed for livestock watering and do not represent a dependable source of water for the MX project because of their low discharge (2 to 3 gpm [0.1 to 0.2 l/s]).

Limited information is available on the valley-fill aquifer in Big Sand Springs Valley. Lithologic logs from an Air Force valley-fill test well in the southeastern portion of the valley (8N/53E-29da) indicate that the valley fill is predominantly fine- to medium-grained sand at this location. Aquifer tests indicate the valley-fill has a transmissivity of approximately 2600 ft^2/day (241 m^2/day) at this location. A sustained discharge of 435 gpm (27 l/s) was obtained during testing. Based on interpretation of lithologic logs, the valley-fill aquifer in Big Sand Springs Valley is believed to be under water-table conditions.

The Air Force test well penetrated tuff beneath the valley fill and there were indications of fractures. It is possible that these fractures could be water-bearing, although this could not be determined with any certainty. Aquifer tests conducted in similar tuff deposits (Dinwiddie and Schroder, 1971) gave transmissivity values from 8 to 254 ft^2/day (0.7 to

24 m^2/day). These values are highly variable due to the nature of flow through fractures.

Little hydrologic information is available on carbonate rocks in Big Sand Springs Valley. Deep underbasin ground-water flow has been postulated from Hot Creek Valley to Railroad Valley. However, the absence of thick sequences of appropriate carbonate hydrostratigraphic units at a cost-effective drilling depth likely preclude the development of the carbonate aquifer in the valley. Consequently, the potential for development of the carbonate aquifers in Big Sand Springs Valley is considered low.

2.2.3.3 Water Quality

Chemical analyses of ground water from several existing wells and one spring indicate that, for the constituents analyzed, all of the water samples are within the recommended criteria for construction water and domestic use (Appendices E1-1 and E1-2). Water-quality data are shown in Appendix F1-2.

Exploratory wells (8N/52E-1bd2 and 3; 8N/52E-15bc2, 3, and 4; 8N/53E-16ac1 and 3) were drilled in the southern portion of the valley as part of a U.S. Atomic Energy Commission underground nuclear testing program (Dinwiddie and Schroder, 1971). Except for fluoride concentration, all samples from the deep exploratory wells were within State of Nevada Primary and Secondary Drinking Water Standards (Appendix E1-2). Samples from the exploratory wells were collected from stratigraphic zones 2000 to 5000 feet (610 to 1524 m) below land surface. Water samples collected from the shallower Air Force test wells meet all state criteria for domestic consumption for the constituents analyzed.

2.2.4 Water-Supply Alternatives

2.2.4.1 Lease or Purchase of Existing Water Rights

There are no approved or pending ground-water appropriations in Big Sand Springs Valley. Water for MX requirements cannot be obtained through the lease or purchase of ground-water rights. Existing surface water rights (253 acre-ft/yr [0.3 hm^3/yr]) are less than the estimated peak-year MX water requirement and thus are also not a viable source.

2.2.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for MX use. Because of the lack of ground-water appropriations, the entire perennial yield (1000 acre-ft/yr [1.2 hm^3/yr]) should be available for temporary use. Based on aquifer tests conducted, the valley-fill aquifer is believed to be capable of supplying water in sufficient quantity and at a rate and quality that will meet the peak construction year requirements. Two production wells with yields of 200 gpm (13 l/s) would be required to meet peak MX water demands of 573 acre-ft/yr (0.7 hm^3/yr).

2.2.4.3 Carbonate Aquifer

The potential for developing the carbonate aquifers in Big Sand Springs Valley is considered to be low. There is little evidence that a productive carbonate aquifer exists at a cost-effective drilling depth. Further research in this area is construction phase of the MX project is within the perennial yield of the valley.

2.2.3.2 Source Capabilities

The only perennial sources of surface water in Big Sand Springs Valley are the small springs which issue from the bedrock-alluvial boundary. These springs are presently developed for livestock watering and do not represent a dependable source of water for the MX project because of their low discharge (2 to 3 gpm [0.1 to 0.2 l/s]).

Limited information is available on the valley-fill aquifer in Big Sand Springs Valley. Lithologic logs from an Air Force valley-fill test well in the southeastern portion of the valley (8N/53E-29da) indicate that the valley fill is predominantly fine- to medium-grained sand at this location. Aquifer tests indicate the valley-fill has a transmissivity of approximately 2600 ft^2/day (241 m^2/day) at this location. A sustained discharge of 435 gpm (27 l/s) was obtained during testing. Based on interpretation of lithologic logs, the valley-fill aquifer in Big Sand Springs Valley is believed to be under water-table conditions.

The Air Force test well penetrated tuff beneath the valley fill and there were indications of fractures. It is possible that these fractures could be water-bearing, although this could not be determined with any certainty. Aquifer tests conducted in similar tuff deposits (Dinwiddie and Schroder, 1971) gave transmissivity values from 8 to 254 ft^2/day (0.7 to

24 m^2/day). These values are highly variable due to the nature of flow through fractures.

Little hydrologic information is available on carbonate rocks in Big Sand Springs Valley. Deep underbasin ground-water flow has been postulated from Hot Creek Valley to Railroad Valley. However, the absence of thick sequences of appropriate carbonate hydrostratigraphic units at a cost-effective drilling depth likely preclude the development of the carbonate aquifer in the valley. Consequently, the potential for development of the carbonate aquifers in Big Sand Springs Valley is considered low.

2.2.3.3 Water Quality

Chemical analyses of ground water from several existing wells and one spring indicate that, for the constituents analyzed, all of the water samples are within the recommended criteria for construction water and domestic use (Appendices E1-1 and E1-2). Water-quality data are shown in Appendix F1-2.

Exploratory wells (8N/52E-1bd2 and 3; 8N/52E-15bc2, 3, and 4; 8N/53E-16ac1 and 3) were drilled in the southern portion of the valley as part of a U.S. Atomic Energy Commission underground nuclear testing program (Dinwiddie and Schroder, 1971). Except for fluoride concentration, all samples from the deep exploratory wells were within State of Nevada Primary and Secondary Drinking Water Standards (Appendix E1-2). Samples from the exploratory wells were collected from stratigraphic zones 2000 to 5000 feet (610 to 1524 m) below land surface. Water samples collected from the shallower Air Force test wells meet all state criteria for domestic consumption for the constituents analyzed.

2.2.4 Water-Supply Alternatives

2.2.4.1 Lease or Purchase of Existing Water Rights

There are no approved or pending ground-water appropriations in Big Sand Springs Valley. Water for MX requirements cannot be obtained through the lease or purchase of ground-water rights. Existing surface water rights (253 acre-ft/yr [0.3 hm^3/yr]) are less than the estimated peak-year MX water requirement and thus are also not a viable source.

2.2.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for MX use. Because of the lack of ground-water appropriations, the entire perennial yield (1000 acre-ft/yr [1.2 hm^3/yr]) should be available for temporary use. Based on aquifer tests conducted, the valley-fill aquifer is believed to be capable of supplying water in sufficient quantity and at a rate and quality that will meet the peak construction year requirements. Two production wells with yields of 200 gpm (13 l/s) would be required to meet peak MX water demands of 573 acre-ft/yr (0.7 hm^3/yr).

2.2.4.3 Carbonate Aquifer

The potential for developing the carbonate aquifers in Big Sand Springs Valley is considered to be low. There is little evidence that a productive carbonate aquifer exists at a cost-effective drilling depth. Further research in this area is recommended only if other water-supply alternatives cannot be developed.

2.2.4.4 Interbasin Transfer

If in-valley sources cannot be developed, the interbasin transfer of water from Little Smoky Valley may be possible. Little Smoky Valley has a perennial yield of 5000 acre-ft/yr (6.2 hm^3/yr) (Nevada State Engineer, 1971). There are 2229 acre/ft-yr (2.7 hm^3/yr) in approved and pending ground-water rights (Woodburn and others, 1981), leaving approximately 2771 acre-ft/yr (3.4 hm^3/yr) of ground water available for appropriation. MX water demands for the peak year of construction in Little Smoky Valley are 742 acre-ft/yr (0.9 hm^3/yr) in 1986. As a result, there would be 2029 acre-ft/yr (2.5 hm^3/yr) available for possible transfer to Big Sand Springs Valley.

2.2.5 Impacts of Development

2.2.5.1 Intrabasin Effects

Only a minor lowering of water levels near MX withdrawal wells is expected in the valley. Based on a well yield of 200 gpm (13 l/s), a transmissivity of 2600 ft^2/day (241 m^2/day), an assumed storativity of 0.07, and a pumping period of two years, a drawdown of less than 1 foot (0.3 m) will occur 1 mile (2 km) from an MX production well. At a distance of less than 3 miles (5 km), no drawdown will occur. These drawdowns will vary somewhat depending on localized hydrologic conditions within the valley. The expected drawdowns should not significantly affect the scattered stock wells which represent the only present ground-water use in the valley if appropriate setback criteria are followed.

The springs in Big Sand Springs Valley are meteoric and are located along the mountain fronts at elevations above the valley-fill aquifers. Withdrawals from the valley-fill aquifer should not affect these springs.

2.2.5.2 Interbasin Effects

Some spring discharges in Railroad Valley, most notably at Lockes, are believed to be derived from ground-water outflow from Big Sand Springs Valley. MX ground-water withdrawals in Big Sand Springs Valley may affect the discharge of these springs. However, since the distance to these springs is great and the rate of withdrawal will be minor, even for the peak year of construction, a noticeable effect on the springs at Lockes is not anticipated. These springs should be monitored as a precautionary measure.

2.3 BIG SMOKY VALLEY

2.3.1 General Physiography and Hydrology

Big Smoky Valley, as defined in this study, is a north-trending basin in Nye and Esmeralda counties, Nevada, and includes southern Big Smoky and Alkali Spring hydrographic basins. The valley is 72 miles (116 km) long and up to 25 miles (40 km) wide. The area of the valley under consideration is 1600 mi^2 (4142 km^2). The elevation of the valley floor ranges from 4800 feet (1463 m) at the two playas to 5800 feet (1768 m) at the north end of the valley. The valley is bounded by the Cedar and Monte Cristo mountains on the west, the Toiyabe Range on the north, the San Antonio Mountains on the east, and the Weepah Hills and Montezuma and Silver Peak ranges on the south. Elevations along the range crests range from 5500 to 11,000 feet (1676 to 3353 m).

There is no surface drainage from Big Smoky Valley. There is indirect evidence for subsurface discharge from Big Smoky Valley to Clayton Valley based on differences in potentiometric levels and water budget imbalances (Rush and Schroer, 1970). The majority of recharge to the valley-fill aquifer in Big Smoky Valley is believed to occur in the mountains and on the alluvial fans. Recharge from these sources is estimated to be about 12,000 acre-ft/yr (14.8 hm^3/yr) (Rush, 1968 and Rush and Schroer, 1970). Only a minor amount of recharge is believed to take place through the finer-grained sediments on the valley floor.

Additional recharge occurs by subsurface inflow from Ione Valley to the west and Ralston Valley to the east. Subsurface flow from these areas is estimated to be over 8000 acre-ft/yr (9.9 hm^3/yr) (Rush, 1968; and Rush and Schroer, 1970). Total recharge is therefore 20,000 acre-ft/yr (24.7 hm^3/yr).

Discharge in southern Big Smoky Valley takes place by evapotranspiration, withdrawal by pumping from wells, spring discharge, and possible subsurface outflow. Evapotranspiration is estimated to be 6400 acre-ft/yr (7.9 hm^3/yr) based on the amount of area that supports phreatophyte growth (Rush, 1968; and Rush and Schroer, 1970). Numerous meteoric springs along the base of the mountain ranges discharge minor quantities of water, primarily from perched aquifers. Alkali Spring (1S/41E-26a) has been identified as regional. Of the remaining 13,600 acre-ft/yr (16.8 hm^3/yr) of recharge, about 13,000 acre-ft/yr (16.0 hm^3/yr) are assumed to leave the valley by subsurface flow to Clayton Valley to the southwest, and the remainder may discharge into Columbus Salt Marsh to the west (Rush and Schroer, 1970).

The hydraulic gradient in the valley-fill aquifer averages 30 feet/mile (6 m/km) from the north down the axis of the valley in the Tonopah Flat area and from 75 to 200 feet/mile (14 to 38 m/km) in Alkali Spring Valley. Depth to water ranges from near surface in the northeast part of the valley, near San Antonio Ranch, to 150 feet (46 m) in the central part of the Tonopah Flat area to less than 50 feet (15 m) in the playas (Appendix Figure B1-3).

Alluvial and lacustrine deposits of Tertiary and Quaternary age occur in thicknesses believed to be from 3000 to 5000 feet (914 and 1524 m) (Rush and Schroer, 1970). The generally coarse-grained alluvial deposits are interlayered with the fine-grained lake deposits near the center of the valley. Playa deposits occur in the topographic low areas of central Alkali Spring Flat and Tonopah Flat. Rocks in the bordering mountain ranges are primarily Tertiary volcanics with localized occurrences of Paleozoic clastic and carbonate rocks. Minor outcrops of granitic igneous rocks occur throughout the boardering mountain ranges.

2.3.2 MX Water Requirements

MX construction in Big Smoky Valley is projected to begin in 1984 and conclude in 1990. The peak annual water demand for MX construction is estimated to be 2040 acre-feet (2.5 hm^3) in 1986. The Air Force has filed for 4146 acre-ft/yr (5.1 hm^3/yr) of ground-water appropriations in Big Smoky Valley from three points of diversion.

2.3.3 Water-Supply Limitations

2.3.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Big Smoky Valley is estimated to be 9000 acre-ft/yr (11.1 hm^3/yr) (Nevada State Engineer, 1971). This estimate is based on the assumption that the total evapotranspiration loss can be salvaged for beneficial use.

Surface-water certificates and proofs total 24,909 acre-ft/yr (30.7 hm^3/yr) in Big Smoky Valley. All of the appropriations occur north of Township 11N. There is surface-water use in the southern portion of the valley, however, the corresponding water rights data are not available from the Nevada State Engineer at this time (DRI, 1980). There are 7665 acre-ft/yr (9.5 hm^3/yr), 4204 acre-ft/yr (5.2 hm^3/yr), and 64,085 acre-ft/yr (79.0 hm^3/yr) of ground-water certificates, permits, and pending applications, respectively, in the Tonopah Flat area (Woodburn and others, 1981). An inventory of ground-water rights in the Alkali Spring Flat area has not been completed as of this date. The estimated present ground-water use is 30,660 acre-ft/yr (37.8 hm^3/yr). Surface-water use for the valley has not been defined but is relatively small.

Mining and irrigation account for over 98 percent of present water use in Big Smoky Valley. Other minor uses are for recreation and wildlife, energy, domestic, and stock watering (DRI, 1980).

The quantity of ground water available for MX use is herein defined as the perennial yield less the amount of present use or approved water rights. In Big Smoky Valley, both existing ground-water rights and ground-water use exceed the perennial yield.

2.3.3.2 Source Capabilities

Springs do not represent a dependable source of water for MX use because they are small and located in relatively inaccessible areas. Some streams, such as Peavine Creek, have variable perennial flow in their upper reachs but infiltrate completely within a short distance of the canyon mouths. Flow to the bottom of the alluvial fans occurs only during peak run-off events.

Short-term aquifer tests were conducted at two existing wells in Big Smoky Valley. Transmissivities were calculated to be 16,000 ft^2/day and 200 ft^2/day (1483 and 19 m^2/day) at the two locations (6N/40E-13add and 3N/40E-2dcc), respectively. Due to the short-term nature of these tests (less than 48 hours), these results cannot be considered reliable nor to provide an accurate indication of valley-fill aquifer conditions. However, based on published data on Big Smoky Valley, the valley-fill aquifer is considered capable of supplying sufficient quantities of water at acceptable rates to meet MX requirements.

The regional carbonate aquifer in Big Smoky Valley is considered to have a very low potential for water-supply development. Appropriate hydrostratigraphic units are not present in significant amounts because the geology is dominated by volcanic rocks.

2.3.3.3 Water Quality

Water-quality data for Big Smoky Valley are listed in Appendix F1-3. Five ground-water samples were collected for chemical analysis by Ertec personnel. Three of the samples were from wells and two were from springs. With the exception of Alkali Hot Spring and well 3N/40E-2dcc, the waters sampled are within the recommended limits for construction use (Appendix E1-1) and Primary and Secondary Drinking Water Standards established by the State of Nevada (Appendix E1-2) for the constituents analyzed. The ground-water sample taken from Alkali Hot Springs exceeded the recommended limit of the Secondary Drinking Water Standard for sulfate (494 mg/l) but not the maximum limit. Water collected from well 3N/40E-2dcc exceeded the Primary Drinking Water Standard for fluoride (1.8 mg/l) as did the sample collected from Alkali Hot Spring (8.2 mg/l). In general, water quality deteriorates toward the playas where horizontal flow terminates and discharge by evapotranspiration takes place.

2.3.4 Water-Supply Alternatives

2.3.4.1 Lease or Purchase of Existing Water Rights

Obtaining water supplies through lease or purchase of existing water rights is the preferred alternative in Big Smoky Valley. Existing surface- and ground-water rights far exceed peak-year MX water requirements.

2.3.4.2 Valley-Fill Aquifer

The valley-fill aquifer in Big Smoky is capable of delivering water at the rate and quantity necessary to meet MX requirements. Because this is a designated valley, it is assumed that development of new MX wells can only be accomplished through lease or purchase of existing water rights and the relocation of these rights to areas suitable for MX needs.

2.3.4.3 Carbonate Aquifer

The carbonate aquifer is considered to have a low potential for development in Big Smoky Valley because of a general lack of carbonate rocks and the presence of volcanic, intrusive, and clastic aquitards. It should be considered only as a low priority alternative.

2.3.4.4 Interbasin Transfer

Interbasin transfer of water from adjacent valleys, other than northern Big Smoky Valley, is not considered a feasible alternative for obtaining MX water supplies. Ralston Valley, the only adjacent valley included in MX investigations, is also a designated valley with no excess water available for transfer.

2.3.5 Impacts of Developments

2.3.5.1 Intrabasin Effects

Water for MX development will probably come from the purchase or lease of water rights from existing holders. Therefore, there will be no overall increase of water use in the valley, however, points of diversion may be changed. Any new MX wells should be located at least 1 mile (2 km) from existing wells and local springs and up to 3 miles (5 km) from Alkali Spring since this spring is presumed to be regional.

The effects of MX pumping on the water table have not been estimated at this time due to the lack of reliable aquifer test data in Big Smoky Valley. Future testing and computer modeling of this valley will provide reliable estimates of MX-related drawdowns. However, it is anticipated that because of the strict criteria for well siting to be employed by the Air Force, the drawdown effects will be minor and of short duration during the construction phase.

2.3.5.2 Interbasin Effects

There should be no interbasin effects resulting from MX withdrawals in Big Smoky if the water-supply source is obtained through the lease or purchase of existing water rights.

2.4 BUTTE VALLEY

2.4.1 General Physiography and Hydrology

Butte Valley is a north-trending basin in north-central White Pine and south-central Elko counties, Nevada. The valley contains two surface-drainage basins separated by a gently sloping alluvial divide. The study area for MX purposes is limitd to southern Butte Valley, which is approximately 57 miles (92 km) in length, 17 miles (27 km) in width, and is 730 mi^2 (1890 km^2) in area. The average valley floor elevation is 6300 feet (1920 m). Butte Valley is bordered on the east by the Cherry Creek Mountains, the southeast by the Egan Range, the west by the Butte Mountains, and the northwest by the Medicine Range. The surrounding mountains range in elevation from 6900 feet to over 10,600 feet (2103 to 3231 m).

Southern Butte Valley is a topographically closed basin with only ephemeral streams present on the valley floor. Runoff from mountain streams is rapidly lost to infiltration at the proximal end of the alluvial fans. Total runoff from the mountains has been estimated to be about 9400 acre-ft/yr (11.6 hm^3/yr) (Glancy, 1968). There are numerous springs in the valley that discharge from both the valley-fill material and carbonate and noncarbonate rocks. None of the springs are believed to be regional. Four springs measured in November 1980 by Ertec were found to discharge from 1 to 100 gpm (0.1 to 6 l/s).

Recharge to the ground-water reservoir is from the infiltration of precipitation in stream channels and in the mountains.

The average annual recharge for Butte Valley from these sources has been estimated to be 15,000 acre-ft/yr (18.5 hm^3/yr). Evapotranspiration losses are approximately 11,000 acre-ft/yr (13.6 hm^3/yr) (Nevada State Engineer, 1971).

The topographic divide between the northern and southern parts of Butte Valley also acts as a ground-water divide. Although the valley-fill reservoir extends continuously through the two basins, the ground-water divide forms a hydraulic barrier that impedes subsurface flow from one basin to the other. There may, however, be flow through the carbonate rocks to adjacent valleys (Glancy, 1968). Appendix Figure B1-4 shows the potentiometric surface in Butte Valley.

The valley-fill aquifer consists of older alluvium of late Tertiary to Quaternary age and younger alluvium of Quaternary age. The older alluvium is comprised of low to moderately permeable mixtures of silt, sand, gravel, and boulders. The younger alluvium is generally finer but better sorted and yields water at higher rates. Underlying these sediments are thick sequences of carbonate and noncarbonate rocks ranging in age from Precambrian to Tertiary. Carbonate rocks are widely exposed throughout the surrounding mountains. Wells have not been drilled into the carbonates, but numerous springs emanate from these rocks and it is assumed that there is some interbasin subsurface flow. The water transmitting capacity of the underlying noncarbonate rocks, which consist of volcanic, metamorphic, and sedimentary rock types, has not been tested by wells.

Some small springs originate in these rock units in the surrounding mountains.

2.4.2 MX Water Requirements

The peak annual demand for water during the MX construction phase is expected to be 1005 acre-feet (1.2 hm^3) in 1988. Construction is projected to begin in 1985 and conclude in 1990. The Air Force has filed applications for the appropriation of 2464 acre-ft/yr (3.0 hm^3/yr) of ground water in Butte Valley from four points of diversion.

2.4.3 Water-Supply Limitations

2.4.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of southern Butte Valley has been estimated to be 14,000 acre-ft/yr (17.3 hm^3/yr) (Nevada State Engineer, 1971). The quantity of ground water available for MX purposes is approximately equal to the perennial yield of 14,000 acre-ft/yr (17.3 hm^3/yr). The peak annual demand during MX construction is considerably less than the available ground-water supply in the valley.

Surface-water use in the valley is primarily for irrigation of alfalfa and native pasture and stock watering. An estimate of the actual amount of surface-water use is not available. At the present time, ground-water use in the valley is limited to domestic or stock-watering purposes and is probably less than 100 acre-ft/yr (0.1 hm^3/yr). An inventory of appropriations for surface- and ground-water is not available at present, however, a study is currently being conducted to quantify the water rights in Butte Valley.

2.4.3.2 Source Capabilities

Surface-water sources in southern Butte Valley are not considered a dependable source of water for the MX project. Perennial flows primarily occur in mountain areas. Major ephemeral flows are diverted to crop use in the valley and do not flow in adequate quantities for sufficient periods of time to represent a reliable source of water.

The valley-fill aquifer is considered a reliable source of water that can be economically recovered from most areas of the valley. Exploratory drilling and aquifer testing has not been conducted as a part of the MX Water Resources program in the valley. Characteristics of the valley-fill aquifer can, therefore, only be estimated. Transmissivities, based on existing well yields, are probably within a range of 1000 to 6000 ft^2/day (93 to 556 m^2/day). If these values are valid, the aquifer could yield water in sufficient quantities and at acceptable rates to meet MX needs.

2.4.3.3 Water Quality

Water samples were collected for chemical analysis from three springs in the southern portion of the valley and from one spring and one stream in the northern end of the valley. These samples and other published water-quality data from wells in the valley indicate that the chemical quality of water, for those constituents analyzed, is within acceptable limits for construction use (Appendix E1-1) and meets Primary and Secondary Drinking Water Standards for the State of Nevada (Appendix E1-2). Water-quality data for Butte Valley are shown in Appendix F1-4.

2.4.4 Water-Supply Alternatives

2.4.4.1 Lease or Purchase of Existing Water Rights

Until an inventory of present water appropriations is completed, it will not be possible to determine if lease/purchase is a viable water-supply alternative. However, it will probably not be necessary to obtain MX water supplies through the lease or purchase of existing water rights in this valley. The perennial yield of the ground-water basin is significantly greater than both the current use and the proposed MX requirements.

2.4.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for MX construction and operation requirements. The quantity of ground water requested in appropriation applications for the MX project in Butte Valley is 2464 acre-ft/yr (3.0 hm^3/yr) and can easily be met by the presently undiverted ground-water supply in the valley-fill aquifer.

2.4.4.3 Carbonate Aquifer

The carbonate aquifer has a high development potential as a source of water in Butte Valley. This potential is based on the presence of favorable hydrostratigraphic units, the lack of significant aquitards, known areas of high density faulting within carbonate rocks of Devonian to middle Cambrian age, and minimal land use restrictions in favorable drilling areas. The carbonate aquifer should be considered only as an alternative source of water since no exploratory drilling and testing to verify water-supply capability has been conducted.

2.4.4.4 Interbasin Transfer

Interbasin transfer of water from adjoining valleys is possible but should not be necessary because the valley-fill aquifer in Butte Valley is capable of meeting MX requirements.

2.4.5 Impacts of Development

2.4.5.1 Intrabasin Effects

Aquifer testing or numerical modeling results are not presently available for Butte Valley. Consequently, impact assessment must be generalized.

All MX production wells will be located at least 1 mile (2 km) from existing wells. The drawdown at that distance is expected to be minor and should not significantly affect any present users. The majority of springs in the valley are meteoric and either originate in the carbonate rocks or are located at elevations above the valley floor. MX withdrawals from the valley-fill aquifer should have no impact on those springs. By locating MX wells at an appropriate distance from valley-fill springs, the effects on discharge rates and, therefore, existing users can be minimized.

2.4.5.2 Interbasin Effects

It is not expected that there will be any interbasin effect on adjacent valleys if MX water requirements are met from the valley-fill aquifer. The ground-water divide between the northern and southern sections of Butte Valley impedes flow from one area to another. Therefore, pumping in the southern section of Butte Valley should have no effect on the northern area.

The connection between the valley-fill and underlying carbonate aquifer is not defined. However, any effects of MX withdrawals from Butte Valley on adjacent valleys are not anticipated.

2.5 CAVE VALLEY

2.5.1 General Physiography and Hydrology

Cave Valley, in Lincoln and White Pine counties, Nevada, is a north-trending, topographically closed basin. The valley is bordered by the Egan Range on the west and the Schell Creek Range on the east. The Schell Creek and Egan Ranges merge to the south and separate Cave Valley from northern Pahranagat Valley. Cave Valley is separated from Steptoe Valley to the north by a low alluvial divide. Crests of these surrounding mountains range in elevation from 7000 to 11,000 feet (2134 to 3353 m). The average elevation of the valley floor is 6100 feet (1859 m). Cave Valley is about 41 miles (66 km) long, 13 miles (21 km) across at its widest point, and encompasses approximately 362 mi^2 (937 km^2).

Although there is no perennial streamflow in Cave Valley, surface-water runoff from the mountains is estimated to be 10,000 acre-ft/yr (12.3 hm^3/yr) (Eakin, 1962b). Runoff is rapidly lost to infiltration on the alluvial fans. Cave Valley Spring, a valley-fill spring in the northern portion of the valley (9N/64E-16bad) has a variable discharge of about 400 gpm (25 l/s); two meteoric springs measured by Ertec in March 1980, in the mountains in the southern part of the valley, discharge less than 1 gpm (0.1 l/s). Eakin (1962b) believes that many of the small springs in the mountains discharge from small perched aquifers.

Ground-water recharge is derived from precipitation within the basin. Some recharge occurs from the infiltration of precipitation at the head of alluvial fans, but most recharge results from percolation of precipitation runoff into the bedrock in the mountains with lateral movement into the valley-fill (Eakin, 1962b). The average annual recharge is estimated to be 14,000 acre-ft/yr (17.3 hm^3/yr) (Nevada State Engineer, 1971). Evapotranspiration is estimated to be 200 acre-ft/yr (0.2 hm^3/yr) and is probably limited to the area near the main drainage channel in Townships 9 and 10N, to tributary channels, and to spring discharge areas (Eakin, 1962b).

Cave Valley is hydrologically open, with underflow to the south and west through carbonate rocks of Paleozoic age. Total discharge by underflow to White River Valley is estimated to be 14,000 acre-ft/yr (17.3 hm^3/yr) (Nevada State Engineer, 1971). The hydraulic gradient in the valley-fill aquifer is southward at 50 feet/mile (9 m/km) along the valley axis. The potentiometric surface ranges in elevation from 6600 feet (2012 m) in the north to about 5200 feet (1585 m) in the south (Appendix Figure B1-5). Depth to water is less than 50 feet (15 m) in parts of northern Cave Valley and greater than 230 feet (70 m) in the southern half of the valley.

The valley-fill aquifer in Cave Valley consists of unconsolidated to partly consolidated clay, silt, sand, and gravel, partly consolidated pyroclastic deposits and welded tuffs, and lacustrine deposits of Tertiary or Quaternary age. A lake occupied the southern part of the valley in late Pleistocene time (Eakin, 1962b).

Bedrock formations exposed in the mountains are assumed to also underlie the valley-fill deposits. The Egan Range on the west side of Cave Valley consists mainly of Paleozoic carbonate rocks with some clastic sedimentary rocks of Paleozoic age and volcanics of Tertiary age. The northern Schell Creek Range is composed of Paleozoic clastic rocks with minor Paleozoic carbonate rocks. Tertiary volcanics dominate the middle of the range, and Paleozoic carbonate rocks predominate in the south (Stewart and Carlson, 1978). The bedrock has been substantially faulted. Fault blocks of Paleozoic carbonates crop out in the northern portion of the valley.

2.5.2 MX Water Requirements

MX construction in Cave Valley is projected to begin in 1983 and conclude in 1987. The peak annual demand for water during the MX construction phase is expected to be 916 acre-feet (1.1 hm^3) in 1984. In July 1980, the Air Force applied for an appropriation of 2076 acre-ft/yr (2.6 hm^3/yr) of ground water in Cave Valley from six points of diversion.

2.5.3 Water-Supply Limitations

2.5.3.1 Perennial Yield, Use, and Appropriations

The perennial yield in Cave Valley has been estimated to be 2000 acre-ft/yr (2.5 hm^3/yr) (Nevada State Engineer, 1971). Certificated rights for ground-water use in Cave Valley total 31 acre-ft/yr (0.04 hm^3/yr). There are no permitted rights or pending applications for ground water, and there is no present ground-water use in Cave Valley (Woodburn and others, 1981; and DRI, 1980). Present surface-water use is estimated at 1013 acre-ft/yr (1.2 hm^3/yr) which includes 11 acre-ft/yr (0.01 hm^3/yr) for stock watering, 2 acre-ft/yr (0.002 hm^3/yr) for domestic use, and 1000 acre-ft/yr (1.2 hm^3/yr) for irrigation. Certificates and proofs for surface-water rights total 2643 acre-ft/yr (3.3 hm^3/yr) which include 32 acre-ft/yr (0.04 hm^3/yr) for domestic use, 497 acre-ft/yr (0.6 hm^3/yr) for stock watering, and 2114 acre-ft/yr (2.6 hm^3/yr) for irrigation (DRI, 1980).

Considering only approved appropriations, the quantity of ground water available for MX use is 1969 acre-ft/yr (2.4 hm^3/yr). The estimated peak annual requirement of 916 acre-feet (1.1 hm^3) is well below the available perennial yield for Cave Valley.

2.5.3.2 <u>Source Capabilities</u>

Cave Valley Spring, in the northern part of the valley (9N/64E-16bad), has a variable discharge of about 650 acre-ft/yr (0.8 hm^3/yr). The spring is the only reliable surface-water source and could be a partial source of water for the construction and operational phases of the MX project.

An aquifer test was performed on the Air Force valley-fill test well at 7N/63E-14ab2. A sustained discharge of 225 gpm (14 l/s) was obtained. Analysis of the data obtained from the test indicated a transmissivity of 2400 ft^2/day (222 m^2/day) for this area of the valley. This indicates that the valley-fill aquifer in this area is capable of supplying water in the necessary amounts and at sufficient rates to meet MX requirements.

The carbonate aquifer in Cave Valley has a high potential for development. This is based on the occurrence of thick sequences of Cambrian to Devonian carbonate rocks and the general lack of known Paleozoic aquitards at drillable depths. In addition, the valley is part of a known regional flow regime, the White River ground-water flow system.

2.5.3.3 Water Quality

Eleven water samples were collected in Cave Valley for water-quality analysis. Data are listed in Appendix F1-5. Three of the samples were from local springs; Cave Valley Spring, located in the northern part of the valley, and Horse and Side-hill springs, located in the southern mountains. The remaining samples were from wells in the valley-fill aquifer. Chemical analyses indicate that, for the constituents analyzed, water from three of the wells and Cave Valley Spring meet construction water-quality criteria and Primary and Secondary Drinking Water Standards for the State of Nevada (Appendices E1-1 and E1-2). Two springs (6N/63E-19adb, 7N/64E-3dca) exceed the recommended Secondary Drinking Water Standard of 500 mg/l total dissolved solids (TDS) for the State of Nevada, but do not exceed the maximum limit of 1000 mg/l TDS. Water from one well (8N/64E-4abd) had a TDS concentration of approximately 2870 mg/l, and samples from two springs had TDS concentrations of 840 mg/l and 740 mg/l. These two springs are probably related to perched ground water in the mountains and are not indicative of the water quality of the valley-fill aquifer. The water from the well at 8N/64E-4abd may also be perched.

Water quality trends in the southern portion of the valley below Township 7N have not been identified. It is expected that the ground water should generally be suitable for construction and drinking water purposes.

2.5.4 Water-Supply Alternatives

2.5.4.1 Lease or Purchase of Existing Water Rights

It is impractical to consider lease or purchase of ground-water rights in Cave Valley because approved and pending appropriations total only 31 acre-ft/yr (0.04 hm^3/yr). Lease or purchase of existing surface-water rights from Cave Valley Spring is a viable partial source of supply for MX construction and operation. The spring has a variable discharge rate yielding about 650 acre-ft/yr (0.8 to hm^3/yr).

2.5.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred supply source to meet MX water requirements. The perennial yield is adequate to meet MX demand, and aquifer testing has shown that appropriate well yields can be obtained.

2.5.4.3 Carbonate Aquifer

The carbonate aquifer is considered to have a high potential for development. However, because actual testing has not been conducted, it should only be considered as an alternative water-supply source.

2.5.4.4 Interbasin Transfer

It will not be necessary to transfer water into Cave Valley because in-valley sources will be capable of meeting MX requirements.

2.5.5 Impacts of Development

2.5.5.1 Intrabasin Effects

Drawdowns around MX production wells in Cave Valley have been calculated based on a transmissivity of 2400 ft^2/day (222 m^2/day), an assumed storativity of 0.01, and a pumping period of two years. At an estimated yield of 250 gpm (16 l/s), the calculated drawdown 1 mile (2 km) from an MX production well would be 1 foot (0.3 m). This is a minimal drawdown and 1 mile (2 km) setbacks from existing wells should preclude any impacts. Appropriate setback distances should also be observed from springs in Cave Valley, especially Cave Valley Spring to avoid impacts.

If surface-water rights are leased or purchased, there may be an effect in the valley because the majority of present use (1000 acre-ft/yr [1.2 hm^3/yr]) is for irrigation. Acreage may have to be withdrawn from agricultural production for the duration of MX use.

2.5.5.2 Interbasin Effects

White River Valley receives approximately 14,000 acre-ft/yr (17.3 hm^3/yr) of ground-water underflow from Cave Valley. Water levels and spring discharge may be affected in White River Valley if the valley-fill aquifer in Cave Valley is developed. However, considering the estimated peak year use in Cave Valley of 916 acre-feet (1.1 hm^3) as compared to the total underflow, effects, if any, would be extremely minor.

2.6 COAL VALLEY

2.6.1 General Physiography and Hydrology

Coal Valley is located in southeastern Nevada and extends from northeastern Lincoln County northward into Nye County. The valley is topographically closed with low alluvial divides separating it from White River Valley to the northeast and the northern end of Garden Valley to the northwest. Water Gap, a topographically open alluvial divide on the western side of the valley, leads upgradient into Garden Valley. Coal Valley is 36 miles (58 km) long, averages 15 miles (24 km) in width, and encompasses 460 mi^2 (1191 km^2). The elevation of the valley floor is 5000 feet (1524 m) in the north and 4940 feet (1506 m) in the south. The valley is bordered by the Golden Gate Range on the west, the Seaman Range on the east, and the north Pahranagat Range on the south. Elevations range from 5300 feet to 8200 feet (1615 to 2499 m).

Streamflow within Coal Valley is ephemeral, with the average annual surface runoff estimated at 400 acre-ft/yr (0.5 hm^3/yr) (Nevada State Engineer, 1971). Water occassionally flows from Garden Valley into Coal Valley through Water Gap. No regional springs occur in Coal Valley. A limited number of small meteoric springs occur within the mountains and around the valley margins.

Ground-water recharge to the valley-fill sediments is primarily derived from the infiltration of precipitation in the mountains and in stream channels through alluvial fans. The average annual recharge is estimated at 2000 acre-ft/yr (2.5 hm^3/yr). Subsurface inflow from Garden Valley through underlying carbonate rocks is estimated at 8000 acre-ft/yr (9.9 hm^3/yr) (Eakin, 1963b).

The Coal Valley basin is a hydrologically open system with a discharge of 10,000 acre-ft/yr (12.3 hm^3/yr) as subsurface outflow to Pahranagat Valley (Eakin, 1963b). The depth to ground-water in the valley is greater than 800 feet (244 m) below land surface. There is, therefore, minimal discharge by evapotranspiration. The potentiometric surface of the valley-fill aquifer is shown in Appendix Figure B1-6.

The valley-fill aquifer in Coal Valley was divided into two units by Eakin (1963b). The older unit, consisting mainly of unconsolidated silt, sand, and gravel derived from adjacent highland areas, has an estimated thickness of several thousand feet. The younger unit consists of unconsolidated clay, silt, sand, and gravel derived in part from a Pleistocene lake that occupied the valley. This unit probably has a maximum thickness of several hundred feet.

The surrounding mountains are composed of carbonates and clastic rocks of Paleozoic age and volcanics of Tertiary age. The carbonate rocks are believed to underly the valley-fill sediments (Eakin, 1963b).

2.6.2 MX Water Requirements

The peak annual demand for ground water during MX construction will be 2285 acre-feet (2.8 hm^3) in 1984. Construction in the valley is projected to begin in 1983 and conclude in 1988. The Air Force has filed ground-water appropriation applications for 3456 acre-ft/yr (4.3 hm^3/yr) from nine points of diversion.

2.6.3 Water-Supply Limitations

2.6.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Coal Valley is estimated to be 6000 acre-ft/yr (7.4 hm^3/yr) (Nevada State Engineer, 1971). This value is based on the total recharge (precipitation and underflow) and total discharge (underflow) for both the valley-fill and carbonate aquifers in both Coal and Garden valleys. Existing hydrologic data provide some evidence of a direct hydrologic connection between the ground-water systems of these two valleys. A combined perennial yield of 12,000 acre-ft/yr (14.8 hm^3/yr) has been equally divided between the two valleys.

Surface-water use in Coal Valley is estimated to be 17 acre-ft/yr (0.02 hm^3/yr), primarily for stock watering. At the present time, 184 acre-ft/yr (0.2 hm^3/yr) of surface-water certificates and proofs have been issued (DRI, 1980). There are 6516 acre-ft/yr (8.0 hm^3/yr) in pending applications for ground-water withdrawals in the valley but no certificated or approved rights (Woodburn and others, 1981).

The quantity of ground-water available for MX use would be the entire perennial yield (6000 acre-ft/yr [7.4 hm^3/yr]) since there are no approved appropriations for ground-water in the valley. Therefore, the peak MX demand of 2285 acre-feet (2.8

hm^3) would not exceed the estimated perennial yield for Coal Valley.

2.6.3.2 Source Capabilities

The ephemeral streamflow and limited surface flow from springs in Coal Valley do not constitute a reliable water supply for MX construction or operation.

An Air Force test well was completed in the valley-fill aquifer in Coal Valley at 1S/59E-34cb2. During testing, a sustained discharge of 450 gpm (28 l/s) was achieved with a drawdown of approximately 69 feet (21 m). The pumping level was in excess of 800 feet (244 m). Transmissivity and storativity were calculated to be 3700 ft^2/day (343 m^2/day) and 0.006, respectively.

Aquifer testing of an Air Force carbonate test well in the northwestern part of the valley (3N/59E-10bd) provided an estimated transmissivity for the carbonate aquifer of 400 ft^2/day (37 m^2/day) and a specific capacity of 1.8 gpm/ft (0.4 l/s/m). The hydrostratigraphic unit (Devonian Guilmette Formation) penetrated at this location is a target aquifer unit, but significant fracturing was not encountered at this site.

2.6.3.3 Water Quality

Chemical analyses of water from the Air Force valley-fill and carbonate test wells (1S/59E-34cb2 and 3N/59E-10bd) and other sampled sites within the valley indicate that ground water is within criteria for construction use (Appendix E1-1). All ground-water samples analyzed meet Primary and Secondary Drinking Water Standards set by the State of Nevada (Appendix E1-2) for the constituents analyzed. From the limited data available, it is expected that the quality of ground water in Coal Valley should generally be suitable for construction and drinking water purposes. Water-quality data for Coal Valley are shown in Appendix F1-6.

2.6.4 Water-Supply Alternatives

2.6.4.1 Lease or Purchase of Existing Water Rights

The lease or purchase of existing water rights is not a viable alternative for obtaining water supplies for the MX project in Coal Valley because of the limited amount of approved ground-water and surface-water appropriations.

2.6.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for MX construction and operation. Based on perennial yield and current use or appropriations, there is sufficient ground water available. Aquifer tests indicate that the valley-fill aquifer is capable of supplying water in sufficient quantity and quality to meet MX requirements although pumping lifts will be great. A minimum of three wells pumping continuously at 450 gpm (28 l/s) will be required to meet peak-year MX construction water requirements in Coal Valley.

2.6.4.3 Carbonate Aquifer

The carbonate aquifer test mentioned previously shows that well siting is critical. At present, because of the risk associated with penetrating a highly fractured zone, development of this water-supply source will be considered only if the valley-fill aquifer needs to be supplemented to meet MX water requirements.

2.6.4.4 Interbasin Transfer

An additional alternative for an MX water supply in Coal Valley would be transfer of water from White River Valley. This valley is adjacent to Coal Valley and contains an abundant supply of water. However, due to the number of appropriations in White River Valley it may be necessary to lease or purchase the water for transfer.

2.6.5 Impacts of Development

2.6.5.1 Intrabasin Effects

Ground-water withdrawal for the MX project should have minor effects on ground-water levels in Coal Valley. An estimate of the drawdown around MX production wells has been made assuming a transmissivity of 3700 ft^2/day (343 m^2/day), a storativity of 0.006, and a pumping rate of 450 gpm (28 l/s) for two years. Using these criteria, at a distance of 1 mile (2 km) the expected drawdown will be 1.4 feet (0.4 m). This is considered a minor impact since all MX wells will be sited at least 1 mile (2 km) from any existing diversions in Coal Valley. At the present time, there are no approved appropriations or ground-water users in the valley.

The limited number of springs in Coal Valley are meteoric and occur along mountain fronts above the valley-fill aquifer. Impacts on these springs are not expected because all MX wells will be located down-gradient and at a substantial distance from any spring.

2.6.5.2 Interbasin Effects

MX ground-water withdrawals in Coal Valley or interbasin transfer from White River Valley may reduce the subsurface outflow through the carbonate aquifers and affect the amount of inflow into Pahranagat Valley. There are insufficient data available to evaluate what, if any, the down-gradient effects will be. Interbasin transfer from White River Valley would reduce water availability in White River Valley.

2.7 DELAMAR VALLEY

2.7.1 General Physiography and Hydrology

Delamar Valley is a north-trending basin in Lincoln County, Nevada. It is separated from Dry Lake Valley to the north and Pahranagat Valley to the southwest by low alluvial divides. The valley is bordered by the Delamar Mountains to the east and the South Pahroc Range to the west. Elevations in these ranges are between 6000 and 7900 feet (1829 and 2408 m). Delamar Valley is approximately 31 miles (50 km) long, 19 miles (31 km) across at its widest point, and encompasses 383 mi^2 (992 km^2).

Delamar Valley is a topographically closed basin. Surface runoff in Delamar, Dry Lake, and Muleshoe valleys is estimated to be 9000 acre-ft/yr (11.1 hm^3/yr) (Nevada State Engineer, 1971). An individual estimate for Delamar Valley is not available. There are no perennial streams in Delamar Valley. Small meteoric springs in the surrounding mountains issue from volcanic and carbonate rocks; no regional springs occur in the valley.

Ground-water recharge derived from the infiltration of precipitation is estimated by Eakin (1963a) to be 1200 acre-ft/yr (1.5 hm^3/yr), and recharge by ground-water inflow from Dry Lake Valley is estimated to be 5000 acre-ft/yr (6.2 hm^3/yr) (Nevada State Engineer, 1971). Total discharge by underflow to Pahranagat Valley is estimated to be 6000 acre-ft/yr (7.4 hm^3/yr) while evapotranspiration losses are considered minor (Nevada State Engineer, 1971).

Delamar Valley is hydrologically open with underflow to the south or southwest through the Paleozoic carbonate rocks. The hydraulic gradient in the valley-fill aquifer is southward at 16 feet/mile (3 m/km) from central Dry Lake Valley to central Delamar Valley. The potentiometric surface ranges in elevation from 3600 to 4200 feet (1097 to 1280 m). The depth to ground water is in excess of 800 feet (244 m) in the central part of Delamar Valley. Locally, there is perched water near the mountains in the southern part of the valley. The potentiometric surface of the valley-fill aquifer in Delamar Valley is shown in Appendix Figure B1-7.

The valley-fill aquifer in the central part of the valley is at least 1200 feet (366 m) thick, based on driller's logs. These logs indicate that the aquifer consists of varying amounts of clay, silt, sand, and gravel in alternating layers of varying thickness and areal extent. Eakin (1963a) describes the valley fill as an unconsolidated to partly consolidated Tertiary to Quaternary unit deposited under subaerial and lacustrine conditions.

Carbonate rocks are believed to partially underlie the valley fill. The mountains bordering Delamar Valley to the west are primarily clastic rocks of Paleozoic age and volcanic and clastic rocks of Tertiary age. The mountains to the east contain similar units as well as significant amounts of carbonate rocks of Paleozoic age (Tschanz and Pampeyan, 1961). Eakin (1963a) states that the carbonate rocks probably underlie the volcanics on the west and south sides of the valley because the carbonates are exposed to the south in Pahranagat Valley.

2.7.2 MX Water Requirements

MX construction in Delamar Valley is projected to begin in 1982 and conclude in 1986. The amount of water required for the peak year of MX construction is estimated to be 679 acre-feet (0.8 hm^3) in 1984. In January 1980, the Air Force filed for 1585 acre-ft/yr (2.0 hm^3/yr) of ground-water appropriations in Delamar Valley.

2.7.3 Water-Supply Limitations

2.7.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Delamar Valley is estimated to be 3000 acre-ft/yr (3.7 hm^3/yr) (Nevada State Engineer, 1971). This is based on Eakin's (1963a) estimate of 6000 acre-ft/yr (7.4 hm^3/yr) discharge for Delamar, Dry Lake, and Muleshoe valleys. The combined discharge was divided, and a perennial yield of 3000 acre-ft/yr (3.7 hm^3/yr) each was assigned to Delamar and to Dry Lake and Muleshoe valleys.

Surface-water use, primarily for stock watering, is estimated to be 37 acre-ft/yr (0.05 hm^3/yr) in Delamar Valley. Surface water rights include 250 acre-ft/yr (0.3 hm^3/yr) of certificates and proofs. The indicated type of use includes 188 acre-ft/yr (0.2 hm^3/yr) for stock watering, 19 acre-ft/yr (0.02 hm^3/yr) for domestic use, and 43 acre-ft/yr (0.05 hm^3/yr) for irrigation (DRI, 1980).

Present ground-water use is estimated to be 7 acre-ft/yr (0.009 hm^3/yr) for stock watering. Certificated rights for ground water in Delamar Valley total 16 acre-ft/yr (0.02 hm^3/yr). There are no permitted rights or pending ground-water applications in the valley (Woodburn and others, 1981).

The quantity of ground water available for MX use totals 2993 acre-ft/yr (3.7 hm^3/yr) when considering present use and 2984 acre-ft/yr (3.7 hm^3/yr) when considering certificated water rights. The peak MX demand of 679 acre-feet (0.8 hm^3) for ground water will not exceed the perennial yield.

2.7.3.2 <u>Source Capabilities</u>

Because of limited and variable discharge, springs or streams in Delamar Valley would not be a reliable source of water for the MX Project.

An Air Force valley-fill aquifer test well was installed in Delamar Valley 6S/63E-12ada1. During testing, the well sustained a discharge rate of 85 gpm (5 l/s) with 85 feet (26 m) of drawdown. The static water level was in excess of 800 feet (244 m). Mechanical difficulties during the initial portion of the test made the early data unreliable and an estimate of storativity impractical. Analysis of the data collected from the observation well indicated a transmissivity of 1100 ft^2/day (102 m^2/day). In general, results of testing indicate that the aquifer has limited well-yield potential.

The carbonate aquifer in Delamar Valley is estimated to have a moderate potential for development. Thick sequences of identified high aquifer potential carbonate rocks do not occur in the valley, however, there are areas of high density faulting present in the carbonate rocks and the valley is in a known regional ground-water flow regime.

2.7.3.3 Water Quality

Four samples were collected for water-quality analyses in the northern half of Delamar Valley. Three of the samples were from local springs in the mountains and one was from the Air Force test well completed in the valley-fill aquifer. Chemical analyses indicate that all the samples are within water-quality criteria for construction-water use (Appendix E1-1) and all but the water from the test well meet Primary and Secondary Drinking Water Standards for the State of Nevada (Appendix E1-2) for the constituents analyzed. Water from the test well (6S/63E-12adal) had an iron concentration of 0.37 mg/l. This exceeds the recommended limit of 0.3 mg/l but does not exceed the maximum limit of 0.6 mg/l. Water-quality data for Delamar Valley are listed in Appendix F1-7.

Water-quality trends cannot be quantitatively extrapolated to the southern half of the valley. It is expected, however, that the ground water should be generally suitable for construction and drinking water purposes.

2.7.4 Water-Supply Alternatives

2.7.4.1 Lease or Purchase of Existing Water Rights

Certificated ground-water rights in Delamar Valley total 16 acre-ft/yr (0.02 hm^3/yr). It will not be possible to lease or purchase sufficient water rights to meet MX water requirements.

2.7.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for MX construction and operation. Aquifer testing has shown that the valley-fill aquifer is of limited potential because of low transmissivity and the excessive depth to water. Although the aquifer does not appear capable of supplying water at high rates of yield, it could supply the amount required for MX needs if numerous widely-spaced wells are constructed.

2.7.4.3 Carbonate Aquifer

The carbonate aquifer in Delamar Valley is considered to have a moderate water-supply potential. It is considered only as an alternative water-supply source because of the uncertainties associated with its development.

2.7.4.4 Interbasin Transfer

Interbasin transfer from Dry Lake Valley is considered an alternative for providing the water supply necessary to meet MX requirements in Delamar Valley. The cost of constructing and transporting water through pipelines is high. The valley-fill aquifer in Dry Lake Valley would be capable of providing water at the required rates, however, the amount of water that would be available for appropriations may not be sufficient for MX requirements in both valleys.

2.7.5 Impacts of Development

2.7.5.1 Intrabasin Effects

Estimates of drawdowns have been made for MX production wells in Delamar Valley assuming a transmissivity of 1200 ft^2/day (111 m^2/day), a storativity of 0.07, a pumping period of two years, and a well yield of 150 gpm (9 l/s). Based on these input values, a drawdown of 0.5 feet (0.2 m) is projected at 1 mile (2 km) from MX production wells. Given the limited groundwater use in Delamar Valley, any impacts to local users could be avoided by appropriate location of MX production wells. There should be no impact on spring discharge in Delamar Valley because all springs occur in the mountains or along the valley margins above the valley-fill aquifer.

2.7.5.2 Interbasin Effects

Water levels and spring discharge could be affected in Pahranagat Valley because it is down gradient and receives underflow from Delamar Valley through the carbonate aquifer. There is insufficient data available on the degree of intercommunication between the valley fill and carbonate aquifers to quantify the impacts, if any, that may occur.

2.8 DRY LAKE VALLEY

2.8.1 General Physiography and Hydrology

Dry Lake Valley is a north-trending basin in Lincoln County, Nevada. The valley is topographically open to Muleshoe Valley to the north and is separated from Delamar Valley to the south by a low alluvial divide. Dry Lake and Muleshoe valleys are considered one hydrologic basin by the Nevada State Engineer. Dry Lake Valley is 38 miles (61 km) long, 21 miles (34 km) across at its widest point, and encompasses 700 mi^2 (1812 km^2). The average valley-floor elevation is 4800 feet (1463 m). The valley is bordered by the North Pahroc Range on the west and the Burnt Springs, Highland, and Bristol ranges on the east. The mountain crests range in elevation from about 7000 feet to over 9000 feet (2134 to 2743 m).

Perennial streamflow is absent in Dry Lake Valley. There is some ephemeral surface-water inflow from Muleshoe Valley. Total runoff from the mountains at the apex of the alluvial fans is estimated to be 9000 acre-ft/yr (11.1 hm^3/yr) (Nevada State Engineer, 1971) for the combined hydrographic areas of Dry Lake, Muleshoe, and Delamar valleys.

One possible regional spring has been identified in Dry Lake Valley at 3N/65E-31cc. All other springs are low discharge meteoric springs which occur in or near the base of the mountains surrounding Dry Lake Valley and issue from clastic rocks of Paleozoic age or volcanics of Tertiary age.

Ground-water recharge is from the infiltration of precipitation in stream channels and surface runoff on the alluvial fans. The average annual recharge for Dry Lake/Muleshoe Valley is estimated to be 4800 acre-ft/yr (5.9 hm^3/yr) (Eakin, 1963a). Of this amount, approximately 2100 acre-ft/yr (2.6 hm^3/yr) is derived from precipitation in the mountains around Muleshoe Valley with the remainder from sources within Dry Lake Valley. Evapotranspiration and water discharged by wells is less than 100 acre-ft/yr (0.1 hm^3/yr). Evapotranspiration only occurs in limited areas near small springs.

Dry Lake Valley is a hydrologically open system with underflow to the south or southwest and possibly to the west through the Paleozoic carbonate rocks. Total discharge by underflow is estimated to be 5000 acre-ft/yr (6.2 hm^3/yr) (Nevada State Engineer, 1971). This is in general agreement with Eakin's (1963a) estimate of 4800 acre-ft/yr (5.9 hm^3/yr) recharge.

The hydraulic gradient in the valley-fill aquifer is southward at 16 feet/mile (3 m/km) from central Dry Lake Valley to central Delamar Valley (Appendix Figure B1-8). The potentiometric surface ranges in elevation from 5000 feet (1524 m) in the north to 4200 feet (1280 m) in the south. The depth to ground water in Dry Lake Valley is in excess of 300 feet (91 m).

The valley-fill in Dry Lake Valley is in excess of 10,000 feet (3048 m) thick in the central part of the valley (Fugro National Inc., 1980). Eakin (1963a) describes the valley-fill sediments as clay, silt, sand, and gravel of Tertiary to Quaternary age deposited under subaerial and lacustrine conditions.

Paleozoic carbonate rocks are exposed in the mountains surrounding the valley and are believed to partially underlie the valley-fill sediments. The mountains bordering Dry Lake Valley to the west contain ash flow tuffs of Tertiary age with some Paleozoic carbonate rocks. The mountains to the east are comprised of Paleozoic carbonates with minor amounts of ash flow tuffs of Tertiary age (Stewart and Carlson, 1978).

2.8.2 MX Water Requirements

The peak annual demand for water in Dry Lake Valley during MX construction is estimated to be 3411 acre-feet (4.2 hm^3) in 1984. Construction is projected to begin in 1982 and conclude in 1987. The Air Force has filed for 3810 acre-ft/yr (4.7 hm^3/yr) of ground-water appropriations in Dry Lake Valley.

2.8.3 Water-Supply Limitations

2.8.3.1 Perennial Yield, Use, and Appropriations

The combined perennial yield for Dry Lake and Muleshoe valleys is estimated to be 3000 acre-ft/yr (3.7 hm^3/yr) (Nevada State Engineer, 1971). This is based on Eakin's (1963a) estimate of 6000 acre-ft/yr (7.4 hm^3/yr) discharge for Muleshoe, Dry Lake, and Delamar valleys combined. The discharge was equally divided and a combined perennial yield of 3000 acre-ft/yr (3.7 hm^3/yr) was assigned to Dry Lake and Muleshoe valleys.

Surface-water use, primarily for stock watering, is estimated to be 21 acre-ft/yr (0.03 hm^3/yr) in Dry Lake Valley.

Surface-water appropriations in the appropriation and permit phase total 2596 acre-ft/yr (3.2 hm^3/yr) (DRI, 1980). At the present time, ground-water use in Dry Lake Valley is minor. Current ground-water permits total 8 acre-ft/yr (0.01 hm^3/yr), certificates total 11 acre-ft/yr (0.01 hm^3/yr), and there are a total of 20 acre-ft/yr (0.02 hm^3/yr) of pending applications for ground-water rights in the valley (Woodburn and others, 1981).

The Nevada State Engineer considers Muleshoe Valley and Dry Lake Valley a single hydrographic unit for perennial-yield estimates and consequently its combined ground-water demand and use must also be considered in evaluating ground-water availability. Peak-year MX demand for Muleshoe Valley is 968 acre-feet (1.2 hm^3) in 1984. The combined peak construction water demand in 1984 and the existing appropriations in both valleys will exceed the perennial yield by 1398 acre-ft/yr (1.7 hm^3/yr). However, if Dry Lake and Muleshoe valleys are hydrologically connected with Delamar Valley as previously discussed, and the perennial yield of Delamar Valley (3000 acre-ft/yr [3.7 hm^3/yr]) and its peak MX demand (679 acre-ft/yr [0.8 hm^3/yr]) is considered, the total peak-year demand for construction water in 1984 is 5058 acre-feet (6.2 hm^3/yr) as compared to the combined perennial yield of 6000 acre-ft/yr (7.4 hm^3/yr). The combined existing ground-water appropriations for the three valleys total 35 acre-ft/yr (0.04 hm^3/yr), indicating sufficient water would be available from the combined basins to meet peak-year MX requirements.

2.8.3.2 Source Capabilities

Surface water in Dry Lake Valley is limited to ephemeral streamflow and scattered small spring discharges. Consequently, surface water in Dry Lake Valley is not a dependable source of water for the MX project.

An Air Force valley-fill aquifer test well was installed in the southern part of the valley (3S/64E-12ac2). Test results indicate a transmissivity and storativity for the valley-fill aquifer of 3400 ft^2/day (315 m^2/day) and 0.013, respectively. These aquifer characteristics suggest that the valley-fill aquifer is capable of yielding water in sufficient quantities and rates to meet MX needs.

An Air Force carbonate aquifer test well was drilled in the northern part of the valley (3N/63E-27ca). Test results show an estimated transmissivity for the carbonate aquifer of about 13,400 ft^2/day (1242 m^2/day) and a specific capacity of 50 gpm/ft (10 l/s/m). These results suggest a significant water-supply capability for the carbonate aquifer. However, the depth to water (853 feet [260 m]) negates some of the benefits of the potential high well yield.

2.8.3.3 Water Quality

Water-quality data for Dry Lake Valley are shown in Appendix F1-8. Chemical analyses of water samples from the two test wells, one existing well, and six springs indicate that, for the constituents analyzed, water quality is within criteria for construction water use (Appendix E1-1). All sample sites but one well (3N/65E-21dba) meet Primary and Secondary Drinking Water Standards for the State of Nevada (Appendix E1-2) for the constituents analyzed. This well, located in the northeastern portion of the valley was found to have a nitrate concentration of 32 mg/1, which exceeds the 10 mg/l Primary Drinking Water Standard for nitrate (as N). This well was used when the Bristol Silver Mine was in operation and could be contaminated from surface sources. Although valley-wide water quality cannot be accurately assessed from the limited data available, it is expected that the ground water should be suitable for construction and drinking water purposes.

2.8.4 Primary Water-Supply Alternatives

2.8.4.1 Lease or Purchase of Existing Water Rights

It will not be possible to obtain MX water supplies through the lease or purchase of ground-water rights in Dry Lake Valley because approved and pending ground-water appropriations total only 39 acre-ft/yr (0.05 hm^3/yr). A significant amount of surface-water appropriations exist, but the actual available supply is questionable.

2.8.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for MX construction and operation. Based on perennial yield, current use, and existing ground-water appropriations, sufficient ground-water is available to meet MX requirements. The aquifer test performed indicates that the valley-fill aquifer is capable of supplying water at the rate necessary and in sufficient quantity and quality to meet MX requirements.

2.8.4.3 Carbonate Aquifer

The carbonate aquifer has a high potential for development as a water-supply source in Dry Lake Valley. Aquifer testing has shown that high yield wells could be developed but the pumping lifts would be excessive. For the latter reason, the carbonate aquifer is considered only as an alternative water-supply source for Dry Lake Valley.

2.8.4.4 Interbasin Transfer

Interbasin transfer will not be necessary in Dry Lake Valley because the valley-fill aquifer is capable of meeting MX requirements. The transfer of water from Dry Lake Valley to Muleshoe and/or Delamar valleys may be considered.

2.8.5 Impacts of Development

2.8.5.1 Intrabasin Effects

A computer simulation of MX production wells in Dry Lake and Muleshoe valleys has been performed. Water withdrawal was simulated for six years at rates required to meet the U.S. Army Corps of Engineers (1981) demand estimates. A transmissivity of 1300 ft^2/day (120 m^2/day) and storativity of 0.05 were used in the simulation. Those values were believed to be most representative of the average aquifer characteristics of all types of sediments in the valley. Pumping rates were varied according to annual MX needs and reached a maximum of one well pumping in Muleshoe Valley at 600 gpm (38 l/s) and five wells in Dry Lake Valley pumping at 420 gpm (26 l/s). Maximum drawdown effects occurred after five years and averaged 5.3 feet (2 m) at a distance of 1 mile (2 km) from the wells in Dry Lake Valley. To provide conservative drawdown estimates, recharge to the valley-fill aquifer was not simulated. Under these unrealistic conditions, an average residual drawdown of 2.5 feet (0.8 m) remained at 1 mile (2 km) after approximately eight years of recovery.

At the present time, ground-water use in Dry Lake Valley consists of widely separated stock-watering wells. Appropriate location of MX production wells will avoid significant impacts to these users. Lowered water levels will have no effect on vegetation because the ground water is more than 300 feet (91 m) below the land surface and well beyond all root systems.

There should be little if any effect on spring discharge in Dry Lake Valley because springs are located within or along the mountain margins and are probably discontinuous with the valley-fill aquifer. One spring in Dry Lake Valley (3N/65E-31cc) may be a regional spring. MX production wells should not be located within 3 miles (5 km) of this spring to avoid any potential impacts.

2.8.5.2 Interbasin Effects

Water levels and spring discharge could be affected in down-gradient valleys in the White River regional ground-water flow system such as Pahranagat and Delamar valleys. Presently, there are insufficient data to evaluate the degree of hydraulic communication between the local valley-fill and regional carbonate aquifers or to evaluate the potential for impacts within the regional flow system. It is not considered likely that impacts will occur in down-gradient valleys within the relatively short time frame of MX withdrawals for construction purposes.

2.9 DUGWAY VALLEY

2.9.1 General Physiography and Hydrology

Dugway Valley is a northwest trending valley in Tooele and Juab counties, Utah. The valley is bordered on the west by the Dugway Mountains and Thomas Range and on the east and northeast by Keg Mountains and the Slow Elk Hills. The valley is 45 miles (72 km) long, has a maximum width of about 35 miles (56 km), and encompasses 890 mi^2 (2304 km^2). The average valley-floor elevation is approximately 4780 feet (1457 m).

All streams in Dugway Valley are ephemeral; spring discharge may sustain low flows in some stream channels in the surrounding mountains during periods of little or no precipitation. Pismire Wash, the principal drainage in the northern portion of the valley, extends northward from the Thomas Range for 35 miles (56 km). Flow in this stream occurs only in response to intense, local thunderstorms or periods of rapid snowmelt (Stephens and Sumsion, 1978). Flow from other streams is rapidly lost to infiltration on the alluvial fans, where it serves to recharge the ground-water reservoir. There is no average annual runoff estimate available for Dugway Valley.

Ground-water recharge in Dugway Valley totals 12,000 acre-ft/yr (14.8 hm^3/yr), of which, less than 5000 acre-ft/yr (6.2 hm^3/yr) are subsurface inflow from Sevier Desert through the Old River Bed (Mower and Feltis, 1968). The remainder is derived from the infiltration of precipitation and snowmelt. Most of the ground-water discharge from Dugway Valley is by subsurface outflow

11 acre-ft/yr (0.01 hm^3/yr) for livestock watering, and 1875 acre-ft/yr (2.3 hm^3/yr) for military uses (UWRL, 1980). Ground-water certificates and proofs total 423 acre-ft/yr (0.5 hm^3/yr) and there are 384 acre-ft/yr (0.5 hm^3/yr) in permits and applications for ground-water rights in the valley (DRI, 1980). Existing water use is concentrated in the central part of the valley and the few seasonal farms and ranches which are located in the Old River Valley. The reasons for the apparent disparity between water use and water rights in Dugway Valley are unknown.

The amount of ground-water available for the MX project in Dugway Valley is difficult to quantify. As mentioned in Section 2.9.2, MX water requirements for the peak year of construction have been estimated at 1901 acre-feet (2.3 hm^3). Because the perennial yield of Dugway Valley is believed to be only a fraction of the combined perennial yield for the Dugway/Government Creek area (12,000 acre-ft/yr [14.8 hm^3/yr]), there may be an insufficient quantity of ground water available to fulfill MX water requirements.

2.9.3.2 <u>Source Capabilities</u>

The potential for the development of surface water and springs as a source of water for the MX project is limited. Most of the streams in the valley are ephemeral and will not provide a dependable water supply. The springs in Dugway Valley have low discharges, commonly less than 10 gpm (1 l/s), are generally in the mountains above the valley floor, and are relatively inaccessible. One possibility is supplying water to the valley floor by pipelines constructed to divert flow from such streams as Indian and Lee creeks in the Simpson Mountains if existing surface-water rights would not be interferred with. These are headwater areas where perennial flow is maintained by ground-water discharge.

The transmissivity and storativity of the valley-fill aquifer are difficult to estimate because aquifer tests have not been performed in the valley. Two Air Force Test wells at (C-12-10) 31cc and (C-11-10)19bb were dry. The first of these wells (C-12-10)31cc was completed at 402 feet (123 m) below land surface after 80 feet (24 m) of silty sand had been penetrated. The second well, (C-11-10)19bb, was terminated at 178 feet (54 m) below land surface in bedrock.

According to Stephens and Sumsion (1978), silt and fine sand dominate in the sediments in the southwest portion of the valley and consequently fairly low well yields would be expected. Nearer to the mountains, the valley-fill material becomes coarser and well yields on the order of a few hundred gallons per minute should be obtainable.

The highly fractured carbonates in the northern Thomas Range are a potential source of water for the MX project in Dugway Valley. However, Ertec field investigations suggest that the carbonate aquifer has a low potential for development due to limited thickness of carbonate rocks and the lack of identified high yielding hydrostratigraphic units.

2.9.3.3 Water Quality

Water-quality data for six wells and three reservoirs are available from a previous investigation in Dugway Valley (Stephens and Sumsion, 1978). In addition, Ertec collected one water sample from Kane Spring, (C-12-10)35baa, for chemical analysis. The data, shown in Appendix F1-9, indicate that, for the constituents analyzed, ground water from wells in the central portion of Dugway Valley exceed the recommended criteria for construction water (Appendix E1-1).

Dissolved solids concentrations also exceed Utah's State Primary Drinking Water Standards in six of the sources sampled (Appendix E1-3). Fluoride concentrations in samples collected from three wells and one reservoir also exceeded Primary Drinking Water Standards. Chloride concentrations in samples collected from eight sources exceed Utah's State Secondary Drinking Water Standards (Appendix E1-3). Table 2.9.1 summarizes the samples that exceed the various water-quality criteria.

Water samples from wells with high TDS were found to be concentrated in a narrow north-northwest trending band, perhaps reflecting the presence of a major fault zone with water being circulated from more saline aquifers at depth. The highest quality water can most likely be obtained away from this area and toward the valley margins.

TABLE 2.9.1. SAMPLE LOCATIONS IN DUGWAY VALLEY THAT EXCEED WATER-QUALITY CRITERIA

SAMPLE LOCATION	SOURCE	PRIMARY STANDARD EXCEEDED	SECONDARY STANDARD EXCEEDED	CONST'N. STANDARD EXCEEDED
(C-9-10)21ddb	Reservoir	TDS (1290 mg/l) Fluoride (2.2 mg/l)	Chloride (285 mg/l)	
(C-9-11)32dda	Well	TDS (9500 mg/l) Fluoride (2.0 mg/l)	Chloride (5500 mg/l)	TDS (9500 mg/l)
(C-10-9)8ccc	Well		Chloride (363 mg/l)	
(C-10-10)2dcc	Well	TDS (1130 mg/l)	Chloride (490 mg/l)	
(C-10-10)31bbb	Well	TDS (3400 mg/l) Fluoride (2.1 mg/l)	Chloride (1900 mg/l)	TDS (3400 mg/l)
(C-11-10)34dcd	Spring	TDS (1910 mg/l)	Chloride (982 mg/l)	
(C-11-11)12aba	Well	TDS (5280 mg/l) Fluoride (2.7 mg/l)	Chloride (3000 mg/l)	TDS (5280 mg/l)
(C-12-10)35baa	Spring		Chloride (700 mg/l)	

2.9.4 Water-Supply Alternatives

2.9.4.1 Lease or Purchase of Existing Water Rights

The lease and purchase of existing surface- and ground-water rights in Dugway Valley is not a viable alternative for obtaining a water supply for MX construction because of the limited amount of approved and pending appropriations (818 acre-ft/yr [1.0 hm^3/yr]).

2.9.4.2 Valley-Fill Aquifer

Because of the undefined perenniel yield, legal availability of water from the valley-fill aquifer is uncertain. Field investigations have shown potential water-quality and well-yield limitations. These results indicate that the valley-fill aquifer may not be capable of supplying water at the rate necessary or in sufficient quantity or quality to meet MX requirements.

2.9.4.3 Carbonate Aquifer

The carbonate aquifer may provide a source of water for MX, but its potential for development has been characterized as low. A practical limitation is that much of the known carbonate rock occurs under land designated as wilderness area, and therefore suitable drilling sites are limited. If the carbonate aquifer is considered as a primary source of water for the MX project, additional hydrologic investigations would be warranted.

2.9.4.4 Interbasin Transfer

The interbasin transfer of ground water from the Government Creek area is the preferred alternative for obtaining a water supply for the MX project. At the present time, a total of 5558 acre-ft/yr (6.8 hm^3/yr) of approved ground-water rights exist in the Government Creek area. Present ground-water use in the area, however, amounts to only 1065 acre-ft/yr (1.3 hm^3/yr). As a result, there is a sufficient quantity of ground water available for lease or purchase and transfer to Dugway Valley to meet MX water requirements for construction. Because the perennial yield of the Government Creek area is believed to be the major portion of the combined perennial yield for the Dugway and Government Creek areas, a substantial amount of unappropriated ground water should also be available for transfer to Dugway Valley.

2.9.5 Impacts of Development

2.9.5.1 Intrabasin Effects

If the valley-fill aquifer in Dugway Valley were developed, it is estimated that three to five wells would be required to meet the peak-year MX construction requirement. If the transmissivity of the aquifer is low, as appears to be the case, drawdowns will be greater than in valleys with more appropriate aquifer conditions. Setback distances from existing wells or points of water use would be adjusted accordingly.

There are no known regional springs in Dugway Valley. The majority of springs are meteoric and are located at elevations above the valley-fill. MX wells in the valley-fill should have no significant impact on these springs.

If the water requirements of the MX project are leased from present users in Dugway Valley or in the Government Creek area and imported into the basin, no impacts should occur in Dugway Valley.

2.9.5.2 Interbasin Effects

Withdrawals from the valley-fill aquifer could reduce groundwater outflow toward the Great Salt Lake Desert. As the amount of MX requirements are only a small proportion of the flow in this system, it is not anticipated that the reduction, if any, in flow would have any adverse impacts upon current users.

2.10 FISH SPRINGS FLAT

2.10.1 General Physiography and Hydrology

Fish Springs Flat is a north-south trending basin in Tooele, Juab, and Millard counties, Utah. The valley is bounded on the west by the Fish Springs Range and on the east by the Thomas Range. It is separated from Whirlwind Valley by a low divide in the Swasey Bottom area and opens in the north onto the Great Salt Lake Desert. The basin is 35 miles (56 km) long, 17 miles (27 km) in width, and encompasses 590 mi^2 (1528 km^2). Elevations in the basin range from 4300 feet (1311 m) on the valley floor to 8523 feet (2598 m) at the mountain crests.

All streams in Fish Springs Flat are ephemeral. Infiltration of mountain runoff on the alluvial fans rapidly depletes streamflow and serves to recharge the ground-water reservoir. Runoff occasionally reaches the valley floor as a result of high intensity summer rainstorms or during periods of rapid snowmelt. Streamflow diversions for irrigation and storage in reservoirs capture the minor amounts of runoff that may reach the valley floor. Surface runoff in Fish Springs Flat, neglecting a small volume due to overflow from spring ponds in Fish Springs National Wildlife Refuge, has been estimated to be 2000 acre-ft/yr (2.5 hm^3/yr) (Bolke and Sumsion, 1978).

Recharge to the valley-fill aquifers from the infiltration of precipitation and snowmelt has been estimated to be 4000 acre-ft/yr (4.9 hm^3/yr). Based on an imbalance in the water budget, Bolke and Sumsion (1978) also have estimated that subsurface inflow totals 31,000 acre-ft/yr (38.2 hm^3/yr). Analysis of the regional potentiometric surface suggests that the source of this interbasin flow is southwest and south of Fish Springs Flat. The potentiometric surface of the valley-fill in Fish Springs Flat is at 4300 feet (1310 m) (Appendix Figure B1-10), whereas, in Snake Valley, it is at 4400 feet (1341 m).

The regional nature of the flow into the basin is also indicated by the discharge and water chemistry at Fish Springs. Bolke and Sumsion (1978) noted that variations in spring discharge correlate with fluctuations in the level of the Great Salt Lake and regional precipitation trends, rather than the local precipitation record. All springs in the Fish Springs Group have been classified as regional.

Discharge from the valley-fill aquifer occurs primarily by evapotranspiration, spring discharge, and subsurface outflow to the Great Salt Lake Desert. Water loss by evapotranspiration occurs in the areas where the depth to water is less than 10 feet (3m) and was estimated by Bolke and Sumsion (1978) to be 8000 acre-ft/yr (9.9 hm^3/yr). The majority of the discharge by springs takes place from the Fish Springs Group. About 26,000 acre-ft/yr (32.1 hm^3/yr) are discharged from this group and about 600 acre-ft/yr (0.7 hm^3/yr) from other smaller springs along the base of the Fish Springs Range (Bolke and Sumsion, 1978). Discharge by wells is minor. There are a few stock watering and domestic wells at the Fish Springs Ranger Station ([C-11-14]23), and water has also been withdrawn at the

Brush-Wellman Mine ([C-13-12]5). The total discharge is probably less than 100 acre-ft/yr (0.1 hm^3/yr). Subsurface outflow to the Salt Lake Desert was believed by Bolke and Sumsion (1978) to be insignificant because of the low hydraulic gradient to the north (3 feet/mile [0.6 m/km]) and the low transmissivity of the valley fill. The depth to ground water in the valley ranges from over 150 feet (46 m) in the south and on the upper portions of alluvial fans to near or at surface in the central and northern portions of the valley.

The valley-fill deposits are composed of mixed, reworked, and interbedded alluvial and lacustrine deposits which include Lake Bonneville sediments. It is also likely that volcanic ash and lava flows are present throughout the valley-fill stratigraphic section considering their presence in the Thomas Range and in the valley-fill at the Brush-Wellman beryllium mine in the southeast portion of Fish Springs Flat.

The Fish Springs and Thomas ranges are composed primarily of carbonate rocks with minor exposure of quartzite, both of Paleozoic age. About half of the area of the Thomas Range is overlain by volcanic extrusive rocks of Tertiary age. The lower slopes of the ranges are covered with alluvial material and colluvium composed of poorly sorted sand and gravel.

2.10.2 MX Water Requirements

The peak annual demand for water during the MX construction is estimated to be 596 acre-feet (0.7 hm^3) in 1986. Construction is projected to begin in 1984 and conclude in 1988. The

Air Force has filed applications for ground-water appropriations totaling 2537 acre-ft/yr (3.1 hm^3/yr) from eight points of diversion.

2.10.3 Water-Supply Limitations

2.10.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Fish Springs Flat is estimated to be 35,000 acre-ft/yr (43.2 hm^3/yr) (Price, 1979a). This figure is based on the water budget calculations of Bolke and Sumsion (1978) which include the 26,000 acre-ft/yr (32.1 hm^3/yr) discharge from the Fish Springs Group. This latter component, however, is an integral part of the Wildlife Refuge and so is not available to the MX project. As a result, the water available for use in Fish Springs Flat is considerably less than is suggested by the perennial yield.

The total water use in Fish Springs Flat is currently 26,399 acre-ft/yr (32.5 hm^3/yr) with 393 acre-ft/yr (0.5 hm^3/yr) being obtained from ground water and 26,000 acre-ft/yr (32.1 hm^3/yr) from surface water, including spring discharge. Ground-water use is divided into 367 acre-ft/yr (0.4 hm^3/yr) for the Fish Springs Flat Wildlife Refuge, 14 acre-ft/yr (0.02 hm^3/yr) for stock watering, and 12 acre-ft/yr (0.01 hm^3/yr) for beryllium mining (UWRL, 1980). Surface-water use is divided into 26,000 acre-ft/yr (32.1 hm^3/yr) for the Fish Springs National Wildlife Refuge, in the northwest portion of the valley, and 6 acre-ft/ yr (0.01 hm^3/yr) for stock watering (UWRL, 1980).

Ground-water rights in Fish Springs Flat include 94 acre-ft/yr (0.1 hm^3/yr) of certificates and proofs and 831 acre-ft/yr (1.0 hm^3/yr) of permits and applications. Surface-water rights include 2602 acre-ft/yr (3.2 hm^3/yr) in certificates and proofs and 3975 acre-ft/yr (4.9 hm^3/yr) in permits and applications (DRI, 1980).

The quantity of ground water available for MX use totals approximately 8600 acre-ft/yr (10.6 hm^3/yr) when the perennial yield and present use in the basin, including spring discharge at the Wildlife Refuge, are considered. Consideration of all ground-water certificates, proofs, permits, and pending applications would reduce ground-water availability to approximately 8000 acre-ft/yr (9.9 hm^3/yr). The peak demand of 596 acre-ft/yr (0.7 hm^3/yr) during MX construction is significantly less than this amount.

2.10.3.2 <u>Source Capabilities</u>

Surface runoff does not represent an adequate or reliable water supply for the MX project. All of the streams in Fish Springs Flat are ephemeral. The only reliable sources of surface water are the bedrock springs which issue at the western margin of the valley, notably the Fish Springs Group. These springs, however, are an integral part of the Fish Springs National Wildlife Refuge and so are not available as a source of water for the MX project.

There is very little information available on the development potential of the valley-fill aquifer in Fish Springs Flat.

Aquifer tests have not been performed and neither transmissivity nor storativity values are known for the valley-fill. The stock and domestic wells which are currently in use in the valley, yield only 12 to 40 gpm (1 to 3 l/s). There is no evidence for the presence of continuous confining layers in the valley-fill aquifer. The installation of test wells and the performance of aquifer tests in Fish Springs Flat are recommended to help quantify the hydraulic capabilities of the valley-fill aquifers.

The Paleozoic carbonate rocks which outcrop in the Fish Springs Range and northern Thomas Range are characterized as having a moderate potential for water-supply development. Limiting factors are the thickness of appropriate hydrostratigraphic units and the availability of drilling areas due to land-use restrictions.

2.10.3.3 Water Quality

Chemical analyses of water samples from twelve springs and three wells are available for Fish Springs Flat (Appendix F1-10). Five of the samples exceed the recommended TDS criteria for construction water (Appendix E1-1). Water with the highest TDS generally issues from the springs at the base of the Fish Springs Range, but water from two of the three wells located in central portion of the valley also contains over 2000 mg/l TDS.

Nine of the samples exceed the Primary Drinking Water Standards of the State of Utah (Appendix E1-3) on the basis of high TDS, fluoride, nitrate, or sulfate levels. Two sources are of marginal but acceptable quality, exceeding State Secondary Standards for chloride and manganese. These are springs in the Fish Springs Group and three wells on the eastern margin of the valley. Table 2.10.1 summarizes those standards that are exceeded in the various samples.

2.10.4 Water-Supply Alternatives

2.10.4.1 Lease or Purchase of Existing Water Rights

A total of 925 acre-ft/yr (1.1 hm^3/yr) of ground water is presently appropriated (or appropriation is pending) in Fish Springs Flat. The majority of the water (734 acre-ft/yr [0.9 hm^3/yr]) is appropriated for mining activities, but present water use for mining totals only 12 acre-ft/yr (0.02 hm^3/yr). Therefore, a sufficient quantity of water may be available for MX construction through lease or purchase of existing ground-water rights.

2.10.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred water-supply source for MX construction and operation in Fish Springs Flat. It has been shown that adequate water is available in the valley-fill aquifer. However, low well yields may occur and poor quality water is widespread. Based on the water requirement for the peak year of MX construction, four wells pumping at approximately 100 gpm (6 l/s) will be necessary. Yields of this magnitude should be obtainable from properly designed wells in the valley fill. Wells in the eastern portion of the valley may provide water of adequate quality for construction and domestic purposes.

2.10.4.3 Carbonate Aquifers

The regional carbonate aquifer is a viable alternative source of ground water. The carbonate aquifer is presently undeveloped and untested in this region. There are, however, two limitations to the development of this aquifer. The hydrostratigraphic unit most suitable for development crops out on land designated as wilderness area, so suitable drilling sites are very limited. Further studies are required to determine whether development of this aquifer would affect the discharge of the springs at the Fish Springs National Wildlife Refuge.

2.10.4.4 Interbasin Transfers

The interbasin transfer of water into Fish Springs Flat may be necessary if the development of the valley-fill and carbonate aquifers is not feasible. Abundant ground water is available in Snake Valley, but the distance of transport is excessive and it would be a high-cost alternative.

2.10.5 Impacts of Development

2.10.5.1 Intrabasin Effects

If the valley-fill aquifer is utilized as the primary source of water for MX construction, the potential for affecting other water users is expected to be minimal. Future aquifer testing and computer modeling will provide estimates of drawdowns around MX production wells in the valley.

There should be little effect on spring discharge in Fish Springs Flat as the result of MX ground-water withdrawals from the valley-fill aquifer. Fish Springs Group and other smaller springs along the base of the Fish Springs Range are believed to be discharging from regional and local carbonate aquifers. The degree of connection between the valley-fill and carbonate aquifers has not been determined, but there should be little potential for impact if these areas are avoided in placement of MX wells.

2.10.5.2 Interbasin Effects

Since there is only limited outflow from Fish Springs toward the Great Salt Lake Desert, it is not anticipated that water withdrawals from the aquifer system in Fish Springs Flat for the MX project will have any significant impact on other basins. Interbasin effects could occur if water is imported from Snake or Tule valleys. The effects, however, would be very minor because of the relatively small quantity of water needed in Fish Springs Flat.

springs along the base of the Fish Springs Range are believed to be discharging from regional and local carbonate aquifers. The degree of connection between the valley-fill and carbonate aquifers has not been determined, but there should be little potential for impact if these areas are avoided in placement of MX wells.

2.10.5.2 Interbasin Effects

Since there is only limited outflow from Fish Springs toward the Great Salt Lake Desert, it is not anticipated that water withdrawals from the aquifer system in Fish Springs Flat for the MX project will have any significant impact on other basins. Interbasin effects could occur if water is imported from Snake or Tule valleys. The effects, however, would be very minor because of the relatively small quantity of water needed in Fish Springs Flat.

2.11 GARDEN VALLEY

2.11.1 General Physiography and Hydrology

Garden Valley extends from northwestern Lincoln County northward into Nye County, Nevada. The valley is topographically open and drains into Coal Valley through a narrow alluvial channel (Water Gap) on the eastern side of Garden Valley. Garden Valley is approximately 50 miles (80 km) long, varies in width from 5 to 21 miles (8 to 24 km), and encompasses a total area of 508 mi^2 (1315 km^2). The valley is bordered on the east by the Golden Gate Range, on the south by the Timpahute Range, and on the northwest by the Quinn Canyon and Grant ranges. Mountain crests range in elevation from 6000 feet (1829 m) to about 11,000 feet (3353 m). The valley floor ranges in elevation from about 5100 feet at Water Gap to 6200 feet (1554 to 1890 m) on the western and southern alluvial fans.

Only ephemeral streams are present in Garden Valley and, occasionally, during periods of high runoff, water flows through Water Gap into Coal Valley. Several small springs occur in or near the base of the western mountains. There are no known regional springs in Garden Valley.

Ground-water recharge in Garden Valley from precipitation and surface runoff is estimated at 10,000 acre-ft/yr (12.3 hm^3/yr) (Eakin, 1963b). Most recharge is from infiltration of precipitation that originates in the Quinn Canyon and Grant ranges with lesser amounts contributed from the Timpahute and Golden Gate ranges.

Garden Valley is a hydrologically open system. Ground-water flow in the valley-fill and carbonate aquifers is predominantly to the southeast. Total discharge to Coal Valley is estimated at 8000 acre-ft/yr (9.9 hm^3/yr) (Nevada State Engineer, 1971). Discharge from the valley-fill aquifer by springs, wells, and evapotranspiration is approximately 2000 acre-ft/yr (2.5 hm^3/yr) (Nevada State Engineer, 1971). The potentiometric surface in the valley-fill aquifer ranges from 5400 to 4900 feet (1646 to 1494 m) with an easterly hydraulic gradient of about 53 feet/ mile (10 m/km). Depths to ground water range from less than 25 feet (8 m) in the north to approximately 500 feet (152 m) in the south (Appendix Figure B1-11).

The valley-fill aquifer occurs primarily within alluvial fan deposits consisting of relatively coarse-grained sediments derived from adjacent highland areas (Eakin, 1963b). The surrounding mountains are composed of carbonate and clastic rocks of Paleozoic age and volcanics and clastics of Tertiary age. The carbonates are believed to be the predominant rock type underlying the valley-fill sediments.

2.11.2 MX Water Requirements

MX construction in Garden Valley is projected to begin in 1983 and continue through 1987. The peak annual demand for water during MX construction is estimated to be 1508 acre-feet (1.9 hm^3) in 1984. The Air Force has filed applications for appropriation of ground water totaling 3456 acre-ft/yr (4.3 hm^3/yr) in Garden Valley from eight points of diversion.

2.11.3 Water-Supply Limitations

2.11.3.1 Perennial Yield Use and Appropriations

The perennial yield of Garden Valley is estimated at 6000 acre-ft/yr (7.4 hm^3/yr) (Nevada State Engineer, 1971). This value is based on the total recharge (precipitation and underflow) and discharge (springs, evapotranspiration, underflow) in the valley. Existing hydrologic data provide some evidence of a direct hydrologic connection between Garden and Coal valleys. As a result, the combined basin perennial yield of 12,000 acre-ft/yr (14.8 hm^3/yr) is equally divided between the two valleys.

Surface-water use in Garden Valley consists of 2 acre-ft/yr (0.002 hm^3/yr) for domestic purposes, 20 acre-ft/yr (0.02 hm^3/yr) for stock watering, and 170 acre-ft/yr (0.2 hm^3/yr) for irrigation. Approved surface-water appropriations total 2145 acre-ft/yr (2.6 hm^3/yr) in the valley (DRI, 1980). Ground-water use in the valley consists of 10 acre-ft/yr (0.01 hm^3/yr) for stock watering, 1 acre-ft/yr (0.001 hm^3/hm) for domestic purposes, and 80 acre-ft/yr (0.1 hm^3/yr) for irrigation. The combined surface- and ground-water use totals 283 acre-ft/yr (0.4 hm^3/yr) (DRI, 1980). There are currently 370 acre-ft/yr (0.5 hm^3/yr) of approved ground-water appropriations and an additional 7060 acre-ft/yr (8.7 hm^3/yr) of pending applications in Garden Valley (Woodburn and others, 1981). The quantity of ground water available for MX use is 5909 acre-ft/yr (7.3 hm^3/yr) when considering existing ground-water use and 5630 acre-ft/yr (6.9 hm^3/yr) when considering approved ground-water rights.

2.11.3.2 Source Capabilities

The intermittent streamflow and small spring discharges do not represent a dependable water source for the MX project in Garden Valley because of the seasonal variability of the quantity of water available.

The valley-fill aquifer is considered capable of supplying sufficient water to meet MX needs. Data from an Air Force test well in the valley-fill sediments (2N/57E-22ba2) indicated an average transmissivity and minimum storativity of 12,000 ft^2/day (1112 m^2/day) and 0.003, respectively. During testing, a well yield of 400 gpm (26 l/s) was maintained for 30 days with 23 feet (7 m) of drawdown. Interpretation of lithologic logs indicate that the valley-fill aquifer is under water-table conditions. The low value of storage obtained during the aquifer test is most likely the early response of the aquifer. If pumping were to continue, a delayed drainage response of the overlying sediments would probably occur indicating water table conditions and a larger storativity.

To date, wells have not penetrated the carbonate aquifer in Garden Valley. An aquifer test conducted by Ertec in the carbonate aquifer of neighboring Coal Valley (3N/59E-10bd) indicated a relatively low transmissivity of 400 ft^2/day (37 m^2/day).

2.11.3.3 Water Quality

Water-quality data for Garden Valley are shown in Appendix F1-11. Chemical analysis of water from the Air Force valley-fill test well indicates that the quality of ground water is within the criteria established for construction water (Appendix E1-1). Analysis of samples collected by Ertec from three wells, three streams, and four springs also indicate the water quality to be suitable for construction purposes. All ground-water samples collected and analyzed from Garden Valley were found to be within Primary and Secondary Drinking Water Standards for the State of Nevada (Appendix E1-2) for the constituents analyzed.

2.11.4 Water-Supply Alternatives

2.11.4.1 Lease or Purchase of Existing Water Rights

Approved ground-water appropriations in Garden Valley total less than one-half of the expected peak annual MX requirements. Therefore, the lease or purchase of ground-water rights would not suffice as the sole water-supply source for the MX project. The lease or purchase of ground-water rights should be considered as a supplemental water-supply source if required. Approved surface water rights total 2145 acre-ft/yr (2.6 hm^3/yr) however, the reliability of the sources is in question.

2.11.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred water-supply source for MX construction and operation. The aquifer test conducted in Garden Valley indicates that the valley-fill aquifer is capable of supplying water in sufficient quantity and quality to satisfy construction and operational needs. Considering existing use and certificated rights there is sufficient water available from the valley-fill aquifer to meet the anticipated needs of the project. Two wells pumping at 500 gpm (32 l/s) would be required to meet the peak water demand of 1508 acre-ft/yr (1.9 hm^3/yr).

2.11.4.3 Carbonate Aquifer

The carbonate aquifer in Garden Valley is considered to have a high potential for water-supply development. The existence of thick hydrostratigraphic sequences of carbonate rocks, the lack of volcanic units and its location within a known regional flow regime, make Garden Valley a potentially excellent location for development of the carbonate aquifer. At present, the carbonate aquifer is considered as an alternative water-supply source.

2.11.4.4 Interbasin Transfer

A possible alternative for a MX water supply in Garden Valley would be a transfer of water from Railroad Valley to Garden Valley. Because the valley-fill aquifer in Garden Valley is capable of meeting the expected peak MX water demands, this alternative has been designated as having a low potential for implementation.

2.11.5 Impacts of Development

2.11.5.1 Intrabasin Effects

Ground-water withdrawal for the MX project should have a minor effect on water levels and existing users. Calculations based on a transmissivity of 12,000 ft^2/day (1112 m^2/day), a pumping rate of 500 gpm (32 l/s), a pumping period of two years, and a storativity of 0.003 indicate drawdowns one mile (2 km) from MX production wells of approximately 1 foot (0.3 m). This drawdown would vary somewhat depending upon local geologic and hydrologic conditions. MX water wells will be located at least 1 mile (2 km) from any existing wells, thus minimal impact on local users would occur. Those areas where depths to ground water permit phreatophyte growth will be avoided, thereby minimizing any impacts to the native plant communities. Any minor lowering the water table in the valley would not have a permanent effect on phreatophyte growth because of the plants natural ability to adapt to a fluctuating water table.

The springs in Garden Valley are meteoric and occur within the mountains or around the margins of the valley. MX production wells in the valley-fill aquifer should have no impact on these springs.

2.11.5.2 Interbasin Effects

MX ground-water withdrawals in Garden Valley may slightly reduce the amount of subsurface outflow to Coal Valley. There are not sufficient data to accurately quantify this impact.

2.12 HAMLIN VALLEY

2.12.1 General Physiography and Hydrology

Hamlin Valley, located in Lincoln and White Pine counties in Nevada and Millard, Beaver, and Iron counties in Utah, is a north-south trending basin topographically open to Snake Valley to the north. The valley is bounded on the west by the Snake Range, Limestone Hills, and White Rock Mountains. To the east and south, Hamlin Valley is separated from Pine Valley and the Escalante Desert by the Needle Range. The highest peaks in the basin are in the Snake Range; Wheeler Peak reaches 13,063 feet (3982 m).

Within the Hamlin Valley study area, two hydrographic basins are present. Both of the basins straddle the Nevada-Utah border. The northern portion of Hamlin Valley is in the Snake hydrographic basin and the southern portion is in the Hamlin hydrographic basin. This division was selected based on cultural and geotechnical siting criteria. As defined, the drainage basin is 84 miles (135 km) long, up to 24 miles (39 km) wide, and encompasses an area of 1360 mi^2 (3522 km^2).

Ground-water recharge in Hamlin Valley occurs by infiltration of rain and snowmelt waters in the mountains and on the alluvial fans and by subsurface inflow from Spring Valley. Precipitation varies throughout the valley. The average annual recorded precipitation at Garrison, Utah, on the valley floor, is only 6.7 inches (17 cm). The recorded average at Lehman Caves, 1550 feet (472 m) higher in elevation than Garrison, is 12.6 inches

(32 cm) (Hood and Rush, 1965). Numerous perennial streams and locally recharged meteoric springs originate in the Snake Range. In other portions of the valley, spring and stream discharge is intermittent. There is one possible regional spring in the valley at 5N/70W-11daa.

The average recharge by precipitation in Hamlin Valley has been estimated to be 28,500 acre-ft/yr (35.0 hm^3/yr) by Ertec. This estimate is based on a method described by Eakin and others (1951), modified to incorporate local climatological data. In addition to the interbasin recharge, 4000 acre-ft/yr (4.9 km^3/yr) of subsurface recharge from Spring Valley has been estimated by Hood and Rush (1965). Of the total recharge, 7000 acre-ft/yr (8.6 hm^3/yr) are estimated to be transpired by phreatophytes and evaporated from Pruess Lake near Garrison, 852 acre-ft/yr (1.1 hm^3/yr) are withdrawn from wells, and nearly 16,000 acre-ft/yr (19.7 hm^3/yr) are discharged from springs. Therefore, the subsurface discharge into Snake Valley is estimated to be 9000 acre-ft/yr (11.1 hm^3/yr).

The potentiometric surface gradient in Hamlin Valley is northward toward Snake Valley and ranges from 14 to 40 feet/mile (3 to 8 m/km) (Appendix Figure B1-12). Depths to ground water in Hamlin Valley range from less than 10 feet (3 m) to about 200 feet (61 m) in the northern part of the valley. In the southern portion of the valley, depths to ground water are believed to be in excess of 300 feet (91 m).

2.12.2 MX Water Requirements

MX construction is projected to begin in Hamlin Valley in 1983 and be completed in 1989. The peak construction-water demand year will be 1984 with an estimated requirement of 2620 acre-feet (3.2 hm^3). Ground-water appropriation applications were filed for Hamlin Valley by Ertec on behalf of the Air Force in 1980. These applications requested 2100 acre-ft/yr (2.6 hm^3/yr) in Nevada and 1364 acre-ft/yr (1.7 hm^3/yr) in Utah.

2.12.3 Water-Supply Limitations

2.12.3.1 Perennial Yield, Use, and Appropriations

The combined perennial yield for the Snake and Hamlin hydrographic basins has been estimated by Price (1979) to be 74,000 acre-ft/yr (91.2 hm^3/yr). The perennial yield for Hamlin Valley used in this study was obtained by a series of computations. First, the percentage of the total recharge by precipitation for the Snake and Hamlin hydrographic basins that actually occurs within the Hamlin Valley study area was estimated. The assumption was then made that the percentage of recharge that occurs in Hamlin Valley is equal to the percentage of the combined perennial yield recoverable in Hamlin Valley. As a result, the perennial yield for Hamlin Valley is estimated to be 25,000 acre-ft/yr (30.8 hm^3/yr). This estimate also assumes that the 4000 acre-ft/yr (4.9 hm^3/yr) of subsurface inflow to the valley is fully recoverable.

It is estimated that present ground-water use in Hamlin Valley is 852 acre-ft/yr (1.1 hm^3/yr) (DRI and UWRL, 1980). Of this amount, 840 acre-ft/yr (1.0 hm^3/yr) are being used for irrigation, 10 acre-ft/yr (0.01 hm^3/yr) for stock watering, and 2 acre-ft/yr (0.002 hm^3/yr) for domestic supplies. Certificated and proven rights in the valley total 3504 acre-ft/yr (4.3 hm^3/yr). In addition, another 31,870 acre-ft/yr (39.3 hm^3/yr) have been permitted or are pending application. Estimates of ground-water rights for the study area described in this report were based on water rights for Hamlin Valley, Nevada, Hamlin Valley, Utah, and Snake Valley, Nevada (DRI, 1980).

Air Force applications request ground-water appropriations totaling 2100 acre-ft/yr (2.6 hm^3yr) from three points of diversion (wells) in Nevada and 1364 acre-ft/yr (1.7 hm^3/yr) from two points of diversion in Utah. All of the points of diversion are located south of T10N in Nevada and T25S in Utah, within the area known as the Hamlin hydrographic basin as defined by the respective state engineers. The perennial yield for the Nevada portion of the hydrographic basin is estimated to be 5000 acre-ft/yr (6.2 hm^3/yr). Although no estimate has been made for the Utah portion, it can be approximated to be slightly less than the Nevada portion based on area and topographic relief. Ground-water rights for the Utah portion of this area appear to be entirely appropriated, however, ground-water rights and permits in the Nevada portion total only 362 acre-ft/yr (0.4 hm^3/yr). Therefore, this area within Hamlin Valley has about 4639 acre-ft/yr (5.7 hm^3/yr) of ground water available for appropriation. This amount would be more than sufficient to supply Air Force requirements.

Surface water in Hamlin Valley is heavily utilized. There are 17,280 acre-ft/yr (21.3 hm^3/yr) of certificated and proven surface-water rights. Permits for surface-water resources and pending applications account for an additional 38,033 acre-ft/yr (46.9 hm^3/yr). About 93 percent of the certificates and proofs and 81 percent of the permits and pending applications requests diversions in the Nevada portion of the valley north of T10N. This area contains numerous perennial streams and springs which are utilized as the primary water source for irrigation and stock watering in the valley.

2.12.3.2 Source Capabilities

Springs and perennial streams in the northwest portion of the valley could provide a dependable source of water to meet MX construction-water requirements. Stream gaging stations operated by the U.S. Geological Survey from 1948 to 1955 in Baker and Lehman creeks recorded average yearly discharges of 6200 acre-feet (7.6 hm^3) and 5420 acre-feet (6.7 hm^3), respectively (Hood and Rush, 1965). In addition, flow rates of 4200 and 3000 gpm (265 and 190 l/s) were measured by Ertec for Big Sand Spring Creek and Snake Creek above the fish hatchery, respectively, in July and August of 1979. Averaged over one year, the cumulative discharge at these two locations would be 11,600 acre-feet (14.3 hm^3).

The valley-fill aquifer is also a reliable source of water in the valley. Transmissivities calculated from aquifer tests on existing wells, performed as part of Ertec's valley reconnaissance program, ranged from 60 ft^2/day (6 m^2/day) to 11,500 ft^2/day (1068 m^2/day). Test results from the Air Force test well (8N/69E-35dc2) indicated a transmissivity of 2500 ft^2/day) (232 m^2/day) and a storativity of 0.01. With the exception of the test performed on a small diameter flowing well, which yielded the transmissivity value of 60 ft^2/day (6 m^2/day), all the aquifer tests conducted in the valley showed transmissivity values of a magnitude considered satisfactory to supply MX requirements with a reasonable number of production wells.

Although no carbonate aquifer exploration wells have been drilled in Hamlin Valley, the potential for development of the regional carbonate aquifer in this area is considered high. This is based on a number of criteria which include the occurrence of thick sequences of appropriate carbonate hydrostratigraphic units, the density of faulting in these units, and the lack of thick sequences of volcanic rocks. A high rating value for water-supply development is further supported by the occurrence of at least one regional spring which discharges from carbonate rocks and by the hypothesized subsurface inflow from Spring Valley through carbonate rocks.

2.12.3.3 <u>Water Quality</u>

Water samples from 27 well, spring, and stream locations in Hamlin Valley have been chemically analyzed (Appendix F1-12). Twenty-three of these samples were collected by Ertec and four by the U.S. Geological Survey (Hood and Rush, 1965).

Based on the analyses conducted, both surface and ground water within the valley generally meet all standards for potability and concrete mixing (Appendices E1-1, E1-2, and E1-3). One exception was noted in these results. The sample from a well located 13N/70E-4cdc contained a fluoride concentration of 1.9 mg/l. The owner of this well also reported a high concentration of coliform bacteria. Based on analysis of water from nearby wells, this contamination appears to be very localized.

2.12.4 Water-Supply Alternatives

2.12.4.1 Lease or Purchase of Existing Water Rights

Although both surface- and ground-water rights have been fully appropriated for the area defined as Hamlin Valley, there appears to be sufficient unappropriated ground water in the Nevada portion of Hamlin hydrographic basin (approximately south of 71N) to supply MX construction requirements.

If lease or purchase of water rights is necessary to meet construction demands, surface-water resources in the northeast portion of the valley could provide all or part of the requirement. This would require the retirement of crop lands.

2.12.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for MX in Hamlin Valley. This consideration is based on the following observations:

- o All perennial surface-water resources in the northeast part of the valley are appropriated and utilized;
- o Surface-water resources in other parts of the valley may not be appropriated but are intermittent and are therefore not considered dependable;
- o There appears to be unappropriated ground-water rights available from Nevada in the central portion of the valley;

- The area of unappropriated ground-water rights corresponds to the area with the highest cluster density, thus, an MX production well field could be designed to minimize transportation of water; and

- Aquifer tests and studies performed to date indicate that the valley-fill aquifer is capable of supplying water at the rate necessary and with sufficient quality to meet MX requirements.

At this time, approximately four wells, each pumping continuously at 450 gpm (28 l/s), would be required to fulfill the estimated water requirement for the peak year of MX construction in the valley.

2.12.4.3 Carbonate Aquifer

Hamlin Valley is considered to have a high potential for carbonate aquifer development. However, because the valley-fill aquifer has a high development potential, is generally more cost effective, and any resultant environmental impacts are more easily identified and mitigated, development of the carbonate aquifer is presently considered an unnecessary but viable alternative.

2.12.4.4 Interbasin Transfer

Interbasin transfer of water to or from Hamlin Valley is considered feasible, although it is not known at this time whether the respective state engineers will allow the transportation of ground water across the state line or from one valley to another. It may be economically feasible and warranted to import water from Spring Valley. Not only does there appear to be significant quantities of unappropriated ground water available in Spring Valley, but a well field could be placed so that the total pumping head and transport distance to deliver the water to Hamlin Valley through a gap in the Limestone Hills would be about 400 feet (122 m) and 5 miles (8 km), respectively. Although interbasin transfer is feasible, it is currently considered a low priority alternative.

2.12.5 Impacts of Development

2.12.5.1 Intrabasin Effects

Calculations based on results of aquifer tests in Hamlin Valley indicate that drawdown produced by MX production wells will be on the order of 1.7 feet (1 m) at a distance of 1 mile (2 km). These calculations assumed a transmissivity of 2500 ft^2/day (232 m^2/day), a storativity of 0.01, a pumping period of two years, and a pumping rate of 450 gpm (28 l/s).

Current cluster layout configurations place much of the MX construction activity in the central portion of the valley, between T6N and T9N in Nevada. Present ground-water development in this area consists of a few stock-watering wells. Drawdowns of less than 2 feet (0.6 m) would have minimal effect on existing users and the environment. North of this area, the water table is at or very near land surface over a large area. The valley-fill aquifer has been extensively developed in much of this region, and any drawdown caused by MX ground-water development would have a greater effect on existing users and the environment.

Several small springs near Baker, Nevada are known to discharge from valley-fill deposits and could be affected by additional ground-water development. MX siting criteria have excluded this area from deployment because of cultural and geotechnical considerations. Therefore, there is not likely to be an impact on springs caused by additional ground-water development to supply MX water requirements in this area.

2.12.5.2 Interbasin Effects

The potentiometric surface in Snake and Spring valleys could be lowered by additional ground-water withdrawal in Hamlin Valley. The boundary between Hamlin and Snake valleys crosses the valley-fill aquifer, therefore, for hydrologic purposes, this boundary does not exist and any drawdown at the boundary in either valley would be propagated across the boundary. Hood and Rush (1965) also suggest that a hydrologic connection between Hamlin and Spring valleys exists, through the carbonate rocks forming the Limestone Hills.

2.13 HOT CREEK VALLEY

2.13.1 General Physiography and Hydrology

Hot Creek Valley is a north-south trending basin in Nye County, Nevada. The valley is bordered by the Hot Creek Range on the west and northwest and the Squaw Hills, Halligan Mesa, Palisades Mesa, and the Pancake Range on the east. Hot Creek Valley is topographically open to Reveille and Railroad valleys to the south and southwest, respectively. The average valley floor elevation is 5300 feet (1615 m). Elevations in the mountains range up to 8000 feet (2438 m). The valley is 51 miles (82 km) long and 21 miles (34 km) wide at its widest point. The area of the valley is 725 mi^2 (1877 km^2).

Streams on the valley floor are ephemeral flowing only in response to snowmelt and infrequent summer storms. A few mountain streams are perennial for a portion of their length. Most of this surface flow is rapidly lost to infiltration on the valley floor. Approximately 1000 acre-ft/yr (1.2 hm^3/yr) of surface flow reaches Railroad Valley (Nevada State Engineer, 1971). Numerous springs discharge water along the boundaries of the valley. Five springs in Hot Creek Valley, all located along the front of the Hot Creek Range, have been classified as regional.

Precipitation in the drainage area is the main source of groundwater recharge to Hot Creek Valley. The average annual recharge from this source is 7000 acre-ft/yr (8.6 hm^3/yr), with another 200 acre-ft/yr (0.2 hm^3/yr) of recharge occurring as subsurface inflow from Little Fish Lake Valley to the northwest through Hot Creek Canyon (Rush and Everett, 1966). Evapotranspiration losses in Hot Creek Valley are estimated to be 4600 acre-ft/yr (5.7 hm^3/yr). A minor amount of ground-water discharges as subsurface outflow into the northern part of Railroad Valley and the southern part of Little Smoky Valley (Nevada State Engineer, 1971).

The hydraulic gradient in the valley-fill aquifer is about 20 feet/mile (4 m/km) from the north and west to the southeast. Depth to water is less than 50 feet (15 m) in the central portion of the basin (Appendix Figure B1-13).

The valley-fill aquifer in Hot Creek Valley reaches a maximum thickness of 7000 feet (2134 m) in the central part of the valley and is composed of alluvial fan, fluvial, and lacustrine deposits. Along the margins of the valley, volcanic rocks of Tertiary age were found to depths of 6500 feet (1981 m) (Fugro National, 1980). Volcanic rocks of Tertiary and Quaternary age are the major rock type in the ranges east of Hot Creek Valley. The western Hot Creek Range is also predominantly composed of these volcanic rocks, except along the lower eastern flank of the range where carbonate rocks of Paleozoic age are found to be interbedded with shales, sandstones, and metamorphic rocks (Howard, 1978).

2.13.2 MX Water Requirements

Construction water requirements for the MX project in Hot Creek Valley are expected to reach a peak annual demand of

1748 acre-feet (2.1 hm^3) in 1987. The construction period is projected to be from 1985 to 1989. The Air Force has filed for 3115 acre-ft/yr (3.8 hm^3/yr) of ground-water appropriations in Hot Creek Valley from five points of diversion.

2.13.3 Water-Supply Limitations

2.13.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Hot Creek Valley is 5500 acre-ft/yr (6.8 hm^3/yr) (Nevada State Engineer, 1971). This value is based on estimates of total recharge and discharge in the hydrographic basin which includes northern Reveille Valley.

Surface-water use in Hot Creek Valley is estimated to be 472 acre-ft/yr (0.6 hm^3/yr) for mining, irrigation, stock watering, and domestic purposes (DRI, 1980). Surface-water certificates and proofs total 1050 acre-ft/yr (1.3 hm^3/yr). In addition, there are 18,865 acre-ft/yr (23.3 hm^3/yr) of pending applications and permits for surface water in Hot Creek Valley (DRI, 1980).

The present amount of ground-water use in Hot Creek Valley is estimated to be 297 acre-ft/yr (0.4 hm^3/yr) for irrigation, domestic, livestock watering, and mining purposes (DRI, 1980). At this time, there are 193 acre-ft/yr (0.2 hm^3/yr) of certificates and 859 acre-ft/yr (1.1 hm^3/yr) of permits for ground water in Hot Creek Valley (Woodburn and others, 1981). An additional 84,260 acre-ft/yr (103.9 hm^3/yr) of ground-water applications are on file (Woodburn and others, 1981).

The quantity of ground water available for MX use is 5203 acre-ft/yr (6.4 hm^3/yr) when considering only existing ground-water use. Based on the number of ground-water certificates and proofs in Hot Creek Valley, the quantity of ground water available is 1681 acre-ft/yr (2.1 hm^3/yr).

2.13.3.2 Source Capabilities

Surface water in Hot Creek basin has good potential for supplying a portion of the water requirements for MX construction. The largest flowing streams are found at Hot Creek Ranch, Warm Springs, and Twin Springs Ranch near the bedrock/valley-fill boundary.

Test results from two Air Force valley-fill aquifer exploration wells in the central portion of the valley (7N/51E-10ad1 and 6N/50E-27ac1) indicate transmissivities of 19,000 ft^2/day (1761 m^2/day) and 1600 ft^2/day (148 m^2/day) and minimum storativities of 0.02 and 0.004, respectively. These wells produced 235 and 375 gpm (15 and 24 l/s) with 45 and 126 feet (14 and 38 m) of drawdown, respectively. Dinwiddie and Schroder (1971) reported low transmissivities (less than 500 ft^2/day [46 m^2/day]) from deep exploratory holes in northern Hot Creek Valley. Available aquifer test data indicate that the valley-fill aquifer in the central portion of the valley is capable of delivering water in quantities sufficient for MX needs. The valley-fill in the northern portion of the valley may not be as hydrologically suitable as a water-supply source.

2.13.3.3 Water Quality

Water-quality data for Hot Creek Valley are shown in Appendix F1-13. Chemical analyses for major constituents from the two Air Force test wells in the valley-fill aquifer indicate that the quality of water meets criteria for construction purposes (Appendix E1-1). Although the quality of ground water was found to be generally potable, the Secondary Drinking Water Standard for iron established by the State of Nevada was exceeded at one well. High iron content is not particularly harmful to health, but can stain pipes and clothing. All other constituents analyzed were found to be within Primary and Secondary Drinking Water Standards for the State of Nevada (Appendix E1-2).

Chemical analyses of ground-water samples collected from numerous wells drilled as part of Operation Faultless, a hydrologic study for the Atomic Energy Commission, indicate a natural tendency toward poorer quality water with depth (Dinwiddie and Schroder, 1971). Ground-water samples from these wells generally exceed the Primary Drinking Water Standard for fluoride and Secondary Drinking Water Standard for TDS. Water from Warm Springs, in southwest Hot Creek Valley, and Hot Creek also exceed fluoride and TDS standards. Both of these sources are regional spring discharge. Butte Spring exceeds the maximum secondary standards for manganese and iron. Blue Jay Spring exceeds the maximum secondary standard for TDS and the recommended secondary standard for sulfate.

2.13.4 Water-Supply Alternatives

2.13.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of existing water rights in Hot Creek Valley is a viable supply alternative for a portion of the water required for MX construction. A total of 1748 acre-feet (2.1 hm^3) of water is expected to be used in the peak construction year of 1987. Presently there are a total of 1143 acre-ft/yr (1.4 hm^3/yr) of certificates and proofs for surface and ground water in Hot Creek Valley.

2.13.4.2 Valley-Fill Aquifer

The valley-fill aquifer in Hot Creek Valley is the preferred water-supply source for the MX project. Approval of sufficient ground-water rights to meet peak-year MX requirements will require approved rights to temporarily exceed the perennial yield. Considering present use, actual ground-water withdrawal in excess of perennial yield would not occur.

Aquifer tests indicate that the valley-fill aquifer, at least in the central part of the valley is capable of providing water at the rates and of adequate quality to meet MX requirements. Five wells pumping at about 250 gpm (16 l/s) will be required to meet MX requirements during the peak year of construction.

2.13.4.3 Carbonate Aquifer

The regional carbonate aquifer in Hot Creek Valley is considered to have a moderate potential for water-supply development. Although a viable supply source, development of the carbonate aquifer should be considered only in the event that other in-valley sources prove impractical.

2.13.4.4 Interbasin Transfer

The interbasin transfer of water to Hot Creek is not considered a viable water-supply alternative because surrounding valleys do not have excess supplies.

2.13.5 Impacts of Development

2.13.5.1 Intrabasin Effects

Anticipated drawdowns due to MX production wells in the valley-fill aquifer have been calculated assuming a transmissivity of 19,000 ft^2/day (1761 m^2/day), a storativity of 0.02, and a pumping period of two years. Based on these values, an MX production well pumping at 250 gpm (16 l/s) is expected to produce a drawdown of 0.2 feet (0.06 m) at a distance of 1 mile (2 km). Actual values will be slightly higher or lower depending on site-specific geologic and hydrologic conditions.

Withdrawals from the valley-fill aquifer may have an effect upon springs that discharge from the valley-fill if drawdown from MX wells occurs near the spring site. Locating MX wells at least 1 mile (2 km) away from such springs will preclude significant impacts on spring discharge. MX production wells should be located at least 3 miles (5 km) from any of the regional springs in the valley.

2.13.5.2 Interbasin Effects

The withdrawal of ground water from Hot Creek Valley could reduce the amount of surface and subsurface flow to Railroad

Valley through the Twin Springs Slough area. To preclude this potential impact, the southeast portion of Hot Creek Valley should be avoided in selecting sites for MX production wells.

2.14 JAKES VALLEY

2.14.1 General Physiography and Hydrology

Jakes Valley is a topographically closed basin in White Pine County, Nevada. The valley is in the northern part of the White River regional ground-water flow system, with Long Valley to the north and White River Valley to the south. Jakes Valley is approximately 26 miles (42 km) long and 21 miles (34 km) across at its widest point. The valley has an area of about 422 mi^2 (1093 km^2). The valley floor has an average elevation of 6400 feet (1951 m).

All streams in Jakes Valley are ephemeral. Meteoric springs issuing from carbonate rocks occur in and at the margins of the surrounding mountains; springs discharging from the valley-fill or regional springs are not present in the valley. Ertec's reconnaissance of Jakes Valley revealed the discharge of selected springs to range from less than 1 gpm (0.06 l/s) to 4 gpm (0.3 l/s) in November 1980.

Jakes Valley is hydraulically open to both Long and White River valleys. Ground-water recharge in Jakes Valley from the infiltration of precipitation and snowmelt in the mountains and across the alluvial fans is 17,000 acre-ft/yr (21.0 hm^3/yr) (Nevada State Engineers, 1971). In addition, 8000 acre-ft/yr (9.9 hm^3/ yr) of subsurface inflow from Long Valley enters Jakes Valley (Nevada State Engineer, 1971). Discharge from the valley as subsurface outflow to White River Valley is estimated to be 25,000 acre-ft/yr (30.8 hm^3/yr) (Nevada State Engineer, 1971). Evapotranspiration discharge is minor in Jakes Valley.

The potentiometric surface in Jakes Valley, as extrapolated from regional potentiometric interpretations, ranges from 6100 feet (1859 m) in the north to less than 6000 feet (1829 m) at the southern end of the valley (Appendix Figure B1-14). The hydraulic gradient in the valley is about 2 feet/mile (0.4 m/km) in a southerly direction.

Depths to ground water in central portions of Jakes Valley are believed to be in excess of 300 feet (91 m). This estimate is based on regional potentiometric interpretations and topographic elevations in the valley. Water-level measurements made by Ertec in three of the four wells present in Jakes Valley indicate that ground-water levels range from 18 to 163 feet (6 to 50 m) below land surface. These wells are located near the margins of the valley, and the wells are believed to be located in areas where perched ground water is present. As a result, these values are not considered to be indicative of the depth to water in the main portion of the valley.

Based on regional geologic mapping and interpretation of the limited number of well drillers logs, the valley fill is composed of gravel, sand, silt, and clay of Tertiary and Quaternary age. Carbonate rocks of Paleozoic age and volcanics of Tertiary age predominate in the surrounding mountains.

2.14.2 MX Water Requirements

Construction in Jakes Valley is projected to begin in 1985 and conclude in 1990. The peak annual demand for water for MX construction is estimated to be 801 acre-feet (1.0 hm^3) in 1988.

The Air Force has applied for 1758 acre-ft/yr (2.2 hm^3/yr) of ground-water appropriations in Jakes Valley from three points of diversion.

2.14.3 Water-Supply Limitations

2.14.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Jakes Valley has been estimated at 12,000 acre-ft/yr (14.8 hm^3/yr) by the Nevada State Engineer (1971). Information on pending and approved surface- and ground-water appropriations are not currently available for Jakes Valley. Reconnaissance of the valley by Ertec personnel indicated that water use in the valley is primarily from spring discharge along the mountains to the west of the valley. Other scattered small discharge mountain springs were also found to be utilized for stock watering. A comprehensive study is presently underway to quantify both water use and pending and approved water rights in the valley. Based on the limited amount of water use found during reconnaissance of the valley, nearly the entire perennial yield (12,000 acre-ft/yr [14.8 hm^3/yr]) should be available for MX use.

2.14.3.2 Source Capabilities

The ephemeral streams and springs in Jakes Valley do not represent a viable water supply for the MX project. The reconnaissance by Ertec indicated that all of the springs in Jakes Valley are located in the surrounding mountains. The maximum discharge recorded during the reconnaissance was 4 gpm (0.3 l/s) at Sammy Springs in the northern part of the valley (18N/59E-10dc).

Very little information is available for the valley-fill aquifer in Jakes Valley. From interpretation of the limited number of drillers' logs available, the valley fill appears similar in character to the valley fill in Long and White River valleys. Based on data from these valleys, the transmissivity may be on the order of 670 ft^2/day (62 m^2/day) to 2000 ft^2/day (185 m^2/day) in the alluvial fans. Lower values are expected along the axis and south-central portion of the basin where playa deposits are present. The valley-fill aquifer throughout much of Jakes Valley is believed to be under water-table conditions. The installation of wells and subsequent aquifer testing are needed to verify these estimates. If the actual values are similar, the valley-fill aquifer would be capable of yielding sufficient water to meet MX construction requirements.

There is also little data available on the carbonate aquifer in Jakes Valley. The carbonate aquifer in Jakes Valley has been designated as having a low potential for development primarily because of a lack of appropriate carbonate hydrostratigraphic units and the occurrence of extensive volcanics.

2.14.3.3 Water Quality

Water samples were collected from three meteoric springs in Jakes Valley: Willow Spring, Sammy Spring, and Sand Spring (Appendix F1-14). Chemical analyses of these samples indicate that waters are suitable for construction use (Appendix E1-1). In addition, the quality of water is within the Primary and Secondary Drinking Water Standards for the State of Nevada (Appendix E1-2).

The absence of springs or operational wells in the valley floor precluded the collection of water samples from the valley-fill aquifer. As a result, data are not available for interpretation of the water quality in this unit.

2.14.4 Water-Supply Alternatives

2.14.4.1 Lease or Purchase of Existing Water Rights

Existing water rights in Jakes Valley have not been quantified to date. Based only on observed present use, it is assumed that the amount of existing appropriations is small. Consequently, the lease or purchase of existing water rights is not considered a viable water supply alternative in Jakes Valley.

2.14.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred water supply source for MX construction and operation in Jakes Valley. A limited number of water rights are believed to exist for the valley and ground-water use is nearly nonexistent. Consequently, nearly the entire perennial yield of 12,000 acre-ft/yr (14.8 hm^3/yr) should be available for development. Well yield, and therefore the number of wells which may be needed to meet MX peak demand requirements, cannot be estimated at this time.

2.14.4.3 Carbonate Aquifer

The carbonate aquifer has been designated as having a low potential for water-supply development. Because of uncertainties associated with its development, the carbonate aquifer should be considered a low priority alternative water-supply source.

2.14.4.4 Interbasin Transfer

The interbasin transfer of water into Jakes Valley is an alternative to pumping from the valley fill. Possible source valleys for transfer are White River and Long. Both these valleys are lower in elevation than Jakes Valley. Substantial pumping lifts would be required to transport water from these valleys into Jakes Valley.

2.14.5 Impacts of Development

2.14.5.1 Intrabasin Effects

Ground-water withdrawals from the valley-fill aquifer are not expected to affect the meteoric springs in Jakes Valley. These springs are located in or at the base of the surrounding mountains and are derived from localized flow in the carbonate rocks.

Exploratory drilling or aquifer testing have not been conducted in Jakes Valley. Therefore, site-specific estimates of drawdown related to MX pumping in the valley cannot be made. Future aquifer testing and computer modeling will provide such estimates. It can be assumed that because existing ground-water use is very limited in Jakes Valley, the impact of properly located MX production wells on present water users would be minimal.

If the regional carbonate aquifer is utilized as a source of water for the MX project, impacts on springs in the surrounding mountains are expected to be minimal. The existing springs are fed by localized flow in the carbonate rocks and do not appear to be associated with the regional flow system.

2.14.5.2 Interbasin Effects

The Nevada State Engineer (1971) estimates that 25,000 acre-ft/yr (30.8 hm^3/yr) discharges from Jakes Valley as underflow to White River Valley. This flow occurs primarily within the regional carbonate aquifer. There are insufficient data on the degree of hydraulic connection between the valley-fill and carbonate aquifer systems to evaluate potential effects on this interbasin flow from withdrawals in the valley-fill aquifer. However, given the temporary nature of MX construction use, it is anticipated that the effect will be minimal. Withdrawals directly from the carbonate aquifer would have a greater potential for impacting underflow to White River Valley. Again, there are presently insufficient data to quantify the effect.

Negative impacts of interbasin transfer would occur in the source valley. Sufficient quantities of water (perennial yield) must be available in the source valley to supply MX construction and operation demands for both the source valley and Jakes Valley simultaneously for interbasin transfer to be a viable water-supply alternative. If water were transferred from Long Valley, a reduction in subsurface inflow to Jakes Valley may occur.

2.15 KOBEH VALLEY

2.15.1 General Physiography and Hydrology

Kobeh Valley is a triangular shaped basin encompassing 875 mi^2 (2265 km^2) in Eureka and eastern Lander counties of Nevada. Kobeh Valley is topographically open to Monitor, Antelope, and Diamond valleys and is surrounded by the Simpson Park Mountains to the north and east, the Mahogany Hills on the southeast, and the Monitor Range on the south. The valley is 39 miles (63 km) in length and has a maximum width of 38 miles (61 km). The average valley floor elevation is 6200 feet (1890 m).

Streamflow within Kobeh Valley is derived from snowmelt runoff, ground-water discharge, and rainfall from infrequent summer rainstorms. Runoff from streams is rapidly lost to infiltration on the alluvial fans and valley floor and serves to recharge the ground-water reservoir. Some surface water enters Kobeh Valley from Monitor Valley to the south. Kobeh Valley, in turn, drains into the topographically lower Diamond Valley to the east. This flow is intermittent with maximum flow occurring from rapid snowmelt runoff (Rush and Everett, 1964).

Total recharge from precipitation is estimated to be 11,000 acre-ft/yr (13.6 hm^3/yr) (Nevada State Engineer, 1971). Rush and Everett (1964) have estimated that there is 6000 acre-ft/yr (7.4 hm^3/yr) of ground-water recharge from subsurface inflow from northern Monitor Valley and Antelope Valley. Therefore, the total ground-water recharge to Kobeh Valley is 17,000 acre-ft/yr (21.0 hm^3/yr).

Ground-water discharge totals 15,000 acre-ft/yr (18.5 hm^3/yr). It occurs mainly as evapotranspiration in the south-central portion of the valley. There is a minor amount of subsurface outflow to Diamond Valley (Rush and Everett, 1964).

The hydraulic gradient in the valley-fill aquifer approximates 10 feet/mile (2 m/km), generally from west to east. Depth to water averages less than 50 feet (15 m) throughout the central portion of the valley (Appendix Figure B1-15).

The valley fill may be several thousand feet thick in the central portion of the basin and is composed of fluvial and lacustrine sediments derived from the surrounding mountains. The mountains surrounding the valley are composed of consolidated sedimentary rocks (including limestones, sandstones, and shales) of Paleozoic age and intrusive and extrusive volcanic rocks of Tertiary age. The mountains in this area have undergone extensive deformational processes resulting in complex geological structures.

2.15.2 MX Water Requirements

The peak annual water demand for MX construction in Kobeh Valley is expected to be 986 acre-feet (1.2 hm^3) in 1986. The projected start of construction is 1985, and completion is expected in 1989.

The Air Force has filed applications for the appropriation of 3530 acre-ft/yr (4.4 hm^3/yr) of ground water in Kobeh Valley from five points of diversion.

2.15.3 Water-Supply Limitations

2.15.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Kobeh Valley is 16,000 acre-ft/yr (19.7 hm^3/yr) (Nevada State Engineer, 1971). This value is based upon the estimated total recharge and discharge within the valley. Ground-water use is estimated to be 3342 acre-ft/yr (4.1 hm^3/yr); 3240 acre-ft (4.0 hm^3) for irrigation, 100 acre-ft (0.1 hm^3) for stock watering, and 2 acre-feet (0.002 hm^3) for domestic purposes (DRI, 1980). Ground-water appropriations include 11,667 acre-ft/yr (14.4 hm^3/yr) of certificates, 3284 acre-ft/yr (4.0 hm^3/yr) of permits, and 9968 acre-ft/yr (12.3 hm^3/yr) in pending applications (Woodburn and others, 1981). There are no estimates of surface-water use in Kobeh Valley; there are no certificates or proofs for surface-water rights. Permits and applications total 723 acre-ft/yr (0.9 hm^3/yr) (DRI, 1980).

The quantity of ground water available for MX use is 12,658 acre-ft/yr (15.6 hm^3/yr) when considering existing use in Kobeh Valley. If certificates and permits are considered, 1049 acre-ft/yr (1.3 hm^3/yr) are available for use. The estimated peak-year demand of 986 acre-feet (1.2 hm^3) in Kobeh Valley is within the limits of ground-water availability.

2.15.3.2 Source Capabilities

Surface water in Kobeh Valley is provided by small meteoric springs which occur near the bedrock/valley-fill boundary and ephemeral stream flow. Because of their small discharge or ephemeral nature, these surface-water sources would not provide a dependable source of water.

Specific capacity tests of wells conducted in Kobeh Valley suggest a range of transmissivities from 390 to 4840 ft^2/day (36 to 450 m^2/day) for the valley-fill aquifer. Large capacity irrigation wells in the southern portion of the valley, however, indicate transmissivities in the range of 7000 ft^2/day (650 m^2/day). Interpretation of information obtained from driller's logs indicate that water-table conditions exist throughout the valley fill.

The carbonate aquifer has a high potential for water-supply development because of the occurrence of assumed high-yield carbonate hydrostratigraphic units at drillable depths and the occurrence of areas of high-density faulting in the carbonate rocks.

2.15.3.3 Water Quality

Eight water samples were collected at various locations throughout the valley to obtain a general description of the quality of water in Kobeh Valley (Appendix F1-15). The chemical quality of all surface- and ground-water samples collected within Kobeh Valley were found to be within the quality criteria established for construction use (Appendix E1-1). In addition, all samples were found to meet the Primary and Secondary Drinking Water Standards for the State of Nevada (Appendix E1-2). These results are believed to be generally indicative of the valley-fill aquifer and localized springs throughout the entire valley.

2.15.4 Water-Supply Alternatives

2.15.4.1 Lease or Purchase of Existing Water Rights

The lease or purchase of water rights for MX construction from existing ground-water users is a viable water-supply alternative given the large amount (11,667 acre-ft/yr [14.4 hm^3/yr]) of certificated ground-water rights. The potential for lease or purchase of surface-water rights is uncertain as the amount of certificated rights is unknown at this time.

2.15.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for the MX project. The valley-fill aquifer has an abundance of good quality ground water obtainable at generally shallow depths. Existing wells have shown the aquifer capable of yielding large quantities of ground water to wells. Two wells pumping continuously at 310 gpm (20 l/s) would be required to supply the peak-year demand for MX construction in Kobeh Valley.

2.15.4.3 Carbonate Aquifer

The carbonate aquifer has been designated as having a high potential for water-supply development. Installation of water-supply wells in the carbonate aquifer is much more costly and involves a higher risk (of not penetrating a productive water-supply zone) than well installation in the valley-fill aquifer. For these reasons, the carbonate aquifer is considered an alternative water-supply source.

2.15.4.4 Interbasin Transfer

Interbasin transfer is not considered a viable water-supply alternative for Kobeh Valley because of the lack of excess water in surrounding potential source valleys.

2.15.5 Impacts of Development

2.15.5.1 Intrabasin Effects

There is a significant ground-water use in Kobeh Valley and consequently locations of MX production wells will have to be carefully chosen to avoid impacts to existing wells. Calculations based on a two-year period of anticipated maximum withdrawal and a pumping rate of 300 gpm (19 l/s) indicate the drawdowns at 1 mile (2 km) from an MX production well would be 1 foot (0.3 m), and at 2 miles, (3 km) drawdown would be essentially zero. These estimates assume a transmissivity and storativity for the valley-fill aquifer of 4000 ft^2/day (379 m^2/day) and 0.1, respectively. MX production wells should be located in areas of the valley away from any existing springs and wells to avoid affecting existing water users and at a minimum should be setback 1 mile (2 km) from any sites of existing use.

Springs located along the base of the surrounding mountains are derived from sources other than the valley fill and therefore should not be affected by ground-water withdrawals from this unit. On the east side of the valley, a few springs with low discharge rates issue from the valley floor. These springs are currently utilized as a water supply for livestock. MX wells should be located an appropriate distance from these and all other springs to avoid impacts on spring discharge.

2.15.5.2 Interbasin Effects

Water levels and spring discharges in Diamond Valley may be affected by ground-water withdrawals in Kobeh Valley. There is little information available to determine the degree of hydrologic connection between Kobeh and Diamond valleys. The effect of ground-water withdrawals in Kobeh Valley on neighboring Diamond Valley will most likely be undetectable given the small water requirments for the peak year of construction (986 acre-feet [1.2 hm^3]) and the temporary nature of the withdrawal.

2.16 LAKE VALLEY

2.16.1 General Physiography and Hydrology

Lake Valley, in Lincoln and White Pine counties, Nevada, is a north-south trending basin encompassing 975 mi^2 (2524 km^2). The Nevada State Engineers Office considers Lake Valley to be two separate hydrographic basins about equal in area; Lake Valley and Patterson Valley, to the north and south, respectively. Lake Valley Hydrographic Basin is topographically closed. Patterson Valley Hydrographic Basin is topographically open and drains to the south into Panaca Valley via Patterson Wash.

The combined maximum length of the valley is 71 miles (114 km) and the maximum width is 20 miles (32 km). The valley is bounded by the Fortification Range on the northeast and east, by the Wilson Creek Range on the southeast, by the Schell Creek Range on the west and northwest, by the Fairview, Bristol, and Highland ranges on the southwest, and by the Pioche Hills to the south.

The average valley floor elevation of the topographically closed northern portion of the valley is 6000 feet (1829 m) and 5600 feet (1707 m) in the topographically open southern portion. About 15 percent of the valley is above 7000 feet (2134 m) in elevation. The surrounding mountains attain elevations slightly in excess of 10,000 feet (3048 m).

Streams on the valley floor are ephemeral, but the headwaters of a few mountain streams are perennial. Rush and Eakin (1963) reported that the northern enclosed basin has an estimated average annual runoff of 8000 acre-ft/yr (9.9 hm^3/yr). Rush (1964) estimated that the southern open drainage basin has an average annual runoff of 3300 acre-ft/yr (4.1 hm^3/yr) with only minor outflow reaching Panaca Valley (Rush, 1964).

Ground-water recharge is estimated to total 19,000 acre-ft/yr (23.4 hm^3/yr) from precipitation infiltrating to the valley-fill aquifer; 13,000 acre-ft/yr (16.0 hm^3/yr) in the northern basin and 6000 acre-ft/yr (7.4 hm^3/yr) in the southern basin (Nevada State Engineer, 1971). Ground-water discharge is 8500 acre-ft/yr (10.5 hm^3/yr) from evapotranspiration in the northern basin, and 9000 acre-ft/yr (11.1 hm^3/yr) by subsurface outflow from the southern basin toward Panaca Valley.

One possible regional spring, Geyser Spring, (9N/65E-4c1) has been identified in Lake Valley. Other springs in the valley are generally small discharge meteoric springs which occur along the mountain fronts. Little North Creek Spring (10N/65E-29c1) has a recorded discharge of 770 gpm (49 l/s) (Rush and Eakin, 1963).

Approximately 25 percent of the northern section of the valley has ground water at depths of less than 50 feet (15 m). Less than 10 percent of the southern section of the valley has ground water at less than 50 feet (15 m). The potentiometric surface of the valley-fill aquifer slopes at a gradient of 4 feet/mile (1 m/km) south to the topographic divide in the valley, and then the slope increases to 15 feet/mile (3 m/km) toward Panaca Valley (Appendix Figure F1-16).

The valley fill is composed of fluvial and lacustrine deposits together with partly consolidated pyroclastic deposits of welded tuff. Sandstones, shales, and carbonate rocks of Paleozoic age and undifferentiated volcanics of Tertiary age underlie the valley fill and are exposed in the surrounding mountain ranges (Howard, 1978).

2.16.2 MX Water Requirements

Peak-year water demand for MX construction in Lake Valley is expected to be 2389 acre-feet (2.9 hm^3) in 1984. Construction is expected to start a year before the peak construction year and be completed by 1987. The Air Force has filed applications for 3805 acre-ft/yr (4.7 hm^3/yr) of ground-water appropriations in Lake Valley from five points of diversion.

2.16.3 Water-Supply Limitations

2.16.3.1 Perennial Yield, Use, and Appropriations

The combined perennial yield for Lake Valley is 16,500 acre-ft/yr (20.3 hm^3/yr); 4500 acre-ft/yr (5.5 hm^3/yr) from Patterson Valley and 12,000 acre-ft/yr (14.8 km^3/yr) from Lake Valley (Nevada State Engineer, 1971). Total water use is presently 18,749 acre-ft/yr (23.1 hm^3/yr), including 14,166 acre-ft/yr (17.5 hm^3/yr) of ground water and 4583 acre-ft/yr (5.6 hm^3/yr) of surface water (DRI, 1980). Surface-water rights in the form of certificates and proofs total 914 acre-ft/yr (1.1 hm^3/yr) and permits and applications total 2828 acre-ft/yr (3.5 hm^3/yr) (DRI, 1980). Ground-water rights include 2257 acre-ft/yr (2.8 hm^3/yr) in certificates and proofs, 3176 acre-ft/yr (3.9

hm^3/yr) of permits, and 26,484 acre-ft/yr (32.7 hm^3/yr) of pending applications (Woodburn and others, 1981). These water rights have been obtained primarily for irrigation, however some are for mining, municipal, domestic, and stock uses.

There is no water available for MX use if the present total use of 18,749 acre-ft/yr (23.1 hm^3/yr) is subtracted from the 16,500 acre-ft/yr (20.3 hm^3/yr) estimated for the perennial yield of both basins that comprise Lake Valley. However, if water use in the basins is considered separately, the northern Lake Valley basin is overused by 6245 acre-ft/yr (7.7 hm^3/yr) while the southern Patterson Valley basin is underused by 3996 acre-ft/yr (4.9 hm^3/yr). The Nevada State Engineer has closed the northern basin to further ground-water development, but the southern basin is still open, and ground water there could be appropriated for MX development. If surface- and ground-water certificates and proofs are considered, 2621 acre-ft/yr (3.2 hm^3/yr) are available in the southern basin and 10,393 acre-ft/yr (12.8 hm^3/yr) are available in the northern basin. If applications and permits are included, no water is available for MX use.

2.16.3.2 Source Capabilities

Because most of the streams are ephemeral and surface water use is at a high level, the potential for further development is limited. Use of developed surface-water sources via lease or purchase of water rights is feasible.

The valley-fill aquifer is heavily developed, especially in northern Lake Valley, and thus is a proven water-supply source. Data from twelve specific capacity tests indicate transmissivity in the valley-fill aquifer ranges from 1000 to 13,000 ft^2/day (93 to 1205 m^2/day). Average transmissivity is assumed to be about 7000 ft^2/day (649 m^2/day).

The potential for carbonate aquifer development in Lake Valley is considered low because of unfavorable geologic and hydro-stratigraphic conditions and land-use restrictions on favorable drilling areas.

2.16.3.3 Water Quality

Water-quality data are available for two wells and one spring in Lake Valley (Appendix F1-16). All of the waters analyzed meet standards for construction use (Appendix E1-1). All of the samples also meet the Nevada Primary and Secondary Standards for Drinking Water (Appendix E1-2) for the constituents analyzed. Although a very limited data base exists, there are no indications of water quality constraints on surface- or ground-water development in Lake Valley.

2.16.4 Water-Supply Alternatives

2.16.4.1 Lease or Purchase of Existing Water Rights

The northern portion of Lake Valley has been closed to further ground-water appropriation by the Nevada State Engineer. Lease or purchase of existing surface- or ground-water rights is the most viable supply alternative for the northern portion of the valley.

2.16.4.2 Valley-Fill Aquifer

The southern portion of Lake Valley has ground water available for appropriation. The aquifer is shallow and is capable of providing well yields of sufficient quantity and quality for MX construction purposes. The preferred water-supply alternative for Lake Valley therefore involves both lease-purchase (in northern Lake Valley) and appropriation of ground water (in southern Lake Valley).

2.16.4.3 Carbonate Aquifer

The overall water-supply development potential of the carbonate aquifer in Lake Valley is low, and it should be considered only an alternate water-supply source. The highest potential area for development is Dutch John Mountain located in the south-western mountains of the northern basin.

2.16.4.4 Interbasin Transfer

Due to the abundance of ground-water in the valley-fill aquifer, there is no perceived need for transfer of water to Lake Valley. In the event that appropriations are not granted and water rights cannot be leased or purchased, the interbasin transfer of water from Spring Valley does offer an alternative water-supply source.

2.16.5 Impacts of Development

2.16.5.1 Intrabasin Effects

Development of a water supply by lease or purchase of existing water rights will cause no additional impact on water levels in the valley-fill aquifer. Aquifer testing and numerical modeling of the ground water system will be required to provide a specific evaluation of anticipated drawdown due to MX production wells. Because MX production wells are planned to be at least 1 mile (2 km) away from existing wells, there should be little impact. All springs in Lake Valley occur around the valley margins and should not be affected by development in the valley-fill aquifer.

2.16.5.2 Interbasin Effects

Spring discharges in Panaca Valley, south of Lake Valley, could be affected by ground-water withdrawals in Lake Valley. Rush (1964) estimated that 9000 acre-ft/yr (11.1 hm^3/yr) of ground water flows from Lake Valley into Panaca Valley. There is little information available to determine the impact that ground-water withdrawals in Lake Valley will have on this regional flow. Because of the distance from withdrawal points to the springs and the short period of significant ground-water withdrawal in Lake Valley, it is estimated that impact on spring discharges in Panaca Valley will not be detectable. These springs should be monitored during the period of MX water use.

2.17 LITTLE SMOKY VALLEY

2.17.1 General Physiography and Hydrology

Little Smoky Valley is a north-south trending basin in southeast Eureka and northeast Nye counties, Nevada. The valley is topographically open to Newark Valley in the north and is 44 miles (71 km) long and from 6 to 18 miles (10 to 29 km) in width. The valley encompasses 585 mi^2 (1515 km^2). The valley floor slopes from an elevation of 6500 feet (1981 m) in the south to 6000 feet (1829 m) in the north. The valley is bordered on the east by the Pancake Range and by the Fish Creek, Antelope, and Park Ranges on the west. The basin is separated from Big Sand Springs Valley to the south and east by shallow alluvium underlain by carbonate rocks of Paleozoic age.

The northern portion of Little Smoky Valley is topographically and hydrologically open, and surface and subsurface flow occurs toward Newark Valley in the north. The southernmost part of the valley is occupied by a playa which is several hundred feet south of a subtle topographic divide. This portion of the valley is topographically closed.

The only perennial stream in Little Smoky Valley is Fish Creek, which is fed by the Fish Creek Springs and flows northeast toward Newark Valley. Generally the streamflow dissipates within 5 miles (8 km) of its point of origin, although Rush and Everett (1966) estimate that 500 acre-ft/yr (0.6 hm^3/yr) of runoff is lost to Newark Valley during infrequent high flows. Most other streamflow in the valley is derived from snowmelt or summer rainstorm runoff and is rapidly lost to infiltration on the alluvial fans where it serves to recharge the ground-water reservoir. The average annual runoff from the valley has been estimated to be 4000 acre-ft/yr (4.9 hm^3/yr) (Rush and Everett, 1966). The southern portion of Little Smoky Valley produces a minor quantity of runoff which drains toward the playa.

The average annual recharge to the ground-water reservoir in the valley is estimated to be 6000 acre-ft/yr (7.4 hm^3/yr), of which, 4000 acre-feet (4.9 hm^3/yr) is from precipitation occuring in the mountains, primarily along the west flank of the valley (Rush and Everett, 1966). A second source is recharge to the valley-fill aquifer in Fish Creek Springs. These springs are classified as regional and are believed to result from interbasin flow through the carbonate rocks from Antelope Valley to the east. The estimated recharge from the springs is 800 acre-ft/yr (1.0 hm^3/yr) (Rush and Everett, 1966). A third source of recharge is a group of springs (Pine, Snowball Ranch, and Indian springs) which occur along the western side of the valley at 14N/51E. These springs also discharge water from carbonate rocks but are not believed to be regional. Rush and Everett (1966) estimate that they recharge 720 acre-ft/yr (0.9 hm^3/yr) to the valley-fill system. Spring discharges are negligible on the east side of the valley.

The nature and quantity of discharge from the valley-fill aquifer has yet to be fully resolved. Rush and Everett (1966) estimate that the phreatophytes in the center of the valley

(13N/53E) transpire 1900 acre-ft/yr (2.3 hm^3/yr) and that subsurface outflow to Newark Valley totals 1000 acre-ft/yr (1.2 hm^3/yr). They also suggest that ground water is discharged by irrigation and stock watering. The quantity of water discharged from the valley-fill aquifer, however, as opposed to surface water derived directly from the carbonate springs, remains to be determined.

The hydraulic gradient in the valley-fill aquifer is northward toward Newark Valley. Ground water occurs at relatively shallow depths in the northern part of the valley. The depth to water increases toward the mountains and south along the axis of the valley (Appendix Figure B1-17). In the extreme southern portion of the valley, the depth to water near the edge of the playa is 500 feet (152 m). This suggests that the playa may be part of a local perched aquifer overlying, and separated from, the main aquifer by a thick, unsaturated zone (Rush and Everett, 1966).

The valley-fill deposits consist predominantly of interfingered fluvial and lacustrine sediments of Late Tertiary age. Rush and Everett (1966) suggest that two Pleistocene lakes once existed in Little Smoky Valley. One lake occurred at the southern end of the valley where a small playa now exists; the second lake occurred in Fish Creek Valley, within northern Little Smoky Valley. The mountains surrounding Little Smoky Valley are primarily composed of carbonate rocks of Paleozoic age. Volcanic rocks of Tertiary age outcrop at the southern end of the valley.

2.17.2 MX Water Requirements

The peak annual demand for water during MX construction in Little Smoky Valley is expected to be 742 acre-feet (0.9 hm^3) in 1986. Construction is projected to begin in 1985 and conclude in 1990. The Air Force has filed applications for groundwater appropriations totaling 2076 acre-ft/yr (2.6 hm^3/ yr) from three points of diversion.

2.17.3 Water-Supply Limitations

2.17.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Little Smoky Valley is estimated to be slightly more than 5000 acre-ft/yr (6.2 hm^3/yr) (Nevada State Engineer, 1971), a figure derived from the reconnaissance study of Rush and Everett (1966).

Ground-water use in Little Smoky Valley is less than 1 acre-ft/yr (0.001 hm^3/yr) for irrigation and stock watering. There are presently 781 acre-ft/yr (0.9 hm^3/yr) of certificated ground-water rights and 1448 acre-ft/yr (1.8 hm^3/yr) in pending applications for ground-water rights in the valley (DRI, 1980).

Surface water use, predominantly for irrigation and stock watering, totals 3325 acre-ft/yr (4.1 hm^3/yr). Surface-water appropriations in the form of certificates and proofs total 9871 acre-ft/yr (12.2 hm^3/yr); 831 acre-ft/yr (1.0 hm^3/yr) are held as permitted rights or in pending applications (DRI, 1980). It should be noted that the figures for surface-water appropriations include the adjacent Big Sand Springs Valley.

The quantity of ground water available for MX use is more than 5000 acre-ft/yr (6.2 hm^3/yr) if existing water use is considered. Considering certificated rights, 4219 acre-ft/yr (5.2 hm^3/yr) are available, and when pending applications are included, 2771 acre-ft/yr (3.4 hm^3/yr) of ground water are available for appropriation.

2.17.3.2 Source Capabilities

Fish Creek Springs is a major source of water for the valley, supplying over 3200 acre-ft/yr (3.9 hm^3/yr) for irrigation use. All of this water, however, is currently appropriated and is not immediately available for the MX project. Other springs in the valley have less potential as they have lower discharges, are relatively inaccessible (being located in mountains which border the valley) and are also largely appropriated.

Tests conducted on four irrigation wells at 17N/54-21 in the northern portion of the valley indicated specific capacities ranging from 34 to 82 gpm per foot (7 to 17 l/s/m) of drawdown. These results suggest a transmissivity for the valley-fill aquifer on the order of 13,000 ft^2/day (1205 m^2/day). Specific capacities and transmissivities of this magnitude indicate that the aquifer in this portion of the valley can yield sufficient quantities of ground water to meet MX requirements. Less is known of the characteristics of the valley-fill aquifer in the southern part of the basin. The presence of lacustrine and playa deposits, however, suggest that transmissivities will be lower.

The potential for carbonate aquifer development in Little Smoky Valley is characterized as low. This is primarily due to the absense of appropriate carbonate hydrostratigraphic units and the presence of significant aquitards in the Paleozoic section.

2.17.3.3 Water Quality

Water-quality analyses of samples from two wells, five springs, and one stream are shown in Appendix F1-17. These analyses indicate that, for the constituents analyzed, the water meets recommended criteria for construction use (Appendix E1-1). All of the samples, with the exception of water from a small spring on the east side of the valley, meet the State of Nevada Primary and Secondary Standards for Drinking Water (Appendix E1-2). The water sample from Pogues Station Spring (15N/54E-11acb) which discharges near the mountains at a rate of only 0.3 gpm (0.02 l/s) exceeds the state standard for sulfate concentration.

There are no water-quality data available for the southern portion of Little Smoky Valley where the water is at greater depths and there is little development. It is expected that the water in this portion of the valley will be of poorer quality due to presence of playa deposits.

2.17.4 Water-Supply Alternatives

2.17.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of existing surface- or ground-water rights is a viable water-supply alternative in Little Smoky Valley. It should, however, not be necessary to implement this alternative because of the availability of unappropriated ground water.

2.17.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for MX construction and operation in Little Smoky Valley. Adequate quantities of ground water are available for appropriation and studies completed to date indicate that the aquifer is capable of supplying water at a rate and quality adequate to meet MX requirements.

2.17.4.3 Carbonate Aquifer

The potential for developing the carbonate aquifer in Little Smoky Valley is low. It should be considered only as an alternative water-supply source.

2.17.4.4 Interbasin Transfer

Interbasin transfer of water should not be considered because in-valley sources should be capable of meeting MX requirements.

2.17.5 Impacts of Development

2.17.5.1 Intrabasin Effects

MX water withdrawals will be minor compared with the perennial yield of the valley, and, consequently, minimal water-level impacts are anticipated. Aquifer testing and numerical modeling of the ground-water system will be required to provide a specific evaluation of anticipated drawdown due to MX production wells.

MX withdrawals may reduce subsurface flow into Newark Valley and the amount of water lost by evapotranspiration from the shallow water table in the northern portion of the valley. The major spring in the valley, Fish Creek Spring, is discharge from a regional carbonate flow system. Withdrawals from the valley-fill aquifer at an appropriate distance should have no effect on discharge. Other springs in the valley discharge from perched systems in the surrounding ranges and should not be affected by additional development of the valley-fill aquifer.

2.17.5.2 Interbasin Effects

Water levels in Newark Valley may be affected because this basin receives subsurface flow from Little Smoky Valley. At present, there are insufficient data to quantify the impact.

2.18 LONG VALLEY

2.18.1 General Physiography and Hydrology

Long Valley is a north-south trending, topographically closed basin in White Pine and Elko counties, Nevada. It is the northernmost valley in the White River regional ground-water flow system. The valley is 48 miles (77 km) long, 10 miles (16 km) across at its widest point, and encompasses 255 mi^2 (660 mi^2). The elevation of the valley floor ranges from 6050 to 6350 feet (1844 to 1935 m).

Surface runoff for the valley, from precipitation and snowmelt in the surrounding mountains, is estimated at 4400 acre-ft/yr (5.4 hm^3/yr) (Nevada State Engineer, 1971). Small springs in the mountains surrounding the valley discharge from carbonate rocks of Paleozoic age and volcanics of Tertiary age (Eakin, 1966). Only one spring, known as Long Valley Slough, is present on the valley floor. Long Valley Slough is believed to be the result of the land surface intersecting the water table. Measurements made by Ertec indicate the discharge of Long Valley Slough increases from 80 to 300 gpm (5 to 19 l/s) between 23N/58E-25c and 23N/58E-36b.

Ground-water recharge in Long Valley is from the infiltration of precipitation on the alluvial fans. Recharge has been estimated at 10,000 acre-ft/yr (12.3 hm^3/yr) (Nevada State Engineer, 1971).

Discharge in Long Valley is from ground-water outflow and evapotranspiration. Evapotranspiration occurs from approximately

11,000 acres (4452 ha) of phreatophytes in the central portion of the valley (Eakin, 1966). The amount of evapotranspiration in Long Valley has been estimated to be 2200 acre-ft/yr (2.7 hm^3/yr) (Nevada State Engineer, 1971).

Long Valley is hydraulically open, with 8000 acre-ft/yr (9.9 hm^3/yr) of ground-water outflow to Jakes Valley to the south (Nevada State Engineer, 1971). The underflow is believed to be derived from discharge from the valley-fill aquifer to the regional carbonate aquifer in the southeastern portion of the valley.

Depths to ground water in Long Valley range from about 270 feet (82 m) below land surface in the southeast to less than 50 feet (15 m) in the central portion of valley (Appendix Figure B1-18). The hydraulic gradient of the valley-fill aquifer is 8 to 9 feet/mile (2 m/km) toward the south. The potentiometric surface of the valley-fill aquifer ranges from 6200 feet (1890 m) in the north-central portion of the valley to 6000 feet (1829 m) in the south-east.

Drillers' logs indicate the valley-fill aquifer is composed of clay, silt, sand, and gravel. Logs indicate that north of the middle of T20N the lithology is generally 60 to 90 percent clay, with varying amounts of sand and gravel. Two wells in 20N/58E, Sections 20 and 34 have 50 to 70 percent sand with about 20 percent clay. Eakin (1961) describes the valley fill as Tertiary to Quaternary age sediments deposited under lacustrine and subaerial conditions. The lower part of the valley-fill contains tuffaceous deposits and freshwater limestone.

Carbonate rocks are exposed in the mountains and are believed to partially underlie the valley fill. The mountains bordering Long Valley contain relatively undisturbed carbonates of Devonian to Mississippian age to the west and carbonates of Pennsylvanian to Permain age to the east.

2.18.2 MX Water Requirements

The peak annual water demand for MX construction in Long Valley is estimated to be 1110 acre-feet (1.4 hm^3) in 1987. Construction is projected to begin in 1984 and conclude in 1990. The Air Force has filed for 1404 acre-ft/yr (1.7 hm^3/yr) of ground-water appropriations in Long Valley from two points of diversion.

2.18.3 Water-Supply Limitations

2.18.3.1 Perennial Yield, Use, and Appropriations

The perennial yield in Long Valley has been estimated to be 6000 acre-ft/yr (7.4 hm^3/yr) (Nevada State Engineer, 1971). Information on pending and approved appropriations for surface and ground water are not available for Long Valley. A reconnaissance of Long Valley by Ertec personnel indicates that there is a limited amount of surface- and ground-water use, primarily for stock watering and mining activities. A comprehensive study is currently being conducted to quantify water rights and use in Long Valley. If present use is small, as appears to be the case, the perennial yield of 6000 acre-ft/yr (7.4 hm^3/yr) should provide for sufficient ground-water development to meet MX requirements.

2.18.3.2 Source Capabilities

The small springs in the mountains are not a viable source of water for the MX project because they have a low discharge and are relatively inaccessible. Long Valley Slough, in the valley-fill aquifer, discharges only 80 gpm (5 l/s) or 129 acre-ft/yr (0.2 hm^3/yr) at the head of the slough, an insufficient yield to be a sole supply for MX construction.

Aquifer testing has not been performed in Long Valley, therefore, hydraulic properties of the aquifer must be interpreted from driller's logs. Based on this information, the transmissivity of the valley-fill is most likely low (less than 1000 ft^2/day [93 m^2/day]) north of Township 20N, where a high percentage of clay is present in the aquifer. The transmissivity in the central and southern portions of the valley should be significantly greater based on the increased percentages of coarser-grained material.

The carbonate aquifer in Long Valley is considered to have only a moderate potential as a water-supply source. Although considerable thickness of carbonate rocks occur, carbonate rocks in Long Valley are relatively undisturbed. Ertec studies indicate that areas of high density faulting within the carbonates are areas of highest potential for ground-water development.

2.18.3.3 Water Quality

Water-quality data for Long Valley are shown in Appendix F1-18. Chemical analyses of samples collected from Long Valley Slough and four wells indicate that TDS concentration in two of the wells (22N/58E-35bb and 21N/59E-5d) exceed the criteria for construction water use (Appendix E1-1). These wells also exceed Nevada State Secondary Drinking Water Standards for sulfate, magnesium, and chloride (Appendix E1-2). Water samples from Long Valley Slough and well 21N/59E-31d exceeded Nevada State Secondary Drinking Water Standards for pH and TDS, respectively.

Only one sample was available from a well in the southern portion of the valley. Chemical analysis of this sample indicates that, for the constituents analyzed, ground water is of acceptable quality for both construction and domestic uses. The absence of wells in the northern portion of the valley precluded sample collection and any interpretation of the quality of ground water in this area.

2.18.4 Water-Supply Alternatives

2.18.4.1 Lease or Purchase of Existing Water Rights

The lease or purchase of existing water rights is not considered a viable water-supply source for MX construction and operation. Estimates of existing water rights are not presently available. Based on observed present use, it is assumed that an insufficient amount of water rights are in effect to make lease or purchase a viable supply option.

2.18.4.1 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for the MX project. Although existing appropriations and current ground-water use are not known, these are believed to be much less than the perennial yield (6000 acre-ft/yr [7.4 hm^3/yr]) for the valley.

Well yields of at least 250 gpm (16 l/s) are believed to be achievable based on the generalized knowledge of the aquifer. At that pumping rate, approximately three wells would be needed to fulfill the water requirements for the peak year of construction. Water-quality considerations may restrict well development to the southern portion of the valley.

2.18.4.3 Carbonate Aquifer

The carbonate aquifer in Long Valley is considered to have a moderate water-supply development potential. Because Long Valley is at the head of the White River regional flow system, the quantity of water available in the carbonate aquifer may be limited. The carbonate aquifer is a viable alternative water-supply source but should only be considered if other in-valley sources prove inadequate.

2.18.4.4 Interbasin Transfer

The interbasin transfer of water to Long Valley is not a feasible alternative because of the limited source capabilities of surrounding valleys.

2.18.5 Impacts of Development

2.18.5.1 Intrabasin Effects

Insufficient aquifer data exist to accurately assess drawdown that will occur around MX production wells. Because existing ground-water withdrawals are limited to widely spaced wells, the impacts from properly located MX wells on current users will likely be minimal.

MX withdrawals are not expected to affect discharges from springs located in the mountains surrounding the valley. These springs are derived from localized flow in the carbonate rocks and are a subtantial distance from the valley floor. Long Valley Slough, the only known spring on the valley floor, has the greatest potential for being affected by MX withdrawals. The spring is in the center portion of the valley (23N/58E-25C) in a high evapotranspiration zone. Lowered water levels in this area would reduce the discharge of Long Valley Slough and the amount of water lost by evapotranspiration from phreatophytes. MX production wells should not be located in the vicinity of this spring.

2.18.5.2 Interbasin Effects

Interbasin effects may occur as the result of MX ground-water withdrawals in Long Valley. Eakin (1966) estimated that 8000 acre-ft/yr (9.6 hm^3/yr) of ground water discharges from the valley-fill aquifer to the carbonates in southeastern Long Valley. Once in the carbonates, the ground-water flows, as part of the White River flow system, toward Jakes Valley. The greatest potential for affecting interbasin flow will occur if MX production wells are located in the southeast portion of the valley.

2.19 MONITOR VALLEY

2.19.1 General Physiography and Hydrology

Monitor Valley is an elongate, north-south trending basin near the junction of Nye, Lander, and Eureka counties, Nevada. The valley is 66 miles (106 km) long and varies in width from 5 to 22 miles (8 to 35 km), with an average width of 19 miles (31 km). The valley encompasses 1060 mi^2 (2744 km^2). Valley floor elevations range from 6300 to 6600 feet (1920 to 2012 m) in the northern part of the valley and from 6800 to 7000 feet (2073 to 2134 m) in the southern part of the valley. The Toquima and Monitor ranges border the valley on the west and east, respectively. The mountain crests range in elevation from about 9000 to over 10,000 feet (2743 to 3048 m), with numerous peaks exceeding 10,500 feet (3200 m).

Streamflow in Monitor Valley originates from precipitation within the drainage area. Most streams are ephemeral, the upper reaches of many mountain streams may, however, be perennial. Generally, runoff in the valley is quickly dissipated as infiltration into the valley fill. The U.S. Geological Survey began operation of three continuous streamflow recording stations in Monitor Valley in October 1977 (USGS, 1979). All three stations show similar seasonal increases in streamflow beginning in March due to the beginning of snowmelt. Streamflow peaks in early June, then recedes rapidly. A small quantity of runoff is contributed from infrequent summer rain showers. The average annual runoff from Monitor Valley has been estimated at 67,000 acre-feet (82.6 hm^3), with 44,000 acre-feet (54.3 hm^3) being produced in the southern part of the valley (Nevada State Engineer, 1971). The valley is topographically open to Kobeh Valley to the north. No estimates of flows northward via Stoneberger Creek have been reported (Nevada State Engineer, 1971). Ertec conducted 14 streamflow measurements, and flows that ranged from 4 to 800 gpm (0.3 to 51 l/s) were obtained in October 1980. Average flow in the major streams was approximately 375 gpm (26 l/s) at the time of Ertec's reconnaissance.

The majority of the springs in Monitor Valley are meteoric. Of nine springs visited by Ertec personnel, one was dry, four were seeps, and the other four were measured or estimated at 15 gpm (1 l/s) or less. Two areas of large spring discharge are found at Potts and Diana's Punchbowl. Rush and Everett (1964) estimate these areas to discharge 1500 acre-ft/yr (1.8 hm^3/yr). Flow in a stream next to Diana's Punchbowl was estimated at 650 gpm (41 l/s) by Ertec. Several hot springs in the area contributed to the flow in this stream.

Ground-water recharge from precipitation is estimated to be 21,300 acre-ft/yr (26.3 hm^3/yr) (Nevada State Engineer, 1971). Ground-water discharge occurs mainly as evapotranspiration (11,200 acre-ft/yr [13.8 hm^3/yr]) and subsurface outflow (8000 acre-ft/yr [9.9 hm^3/yr]) (Nevada State Engineer, 1971).

The potentiometric surface ranges from 6900 feet (2103 m) in the southern part of the valley to 6300 feet (1920 m) in the north. The hydraulic gradient in the valley fill aquifer is northward at approximately 19 feet/mile (4 m/km) in the southern part of the valley and 8 feet/mile (2 m/km) in the northern part of the valley (Appendix Figure B1-19). The depth to ground water is 50 feet (15 m) or less in the southern part of the valley and generally increases to the north.

The average underflow from the northern part of Monitor Valley to Kobeh Valley is estimated to be 6000 acre-ft/yr (7.4 hm^3/yr) (Nevada State Engineer, 1971). This estimate is based on an assumed transmissivity of 13,500 ft^2/day (1251 m^2/day), a ground-water gradient of about 10 feet/mile (2 m/km) and an effective width of flow of about 6 miles (10 km) (Rush and Everett, 1964).

The thickness of the valley-fill aquifer is not known. The valley-fill material is composed of older and younger alluvium. The older alluvium is unconsolidated to poorly consolidated and poorly sorted gravel, sand, and silt. The young alluvium is unconsolidated gravel, sand and silt. The eastern flank of the Monitor Range is comprised predominantely of carbonate rocks, which range in age from Cambrian to Permian and are estimated to be about 25,000 feet (7620 m) thick (Rush and Everett, 1964).

2.19.2 MX Water Requirements

The peak annual demand for water during MX construction is expected to be 2141 acre-feet (2.6 hm^3) in 1988. Construction is projected to commence in 1984 and conclude in 1990. The Air Force has filed applications for 2112 acre-ft/yr (2.6 hm^3/yr) of ground-water appropriations in Monitor Valley from three points of diversion.

2.19.3 Water-Supply Limitations

2.19.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Monitor Valley is estimated to be 18,000 acre-ft/yr (22.2 hm^3/yr) (Nevada State Engineer, 1971). Total water use in Monitor Valley is presently 4558 acre-ft/yr (5.6 hm^3/yr), which includes 4220 acre-ft/yr (5.2 hm^3/yr) of surface water and 338 acre-ft/yr (0.4 hm^3/yr) of ground water (DRI, 1980). Mining operations in the southwestern portion of the valley account for most of the ground-water use. Irrigation is responsible for most of the surface-water use, with only 18 acre-ft/yr (0.02 hm^3/yr) being used for stock watering and domestic purposes (DRI, 1980). Approved ground-water appropriations in the form of certificates and proofs total 266 acre-ft/yr (0.3 hm^3/yr), with an additional 30,071 acre-ft/yr (37.1 hm^3/yr) of appropriations in the form of pending permits and applications (DRI, 1980). Approved surface-water appropriations in the form of certificates and proofs total 10,458, acre-ft/yr (12.9 hm^3/yr), with an additional 11,274 acre-ft/yr (13.9 hm^3/yr) of appropriations in the form of pending permits and applications (DRI, 1980).

2.19.3.2 Source Capabilities

Surface water in Monitor Valley occurs as springs and variable discharge streams. These generally have greater discharges in the spring and summer months because of runoff from snowmelt and infrequent rain. Surface runoff is estimated to be 67,000 acre-ft/yr (82.6 hm^3/yr).

Transmissivity of the valley-fill aquifer has been estimated by Rush and Everett (1964) to be 13,500 ft^2/day (1251 m^2/day) in the northern part of the valley. Specific aquifer test data are not available. The lithology of the valley fill suggests that wells of adequate yield can be developed.

Ertec studies indicate that the potential for carbonate aquifer development in Monitor Valley is low. This is a reflection of the general lack of appropriate carbonate hydrostratigraphic units and the occurrence of significant amounts of volcanics and Paleozoic aquitard units.

2.19.3.3 Water Qualtiy

Water-quality data for Monitor Valley are shown in Appendix F1-19. Three ground-water samples analyzed by the U.S. Geological Survey are presented in Rush and Everett (1964). Additionally, Ertec collected seven ground-water and 10 surface-water samples for water-quality analyses. These analyses indicate that the quantity of water in Monitor Valley is within acceptable levels for construction use (Appendix E1-1).

One surface-water sample (15N/47E-35dd) exceeded the State of Nevada Primary Drinking Water Standard for fluoride (2.3 mg/l). This sample was obtained from a stream which receives the majority of its flow from hot springs in the vicinity. A well located near the center of the valley (12N/47E-19bb) exceeds the State of Nevada Secondary Drinking Water Standard for TDS (1000 mg/l). The remaining samples meet all Primary and Secondary Drinking Water Standards set by the State of Nevada (Appendix E1-2). Although the valley-wide water quality cannot be accurately extrapolated from the limited data available, it is expected that water quality will generally be suitable for construction and drinking water purposes.

2.19.4 Water-Supply Alternatives

2.19.4.1 Lease or Purchase of Existing Water Rights

There are 10,458 acre-ft/yr (12.9 hm^3/yr) in approved surface-water appropriations. Lease or purchase of a portion of these rights is a viable water-supply alternative for MX construction. The limited number of existing ground-water appropriations (266 acre-ft/yr [0.3 hm^3/yr]) precludes consideration of lease or purchase of existing ground-water rights.

2.19.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred water-supply source for MX construction and operation. Only 338 acre-ft/yr (0.4 hm^3/yr) and 266 acre-ft/yr (0.3 hm^3/yr) of ground-water use and approved appropriations, respectively, presently exist in the valley (DRI, 1980). The perennial yield for Monitor Valley is estimated to be 18,000 acre-ft/yr (22.2 hm^3/yr) (Nevada State Engineer, 1971). Consequently, there is in excess of 17,000 acre-ft/yr (21.0 hm^3/yr) available for appropriation and MX use.

2.19.4.3 Carbonate Aquifer

The carbonate aquifer has low development potential but is a viable alternative water-supply source. If sufficient supplies of water cannot be obtained from the valley fill, additional studies should be conducted to further define the capabilities of the carbonate aquifer in Monitor Valley.

2.19.4.4 Interbasin Transfer

Interbasin transfer is not a viable water-supply alternative for Monitor Valley because of the lack of an adjoining source valley with excess water.

2.19.5 Impacts of Development

2.19.5.1 Intrabasin Effects

Drawdown due to ground-water withdrawals for the MX project are expected to be minimal. Assuming a transmissivity of 13,500 ft^2/day (1251 m^2/day), a storativity of 0.1, and a pumping period of two years, drawdown 1 mile (2 km) from a well pumping 650 gpm (41 l/s) would be 1.5 feet (0.5 m).

There are springs in the central portion of the valley which may be affected by ground-water withdrawals from the valley-fill aquifer. Appropriate setback distances should preclude significant impacts to these springs. The south central portion of the valley is an area which is dependent on shallow ground water levels for support of livestock grazing and watering and wildlife habitats. MX ground-water withdrawals in this area could result in impact to the pasture. This impact would be localized around the well site.

2.19.5.2 Interbasin Effects

MX ground-water withdrawals in Monitor Valley may reduce outflow of ground-water to Kobeh Valley. There are insufficient data to quantify what, if any, the effects will be.

2.20 MULESHOE VALLEY

2.20.1 General Physiography and Hydrology

Muleshoe Valley is a north-south trending basin in Lincoln County, Nevada. The valley is bordered by the Schell Creek Range on the west and north and the Fairview Range, Dutch John, and Grassy mountains to the east. The mountain crests range in elevation from about 7000 to 8800 feet (2134 to 2682 m). Muleshoe Valley is topographically open to Dry Lake Valley to the south through a narrow constriction. Both valleys are considered one hydrographic basin by the Nevada State Engineers Office. The valley is approximately 21 miles (34 km) long, 14 miles (23 km) across at its widest point, and encompasses approximately 200 mi^2 (518 km^2). The average valley floor elevation is about 5700 feet (1737 m).

Eakin (1963a) estimated recharge from the infiltration of precipitation for Dry Lake and Muleshoe valleys to be 4800 acre-ft/yr (5.9 hm^3/yr). The average annual recharge for Muleshoe Valley was estimated to be approximately 2100 acre-ft/yr (2.6 hm^3/yr) during ground-water system modeling using Eakin's (1963a) elevation, precipitation, and infiltration distributions.

Perennial streams are not present in the valley. Total runoff from the mountains to the alluvial fans in Dry Lake, Delamar, and Muleshoe valleys has been estimated at 9000 acre-ft/yr (11.1 hm^3/yr) (Nevada State Engineer, 1971). Small meteoric springs in the mountains issue from carbonate and tuffaceous volcanic rocks. Discharge from eight springs measured in May 1980 by Ertec ranged from less than 1 to 82 gpm (<1 to 5 l/s).

Ground-water discharge is by underflow to the south or southwest through fractured carbonates of Paleozoic age. The potentiometric surface ranges in elevation from about 5600 feet in the north to 5000 feet in the south (1707 to 1524 m) (Appendix Figure B1-20). The depth to ground water is in excess of 250 feet (76 m) in the central part of the valley.

Gravity surveys in Dry Lake Valley indicate a depth to bedrock of about 1000 feet (305 m) 2 miles (3 km) south of Muleshoe Valley (Fugro National, Inc., 1980). Based on interpretation of driller's logs, the aquifer in the southern part of the valley is at least 1130 feet (344 m) thick. Test borings drilled by Ertec indicate that the valley-fill material is composed of gravelly sand, sand, silt, and clay alluvial type deposits. Eakin (1963a) describes the sediments in Dry Lake and Muleshoe valleys as Tertiary to Quaternary in age, deposited under subaerial and lacustrine conditions.

The Schell Creek Range is composed of volcanics of Tertiary age to the north and clastic and carbonate rocks of Paleozoic age to the south. The Dutch John and Grassy mountains to the east contain clastic and carbonate rocks of Paleozoic age. The Fairview Range is composed of volcanic rocks of Tertiary age (Howard, 1978).

2.20.2 MX Water Requirements

The peak annual demand for water during MX construction is estimated to be 968 acre-feet (1.2 hm^3) in 1984. Construction is projected to begin in 1983 and conclude in 1987. The Air Force has filed for 1731 acre-ft/yr (2.1 hm^3/yr) of ground-water appropriations in Muleshoe Valley from three points of diversion.

2.20.3 Water-Supply Limitations

2.20.3.1 Perennial Yield, Use, and Appropriations

The perennial yield estimate for Muleshoe and Dry Lake valleys is 3000 acre-ft/yr (3.7 hm^3/yr) (Nevada State Engineer, 1971). Muleshoe Valley contributes about 40 percent of the total recharge and therefore its perennial yield may be about 1200 acre-ft/yr (1.5 hm^3/yr). Eakin (1963a) estimated that the combined discharge for Dry Lake and Muleshoe valleys of 4800 acre-ft/yr (5.9 hm^3/yr) flows southward into Delamar Valley, and that a total of 6000 acre-ft/yr (7.4 hm^3/yr) flows from Delamar to Pahranagat Valley.

Estimated surface water use in Muleshoe and Dry Lake valleys is 21 acre-ft/yr (0.03 hm^3/yr) for stock watering (DRI, 1980). Permits and pending applications for surface water in Muleshoe and Dry Lake valleys total 2596 acre-ft/yr (3.2 hm^3/yr) (DRI, 1980). At the present time, there is no use of ground-water in Muleshoe Valley and very minor use in Dry Lake Valley. Ground-water rights in Muleshoe and Dry Lake valleys include 8 acre-ft/yr (0.01 hm^3/yr) of permits, 11 acre-ft/yr (0.01

hm^3/yr) of certificates and proofs, and 20 acre-ft/yr (0.02 hm^3/yr) of pending applications (Woodburn and others, 1981).

Considering the minor amount of existing use and approved ground-water rights, the quantity of ground water available for MX use in Muleshoe and Dry Lake Valleys is approximately 3000 acre-ft/yr (3.7 hm^3/yr). The peak MX demands for Muleshoe and Dry Lake valleys total 4379 acre-feet (5.4 hm^3) in 1984. This amount is approximately 1400 acre-feet (1.7 hm^3) greater than ground-water availability as based on perennial yield.

2.20.3.2 Source Capabilities

The combined discharge of the eight springs measured in Muleshoe Valley in May 1980 totaled 71 acre-ft/yr (0.1 hm^3/yr). This is not sufficient quantity to meet MX requirements. In addition, known surface-water sources in Muleshoe and Dry Lake valleys are fully appropriated.

An Air Force valley-fill aquifer test well was drilled in Muleshoe Valley at 4N/64E-7dc2. The discharge rate was 50 gpm (32 l/s) with a drawdown of 367 feet (112 m). Analysis of data collected during aquifer testing yielded a preliminary transmissivity estimate of 130 ft^2/day (12 m^2/day). Results from this test well would suggest that the valley-fill aquifer has a limited potential for ground-water development.

There are no carbonate aquifer test data available for Muleshoe Valley, however, a carbonate aquifer exploration well is located 5 miles (8 km) south in Dry Lake Valley (3N/63E-27ca). Test data for this well indicated a transmissivity of about 13,400 ft^2/day (1242 m^2/day) and a specific capacity of 50 gpm/ft (10 l/s/m) for the carbonate aquifer. Based on these results and the existence in Muleshoe Valley of significant amounts of highly faulted carbonate rocks, the carbonate aquifer is estimated to have a high potential for water-supply development.

2.20.3.3 Water Quality

Samples were collected for chemical analyses from springs and the Air Force test well in Muleshoe Valley (Appendix F1-20). All of the constituents analyzed from the spring samples were found to be within criteria for construction use (Appendix E1-1) and Primary and Secondary Drinking Water Standards for the State of Nevada (Appendix E1-2).

Chemical analysis of the water sample taken from the Air Force test well (4N/64E-7dc2) indicates that the ground water at this site exceeds state secondary drinking water standards for TDS and manganese.

2.20.4 Water-Supply Alternatives

2.20.4.1 Lease or Purchase of Existing Water Rights

There are insufficient approved surface or ground-water rights in Muleshoe Valley to consider lease/purchase as a viable water-supply option for MX construction and operation.

2.20.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred water-supply source for MX construction in Muleshoe Valley. Although the aquifer test conducted at the Air Force test well in Muleshoe Valley indicated a very low well yield (50 gpm [3 l/s]) it is considered likely that greater well yields can be obtained in other parts of the valley. If well yields of only 250 gpm (15 l/s) can be obtained, a total of three MX water-supply wells will be able to meet the peak-year MX water demands.

2.20.4.3 Carbonate Aquifer

Although the carbonate aquifer has a high potential for development, it is only being considered as an alternative for development. Due to the high risk associated with developing the carbonate aquifer it is more feasible to initially develop the valley-fill aquifer.

2.20.4.4 Interbasin Transfer

Because of water availability conditions in surrounding valleys, interbasin transfer is not considered a viable water-supply option for Muleshoe Valley.

2.20.5 Impacts of Development

2.20.5.1 Intrabasin Effects

A computer simulation of MX production wells in Muleshoe and Dry Lake valleys withdrawing water for six years from both valleys was performed. A uniform transmissivity of 1300 ft^2/day (120 m^2/day) and storativity of 0.05 were used in the simulation. These values were assumed to be representative of average aquifer characteristics. Pumping rates were varied according to estimated annual MX needs and reached a maximum of one well pumping in Muleshoe at 600 gpm (38 l/s) and five wells in Dry

Lake pumping at 420 gpm (26 l/s). Maximum drawdown effects occurred after five years and were about 6 feet (2 m) at a distance of 1 mile (2 km) from the well in Muleshoe Valley. If, as anticipated, a number of lower yield wells were to be developed in Muleshoe Valley, the drawdown around each may be less than that simulated for the one high yield well.

The absence of wells in Muleshoe Valley prevents MX withdrawals from impacting existing ground-water users. MX wells will be located a minimum of 1 mile (2 km) from springs to minimize the potential for impacting all water users in Muleshoe Valley.

2.20.5.2 Interbasin Effects

Subsurface discharge to Dry Lake Valley could be affected by ground-water development in Muleshoe Valley. There are not enough data to quantify what the effects, if any, would be.

2.21 NEWARK VALLEY

2.21.1 General Physiography and Hydrology

Newark Valley is an elongate, north-south trending basin encompassing about 800 mi^2 (2071 km^2) in western White Pine County, Nevada. Surrounding Newark Valley are the Diamond, Ruby, and White Pine mountains and the northern end of the Pancake Range. The average valley floor elevation is 5900 feet (1798 m). Newark Valley is topographically open to Little Smoky Valley to the southwest at about 6000 feet (1829 m) elevation. The valley has a maximum length of 48 miles (77 km) and a maximum width of 22 miles (35 km).

Streamflow is ephemeral and is derived from snowmelt runoff and rainfall from infrequent summer storms. Runoff from mountain streams is rapidly lost to infiltration on the alluvial fans and serves to recharge the ground-water reservoir. Surface-water runoff is estimated to be 8000 acre-ft/yr (9.9 hm^3/yr) (Nevada State Engineer, 1971). Ground-water recharge is estimated to be 18,500 acre-ft/yr (22.8 hm^3/yr); 17,500 acre-ft/yr (21.6 hm^3/yr) from precipitation and 1000 acre-ft/yr (1.2 hm^3/yr) from subsurface inflow from Little Smoky Valley (Eakin, 1960).

Ground-water discharge is estimated to be 18,500 acre-ft/yr (22.8 hm^3/yr) from evapotranspiration, primarily in the north-central portions of the valley (Nevada State Engineer, 1971). Depth to ground water in central portions of the valley is generally less than 50 feet (15 m) (Appendix Figure B1-21).

The valley-fill in Newark Valley is composed of alluvial, fluvial, and lacustrine sediments. The surrounding mountains and rocks underlying the valley-fill are limestone, shale, and sandstone of Paleozoic age and Tertiary age intrusive and extrusive rocks.

2.21.2 MX Water Requirements

Peak-year water demand for MX construction in Newark Valley is expected to be 1486 acre-feet (1.8 hm^3) in 1988. Construction is projected to last six years, from 1984 to 1989. The Air Force has filed for 1404 acre-ft/yr (1.7 hm^3/yr) of ground-water appropriations from two points of diversion.

2.21.3 Water-Supply Limitations

2.21.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Newark Valley is 18,000 acre-ft/yr (22.2 hm^3/yr) (Nevada State Engineer, 1971). This value is based on estimates of total recharge and discharge in the basin.

The present amount of ground-water use in Newark Valley is 6507 acre-ft/yr (8.0 hm^3/yr); 6435 acre-ft/yr (7.9 hm^3/yr) for irrigation and 72 acre-ft/yr (0.1 hm^3/yr) for other mining, stock, and domestic uses (DRI, 1980). Certificates and proofs for ground water total 42 acre-ft/yr (0.05 hm^3/yr) for stock watering. Permits and applications total 24,939 acre-ft/yr (30.8 hm^3/yr) mainly for irrigation and mining (DRI, 1980).

Surface-water use is estimated to be 515 acre-ft/yr (0.6 hm^3/yr) and is used for irrigation and stock watering. Certificates and proofs for surface-water total 537 acre-ft/yr (0.7 hm^3/yr); 456 acre-ft/yr (0.6 hm^3/yr) for irrigation and 72 acre-ft/yr (0.1 hm^3/yr) for stock watering. Permits and applications for surface-water total 35 acre-ft/yr (0.04 hm^3/yr) (DRI, 1980).

The quantity of ground water available for MX use is 11,493 acre-ft/yr (14.2 hm^3/yr) if only existing ground-water use is considered. If certificates and proofs for ground water in Newark Valley are considered, the quantity of ground water available is 17,958 acre-ft/yr (22.1 hm^3/yr). When all permits and pending applications are also included, ground-water rights exceed the perennial yield.

2.21.3.2 Source Capabilities

Springs occurring around the valley margins generally have small discharges. The few springs with significant discharge are appropriated. There are several streams in the central and northern portion of the valley which flow perennialy near the bedrock/valley-fill boundary. Surface-water flow of this magnitude is not readily found in the southern portion of the basin where MX construction is planned.

Exploratory drilling and testing has not been conducted in the valley-fill aquifer in Newark Valley. There are numerous large irrigation wells currently in use in the west and southwest portions of the valley. Specific capacity tests performed by drillers in 17N/54E, Sections 18 and 21, suggest transmissivities between 8000 and 25,000 ft^2/day (743 to 2322 m^2/day).

The carbonate aquifer in Newark Valley is considered to have a low potential for development. This is based on the lack of appropriate carbonate hydrostratigraphic units and structural deformation and the occurrence of significant aquitard units in the Paleozoic section.

2.21.3.3 Water Quality

Water-quality data for Newark Valley are shown in Appendix F1-21. Water samples were collected by Ertec from wells, springs, and streams around the margins of the valley. Chemical analyses of major constituents indicate that the quality of ground water and surface water is within the criteria established for construction use (Appendix E1-1). The constituents analyzed were also found to be within Primary and Secondary Drinking Water Standards established by the State of Nevada (Appendix E1-2). Ground water in the vicinity of the central playa may be unpotable due to accumulation of dissolved solids, but this has not been verified by sampling.

2.21.4 Water-Supply Alternatives

2.21.4.1 Lease or Purchase of Existing Water Rights

The lease or purchase of water rights is a viable water-supply alternative for partial support of the MX project. Surface- and ground-water certificates and proofs total 537 and 42 acre-ft/yr (0.7 and 0.05 hm^3/yr), respectively.

2.21.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred water-supply source for MX construction and operation in Newark Valley. The aquifer is generally shallow, has high transmissivities, and good quality water. Two wells pumping continuously at 450 gpm (28 l/s) will be required to fulfill the water demand (1486 acre-ft/yr [1.8 hm^3/yr]) for the peak year of construction. Although one well pumping at 900 gpm (57 l/s) may be feasible in Newark Valley, a multi-well scenerio is believed better for water distribution considerations.

2.21.4.3 Carbonate Aquifer

Preliminary analyses indicate a low potential for development of the carbonate aquifer in Newark Valley. This water-supply source should be considered only as an alternative to the valley-fill aquifer.

2.21.4.4 Interbasin Transfer

Because there is an abundance of water available for MX development from sources within the valley, there should be no need to transfer water from other basins. However, the potential exists for transfer of water from Little Smoky or Railroad valleys to the south.

2.21.5 Impacts of Development

Drawdowns associated with MX production wells pumping at 450 gpm (28 l/s) continuously for two years in Newark Valley will be about 1 foot (0.3 m) at a distance of 1 mile (2 km) from the well. This calculation is based on an estimated transmissivity of 16,500 ft^2/day (1529 m^2/day) and a storativity of 0.1. Actual drawdown values may differ slightly because of site-specific geologic and hydrologic conditions. All MX production wells will be located a minimum of 1 mile (2 km) from existing wells and springs to minimize the potential for affecting current water users.

There should be little effect on spring discharge in Newark Valley because the majority of the springs occur at elevations above the valley-fill aquifer along the mountain margins. Springs on the valley floor are located in the northern portion of the valley at a considerable distance from planned MX construction areas. Pumping from MX production wells has a low potential for affecting these springs.

Warm Spring (23N/56E-36ddc), located in the far northeastern portion of the valley, is identified as a possible regional spring. The nearest planned MX construction area is about 20 miles (32 km) from this spring.

2.21.5.2 Interbasin Effects

Newark Valley has no surface or subsurface outflow. Consequently, there should be no effects in other valleys from MX withdrawals.

2.22 PAHROC VALLEY

2.22.1 General Physiography and Hydrology

Pahroc Valley is located in central Lincoln County, Nevada. Pahroc Valley has been referred to as Six-Mile Basin by Eakin (1963c) and is included in estimates of perennial yield, surface runoff, ground- and surface-water discharge, and recharge for Pahranagat Valley. Pahroc Valley is topographically closed but is presumed to have subsurface hydrologic connection with Pahranagat Valley.

Pahroc Valley is approximately 14 miles (23 km) long, 10 miles (16 km) wide, and encompasses about 140 mi^2 (362 km^2). The average valley floor elevation is 4600 feet (1402 m). Pahroc Valley is bordered on the west by the Hiko Range and on the east by the North and South Pahroc ranges. The valley is connected to Delamar and Pahranagat valleys by low topographic divides.

Pahroc Valley has no perennial streamflow and there is no estimate of annual surface runoff from the mountains. A few seasonal springs issue from volcanic, clastic, and carbonate rocks of Tertiary and Paleozoic age. Ertec's reconnaissance of Pahroc Valley, conducted in May 1980, found one spring site in southern Pahroc Valley which was dry at the time of attempted sampling.

Recharge occurs on the alluvial fans through infiltration of seasonal precipitation. The average annual recharge is estimated to be 300 to 400 acre-ft/yr (0.4 to 0.5 hm^3/yr). This approximate recharge figure was calculated by taking Eakin's (1963c) estimated recharge from precipitation for Pahranagat

Valley and multiplying by the ratio of the areas of Pahroc and Pahranagat valleys. During Ertec's reconnaissance, no areas of evapotranspiration or discharge by wells were noted.

The potentiometric surface elevation is less than 3800 feet (1158 m) throughout most of the valley (Appendix Figure B1-22). Depths to water in portions of Pahroc Valley are in excess of 500 feet (152 m).

The thickness of the valley fill is variable. According to driller's logs, a valley-wide rhyolitic volcanic flow is present between 16 and 1111 feet (5 and 339 m) below land surface. The overlying valley-fill is composed of unconsolidated to partially consolidated silt, sand, and gravel of Tertiary to Quaternary age. These sediments were deposited under subaerial to lacustrine conditions (Eakin, 1963c). Carbonate rocks of Paleozoic age and volcanics of Tertiary age are exposed in the bordering mountain ranges.

2.22.2 MX Water Requirements

The projected period of MX construction in Pahroc Valley is 1982 to 1986. Peak-year water demand for Pahroc Valley is estimated to be 341 acre-feet (0.4 hm^3) in 1984. The Air Force has filed ground-water appropriation applications for 1388 acre-ft/yr (1.7 hm^3/yr) for Pahroc Valley from four points of diversion.

2.22.3 Water-Supply Limitations

2.22.3.1 Perennial Yield, Use, and Appropriations

Perennial yield has not been estimated for Pahroc Valley but is included in the estimated 25,000 acre-ft/yr (30.8 hm^3/yr) for Pahranagat Valley (Nevada State Engineer, 1971). Therefore, water rights and use in Pahranagat Valley must be considered in determining water availability for Pahroc Valley. Surface-water use in Pahranagat Valley is 14,484 acre-ft/yr (17.9 hm^3/yr) for irrigation and 15 acre-ft/yr (0.02 hm^3/yr) for stock watering (DRI, 1980). Certificates and proofs for surface water total 22,114 acre-ft/yr (27.3 hm^3/yr) (DRI, 1980). Ground-water use in Pahranagat Valley totals 17,395 acre-ft/yr (21.4 hm^3/yr); 15,600 acre-ft/yr (19.2 hm^3/yr) for irrigation, 16 acre-ft/yr (0.02 hm^3/yr) for stock watering, 198 acre-ft/yr (0.2 hm^3/yr) for domestic use, and 1581 acre-ft/ yr (1.9 hm^3/yr) for recreation and wildlife use (DRI, 1980). Certificates and permits for ground-water total 23,680 acre-ft/yr (29.2 hm^3/yr), and there are 32,370 acre-ft/yr (39.9 hm^3/yr) in pending applications for ground water (Woodburn and others, 1981). Approved ground-water rights are 1320 acre-ft/yr (1.6 hm^3/yr) less than the perennial yield. This amount of ground water may be available for appropriation.

2.22.3.2 Source Capabilities

Springs and streams in Pahroc Valley are seasonal, of very limited discharge, and are not considered a realiable source of water.

Driller's logs afford the only information available for assessment of the valley-fill aquifer within the valley . These logs indicate that the valley-fill aquifer is composed primarily of fine-grained sand and clay of varying degrees of cementation.

These logs document the penetration of volcanic strata between 16 and 1111 feet (5 and 339 m). A well at 4S/61E-28cac was drilled by conventional rotary methods to 1143 feet (348 m). No water-bearing strata were penetrated. The well was subsequently deepened to 1314 feet (401 m). The redrilled well penetrated 89 feet into volcanics. The well produced 200 gpm (13 l/s) when tested. It is uncertain whether the water produced was derived from valley-fill sediments or the volcanics. In general, it must be assumed that the well yield potential of the valley-fill aquifer is low.

The carbonate aquifer in Pahroc Valley is considered to have a high potential for water-supply development. The valley is part of the White River regional ground-water flow system and appropriate carbonate hydrostratigraphic units occur in the valley and are highly fractured. That large volumes of ground water are moved through the White River system is evidenced in adjacent Pahranagat Valley where Ash, Crystal, and Hiko springs discharge a total of 25,000 acre-ft/yr (30.8 hm^3/yr) from the carbonate aquifer (Eakin, 1963c).

2.22.3.3 Water Quality

There were no water-quality samples taken during Ertec's reconnaissance of Pahroc Valley. Water-quality samples analyzed from White River Valley, which is upgradient from Pahroc Valley, meet Primary and Secondary Standards for Drinking Water in Nevada (Appendix E1-2).

2.22.4 Water-Supply Alternatives

2.22.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of water rights in Pahranagat Valley is a viable water-supply alternative if in-valley sources are not adequate to meet MX requirements. It is assumed that this would not be considered interbasin transfer since both valleys are considered in the same hydrographic basin by the Nevada State Engineer.

2.22.4.2 Valley-Fill Aquifer

The valley-fill aquifer in Pahroc Valley is the preferred water-supply source for MX construction and operation. Although the water-supply capabilities of the valley-fill aquifer are limited, MX requirements are also small (peak of 341 acre-feet [0.4 hm^3]). There is approximately 1320 acre-ft/yr (1.6 hm^3/yr) of unappropriated ground water that may be available to the Air Force for use in Pahroc Valley.

2.22.4.3 Carbonate Aquifer

The carbonate aquifer is a viable water-supply option because of its high development potential. Because of the higher cost and risk involved, it should not be developed unless valley-fill sources and lease/purchase alternatives prove inadequate.

2.22.4.4 Interbasin Transfer

The transfer of ground or surface water from Pahranagat to Pahroc Valley is a viable supply alternative. This may not be considered interbasin transfer since both valleys are considered one hydrographic basin by the Nevada State Engineer.

2.22.5 Impacts of Development

2.22.5.1 Intrabasin Effects

It cannot be determined at this time what the effect of MX pumping will be on water levels in Pahroc Valley since existing data on the aquifer system in the valley are minimal. Future aquifer testing and computer modeling will permit quantification of drawdown that would be associated with MX pumping. Spring discharge will not be affected because all springs are meteoric and their discharge points are located at elevations above the valley fill.

2.22.5.2 Interbasin Effects

Any interbasin effects of MX withdrawals, whether from Pahroc Valley or Pahranagat Valley, will be minor because of the relatively small amount of water that will be withdrawn. MX withdrawals peak at 341 acre-feet (0.4 hm^3) during construction.

2.23 PENOYER VALLEY

2.23.1 General Physiography and Hydrology

Penoyer Valley, also known as Sand Springs Valley, is a topographically closed basin in western Lincoln County, Nevada. The MX study area is within the northern half of Penoyer Valley and is approximately 23 miles (37 km) long, 18 miles (29 km) wide, and encompasses about 415 mi^2 (1074 km^2). The average valley floor elevation is 5000 feet (1524 m). The valley is bounded by the Worthington (Shadow) Mountains and Timpahute Range on the east and by the Groom Mountains on the south. The Quinn Canyon Range lies to the north. The mountain crests range in elevation from 8000 to 9000 feet (2438 to 2743 m).

Streamflow in Penoyer Valley is derived from snowmelt runoff, predominantly from the Quinn Canyon Range, ground-water discharge from springs in the Worthington Mountains and Timpahute Range, and from infrequent summer storms. All streams in the valley are ephemeral. Streamflow that does occur is diverted for irrigation use or is rapidly lost to infiltration on the alluvial fans, serving to recharge the ground-water reservoir. The average annual runoff has been estimated to be approximately 1000 acre-ft/yr (1.2 hm^3/yr) (Van Denburgh and Rush, 1974). Numerous springs occur along the margins of the valley and in the mountains. Six springs were measured by Ertec in June 1980, discharges ranged from less than 1 gpm to 55 gpm (0.1 to 4 l/s). Three other spring locations, including Sand Spring (2S/55E-26dda), were visited at that time, and no flow was observed. Sand Spring, located in the center of the valley floor, has been identified as a possible regional spring based on previous temperature and water-chemistry measurements but may only be indicative of deep circulation within Penoyer Valley.

Penoyer Valley is assumed to be a hydrologically closed basin (Van Denburgh and Rush, 1974). Ground-water recharge to the valley-fill aquifer is estimated to be 4300 acre-ft/yr (5.3 hm^3/yr) and is derived from precipitation. Ground-water discharge is primarily by evapotranspiration and is estimated to be 3800 acre-ft/yr (4.7 hm^3/yr) (Van Denburgh and Rush, 1974).

Depths to ground water range from less than 50 feet (15 m) in the central portion of the valley to greater than 150 feet (46 m) along the valley margins (Appendix Figure B1-23). The direction of ground-water flow is toward the playa in the south-central portion of the valley. A major pumping center for irrigation use is present just south of the playa area of Penoyer Valley.

The valley-fill deposits are composed of mixed, reworked, and interlayered alluvial and lacustrine deposits. Carbonate rocks of Paleozoic and Mesozoic age in the mountain ranges have undergone extensive structural deformation from regional tectonic forces and local granitic intrusions.

2.23.2 MX Water Requirements

The peak annual demand for water during MX construction is expected to be 1778 acre-feet (2.2 hm^3) in 1985. Construction is projected to begin in 1983 and conclude in 1988.

The Air Force has filed applications for appropriation of 2422 acre-ft/yr (3.0 hm^3/yr) of ground water in Penoyer Valley from two points of diverions.

2.23.3 Water-Supply Limitations

2.23.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Penoyer Valley is 4000 acre-ft/yr (4.9 hm^3/yr) (Van Denburgh and Rush, 1974). Total ground-water use is estimated to be 5691 acre-ft/yr (7.0 hm^3/yr), of which 3000 acre-ft/yr (3.7 hm^3/yr) are used for irrigation and 2687 acre-ft/yr (3.3 hm^3/yr) are used for mining purposes. Because of this overdraft condition, the valley has been closed to further ground-water appropriations by the Nevada State Engineer.

Existing surface-water use is estimated to be 22 acre-ft/yr (0.03 hm^3/yr) for stock watering (DRI, 1980). There are 21,267 acre-ft/yr (26.2 hm^3/yr) in certificated and permitted ground-water rights and an additional 50,000 acre-ft/ yr (61.7 hm^3/yr) in pending applications (Woodburn and others, 1981). Surface-water certificates and proofs total 162 acre-ft/yr (0.2 hm^3/yr) with 2212 acre-ft/yr (2.7 hm^3/yr) in permits and pending applications (DRI, 1980).

2.23.3.2 Source Capabilities

Surface water in Penoyer Valley is not considered a dependable source of water for the MX project. Surface flows from springs are fully appropriated and not of sufficient quantity throughout the year to be a reliable source of water.

Driller's tests of irrigation wells which penetrate the valley-fill aquifer resulted in specific capacities ranging from 11 to 135 gpm (0.1 to 9 l/s) per foot of drawdown. This suggests a range of transmissivities of 2700 to 32,000 ft^2/day (250 to 2966 m^2/day). Based on these values, it can be assumed that the valley-fill aquifer in Penoyer Valley is capable of yielding water in sufficient quantities and at the rates required to meet MX needs.

There has been no exploratory drilling in the carbonate aquifer in Penoyer Valley. The potential for carbonate aquifer development is considered to be low due to the lack of appropriate carbonate hydrostratigraphic units and the probable lack of regional flow in the carbonate rocks.

2.23.3.3 Water Quality

Water-quality data for Penoyer Valley are presented in Appendix F1-23. Six water samples were collected by Ertec for chemical analyses. Results of the analyses indicate that ground water in the valley is suitable for construction purposes based on the criteria established for concrete mixing (Appendix E1-1). All water samples also meet Nevada State Primary and Secondary Drinking Water Standards (Appendix E1-2).

2.23.4 Water-Supply Alternatives

2.23.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of existing ground-water rights is the preferred water-supply source for MX construction and operation in Penoyer Valley. In the 1960s, the Desert Land Entry Program allowed the development of the south-central portion of the valley for agriculture. Since that time, rising energy fuel prices have forced many farmers to abandon their land. At present ground-water use is limited to 5691 acre-ft/yr (7.0 hm^3/yr) although ground-water rights total 21,267 acre-ft/yr (26.2 hm^3/yr).

2.23.4.2 Valley-Fill Aquifer

Penoyer Valley is currently designated as a critical ground-water basin and is closed to further ground-water development.

The valley-fill aquifer is believed to be an adequate source of water in Penoyer Valley. Although aquifer tests have not been performed, the large number of high production wells indicate that the aquifer is capable of yielding a water supply sufficient to meet MX requirements. However, because Penoyer Valley is a designated basin, appropriation of additional ground-water may not be authorized. As a result, development of the valley-fill aquifer is considered only as a possible alternative water-supply source.

2.23.4.3 Carbonate Aquifer

The potential for development of the carbonate aquifer is limited. It should, however, be considered a low-priority alternative in the event that lease or purchase of existing water rights cannot be negotiated and development of the valley-fill aquifer is not allowed.

2.23.4.4 Interbasin Transfer

If in-valley sources cannot be developed, importation of water from Railroad Valley is a viable supply alternative. Interbasin transfer of water will be at the discretion of the Nevada State Engineer.

2.23.5 Impacts of Development

2.23.5.1 Intrabasin Effects

The location of MX production wells north of the primary agricultural area and the apparent high transmissivity of the valley-fill aquifer suggest that impacts will be minimal. The magnitude of any potential impacts will be quantified after aquifer testing and computer modeling have been conducted for this valley.

The majority of springs within the valley are fed by local perched systems and will not be affected by water withdrawals from the valley-fill aquifer. MX production wells should be located a minimum of 3 miles from Sand Spring to avoid impact to this mid-valley possible regional spring.

2.23.5.2 Interbasin Effects

There is no known interbasin surface or subsurface drainage into or out of Penoyer Valley (Van Denburgh and Rush, 1974). Consequently, water-supply development in Penoyer Valley should have no effect on neighboring valleys.

2.24 PINE VALLEY

2.24.1 General Physiography and Hydrology

Pine Valley is a north-south trending basin in Millard, Beaver, and Iron counties, Utah. The valley is topographically closed, with the Wah Wah Mountains to the east and the Needle Range to the west. It is separated from the Ferguson Desert to the north and the Escalante Desert to the south by low topographic divides. The mountain crests range in elevation from about 8000 to 9790 feet (2438 to 2984 m). The average elevation of the valley floor is 5600 feet (1707 m). The valley is about 44 miles (71 km) long, is 24 miles (39 km) across at its widest point, and encompasses about 730 mi^2 (1890 km^2).

All streams within Pine Valley are ephemeral except for the headwaters of Sheep, Indian, and Pine Grove creeks. Of the approximately 80 known springs in the valley, most issue from perched ground water in extrusive igneous rocks. Some springs issue from carbonate rocks and quartzite. All of the known springs discharge at elevations above 6200 feet (1890 m). Many of the springs have variable discharge rates and some only flow in response to precipitation and snowmelt (Stephens, 1976).

Total precipitation within the basin is 410,000 acre-ft/yr (505.5 hm^3/yr). Of this amount, approximately 21,000 acre-ft/yr (25.9 hm^3/yr) recharge the ground-water reservoir. Recharge occurs where runoff infiltrates in and along stream channels below an elevation of 6000 feet (1829 m) and in the mountains. Less than 500 acre-ft/yr (0.6 hm^3/yr) of the runoff reaches the playa in the north end of Pine Valley (Stephens, 1976).

Ground-water discharge totals about 21,000 acre-ft/yr (25.9 hm^3/yr), which includes 650 acre-ft/yr (0.8 hm^3/yr) of spring discharge, 940 acre-ft/yr (1.2 hm^3/yr) of seepage to streams, 5500 acre-ft/yr (6.8 hm^3/yr) of evapotranspiration, and 14,000 acre-ft/yr (17.3 hm^3/yr) of subsurface outflow (11,000 acre-ft/yr [13.6 hm^3/yr] to Snake Valley and 3000 acre-ft/yr [3.7 hm^3/yr] to Wah Wah Valley). Areas of evapotranspiration include 5000 acres (2024 ha) along Turkey Wash and Indian, Sheep, and Pine Grove creeks and 500 acres (202 ha) surrounding existing springs (Stephens, 1976).

Ground water occurs under confined and unconfined conditions in Pine Valley. Confined conditions occur locally in the valley-fill aquifer where impermeable volcanic rocks are interbedded with sedimentary materials. Shallow water-table conditions occur along Turkey Wash and Indian, Sheep, and Pine Grove creeks. These areas represent perched zones and are not indicative of the regional water table (Stephens, 1976). The potentiometric surface of the valley-fill aquifer ranges in elevation from 5400 feet (1646 m) in the central portion of Pine Valley, to 4800 feet (1463 m) in the northern portion (Appendix Figure B1-24). The hydraulic gradient is 30 to 40 feet/mile (6 to 8 m/km) to the north or northeast, with underflow probably going to Snake Valley. The depth to water ranges from 300 feet to over 460 feet (91 to 140 m) below land surface in the north-central portions of the valley.

There is one anomalous well at 26S/17W-17d with a reported depth to water of over 700 feet (213 m). Stephens (1976) believes this well probably penetrates a different hydrostratigraphic unit within the valley-fill aquifer that is not in hydraulic continuity with the main body of the valley-fill aquifer.

Based on interpretation of drillers' logs for wells completed in Pine Valley, the valley-fill aquifer is at least 1300 feet (396 m) thick. These logs indicate that one well has been drilled to a depth of 2000 feet (610 m) in the valley. Quartzite boulders were penetrated from 1160 to 1577 feet (354 to 481 m) and there is no record of the lithology of the last 400 feet (122 m). The valley-fill aquifer consists of channel deposits composed of sand and gravel with some clay and silt, lacustrine deposits of clay and silt, alluvial deposits of boulders, gravel, sand, silt, and clay, and some interbedded extrusive igneous rocks. These deposits are unconsolidated to well-cemented sediments of Tertiary to Quaternary age (Stephens, 1976).

The bedrock exposed in the mountains is assumed to underlie the valley-fill aquifer. The Needle Range is primarily composed of extrusive igneous rocks of Tertiary age with some sedimentary and metasedimentary carbonate and quartzitic rocks of Paleozoic age in the north. The Wah Wah Mountains primarily contain sedimentary and metasedimentary carbonate rocks of Paleozoic age in the north and are primarily sedimentary and metasedimentary quartzitic rocks of Paleozoic age with some igneous rocks of Tertiary age in the south (Stokes, 1964).

2.24.2 MX Water Requirements

The amount of water required during the peak year of MX construction is expected to be 2209 acre-feet (2.7 hm^3) in 1984. Construction is projected to begin in 1983 and conclude in 1987. In July 1980, the Air Force filed for 2421 acre-ft/yr (3.0 hm^3/yr) of ground-water appropriations in Pine Valley.

2.24.3 Water-Supply Limitations

2.24.3.1 Perennial Yield, Use, and Appropriations

The perennial yield in Pine Valley has been estimated to be 7000 acre-ft/yr (8.6 hm^3/yr) (Price, 1979a). Present ground-water use in the valley is estimated to be 18 acre-ft/yr (0.02 hm^3/yr) for stock watering and some domestic use at the Desert Experimental Range Station. Planned future use for molybdenum mining is estimated to be 6000 to 10,000 acre-ft/yr (7.4 to 12.3 hm^3/yr) (UWRL, 1980). Certificated rights for ground-water total 221 acre-ft/yr (0.3 hm^3/yr) (DRI, 1980). Permits and applications for ground-water rights total 17,266 acre-ft/yr (21.3 hm^3/yr), which includes 15,243 acre-ft/yr (18.8 hm^3/yr) requested by Pine Grove Associates for use in conjunction with molybdenum mining (DRI, 1980).

Present surface-water use in Pine Valley is estimated to be 29 acre-ft/yr (0.04 hm^3/yr) for livestock watering (UWRL, 1980). Surface-water rights include 8995 acre-ft/yr (11.1 hm^3/yr) of certificates and proofs and 2416 acre-ft/yr (3.0 hm^3/yr) of permits and applications (DRI, 1980).

The quantity of ground water available for MX use is 6982 acre-ft/yr (8.6 hm^3/yr) when considering existing use, and 6779 acre-ft/yr (8.4 hm^3/yr) when considering approved appropriations. Pending applications for ground-water appropriations exceed perennial yield by 10,266 acre-ft/yr (12.7 hm^3/yr).

2.24.3.2 Source Capabilities

Perennial streamflow is very minor in Pine Valley. Springs represent the only source of perennial surface water, however, springs in Pine Valley do not represent a dependable source of water for the MX project because they are located in the mountains or along the mountain front, are relatively inaccessible, have a low discharge (650 acre-ft/yr [0.8 hm^3/yr]), and many only flow in response to precipitation and snowmelt.

An Air Force aquifer test well has been drilled in Pine Valley to determine the hydraulic characteristics of the valley fill. Data from the aquifer test performed in the northern portion of the valley, (C-26-17)10aa2, indicate a transmissivity and storativity for the valley-fill aquifer of about 330 ft^2/day (31 m^2/day) and 0.002, respectively. A bailer test in the central part of the valley, (C-28-17)22dda, indicated a specific capacity of 0.33 gpm/ft (0.1 l/s/m), while a well at the Desert Experimental Range Station has a reported specific capacity of 0.8 gpm/ft (0.2 l/s/m). The reported maximum well yield is 100 gpm (6 l/s) (Stephens, 1976). These data indicate that the aquifer has limited potential for high yield wells.

There are little data on the carbonate aquifer in Pine Valley. The aquifer has an estimated low potential for water-supply development because 1) there are aquitards of Paleozoic age present 2) volcanic and intrusive rocks are present which yield areas of low potential and 3) there are limited areas of high density faulting in carbonate aquifer units.

2.24.3.3 Water Quality

Water quality data are available from 15 locations including two ephemeral streams, eight springs, four wells, and one mine (Appendix F1-24). Nine of the samples were collected and tested by the U.S. Geological Survey, and six samples were collected by Ertec. All of the samples were within criteria for construction use (Appendix E1-1). All of the samples also meet Primary and Secondary Drinking Water Standards for the State of Utah (Appendix E1-3).

Four of the samples collected were from wells penetrating the valley-fill aquifer in the northern portion of the valley. There are no data available on water quality of the valley-fill aquifer in the southern part of the valley.

2.24.4 Water-Supply Alternatives

2.24.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of existing water rights is a viable water-supply alternative in Pine Valley. Approved appropriations total 221 acre-ft/yr (0.3 hm^3/yr) for ground water and 8995 acre-ft/yr (11.1 hm^3/yr) for surface water.

2.24.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred water-supply source for MX construction and operation in Pine Valley. Although data mentioned previously indicate that the aquifer is of limited potential, it is capable of supplying the amount of water required for MX needs if several, widely-spaced wells are constructed. In addition, sufficient water is available when considering present use or approved ground-water appropriations.

2.24.4.3 Carbonate Aquifer

The carbonate aquifer in Pine Valley has an estimated very low potential for development and is not considered a viable alternative source of water for the MX project.

2.24.4.4 Interbasin Transfer

Transfer of water from Snake Valley into Pine Valley is a viable water-supply alternative. This alternative should have a low priority, however, because of the difficulty and cost associated with importing water.

2.24.5 Impacts of Development

2.24.5.1 Intrabasin Effects

Computer simulations of MX production wells in Pine Valley have been performed. Rates of withdrawal were based on the expected yearly construction water needs estimated by the Army Corps of Engineers (1981) for the period 1983 to 1987. A transmissivity of 1300 ft^2/day (120 m^2/day) and storativity of 0.1 were felt to be representative of sediments found throughout the valley-fill aquifer system and were used in the simulation.

Withdrawals were simulated for five wells pumping at 270 gpm (17 l/s). After five years, the maximum drawdown at a 1 mile (2 km) radius from each well was 3.9 feet (1.2 m). Complete recovery was not achieved within 30 years after cessation of pumping because vertical recharge on the valley floor and the absence of recharge from underlying sediments was not simulated. However, residual drawdown after 30 years, even with this unrealistically conservative approach, was generally less than one-half foot (0.2 m) at each well site.

Impacts of ground-water withdrawals on springs are not expected because all springs issue from perched ground-water systems in the mountains at elevations above 6200 feet (1890 m).

2.24.5.2 Interbasin Effects

Water levels and spring discharge could be effected in Snake Valley because it is down gradient and receives underflow from Pine Valley. There are not enough data to quantity what, if any, the impact will be. The estimated peak-year use in Pine Valley is only about three percent of the perennial yield of Snake Valley.

If ground water is imported into Pine Valley from Snake Valley, additional impacts may result in Snake Valley. The degree of this impact is dependent upon the quantity of ground water exported to Pine Valley as well as the quantity required to fulfill MX requirements in Snake Valley.

2.25 RAILROAD VALLEY

2.25.1 General Physiography and Hydrology

Railroad Valley is a north-south trending, hydrographic basin encompassing parts of Nye and White Pine counties in east-central Nevada. One of the largest topographically closed basins in Nevada, Railroad Valley is 110 miles (177 km) long and varies from 15 to 25 miles (24 to 40 km) in width. The basin covers 2752 mi^2 (7125 km^2).

The mountains along the east and west sides of the valley, which include the Quinn Canyon, Grant, White Pine, Pancake, and Reveille ranges, are from 7000 to 10,000 feet (2134 to 3048 m) in elevation with Currant Mountain at 11,513 feet (3509 m), the highest point in the basin. The lowest point in the basin is 4706 feet (1434 m) in elevation on the northern playa. This playa is the remnant of a large lake which existed during the Pleistocene and had a maximum area of about 430 mi^2 (1113 km^2) (Van Denburgh and Rush, 1974). There is a smaller playa in the southern part of the valley at an elevation of 4845 feet (1477 m).

Streamflow within Railroad Valley is derived from snowmelt runoff, ground-water discharge, and rainfall runoff from infrequent summer storms. Mountain streams are generally perennial at least for a portion of their length while on the valley floor, the streams are ephemeral. Runoff to the playas occurs only during the largest storms and is quickly evaporated. Runoff from the mountains serves to recharge the ground water within the valley fill. A small amount is lost to evapotranspiration.

The U.S. Geological Survey operates one continuous streamflow gaging station in Railroad Valley. This station is on Little Currant Creek, and the average annual discharge is 2320 acre-feet (2.9 hm^3) (Van Denburgh and Rush, 1974). Little Currant Creek is considered an intermittent stream because at times during dry years this stream has no flow. The no-flow period may extend for several months but may not occur at all during wet years. Normally, low base flows, sustained by ground-water discharge, occur from late summer through early spring. Snowmelt runoff usually begins in March or April and is responsible for the peak flows which occur in May and June. Similar patterns can be expected for other high elevation streams such as the four mountain streams draining the eastern mountain ranges; Big Creek, Willow Creek, Hooper Creek, and Troy Canyon Creek.

Many springs occur within the mountains and around the margin of Railroad Valley. At least 15 springs with discharge in excess 100 gpm (6 l/s) at certain times of the year are known. Four of these springs have been classified as regional. These are Big Warm Spring (13N/56E-32bac), Little Warm Spring (12N/56E-5ac), Locke's Big Spring (8N/55E-15acd), and Abel Spring (6N/54E-23bd).

Although Railroad Valley is a topographically closed basin, an estimated 1000 acre-ft/yr (1.2 hm^3/yr) of ground water are discharged through the valley-fill and carbonate aquifers to Kawich Valley to the south (Blankennagel and Weir, 1979). Van Denburg and Rush (1974) noted, however, that this estimate may be too small. Railroad Valley also receives about 1200 acre-ft/yr (1.5 hm^3/yr) of surface flow from Hot Creek Valley via Twin Springs Slough.

Van Denburgh and Rush (1974) estimated the total ground-water recharge to Railroad Valley to be 52,000 acre-ft/yr (64.1 hm^3/yr) from precipitation and 3000 acre-ft/yr (3.7 hm^3/yr) from subsurface inflow. They noted that, due to difficulties in estimating subsurface inflow, this latter estimate could be considerably lower than the actual subsurface recharge. For water budget calculations, Van Denburgh and Rush (1974) reported a total recharge of 75,000 acre-ft/yr (92.5 hm^3/yr) for Railroad Valley.

Discharge of ground water from Railroad Valley occurs mainly as evapotranspiration with only small discharge reported through subsurface outflow. Van Denburgh and Rush (1974) estimated the total evapotranspiration to be 80,000 acre-ft/yr (98.6 hm^3/yr) and estimated that subsurface outflow through the valley-fill or carbonate aquifer to Kawich Valley totals at least 1000 acre-ft/yr (1.2 hm^3/yr).

The potentiometric surface of the valley-fill aquifer ranges in elevation from over 5000 feet (1524 m) to less than 4800 feet (1463 m) and slopes southward in the northern portion of the valley (Appendix Figure B1-25A). In the southern portion of the valley, the potentiometric surface slopes gently northward with an average elevation of 4800 feet (1463 m) (Appendix Figure B1-25B). Depths to water vary, but it is estimated that 40 to 50 percent of the valley has ground water at depths of less than 50 feet (15 m). The shallowest ground water is in the central portions of the valley and the depth to ground water increases to over 200 feet (61 m) along the valley margins as the land surface elevation increases.

The valley-fill deposits consist of interbedded gravel, sand, silt, and clay with sand and gravel predominating along the valley margins and grading to silt and clay in the playa areas. Volcanics of Tertiary age crop out in the mountains to the west and south and underlie the northwestern and southern parts of the valley. Carbonate rocks of Paleozoic age crop out in the mountains to the east and west and probably underlie the valley-fill aquifer in the northern part of the valley.

2.25.2 MX Water Requirements

The peak annual MX water requirement during construction in Railroad Valley is expected to be 3697 acre-feet (4.6 hm^3) in 1985. Construction is projected to begin in 1983 and conclude in 1989. The quantity of ground water requested in Air Force appropriations applications in Railroad Valley is 4148 acre-ft/yr (5.1 hm^3/yr) from four points of diversion.

2.25.3 Water-Supply Limitations

2.25.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Railroad Valley is estimated to be 75,000 acre-ft/yr (92.5 hm^3/yr) (Van Denburgh and Rush, 1974). This estimate is based on recharge from precipitation and subsurface inflow and discharge by wells, evapotranspiration, and subsurface outflow. The perennial yield figure is based on the assumption that some of the losses to evapotranspiration can be salvaged and that one-half of the subsurface outflow to Kawich Valley could be recovered.

Ground-water use in Railroad Valley basin is estimated to be 4206 acre-ft/yr (5.2 hm^3/yr) of which 2034 acre-ft/yr (2.5 hm^3/yr) is used for recreation and wildlife, 1980 acre-ft/yr (2.4 hm^3/yr) for irrigation, and the remaining 192 acre-ft/yr (0.2 hm^3/yr) is used for mining, domestic, and stock purposes (DRI, 1980). At the present time, certificates and proofs for ground water total 10,592 acre-ft/yr (13.1 hm^3/yr) and another 147,780 acre-ft/yr (182.2 hm^3/yr) of permits, and applications are on file at the State Engineer's Office pending approval (Woodburn and others, 1981).

Surface-water use is estimated to be 10,983 acre-ft/yr (13.5 hm^3/yr) of which 9900 acre-ft/yr (12.2 hm^3/yr) is used for irrigation purposes. The remaining surface water used is for recreation, wildlife, mining, stock, and domestic purposes. Certificates and proofs for surface-water in Railroad Valley total 17,090 acre-ft/yr (21.1 hm^3/yr). An additional 7238 acre-ft/yr (8.9 hm^3/yr) of applications and permits are on file (DRI, 1980).

The quantity of ground water available for MX use is approximately 70,794 acre-ft/yr (87.3 hm^3/yr) when considering existing use. Water availability is 64,408 acre-ft/yr (79.4 hm^3/yr) when considering approved appropriations.

2.25.3.2 Source Capabilities

Surface water availability in Railroad Valley is significant. Streams are intermittent on the valley floor. However, several large discharge springs occur around the margins of the valley. Discharge of many of these springs is perennial and they do provide a dependable water-supply source.

Two Air Force valley-fill exploration wells have been drilled in Railroad Valley. Data from the aquifer test performed in the northern part of the valley (10N/58E-17bd1) indicate a transmissivity and storativity for the valley-fill aquifer of about 7900 ft^2/day (732 m^2/day) and 0.001, respectively. Data from the test well in the southern part of Railroad Valley (3N/52E-2da1) indicate a transmissivity of 11,000 ft^2/day (1020 m^2/day) and storativity of 0.06.

The estimated yield from large diameter water wells in Railroad Valley is approximately 750 gpm (47 l/s). This suggests that five wells would be required to withdraw the peak amount of water needed for MX purposes in Railroad Valley.

The potential for carbonate aquifer development in Railroad Valley is considered high. This is based on the occurrence of favorable carbonate hydrostratigraphic units, extensive faulting, and the apparent presence of regional flow as evidenced by the occurrence of regional springs.

2.25.3.3 Water Quality

Numerous water-quality analyses have been reported from Railroad Valley (Appendix F1-25). Twelve samples were collected by Ertec and were analyzed for major constituents. The other samples were analyzed by the U.S. Geological Survey and reported by Van Denburgh and Rush (1974).

The results of the chemical analysis indicates that ground water in Railroad Valley is generally of good quality. For the constituents analyzed all of the samples collected were found to be within criteria for concrete mixing (Appendix E1-1). Nevada State Primary Drinking Water Standards (Appendix E1-2) for fluoride were exceeded in three wells (3N/53E-35bac, 1N/53E-7adc, and 6N/56E-5acc) and one spring (6N/54E-23bd). In addition, the water collected from the well at 1N/53E-7adc was found to exceed the recommended Nevada State Secondary Drinking Water Standards for sulfate, chloride, pH, and TDS. Chemical analyses from the two Air Force test well sites (10N/58E-17bd1 and 3N/52E-2da1), both of which penetrate the valley-fill aquifer, indicate that the ground water is generally of good quality with dissolved solid contents of 382 and 437 mg/l.

Because of the sparsity and distribution of data, only generalizations can be made about the water quality in Railroad Valley. It appears that ground water throughout the valley is adequate for construction purposes. Potable water can be obtained, but site location must be considered.

2.25.4 Water-Supply Alternatives

2.25.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of existing water rights is a viable water-supply alternative for MX construction and operation. Permitted and certificated ground-water rights total 10,592 acre-ft/yr (13.1 hm^3/yr), and approved rights for surface water total 17,090 acre-ft/yr (21.1 hm^3/yr).

2.25.4.2 Valley-Fill Aquifer

The valley-fill aquifer in Railroad Valley is the preferred source of water to meet MX water requirements for construction and operation. Aquifer tests performed by Ertec in the northern and southern portions of the valley indicate that the valley-fill aquifer has relatively high transmissivity and is capable of delivering water at sufficient rates and quantities to meet MX requirements. Chemical analysis has shown that the ground-water quality is variable, but that potable supplies can be developed.

2.25.4.3 Carbonate Aquifer

The carbonate aquifer is a viable alternative water-supply source for the MX requirements. It has a high potential for development but should be considered only if valley-fill aquifer development and lease/purchase are precluded for some reason.

2.25.4.4 Interbasin Transfer

Interbasin transfer to Railroad Valley is not a viable water supply alternative because of the lack of any surrounding valley with excess water availability. Railroad Valley is itself being considered as a potential source of water for transfer to other valleys.

2.25.5 Impacts of Development

2.25.5.1 Intrabasin Effects

Calculations on aquifer test results show that the expected drawdown 1 mile (2 km) from a well in the northern part of the valley pumping at a rate of 700 gpm (44 l/s) for a two-year period would be less than 0.5 feet (0.2 m); at a radius of less than 3 miles (5 km) no drawdown effects would be noticeable.

Based on results of testing in the southern portion of Railroad Valley, the expected drawdown at a distance of 1 mile (2 km) from a well pumping at a rate of 700 gpm (44 l/s) for two years would be 0.6 feet (0.2 m).

Ground-water withdrawals from the valley-fill aquifer may affect springs that originate on the valley floor and well setbacks should be at least 1 mile (2 km). Springs located in the surrounding mountains at elevations above the valley floor should not be effected by MX withdrawals in the valley-fill aquifer. The effects of withdrawals from the valley-fill on regional springs is assumed to be minimal, however, as a precaution, minimum well setbacks of 3 miles (5 km) are recommended.

2.25.5.2 Interbasin Effects

Ground-water withdrawals for MX requirements from the valley-fill aquifer should result in no interbasin effects in the neighboring valleys because the MX water requirements in the valley are small compared to the perennial yield estimated for Railroad Valley.

Withdrawals from the regional carbonate aquifer in Railroad Valley could affect discharge flows from regional springs in downgradient valleys. At present, there are insufficient data to quantify the impact, if any.

2.26 RALSTON VALLEY

2.26.1 General Physiography and Hydrology

Ralston Valley is an elongated, north-south trending basin in western Nye County, Nevada, encompassing 970 mi^2 (2511 km^2). Surrounding Ralston Valley are the Monitor Range, Cactus Range, Goldfield Hills, San Antonio Mountains, and Toquima Range. Geologically, Ralston Valley is a combination of two deep alluvial basins of unequal size. These basins are separated by an area of shallow bedrock located about 15 miles (24 km) northeast of Tonopah, Nevada. Much of the ground water that flows from the northern basin toward the south through this area is utilized as a municipal supply by Tonopah or is consumed by evapotranspiration. South of this area, depth to water increases rapidly to several hundred feet.

Streamflow is ephemeral and is derived from snowmelt runoff, ground-water discharge, and rainfall from infrequent summer storms. Runoff from mountain streams is rapidly lost to infiltration on the alluvial fans and valley floor and serves to recharge the ground-water supply. No major springs occur within the valley; several meteoric springs occur above the valley floor along the mountain fronts.

Ground-water recharge is estimated to be 8000 acre-ft/yr (9.9 hm^3/yr), 5000 acre-ft/yr (6.2 hm^3/yr) from precipitation and 3000 acre-ft/yr (3.7 hm^3/yr) from Stone Cabin Valley as subsurface flow (Nevada State Engineer, 1971). Ground-water discharge is estimated to be 8000 acre-ft/yr (9.9 hm^3/yr), 2500 acre-ft/yr (3.1 hm^3/yr) from evapotranspiration and 5500 acre-ft/yr (6.8 hm^3/yr) as subsurface outflow to the south (Eakin, 1961).

The potentiometric gradient of the valley-fill averages about 40 feet/mile (7 m/km) from north to south down the axis of the valley in the northern half and about 10 feet/mile (2 m/km) from north to south in the southern half of the valley (Appendix Figure B1-26). Where the northern portion of the basin drains to the south, evapotranspiration occurs. Depth to water is generally less than 50 feet (15 m) in this area. North and south of this central region, depths to water are greater than 150 feet (46 m) and 300 feet (92 m), respectively. In south-eastern Ralston Valley, where underflow from Stone Cabin Valley enters, the depth to water is about 100 feet (30 m).

2.26.2 MX Water Requirements

Peak annual water demand for MX construction in Ralston Valley is expected to be 2222 acre-feet (2.7 hm^3) in 1988. Construction is projected from 1984 to 1990. The Air Force has filed applications for appropriation of 4152 acre-ft/yr (5.1 hm^3/yr) of ground water in Ralston Valley from eight points of diversions.

2.26.3 Water-Supply Limitations

2.26.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Ralston Valley is 6000 acre-ft/yr (7.4 hm3/yr) (Nevada State Engineer, 1971). This estimate is based on recharge from precipitation and subsurface inflow and discharge by evapotranspiration, springs, wells, and subsurface outflow.

Ground-water use is estimated to be 1005 acre-ft/yr (1.2 hm^3/yr) for irrigation, Tonopah municipal supply, livestock, and culinary uses (DRI, 1980). Certificated and permitted ground-water rights total 2023 acre-ft/yr (2.5 hm^3/yr), and applications pending approval total 17,920 acre-ft/yr (22.1 hm^3/yr) (Woodburn and others, 1981). Surface-water use is estimated to be 68 acre-ft/yr (0.1 hm^3/yr) for irrigation and livestock watering (DRI, 1980). Certificates and proofs total 162 acre-ft/yr (0.2 hm^3/yr), and permits and applications total 8683 acre-ft/yr (10.7 (hm^3/yr) (DRI, 1980).

Ground-water availability for MX requirements is about 5000 acre-ft/yr (6.2 hm^3/yr) when considering existing use. Ground water availability is approximately 4000 acre-ft/yr (4.9 hm^3/yr) when considering approved appropriations.

2.26.3.2 Source Capabilities

Surface water in Ralston Valley occurs as intermittently flowing streams and small discharge springs and is not considered of sufficient magnitude to be viewed even as a partial supply source for MX construction and operation.

The water-supply capabilities of valley-fill aquifer in Ralston Valley are not well defined. No Air Force test wells have been drilled in the valley. The northern basin has the best indication of easily obtainable good quality ground water. The City of Tonopah, however, has declared all areas within 15 miles (24 km) of their municipal well field as a protected ground-water area. The southern basin typically has greater depths to ground water, and limited data suggest that transmissivities may be low. Further exploration and aquifer testing is needed to better define the capabilities of this supply source.

The carbonate aquifer in Ralston Valley has a low potential for water-supply development because of the presence of thick sequences of volcanic rocks and the lack of appropriate carbonate hydrostratigraphic units.

2.26.3.3 Water-Quality

Chemical analyses of samples collected from four wells and two springs are available for Ralston Valley (Appendix F1-26). The springs (7N/43E-25bca and 5N/45E-21cb) were sampled by Ertec as part of the MX field investigation. For the constituents analyzed, all of the samples were found to be within the criteria established for concrete mixing (Appendix E1-1). All samples were also found to meet the Nevada State Primary and Secondary Drinking Water Standards (Appendix E1-2). In general, it is believed that water supplies suitable for both construction and domestic purposes can be developed in Ralston Valley.

2.26.4 Water-Supply Alternatives

2.26.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of existing water rights is a viable partial water-supply alternative for MX construction and operation in

Ralston Valley. Approved ground- and surface-water rights total 2023 and 162 acre-ft/yr (2.5 and 0.2 hm^3/yr), respectively.

2.26.4.2 Valley-Fill Aquifer

The valley-fill aquifer in Ralston Valley is the preferred water-supply source for MX construction. The central portion of the valley where the City of Tonopah wells are located should be avoided. Well-yield capability in the rest of the valley is not well defined but should be adequate for MX requirements. Drilling and testing are planned to verify this assumption.

2.26.4.3 Carbonate Aquifer

The carbonate aquifer has low potential for development as a source of water for MX construction. It should only be considered as an alternative water-supply source if no other water is available for MX use in Ralston Valley.

2.26.4.4 Interbasin Transfer

Transfer of water from adjacent valleys into Ralston Valley is not considered a viable water-supply alternative because of unfavorable supply conditions in the potential source valleys.

2.26.5 Impacts of Development

2.26.5.1 Intrabasin Effects

It is anticipated that, with appropriate setbacks from existing points of diversion, there will be minimal effect on existing water users due to MX withdrawals. The 15-mile (24-km) setback required by the City of Tonopah should preclude any impacts to the municipal well field. Future aquifer tests will provide a basis for quantifying the expected amount of drawdown resulting from MX pumpage within Ralston Valley.

Valley-fill aquifer withdrawals may have an effect upon springs that originate on the valley floor. The north-central portion of the basin is the only area where this could occur since a few small springs occur along the alluvial fans. All other springs originate at elevations above the bedrock/valley-fill boundary and would not be effected by pumping from the valley-fill aquifer.

2.26.5.2 Interbasin Effects

Ground-water withdrawals in southern Ralston Valley could have an effect upon subsurface outflow to the south. There are insufficient data to quantify this impact, if any.

2.27 REVEILLE VALLEY

2.27.1 General Physiography and Hydrology

Reveille Valley is in Nye County, Nevada, and encompasses the southern end of the Hot Creek Hydrographic Basin and a portion of the Southern Railroad Hydrographic Basin. Reveille Valley is approximately 25 miles (40 km) long, 12 miles (19 km) across at its widest point, and encompasses about 300 mi^2 (777 km^2). Mountain ranges bordering Reveille Valley are the Reveille Range on the east and the Kawich Range on the west. Elevations range between 6500 and 9000 feet (1981 and 2743 m). The average valley floor elevation is 6200 feet (1890 m). Reveille Valley is open in the north to Hot Creek Valley and in the south to southern Railroad Valley.

Streamflow within Reveille Valley is ephemeral. Runoff originating as snowmelt or rainfall in the surrounding mountains is rapidly lost as infiltration on the alluvial fans and serves to recharge ground-water supplies. Surface runoff reaches the valley floor infrequently.

Reveille Valley is separated into two drainage areas of about equal size by an alluvial divide that lies just north of the Mount Diablo baseline. The valley north of this divide drains northward through Reveille Wash into Hot Creek Valley and eventually into Railroad Valley by way of Twin Spring Slough.

The valley south of the alluvial divide drains southeastward around the southern extent of the Reveille Range and then northward into Railroad Valley. Shallow bedrock is believed to underlie the topographic divide near the center of the valley restricting flow within the valley.

Ground-water recharge from precipitation to Hot Creek Valley is 7000 acre-ft/yr (8.6 hm^3/yr) and 6000 acre-ft/yr (7.4 hm^3/yr) to southern Railroad Valley (Nevada State Engineer, 1971). A portion of these estimates includes ground water that is recharged to Reveille Valley. The two drainage areas in Reveille Valley contribute to the 1200 acre-ft/yr (1.5 hm^3/yr) discharge to Railroad Valley via Twin Springs Slough in the Hot Creek Basin and to the 1000 acre-ft/yr (1.2 hm^3/yr) discharged through the valley-fill and carbonate aquifers to Kawich Valley to the south in the southern Railroad drainage basin (Van Denburgh and Rush, 1974).

The discharge of ground water from Reveille Valley occurs mainly as subsurface outflow with only small losses occurring as the result of evapotranspiration and livestock watering. Warm Springs, near the boundary between Reveille and Hot Creek valleys, is the area where most evapotranspiration occurs and is part of the 5200 acre-ft/yr (6.4 hm^3/yr) estimated for evapotranspiration in Hot Creek hydrographic basin. Other springs discharge smaller quantities and are largely captured near their source and transported by pipeline for livestock watering. Springs occur both within the valley fill and along the mountain front.

Ground water flows both north and south from the midvalley topographic divide. The depth to water is estimated to be greater than 250 feet (76 m) throughout much of Reveille Valley (Appendix Figure B1-27). However, depth to ground water is less than 50 feet (15 m) near a few springs on the west side of the valley and near the Hot Creek Valley-Reveille Valley boundary where Warm Springs discharges into the valley-fill sediments.

2.27.2 MX Water Requirements

Peak annual water demand for MX construction in Reveille Valley is expected to be 1108 acre-feet (1.4 hm^3) in 1985. Construction is projected to begin in 1983 and conclude by 1989. The Air Force has filed requests for appropriation of 2770 acre-ft/yr (3.4 hm^3/yr) of ground water from five points of diversion.

2.27.3 Water-Supply Limitations

2.27.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Reveille Valley has not been estimated separately but is part of the perennial yield estimated for Hot Creek Valley and Railroad Valley, 6000 acre-ft/yr (7.4 hm^3/yr) (Nevada State Engineer, 1971) and 75,000 acre-ft/yr (92.5 hm^3/yr), respectively (Van Denburgh and Rush, 1974).

Water use in Reveille Valley is predominantly for irrigation, livestock, and domestic purposes. Although the amount of usage has not been quantified, estimates of water rights for Hot Creek and southern Railroad valleys include portions of Reveille Valley.

Ground-water availability for MX use in Reveille Valley can be estimated by considering the water rights in Hot Creek and southern Railroad valleys along with the combined MX demand for these valleys and Reveille Valley. Certificated and permitted water rights in Hot Creek Valley total 1052 acre-ft/yr (1.3 hm^3/yr) with 84,260 acre-ft/yr (103.9 hm^3/yr) in pending irrigation applications (Woodburn and others, 1981). The combined MX demand for water in Hot Creek and Reveille valleys in 1985 is 1326 acre-feet (1.6 hm^3). This amount, combined with approved water rights, is well within the estimated 6000 acre-ft/yr (7.4 hm^3/yr) perennial yield of Hot Creek Valley. Certificated and permitted ground-water rights in southern Railroad Valley, including a portion of Reveille Valley, total 378 acre-ft/yr (0.5 hm^3/yr) with 46,080 acre-ft/yr (56.8 hm^3/yr) in pending applications (Woodburn and others, 1981). The combined MX demand for water in Reveille and both north and south Railroad valleys in 1985 is 4764 acre-ft/yr (5.9 hm^3/yr). This amount, combined with approved ground-water rights for Reveille and southern Railroad valleys (378 acre-ft/yr [0.5 hm^3/yr]) and those in northern Railroad Valley (10,214 acre-ft/yr [12.6 hm^3/yr]), total 15,356 acre-ft/yr (18.9 hm^3/yr). This amount is well within the estimated perennial yield of 75,000 acre-ft/yr (92.5 hm^3/yr) for the ground-water basin.

2.27.3.2 <u>Source Capabilities</u>

Surface water in Reveille Valley is very limited and is fully appropriated and diverted for livestock watering. The only continuous flow recording station in Reveille Valley was operated from 1967 to 1970 by the U.S. Geological Survey on Warm Springs, the largest spring in the valley.

For the three years of record the discharge varied from 193 to 233 gpm (12 to 15 l/s) (Van Denburgh and Rush, 1974).

An Air Force valley-fill aquifer test well was drilled at 3N/50E-13ca2. Aquifer test data indicate a transmissivity of 5000 ft^2/day (463 m^2/day) and a storativity of 0.01 for the valley-fill aquifer at that location. Well yield during testing was 550 gpm (35 l/s) with 90 feet (27 m) of drawdown. These preliminary results indicate that the valley-fill aquifer is capable of delivering water in sufficient quantity to meet MX requirements.

The carbonate aquifer has low potential for water-supply development in Reveille Valley. This estimate is based upon the lack of appropriate carbonate hydrostratigraphic units, the predominance of volcanics, and the valleys lack of relationship to known regional flow systems.

2.27.3.3 Water Quality

Water-chemistry data for Reveille Valley are presented in Appendix F1-27. Water from the Air Force test well meets the Primary and Secondary Drinking Water Standards for the State of Nevada (Appendix E1-2). Five samples were collected from springs, streams, and an existing well in Reveille Valley. All samples are within standards for potable water supplies in the State of Nevada (Appendix E1-2). All waters sampled also meet construction water criteria (Appendix E1-1). Development of water resources in Reveille Valley should be feasible from a water-quality standpoint.

2.27.4 Water-Supply Alternatives

2.27.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of existing water rights is a viable partial water-supply alternative for MX construction and operation in Reveille Valley.

2.27.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred water-supply source for MX construction in Reveille Valley. There is sufficient ground water available in the valley-fill aquifer to meet peak MX requirements without exceeding the perennial yield considering either Hot Creek or Railroad Valley estimates which include Reveille Valley. Aquifer testing has shown that the valley fill is capable of well yields of at least 550 gpm (35 l/s).

2.27.4.3 Carbonate Aquifer

The carbonate aquifer is not considered to be a viable water-supply alternative. Exploration should be conducted only if no other water-supply source for MX construction is available.

2.27.4.4 Interbasin Transfer

Transfer of water from valleys surrounding Reveille Valley is a viable water-supply alternative. Water from Hot Creek or Railroad valleys, which have abundant supplies, could be transferred to Reveille Valley. This alternative should be employed only if the water in the valley-fill aquifer in Reveille Valley were not available for MX use.

2.27.5 Impacts of Development

2.27.5.1 Intrabasin Effects

Calculations based on a transmissivity of 5000 ft^2/day (463 m^2/day), a storativity of 0.01, and a pumping period of two years indicate that drawdown at 1 mile (2 km) from a MX production well pumping at a rate of 350 gpm (22 l/s) is expected to be less than 1 foot (0.3 m). Therefore, existing water users in Reveille will not be noticeably impacted by MX withdrawals because wells will be located at least 1 mile (2 km) from existing wells.

There should be no effect of MX withdrawals on springs discharging at elevations above the valley-fill aquifer along the margins of the valley. MX production wells should be located a minimum of 1 mile (2 km) from the few springs on the valley floor to avoid impacts.

2.27.5.2 Interbasin Effects

There should be a minimal effect on adjoining basins from ground-water withdrawals in Reveille Valley. Ground-water flow to Hot Creek Valley to the north may be slightly reduced as a result of MX withdrawals in Reveille Valley. Ground-water withdrawals in southern Reveille Valley may effect the subsurface discharge of ground water into southern Railroad Valley also. The effects will be minor and of short duration because of the relatively short period that significant withdrawals are anticipated. There are insufficient data to quantify the impact.

2.28 SEVIER DESERT

2.28.1 General Physiography and Hydrology

Sevier Desert is a large basin in west central Utah that includes parts of Millard, Juab, and Tooele counties. The study area, which is only a portion of the total Sevier Desert area, is bounded on the west by the Little Drum, Drum, and McDowell mountains, on the north by the Simpson and Sheeprock mountains, and on the east by the Gilson and Canyon mountains. The southern boundary of the study area is located just north of the City of Delta. The area of study is 48 miles (77 km) long, 24 miles (39 km) across at its widest point, and encompasses 970 mi^2 (2511 km^2). The average valley floor elevation is 4800 feet (1463 m), while the elevations in the surrounding mountains range from 6500 to 9700 feet (1981 to 2957 m).

Several perennial streams originate in the mountains surrounding the basin. This flow is lost as infiltration on the alluvial fans along the mountain fronts. There are also numerous intermittent streams which flow during a portion of the year but also percolate into the valley fill along the mountain fronts. Streams in the mountains along the west side of Sevier Desert are all ephemeral and flow only in response to intense summer storms. The Sevier River, located along the eastern edge of the study area, carries flow onto the valley floor only during periods of extremely high runoff. Most of the flow in this river is stored in upstream reservoirs and diverted for irrigation use. The average annual flow in the river prior to diversions is about 139,000 acre-feet (171.4 hm^3) (Eakin and others, 1976).

Ground-water recharge to the valley fill of the Sevier Desert is by the infiltration of precipitation through unconsolidated sediments, seepage from streams and canals, percolation of irrigation water, flow through fractured consolidated rock, and underflow from other basins. The main areas of ground-water recharge are on the north and eastern edges of the basin. Ground-water flow is from the valley margin toward the playa areas to the west and the Old River Bed area to the north. Ground water enters the Sevier Desert as underflow from both Pavant and Beaver River valleys. The estimated annual recharge from all the above sources is 186,000 acre-feet (229.3 hm^3) (Eakin and others, 1976).

The Sevier Desert is a hydraulically open system with underflow to the south toward Sevier Lake playa and to the north beneath the Old River Bed. The exact amount of outflow is not known but it is probably less than 5000 acre-ft/yr (6.2 hm^3/yr) through the Old River Bed (Mower and Feltis, 1968). An estimated 135,000 to 175,000 acre-feet (166.5 to 215.8 hm^3) of ground water is consumed by evapotranspiration each year in the low-lying areas of the entire Sevier Desert where depths to water are generally less than 30 feet (9 m) (Mower and Feltis, 1968).

The only significant concentration of springs occurs around the margins of the Simpson Mountains in the northeast corner of the study area. Several of these springs have significant discharge and have been classified as regional or possible regional springs.

The valley-fill deposits consist of interbedded silt, clay, and evaporites in the playa area and gravel and sand in the adjacent alluvial fans. Volcanics of Tertiary age and limited carbonate rocks of Paleozoic age crop out in the mountain ranges flanking the valley.

The water table within the valley-fill aquifer slopes to the southwest as well as away from a hydrologic divide, ([C-12-11] and [C-12-10]), toward the northwest and toward Dugway Valley (Appendix Figure B1-28). The ground-water gradient for the valley-fill aquifer in the Sevier Desert averages 8 feet/mile (2 m/km) from the recharge area in the Sheeprock, Simpson, and Tintic mountains toward the south and west. The hydraulic gradient in the north-west through the Old River Bed toward Dugway Valley is 20 feet/mile (4 m/km).

Records compiled by the U.S. Geological Survey (1979) and ground-water level measurements collected by Ertec in 1979 and 1980 indicate that the depth to ground water is less than 10 feet (3 m) in the Delta area with several flowing wells reported. Measured depths to water exceed 200 feet (61 m) along the valley margins to the northwest where land surface elevations are higher.

2.28.2 MX Water Requirements

The peak annual demand for water during MX construction is expected to be 1870 acre-feet (2.3 hm^3) in 1984. Construction is projected to begin in 1983 and conclude in 1988. The U.S. Air Force has filed for 2076 acre-ft/yr (2.6 hm^3/yr) of ground-water appropriations for Sevier Desert from three points of diversion.

2.28.3 Water-Supply Limitations

2.28.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of the study area has been estimated to be 24,500 acre-ft/yr (30.2 hm^3/yr) by Ertec. This estimate is based upon the Hill Method for perennial yield determination described by Todd (1959) using pumping rates and potentiometric level declines for the period 1960 to 1977 compiled by the Utah Division of Water Resources.

Present demands on the ground-water reservoir are estimated to be slightly more than 49,000 acre-ft/yr (60.4 hm^3/yr) for irrigation, industrial, and domestic uses. Certificates and proofs total 42,374 acre-ft/yr (52.2 hm^3/yr) while permits and applications total 929,134 acre-ft/yr (1145.6 hm^3/yr) (UWRL, 1980). These include 709,520 acre-ft/yr (874.8 hm^3/yr) considered the "beneficial annual right" to Chevron Oil Company for several electric power plants planned in the area. The Fumerole Buttes, approximately 15 miles (24 km) northwest from Delta just outside of the study area boundary, is the area of diversion.

There are 203,054 acre-ft/yr (250.4 hm^3/yr) of surface water use in Sevier Desert. Permits and applications for surface water total 4239 acre-ft/yr (5.2 hm^3/yr). Certificates and proofs for surface-water rights are 8458 acre-ft/yr (10.4 hm^3/yr) (UWRL, 1980).

Because the present use exceeds the available perennial yield of the ground-water basin, the Utah State Engineer has closed the basin to any further appropriations of ground water.

2.28.3.2 Source Capabilities

Surface-water sources in the study area are significant but are fully appropriated. Surface flow from springs in the basin is fully appropriated and is not of sufficient quantity throughout the year to be a reliable source of water.

The valley-fill aquifer system is capable of supplying the necessary water for MX requirements in most areas of the valley. Two artesian aquifers in the valley-fill material have been identified and numerous aquifer tests have been performed by the U.S. Geological Survey. Data from these tests indicate that the lower aquifer has a transmissivity range from 2000 to 26,800 ft^2/day (185 to 2484 m^2/day) and the upper aquifer a range from 3350 to 46,900 ft^2/day (311 to 4347 m^2/day). Storativity ranges from .001 to .0001 (Mower and Feltis, 1968). The lower transmissivities occurred in those wells that were located away from the Sevier River toward the center of the basin. High transmissivities occurred near the edges of the system along the Sevier River channel. Based on this information, it would be expected that well yields in excess of 750 gpm (47 l/s) could be obtained through proper well placement and design.

The carbonate aquifer in this area is considered to have a low potential for water-supply development. Carbonate rocks crop out in the mountain ranges flanking the valley, however,

appropriate hydrostratigaphic units are not in abundance and significant Paleozoic aquitard units are present.

2.28.3.3 Water Quality

Water-chemistry data for Sevier Desert are presented in Appendix F1-28. Water-quality analyses of eight well samples collected by Ertec in March 1980 indicate that only four of the eight wells meet Primary and Secondary Drinking Water Standards for the State of Utah (Appendix E1-3). Those wells that did not meet all the standards are listed in Table 2.28.1. All four of these samples exceeded the recommended level for chloride (250 mg/l) and are located near the sand dune areas east of Cherry Creek. Water samples from two wells, (C-14-6)9bab and (C-14-6) 9dda, were found to exceed water-quality criteria for TDS for concrete mixing (Appendix E1-1). The water quality varies widely throughout the area. In general, it can be expected that ground water from those areas that have historically yielded good quality water would be suitable for construction and drinking water purposes.

2.28.4 Water-Supply Alternatives

2.28.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of existing water rights is the preferred water-supply source for MX construction and operation in Sevier Desert because present ground-water appropriations exceed the estimated perennial yield of the basin. Both surface- and ground-water sources are considered to be fully appropriated by the Utah State Engineer. Sufficient approved water rights are available to meet MX requirements.

TABLE 2.28.1 SAMPLE LOCATIONS IN SEVIER DESERT THAT EXCEED WATER-QUALITY CRITERIA

SAMPLE LOCATION	SOURCE	PRIMARY STANDARD EXCEEDED	SECONDARY STANDARD EXCEEDED	CONSTRUCTION STANDARD EXCEEDED
(C-13-6)12bcb	Well		Chloride (460 mg/l)	
(C-13-6)26bac	Well	Sulfate (531 mg/l)		
		TDS >2000 mg/l	Chloride (680 mg/l)	TDS >2000 mg/l
(C-14-6)9bab	Well	Fluoride (1.77 mg/l)	Chloride (480 mg/l)	
(C-14-6)9dda	Well	TDS >2000 mg/l	Chloride (660 mg/l)	TDS >2000 mg/l

2.28.4.2 Valley-Fill Aquifer

The valley-fill aquifer system represents a satisfactory source of water for MX construction and operation. Previous aquifer tests indicate that both aquifer systems in the valley fill are capable of producing water at the rates required for MX purposes. Published data on quality of ground water in the Sevier Desert indicate that wells located in the southern portion of the study area, north of Delta, produce water of acceptable quality for both domestic and construction use. Although the aquifer can physically meet MX requirements, it is not considered available because Sevier Desert is a closed ground-water basin.

2.28.4.3 Carbonate Aquifer

The carbonate aquifer in Sevier Desert has a very low potential for water-supply development. Exploratory drilling has not been performed in this area. At this time, the carbonate aquifer is not viewed as a viable water-supply alternative.

2.28.4.4 Interbasin Transfer

Interbasin transfer of water to Sevier Desert is not considered a viable water-supply alternative because of limited water availability in surrounding valleys.

2.28.5 Impacts of Development

2.28.5.1 Intrabasin Effects

Drawdown due to ground-water withdrawals to meet MX requirements in Sevier Desert will not exceed present levels if water supplies are obtained through lease or purchase of existing water rights.

2.28.5.2 Interbasin Effects

There should be minimal impact to adjacent valleys by MX withdrawals from the valley-fill aquifers in the Sevier Desert. Underflow to other valleys would not be disrupted to any greater extent than is already occurring by existing withdrawals if ground water is obtained through the lease or purchase of present rights.

2.29 SNAKE VALLEY

2.29.1 General Physiography and Hydrology

Snake Valley, in Millard, Juab, and Tooele counties, Utah, and White Pine and Lincoln counties in Nevada, is a north-south trending valley which opens out onto the Great Salt Lake Desert to the north. Hamlin Valley is to the south, separated by a narrow divide and considered a separate valley but part of the same hydrologic system. Snake Valley is about 90 miles (145 km) long, 30 miles (48 km) across at its widest point, and encompasses approximately 700 mi^2 (1812 km^2).

Valley-fill deposits consist mainly of clay, silt, and sand in lacustrine areas at the center of the valley and predominantly gravel and sand in the alluvial fan deposits along the valley margins. Ground-water recharge is 68,500 acre-ft/yr (84.5 hm^3/yr) from precipitation and approximately 5000 acre-ft/yr (6.2 hm^3/yr) in subsurface underflow from Hamlin Valley. Ground-water discharge is by evapotranspiration (71,500 acre-ft/yr [88.2 hm^3/yr]) and by underflow to the Great Salt Lake Desert and east to the Confusion Range. These estimates are based on studies conducted by Hood and Rush (1965), who made estimates for the whole Snake-Hamlin system, and Huntley (1981) who reported on Snake Valley.

Nearly all the streams in the valley are ephemeral except for the upper reaches of certain mountain creeks. Near the base of the mountains, water is rapidly lost into the alluvial fans and serves to recharge the ground-water system. There are two perennial streams, Warm Creek and Big Smoky Creek, on the valley floor; both are maintained by spring discharge. Meteoric springs, several of significant discharge, occur around the valley margin. At least two regional springs, Twin Spring and Warm Spring, (C-16-18)31bc and (C-15-19)31bc, occur in the southern end of the valley.

Ground water in Snake Valley occurs under both confined and unconfined conditions. The potentiometric surface of the valley-fill aquifer slopes north to the Great Salt Lake. There is also an easterly component of the gradient recharging from the west and flowing through the Ferguson Desert area. The depth to water ranges from several feet above land surface at some flowing wells along the valley axis to in excess of 150 feet (46 m) below land surface along the valley margins (Appendix Figure B1-29).

2.29.2 MX Water Requirements

The peak annual demand for water during MX construction is expected to be 3094 acre-feet (3.8 hm^3) in 1986. Construction is projected to begin in 1984 and conclude in 1989. The Air Force has filed for 5687 acre-ft/yr (7.0 hm^3/yr) in ground-water appropriations from five points of diversion.

2.29.3 Water-Supply Limitations

2.29.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Snake Valley is estimated to be 49,000 acre-ft/yr (60.4 hm^3/yr) (Gates, 1978). Total water use in the Utah portion of Snake Valley is currently 30,962 acre-ft/yr

(38.2 hm^3/yr) including 14,141 acre-ft/yr (17.4 hm^3/yr) of ground water and 16,821 acre-ft/yr (20.7 hm^3/yr) of surface water (UWRL, 1980). Over 99 percent of this use is for the irrigation of crops. Figures for water use in the Nevada portion of Snake Valley are not presently available. The Desert Research Institute (1980) estimates water use to be 10,109 acre-ft/yr (12.5 hm^3/yr), however, a different boundary between Snake and Hamlin valleys was used than is presented in this report. Most of this 10,109 acre-ft/yr (12.5 hm^3/Yr) is believed to be used in Hamlin Valley, and only minor use, less than about 1000 acre-ft/yr (1.2 hm^3/yr), is believed to be used in Snake Valley.

Both ground- and surface-water rights have been tabulated for Snake Valley, Nevada, and Snake Valley, Utah, by DRI (1980). These figures have been adjusted to reflect the amount of water rights in the area defined as Snake Valley in this report. There are 10,421 acre-ft/yr (12.8 hm^3/yr) in approved appropriations (certificates and proofs) issued for ground water and 14,375 acre-ft/yr (17.7 hm^3/yr) for surface water. In addition, permits and applications for 46,185 acre-ft/yr (56.9 hm^3/yr) of ground water and 4175 acre-ft/yr (5.1 hm^3/yr) of surface water also exist.

2.29.3.2 Source Capabilities

The availability of perennial streamflow on the valley floor and springs with large discharge suggests that surface water may provide a viable source of water for the MX project in this valley. This water is heavily appropriated, however, indicating that the lease or purchase of existing rights may be required to utilize this supply.

Five aquifer tests were conducted on existing wells at (C-14-18) 17aaa, (C-19-19)34adb, (C-19-19)34dac, (C-19-19)35bdd, and (C-19-19)35dcd to evaluate the hydraulic characteristics of the valley-fill aquifer. Transmissivity values ranging from 1900 to 47,000 ft^2/day (176 to 4356 m^2/day) and storativities ranging from 0.08 to 9.7×10^{-5} have been calculated for the valley fill. The average transmissivity from the five aquifer tests is 26,830 ft^2/day (2487 m^2/day).

The results of the aquifer tests as well as the identification of flowing wells in the northeast and along the eastern margin of the valley indicate that the valley-fill aquifer is at least partially confined. A review of lithologic logs indicate that water-table conditions prevail throughout much of the valley.

Well yields in Snake Valley range from a few gallons per minute for some flowing wells to over 1000 gpm (63 l/s) for some large diameter irrigation wells. It is anticipated that well yields up to 1000 gpm (63 l/s) are obtainable throughout much of the suitable construction area with wells about 300 feet (98 m) in depth.

The carbonate aquifer is considered to have a moderate potential for water-supply development. This is based on the occurrence of carbonate rocks and high density faulting and the general lack of volcanic or intrusive rocks. Oil well drilling records indicate that carbonate rocks in the valley are highly conductive and contain fresh water (Hood and Rush, 1965).

2.29.3.3 Water Quality

Twenty-six ground- and surface-water samples were collected by Ertec from Snake Valley for chemical analysis. The results of these analyses, along with existing water chemistry data are listed in Appendix F1-29. The data indicate that both surface and ground waters are suitable for use in construction of MX facilities (Appendix B1-1). In addition, with the excep tion of two samples, all of the water samples collected in Snake Valley meet Primary and Secondary Drinking Water Standards for the States of Nevada and Utah (Appendices E1-2 and E1-3).

The chemical analysis of a ground-water sample collected by Ertec from (C-21-17)8dcb indicated a fluoride concentration of 2.2 mg/l exceeding the minimum Primary Drinking Water Standard for the State of Utah of 1.6 mg/l. This high concentration is not believed to be indicative of the valley-fill, based on the chemical analyses of the remaining water samples collected throughout the valley. Water-quality data provided by Hood and Rush (1965) indicate that a ground-water sample from a well at (C-15-17)8baa has a sulfate concentration of 889 mg/l and a chloride concentration of 290 mg/l. These concentrations are in excess of Utah State Primary Drinking Water Standards for sulfate (500 mg/l) and Secondary Drinking Water Standards for chloride (250 mg/l). The analyses were performed in 1949 and may not be indicative of the valley-fill aquifer in Snake Valley today. The quality of water in Snake Valley is believed to be suitable for all MX requirements.

2.29.4 Water-Supply Alternatives

2.29.4.1 Lease or Purchase of Existing Water Rights

There are 10,421 acre-ft/yr (12.8 hm^3/yr) of approved ground-water rights and 14,375 acre-ft/yr (17.7 hm^3/yr) of approved surface-water rights in Snake Valley. Lease or purchase of existing water rights is a viable water-supply alternative for MX construction and operation.

2.29.4.2 Valley-Fill Aquifer

The valley-fill aquifer in Snake Valley is the preferred source of water for MX construction and operation. Sufficient unappropriated ground water remains, and the valley-fill aquifer is capable of supplying water in the amount and quality necessary to meet MX requirements. Four wells pumping at 500 gpm (32 l/s) will be necessary to meet the maximum water demand of 3094 acre-ft/yr (3.8 hm^3/yr) for the peak year of MX construction.

2.29.4.3 Carbonate Aquifer

The carbonate aquifer in Snake Valley is a viable alternative water-supply source. No testing has been done because the valley-fill aquifer is believed to offer the most economical source of water.

2.29.4.4 Interbasin Transfer

Interbasin transfer is not a viable water-supply alternative for Snake Valley because Spring Valley, which is the only potential source valley, is located wholly in Nevada. Interstate transfer of water would most likely not be permitted by either of the state engineers.

2.29.5 Impacts of Development

2.29.5.1 Intrabasin Effects

The impacts expected from ground-water withdrawals in Snake Valley have been estimated from information obtained from aquifer tests as well as numerical simulation of the known hydrologic conditions that exist in Snake Valley. The estimated drawdown 1 mile (2 km) from a well pumping continuously at 500 gpm (32 l/s) for two years is estimated to be less than 1 foot (0.3 m). This calculation was made using a transmissivity of 26,830 ft^2/day (2487 m^2/day) and a storativity of 0.1, indicative of water-table conditions. A well with the same yield located along the eastern margin of the valley, where confined conditions are believed to exist and the storativity may be about 0.001, will have an estimated drawdown of about 2 feet (0.6 m) at a distance of 1 mile (2 km).

The springs on the east side of Snake Valley discharge on the valley floor. Their discharge could be affected if the water table is lowered in the area. Springs on the west side of the valley are generally higher in the mountains and should not be affected by valley-fill development.

2.29.5.2 Interbasin Effects

Water levels and spring discharge could be affected in Tule Valley, Fish Springs Flat, and the Great Salt Lake Desert. There is not enough data available on regional flow patterns to quantify what, if any, the effects will be.

2.30 SPRING VALLEY

2.30.1 General Physiography and Hydrology

Spring Valley, in White Pine and Lincoln counties, Nevada, is a north-south trending, elongate valley typical of the Basin and Range Province. The valley is approximately 120 miles (193 km) in length, 15 miles (24 km) in width, and encompasses 1661 mi^2 (4300 km^2). The average valley floor elevation is 5700 feet (1737 km). Spring Valley is a topographically closed basin bordered on the east by the Antelope Range, Snake Range, and Limestone Hills and on the west by the Schell Creek and Fortification ranges. Mountain crest elevations range from 8000 feet (2438 m) to 13,063 feet (3982 m) at Wheeler Peak. A low topographic divide separates Spring Valley from Antelope and Hamlin valleys at the valley's northeastern and southeastern boundaries, respectively.

Numerous seasonal and perennial streams, fed by snowmelt and precipitation, discharge from the flanks of the bordering mountain ranges. Of the 10 major streams, seven streams were measured by Ertec in May 1980. Stream discharge ranged from 1700 to 12,000 gpm (107 to 757 l/s). The estimated annual runoff from the mountains is 90,000 acre-ft/yr (111.0 hm^3/yr) (Rush and Kazmi, 1965).

Three springs were measured by Ertec and were flowing from 300 to 42,000 gpm (9 to 2650 l/s). Springs are meteoric and issue from fractures and faults in quartzites, dolomites, and limestones.

Ground-water recharge to Spring Valley occurs by infiltration of surface runoff along alluvial fans and totals 75,000 acre-ft/yr (92.5 hm^3/yr) (Nevada State Engineer, 1971). Regional ground-water underflow from Tippett Valley accounts for an additional 2000 acre-feet (2.5 hm^3) of annual ground-water recharge (Nevada State Engineer, 1971). Surface and ground-water discharge occurs over an extensive portion of the valley floor. An estimated 70,000 acre-ft/yr (86.3 hm^3/yr) of water is discharged by evapotranspiration (Nevada State Engineer, 1971). Ground-water underflow discharges 4000 acre-feet (4.9 hm^3) of water annually into Hamlin Valley (Nevada State Engineer, 1971).

The hydraulic gradients in the northern half of Spring Valley are interpreted from the valley potentiometric map (Appendix Figure B1-30). The gradient for northern Spring Valley is 35 feet/mile (7 m/km) south and 10 feet/mile (2 m/km) north to the playa area in 17N/67E. The gradient for southern Spring Valley trends south at about 6 feet/mile (1 m/km) into Hamlin Valley. Depths to ground water range from land surface to over 400 feet (122 m).

The total thickness of the valley fill has not been determined. A flowing well in northern Spring Valley was drilled to a depth of 1040 feet (317 m) with no indication of bedrock penetration (Rush and Kazmi, 1965). The valley fill is composed of lake, alluvial fan, and playa deposits. Rush and Kazmi (1965) characterize the valley fill as older alluvium, composed of sand and gravel of Tertiary and Quaternary age derived from adjacent mountains, and younger alluvium, composed of reworked channel sand, silt, clay, and lacustrine deposits of Pleistocene age.

Carbonates of Paleozoic age are exposed in both the Snake and Schell Creek ranges and are inferred to underlie valley-fill sediments (Rush and Kazmi, 1965). Volcanics of Tertiary age are exposed in the ranges at the northern and southern ends of the valley.

2.30.2 MX Water Requirements

The MX construction period in Spring Valley is projected to be from 1983 to 1987. Peak annual water demand is expected to be 629 acre-feet (0.8 hm^3) in 1984. The Air Force has filed for 2425 acre-ft/yr (3.0 hm^3/yr) of ground-water rights in Spring Valley from five points of diversion.

2.30.3 Water-Supply Limitations

2.30.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Spring Valley is estimated to be 100,000 acre-ft/yr (123.3 hm^3/yr) by the Nevada State Engineer (1971). This estimate is based on the assumption that all the ground-water evapotranspiration loss of 70,000 acre-ft/yr (86.3 hm^3/yr) can be salvaged as well as the surplus playa runoff (approximately 30,000 acre-ft/yr [37.0 hm^3/yr]).

Surface-water use for domestic, stock, energy, and irrigation activities is estimated at 15,423 acre-ft/yr (19.0 hm^3/yr) (DRI, 1980). There are 27,194 acre-ft/yr (33.5 hm^3/yr) of approved surface-water rights and an additional 63,181 acre-ft/yr

(77.9 hm^3/yr) of permits and pending applications for appropriations.

Ground-water pumpage for domestic, stock, irrigation, and mining use is estimated at 4,781 acre-ft/yr (5.9 hm^3/yr) (DRI, 1980). There are 21,812 acre-ft/yr (26.9 hm^3/yr) of certificates and permits for ground water in Spring Valley (Woodburn and others, 1981). In addition, 2594 acre-ft/yr (3.2 hm^3/yr) of pending applications also exist in the valley (Woodburn and others, 1981).

Based on the above information, there are 49,006 acre-ft/yr (60.4 hm^3/yr) of approved surface- and ground-water rights that may be available for use during the MX project through lease or purchase. Based on a perennial yield of 100,000 acre-ft/yr (123.3 hm^3/yr) and approved ground-water rights totaling 21,812 acre-ft/yr (26.9 hm^3/yr), there are 78,188 acre-ft/yr (96.4 hm^3/ yr) of ground water available from the valley fill for the MX project. Considering existing use and the perennial yield, 95,219 acre-ft/yr (117.4 hm^3/yr) of ground water in the valley-fill aquifer are not being utilized.

2.30.3.2 Source Capabilities

Surface water from springs and streams is diverted for irrigation and stock watering. Most, if not all, available surface water has been appropriated in Spring Valley. There are sufficient amounts for MX project use, however, lease or purchase of surface-water rights from existing users will be the only means of obtaining water from this source.

In 1980, an Air Force valley-fill test well was drilled in the southern portion of Spring Valley (9N/68E-3ab1) to determine the hydraulic characteristics of the valley fill. The results from aquifer tests conducted did not allow for accurate calculation of transmissivity and storativity values because of pump malfuntion. Well yield during testing was 600 gpm (38 l/s) with only 14 feet (4.3 m) of drawdown. The results from a short-term aquifer test conducted in an existing well in the south-central portion of the valley (12N/67E-13dd) indicated a transmissivity of 474 ft^2/day (44 m^2/day). Specific capacity tests from numerous wells in the valley indicate transmissivity ranges of 1500 to 30,000 ft^2/day (139 to 2781 m^2/day). These data, along with information obtained from field reconnaissance and interpretation of lithologic logs, indicate that the the transmissivity and storativity of the valley fill varies greatly with location. Much of the valley-fill aquifer is believed to be under water-table conditions; confined conditions occur in areas containing playa deposits of Pleistocene age.

The carbonate aquifer has an estimated high potential for water-supply development. A significant amount of fractured and faulted carbonate rocks are present. In addition, Spring Valley is part of a known regional flow regime. No exploratory drilling has been conducted in the valley or in the near vicinity.

2.30.3.3 Water Quality

Water-chemistry data for Spring Valley are presented in Appendix F1-30. Fifteen ground- and surface-water samples were collected by Ertec for chemical analyses. The analyses indicate that all samples are within the criteria established for construction use (Appendix E1-1). In addition, all of the constituents analyzed were within Primary and Secondary Drinking Water Standards established by the State of Nevada (Appendix E1-2). The quality of water within Spring Valley is believed to be suitable for both the construction and operational phases of the MX project.

2.30.4 Water-Supply Alternatives

2.30.4.1 Lease or Purchase of Existing Water Rights

There are 27,194 acre-ft/yr (33.5 hm^3/yr) of approved surface-water rights and 21,812 acre-ft/yr (26.9 hm^3/yr) of approved ground-water appropriations in Spring Valley. The lease or purchase of existing surface- or ground-water rights is a viable alternative for obtaining the required water supply for the MX construction and operation.

2.30.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred water-supply source for MX construction and operation in Spring Valley. Based on a perennial yield of 100,000 acre-ft/yr (123.3 hm^3/yr) and 21,812 acre-ft/yr (26.9 hm^3/yr) of certificated and permitted ground water rights, 78,188 acre-ft/yr (96.4 hm^3/yr) are potentially available for MX project use. Aquifer testing and chemical analyses of ground-water samples indicate that the valley fill is a viable source of good quality water. One well pumping continuously at 390 gpm (25 l/s) will be necessary to fulfill MX water requirements for the peak year of construction (629 acre-ft/yr [0.8 hm^3/yr]).

2.30.4.3 Carbonate Aquifer

The regional carbonate aquifer is a viable water-supply alternative but should not be implemented unless other in-valley sources are not available.

2.30.4.4 Interbasin Transfer

The interbasin transfer of water is not a viable water-supply alternative because potential source valleys are not available.

2.30.5 Impacts of Development

2.30.5.1 Intrabasin Effects

Because of the relatively small quantity of water required for the peak year of MX construction (629 acre-feet [0.8 hm^3]) and the criteria used to site production wells, the impacts on existing water users in Spring Valley are expected to be minimal. If water rights are leased or purchased, some agricultural lands may be retired thereby affecting the present land use in Spring Valley. Because of the large quantity of ground water potentially available for appropriation, this impact is not expected to occur.

The potential for affecting springs in Spring Valley as the result of ground-water withdrawals is low. Springs identified in the valley as part of Ertec's reconnaissance were found in the surrounding mountains at elevations above the valley fill. These springs are believed to be derived locally, primarily from carbonate rocks. Regional springs were not identified in Spring Valley. Because the mountain springs are not believed to be derived from the valley-fill aquifer, no impacts are expected to occur as the result of pumping from this unit. In addition, the potential for affecting springs as the result of pumping from the regional carbonate aquifer would also be low because of the local nature of the springs.

2.30.5.2 Interbasin Effects

Interbasin impacts are not expected to occur as the result of ground-water pumping from the valley-fill aquifer. However, in the unlikely event that the carbonate aquifer is utilized as the primary source of water for the MX project, the potential for interbasin impacts will increase. As mentioned in Section 2.1, 4000 acre-ft/yr (4.9 hm^3/yr) of ground water discharges to Hamlin Valley (Nevada State Engineer, 1971). If the carbonate aquifer is designated as the sole water-supply source for the MX project in Spring Valley (requiring 629 acre-feet [0.8 hm^3]), a reduction in subsurface outflow may occur. Insufficient data are available to quantify the amount of impact.

2.31 STEPTOE VALLEY

2.31.1 General Physiography and Hydrology

Steptoe Valley is a north-south trending basin in White Pine County, Nevada. The study area, as defined by this report is approximately 35 miles (56 km) long, averages 15 miles (24 km) in width, and encompasses about 525 mi^2 (1359 km^2). The northern limit of the study area is the town of Ely, Nevada. The study area is bounded by the Schell Creek Range on the east and the Egan Range to the west. The mountain crests range in elevation from about 7000 feet (2134 m) to over 10,000 feet (3048 m). Both ranges are primarily composed of carbonate rocks of Paleozoic age with some minor occurrences of volcanics and igneous intrusives of Tertiary age.

Eakin and others (1967) identified the two principal aquifers within the valley as valley-fill deposits and fractured carbonates of Paleozoic Age. The valley-fill deposits consist of interbedded gravel, sand, silt, and clay. The fractured carbonates underlie the valley-fill deposits and, as indicated above, crop out in the mountain ranges flanking the valley to the east and west.

Steptoe Creek is the only perennial stream in the valley. There is no surface-water inflow to Steptoe Valley. There is, however, approximately 1000 acre-ft/yr (1.2 hm^3/yr) of surface-water outflow to Goshute Valley to the north. Total runoff from the mountains in Steptoe Valley is estimated to be 78,000 acre-ft/yr (96.2 hm^3/yr) (Nevada State Engineer, 1971). There are many local springs in or near the base of the surrounding mountains. Spring discharge rates measured by Ertec in June 1980 ranged from less than 1 gpm (0.06 l/s) to 4600 gpm (290 l/s). Two possible regional springs have been identified, Monte Neva Hot Spring (21N/63E-24) and McGill Spring (18N/64E-21bdd).

Ground-water recharge in Steptoe Valley is from infiltration of streamflow and surface-water runoff from the mountains and mountain springs. The ground-water recharge from precipitation has been estimated at 85,000 acre-ft/yr (104.8 hm^3/yr) (Nevada State Engineer, 1971). Evapotranspiration, estimated at 70,000 acre-ft/yr (86.3 hm^3/yr), occurs in about 223 mi^2 (577 km^2) of the valley (Eakin and other, 1967). Steptoe Valley is a hydrologically open system. There is no surface or ground-water inflow known, but there is an undetermined amount of ground-water outflow and 1000 acre-ft/yr (1.2 hm^3/yr) of surface-water outflow to Goshute Valley (Nevada State Engineer, 1971).

The water table within the valley-fill aquifer slopes northward as well as away from the mountains toward the valley axis (Eakin and others, 1967). Several areas adjacent to Steptoe and Duck creeks were reported to have depths to ground water of less than 20 feet (6 m). Water-level records compiled by the Soil Conservation Service (Cheney, personal communication, 1980) indicate that several perched aquifers exist with ground-water levels about 20 feet (6 m) below land surface. Basinward from these perched aquifers, water levels decline to between 60 to 100 feet (18 to 30 m) below land surface (Appendix Figure B1-31). Records compiled by the U.S. Geological Survey (1979) indicate that ground-water levels in parts of Steptoe Valley declined as much as 20 feet (6 m) during the period from 1954 to 1964. Since that time, however, ground-water levels have recovered to their pre-1954 levels.

2.31.2 MX Water Requirements

The water requirements for the MX construction and operation in Steptoe Valley are presently undefined. The Air Force has filed for 7000 acre-ft/yr (8.6 hm^3/yr) of ground-water appropriations in Steptoe Valley.

2.31.3 Water-Supply Limitations

2.31.3.1 Perennial Yield, Use, and Appropriations

The perennial yield for Steptoe Valley is 70,000 acre-ft/yr (86.3 hm^3/yr) (Nevada State Engineer, 1971). Ground-water use in Steptoe Valley totals 12,497 acre-ft/yr (15.4 hm^3/yr) (DRI, 1980). This usage is divided into 346 acre-ft/yr (0.4 hm^3/yr) for municipal purposes, 163 acre-ft/yr (0.2 hm^3/yr) for domestic purposes, 60 acre-ft/yr (0.07 hm^3/yr) for stock watering, 11,057 acre-ft/yr (13.6 hm^3/yr) for irrigation, and 871 acre-ft/yr (1.1 hm^3/yr) for mining (DRI, 1980). Ground-water rights in the valley include 37,552 acre-ft/yr (46.3 hm^3/yr) in certificates, 11,646 acre-ft/yr (14.4 hm^3/yr) in permits, and 102,429 acre-ft/yr (126.3 hm^3/yr) in pending applications (Woodburn and others, 1981). Included in these water rights are 30,000 acre-ft/yr (37.0 hm^3/yr) filed on behalf of the White Pine Power Project. This action has resulted in the "designation" of Steptoe Valley as a critical ground-water basin by the Nevada State Enginner's Office because the total of approved and pending ground-water appropriations exceeds the estimated perennial yield.

Surface-water use in the Steptoe Valley includes 2526 acre-ft/yr (3.1 hm^3/yr) for municipal purposes, 124 acre-ft/yr (0.2 hm^3/yr) for domestic purposes, 61 acre-ft/yr (0.08 hm^3/yr) for stock watering, and 443 acre-ft/yr (0.5 hm^3/yr) for recreation and wildlife (DRI, 1980). The total surface-water use in Steptoe Valley is 24,231 acre-ft/yr (29.9 hm^3/yr) (DRI, 1980). Surface-water rights in Steptoe Valley are limited to 7627 acre-ft/yr (9.4 hm^3/yr) of permits and pending applications (DRI, 1980).

2.31.3.3 Source Capabilities

The potential for further development of surface water in Steptoe Valley seems very limited. Streams in the valley are all ephemeral with the exception of Steptoe Creek, which is used for stock watering and irrigation.

Estimates of the hydraulic properties of the valley-fill aquifer indicate the transmissivity ranges from 1337 to 13,367 ft^2/day (124 to 1239 m^2/day) (Eakin and others, 1967). Interpretation of available lithologic logs indicates that the valley-fill is under water-table conditions. Based on these data, the valley-fill aquifer is believed to be capable of supplying water for the MX project in Steptoe Valley.

The carbonate aquifer in Steptoe Valley is considered to have a moderate water-supply development potential. An aquifer test performed in the carbonates in the southern part of Steptoe Valley (12N/63E-12ba) provided a transmissivity estimate of 200 ft^2/day (19 m^2/day) and a well yield of 100 gpm (6 l/s). The hydrostratigraphic unit penetrated at this location was the lower Ely Limestone of Pennsylvanian age which, based on Ertec's field investigations, is considered a low yielding aquifer.

2.31.3.4 Water Quality

Water-quality data available for Steptoe Valley are listed in Appendix F1-31. These samples were collected from springs, streams, and wells throughout the basin. Of the 29 water samples, Ertec collected 23, of which 16 were from springs, one from a surface-water source, and five from wells. For the constituents analyzed, the quality of all water samples is suitable for use in construction (Appendix E1-1) and for drinking water use (Appendix E1-2).

2.31.4 Water-Supply Alternatives

2.31.4.1 Lease or Purchase of Existing Water Rights

The purchase or lease of existing water rights is the preferred water-supply alternative for the MX project in Steptoe Valley. At the present time, there are 37,552 acre-ft/yr (46.3 hm^3/yr) of certificated rights and 11,646 acre-ft/yr (14.4 hm^3/yr) of permits for ground water. There is only 12,497 acre-ft/yr (15.4 hm^3/yr) of ground-water use in the valley, leaving approximately 36,700 acre-ft/yr (45.3 hm^3/yr) of appropriated ground-water available for lease or purchase.

2.31.4.2 Valley-Fill Aquifer

The valley-fill aquifer is a viable water-supply alternative for MX construction and operation in Steptoe Valley. The valley-fill aquifer is believed to be capable of supporting the required amount of ground water for the peak year of construction. Well yields of 250 gpm (16 l/s) can be expected.

There are presently 49,198 acre-ft/yr (60.7 hm^3/yr) of approved ground-water rights in Steptoe Valley. Based on a perennial yield of 70,000 acre-ft/yr (86.3 hm^3/yr), approximately 20,802 acre-ft/yr (25.6 hm^3/yr) of unappropriated ground water remains in the valley. This amount is substantially more than that required for the MX program. However, if a substantial portion of the pending applications (102,429 acre-ft/yr [126.3 hm^3/yr]) is approved, additional ground water would not be available for appropriation.

A large portion of the pending applications for ground-water rights have been filed for the White Pine Power Project. Approval of these applications would prevent further appropriations in Steptoe Valley. However, water for the White Pine Power Project will not be needed until about 1990. At that time, water requirements for the MX project should only be for the operational phase and therefore be relatively minor.

2.31.4.3 Carbonate Aquifer

The carbonate aquifer in Steptoe Valley has a moderate potential for development and is thus, a viable water-supply alternative.

2.31.4.4 Interbasin Transfer

Interbasin transfer is a viable water-supply alternative because Spring Valley is a potential source valley. Interbasin transfer should be a low priority alternative.

2.31.5 Impacts of Development

2.31.5.1 Intrabasin Effects

A well pumping continuously at 250 gpm (16 l/s) for two years, under the conditions described in Section 2.3.2 (an average transmissivity of 7352 ft^2/day [681 m^2/day] and a specific yield of 0.1), will produce a drawdown of less than 1 foot (0.3 m) at a distance of 1 mile (2 km) from the pumping center. There should be little effect on spring discharge in Steptoe Valley because the majority of the springs are derived from sources other than the valley fill, are local in nature, and are located at elevations above the valley floor. MX production wells should be setback a minimum of 3 miles (5 km) from all regional springs to avoid potential impact.

2.31.5.2 Interbasin Effects

Interbasin effects are unlikely to occur as a result of ground-water withdrawals in Steptoe Valley. MX ground-water withdrawals are not expected to affect surface-water flow in the valley. Because the quantity of ground-water outflow from Steptoe Valley is believed to be minor, any impacts on this discharge will most likely be minimal in Goshute Valley.

2.32 STONE CABIN VALLEY

2.32.1 General Physiography and Hydrology

Stone Cabin Valley is a north-south trending basin in central Nye County, Nevada. The basin is approximately 52 miles (84 km) long, ranges in width from 10 to 25 miles (16 to 40 km), and encompasses about 985 mi^2 (2550 km^2). The valley floor, at an average elevation of 5700 feet (1737 m), is bounded on the west and north by the Monitor Range, on the east by the Hot Creek and Kawich ranges, and on the south by Cactus Flat. The surrounding mountain ranges attain elevations ranging between 7500 and 9500 feet (2286 and 2896 m).

Surface flow within Stone Cabin Valley is derived from snowmelt runoff, ground-water discharge, and rainfall from infrequent summer storms. Streams are generally ephemeral in nature, except for a few mountain streams that exhibit intermittent flow in their upper reaches. Surface flow from mountain areas is predominantly lost to infiltration on the alluvial fans and serves to recharge the alluvial aquifer.

Stone Cabin Valley is a topographically open basin. Ground-water discharge includes both subsurface outflow and evapotranspiration. About 3000 acre-ft/yr (3.7 hm^3/yr) of ground water discharges southwestward into Ralston Valley through the valley-fill aquifer (Nevada State Engineer, 1971). Evapotranspiration in Stone Cabin Valley is estimated to be 2000 acre-ft/yr (2.5 hm^3/yr) based on the area of major phreatophyte growth near the central portion of the valley (Nevada State Engineer, 1971).

Here, the water table is shallow because of a constriction in the valley and shallow bedrock. The basin is essentially divided into two north-south trending, elongated subbasins. The north-western subbasin receives drainage from about one-half of the valley. The drainage is either evapotranspired near the constriction or drains into the southeastern body of valley-fill sediments. Ground-water recharge in Stone Cabin Valley is derived from precipitation and is estimated to be 5000 acre-ft/yr (6.2 hm^3/yr) (Nevada State Engineer, 1971).

Springs in Stone Cabin Valley occur around the valley margin and are of small discharge. Two of the small springs located on the eastern side of the valley have elevated temperatures and have been identified as possible regional springs.

The mountains surrounding Stone Cabin Valley are composed mostly of volcanics of Tertiary age and shale and limestone of Paleozoic age. The valley fill is composed of surface detritus, sand and gravel, and playa or lacustrine deposits of Quaternary age (Eakin, 1962a).

The potentiometric gradient of Stone Cabin Valley averages about 15 feet/mile (3 m/km) from the northeast to the southwest along the axis of the basin (Appendix Figure B1-32). The depth to water is generally greater than 100 feet (30 m) except in the very center of the valley where relatively shallow water and evapotranspiration occur.

2.32.2 MX Water Requirements

The peak annual demand for water during MX construction is expected to be 2534 acre-feet (3.1 hm^3) in 1986. Construction is projected to begin in 1982 and conclude in 1989. The Air Force has applied for 4152 acre-ft/yr (5.1 hm^3/yr) of ground-water rights from eight points of diversion.

2.32.3 Water-Supply Limitations

2.32.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Stone Cabin Valley is 2000 acre-ft/yr (2.5 hm^3/yr) (Nevada State Engineer, 1971). This value is low compared to the 5000 acre-ft/yr (6.2 hm^3/yr) of ground-water recharge which occurs. The difference between recharge and perennial yield is the underflow southward and westward out of the drainage basin. The extent to which the yields could be increased above the perennial yield would be related largely to the amount of discharge by underflow through bedrock from the valley that could be salvaged. In any event, on a continuing basis, it could not exceed the estimated average annual recharge of 5000 acre-ft/yr (6.2 hm^3/yr). The estimated perennial yield of 2000 acre-ft/yr (2.5 hm^3/yr) represents the quantity of ground water that could be developed without having potential to cause a reduction of the supply in Ralston Valley.

Surface-water use, primarily for irrigation, livestock, and domestic supply, is estimated to be 537 acre-ft/yr (0.7 hm^3/yr) in Stone Cabin Valley. Approved surface-water appropriations total 518 acre-ft/yr (0.6 hm^3/yr) (DRI, 1980). Present ground-water use is estimated to be 970 acre-ft/yr (1.2 hm^3/yr) mainly for irrigation, mining, livestock, and domestic supply (DRI, 1980). Ground-water rights in Stone Cabin Valley include 2673 acre-ft/yr (3.3 hm^3/yr) of certificates, 16 acre-ft/yr (0.02 hm^3/yr) of permits, and 3520 acre-ft/yr (4.3 hm^3/yr) of pending applications (Woodburn and others, 1981).

Ground water is overappropriated in Stone Cabin Valley and the valley has been designated and closed to further ground-water appropriations by the Nevada State Engineer. The peak MX water demand of 2534 acre-feet (3.1 hm^3) would exceed the legally established perennial yield (2000 acre-ft/yr [2.5 hm^3/yr]) by 1477 acre-ft/yr (1.8 hm^3/yr) when considering existing ground-water use and by 4135 acre-ft/yr (5.1 hm^3/yr) when considering approved ground-water rights.

2.32.3.2 Source Capabilities

Surface water occurs near the bedrock/valley-fill boundary as small springs and intermittent streams. Because of the limited amount of surface water and the intermittent nature of flow, surface water is not considered a viable supply source for MX needs.

Limited data are available on the production capability of the valley-fill aquifer. However, the valley-fill aquifer is believed to be a reliable source of good quality water economically obtainable in almost any area of the valley. The estimated transmissivity of the valley-fill aquifer is 4000 ft^2/day (371 m^2/day) which is based on observations of well production for the few wells found in southern Stone Cabin Valley.

The potential for development of the carbonate aquifer in Stone Cabin Valley is low because there are thick sequences of volcanic or intrusive bodies in this area and appropriate carbonate hydrostratigraphic units are not exposed nor are believed to be at drillable depths.

2.32.3.3 Water Quality

Water-quality data for Stone Cabin Valley are shown in Appendix F1-32. All ground water sampled in Stone Cabin Valley meets criteria for construction use (Appendix E1-1). Ground water generally meets Nevada Primary and Secondary Drinking Water Standards (Appendix E1-2). Water-quality analyses from one well and one spring in southern Stone Cabin Valley both exceed primary standards for iron. The spring water also exceeds primary standards for fluoride, manganese, and TDS. The well water may have has a high iron content due to rusted casing. This shallow windmill-driven livestock well was sampled after an unknown period of disuse. The spring was flowing at 0.5 gpm (0.03 l/s) at the time of sampling. The spring discharges from an outcrop of volcanic rock and is probably representative of very localized flow.

2.32.4 Water-Supply Alternatives

2.32.4.1 Lease or Purchase of Existing Water Rights

Because Stone Cabin Valley is a designated ground-water basin, lease or purchase of existing water rights is the preferred water-supply source for MX construction and operation. However, total approved ground- and surface-water rights in the valley are only 3191 acre-ft/yr (3.9 hm^3/yr). Peak year MX water requirements are estimated to be 2534 acre-feet (3.1 hm^3) and thus almost all water rights in the valley would have to be leased or purchased for a short period of time. Since this is an unlikely scenario, lease/purchase should be viewed as only a partial water-supply source.

2.32.4.2 Valley-Fill Aquifer

The valley-fill aquifer is physically a viable water-supply alternative in Stone Cabin Valley but may not be so legally. For the state to authorize additional ground-water appropriations for MX would require a decision to allow ground-water overdraft in the valley for a three- to four-year period of time. If overdraft were allowed, the valley-fill aquifer should be capable of yielding water in sufficient quantities to meet MX requirements.

2.32.4.3 Carbonate Aquifer

The carbonate aquifer is considered to have a very low potential for successful water-supply development and is not viewed as a viable water-supply alternative. However, if no other sources of water for MX construction are available, exploratory drilling and testing would be warranted.

2.32.4.4 Interbasin Transfer

Interbasin transfer of water is a viable water-supply alternative for a portion of MX requirements in Stone Cabin Valley. Of the neighboring valleys, Hot Creek and Ralston may have small amounts of unused ground water which could be developed, leased or purchased and imported to Stone Cabin Valley. Neither potential source valley would have sufficient available ground water to meet total MX requirements in Stone Cabin Valley.

2.32.5 Impacts of Development

2.32.5.1 Intrabasin Effects

Development of MX water supplies through lease or purchase of existing water rights or importation would cause no additional impact to the hydrologic system in Stone Cabin Valley. Development of MX water supplies by increased withdrawals from the valley-fill aquifer (temporary overdraft) would cause localized water-level declines in the valley. The extent of these impacts cannot be evaluated until aquifer testing and numerical modeling are completed.

2.32.5.2 Interbasin Effects

Further development of the valley-fill aquifer in Stone Cabin Valley may affect underflow to Ralston Valley. At present, there are insufficient data to quantify this potential impact. Because of the temporary nature of withdrawals for MX construction, it is anticipated that the effect will be minimal.

2.33 TULE VALLEY

2.33.1 General Physiography and Hydrology

Tule Valley, located in Juab and Millard counties in west-central Utah, is a topographically closed basin with mountain ranges on the east and west and low topographic divides to the north and south. The drainage basin is 65 miles (105 km) long, 8 to 22 miles (13 to 35 km) wide, and encompasses an area of 940 mi^2 (2434 km^2). The average valley floor elevation is approximately 4600 feet (1402 m). The basin is bounded on the east by the House and Fish Spring ranges and on the west by the Confusion Range.

Streamflow in Tule Valley is ephemeral or intermittent. Runoff from mountain streams is lost to infiltration on the alluvial fans where it recharges the ground-water reservoir. Streamflow only reaches the valley floor during intense storms or periods of rapid snowmelt. The average annual runoff at an elevation of 4500 feet (1372 m) in Tule Valley is estimated to be 4000 acre-ft/yr (4.9 hm^3/yr), although this figure may be an underestimate since it does not consider runoff lost to infiltration (Stephens, 1977). The only perennial flow in the valley is provided by numerous small springs around the valley margin and a group located in the north-central valley floor. These springs in the center of the valley are believed to indicate the presence of a fault zone. The discharge from these springs ranges from 0.1 to 100 gpm (0.01 to 6 l/s) (Stephens, 1977). Two of these springs, for which temperature and water chemistry data exist, have been classified as possible regional springs.

Ground-water recharge in Tule Valley is estimated to be 7600 acre-ft/yr (9.4 hm^3/yr) from precipitation and 32,000 acre-ft/yr (39.4 hm^3/yr) from subsurface inflow. This latter figure is based on an imbalance in the ground-water budget (Stephens, 1977). The regional potentiometric surface suggests that inter-basin flow is occurring from Ferguson Desert and Wah Wah Valley, although a quantitative analysis of this inflow is not possible with data presently available.

Discharge is largely from evapotranspiration and was calculated by Stephens (1977) to be 40,000 acre-ft/yr (49.3 hm^3/yr). Ground water in the valley-fill aquifer flows away from the principal recharge areas at the valley margins toward the northern playa with a hydraulic gradient of 3 feet/mile (1 m/km) (Appendix Figure B1-33). Below 4425 feet (1349 m), most of the valley floor is perennially saturated, and the ground water discharges directly from the water table by spring flow and evapotranspiration.

A north-south trending fault along the western base of the House Range may be a sink for water moving through the valley-fill and carbonate aquifers in Tule Valley. This major fault, which forms Sand Pass, a narrow divide separating the Fish Springs and House ranges along the north and east side of the valley and extends northward along the eastern base of the Fish Springs Range (Stokes, 1964), may be a significant conduit for ground-water movement into and out of the valley. If this is so, the volume of water moving through Tule Valley may be considerably larger than the estimates given above.

The mountains surrounding Tule Valley are composed primarily of carbonate rocks of Mesozoic and Paleozoic age. Minor amounts of younger igneous rocks occur throughout the ranges. Numerous outcrops of carbonate rocks protrude through the valley-fill deposits. The valley-fill deposits consist of interfingered alluvial and lacustrine sediments. As a result, water in this aquifer probably occurs under locally confined and unconfined conditions.

2.33.2 MX Water Requirements

The peak annual demand for water during MX construction is expected to be 2447 acre-feet (3.0 hm^3) in 1986. Construction is projected begin in 1983 and conclude in 1990. The Air Force has filed applications for ground-water appropriations totaling 4146 acre-ft/yr (5.1 hm^3/yr) from eight points of diversion.

2.33.3 Water-Supply Limitations

2.33.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of Tule Valley is estimated to be 32,000 acre-ft/yr (39.4 hm^3/yr) (Price, 1979) based on the water budget calculations of Stephens (1977). Total water use in the valley is 33 acre-ft/yr (0.04 hm^3/yr), of which 20 acre-ft/yr (0.02 hm^3/yr) is ground water and 13 acre-ft/yr (0.02 hm^3/yr) is surface water (UWRL, 1980). Surface-water appropriations, in the form of certificates and proofs, total 2186 acre-ft/yr (2.7 hm^3/yr), and an additional 53 acre-ft/yr (0.07 hm^3/yr) are held in the form of permitted rights or as applications pending approval (UWRL, 1980). Fifty acre-ft/yr (0.06 hm^3/yr) in certificates and proofs have been issued for ground water. Ground-water permits and applications pending approval total 53 acre-ft/yr (0.07 hm^3/yr) (UWRL, 1980).

The quantity of ground water available for the MX project is approximately equal to the perennial yield of 32,000 acre-ft/yr (39.4 hm^3/yr) because of the minimal levels of current use and approved ground-water appropriations.

2.33.3.2 <u>Source Capabilities</u>

Streamflow in Tule Valley is very limited and intermittent. The meteoric springs in the House and Confusion ranges do not represent a dependable source of water for the MX project because they are relatively inaccessible and have a total discharge estimated to be less than 100 acre-ft/yr (0.1 hm^3/yr). The potential of the springs in the northern valley floor is uncertain. No attempt was made by Ertec to measure the discharge of these springs because they flow directly into areas of standing surface water. The flow of these springs, together with direct discharge from the saturated zone, has been estimated at 40,000 acre-ft/yr (49.3 hm^3/yr) (Stephens, 1977). Salvage of a portion of this water may be feasible.

Two Air Force valley-fill aquifer test wells have been drilled in Tule Valley. The test well in the southern portion of the valley (C-20-14)6dd1 was pumped at a discharge rate of 50 gpm (3 l/s) for 72 hours. Recovery data were collected for an additional 36.7 hours. Maximum drawdown in the test well was 296 feet (90 m). Mechanical difficulties with the pump which resulted in numerous discharge variations and subsequent adjustments made the data collected unreliable and analysis inappropriate.

The second test well, in the northern portion of Tule Valley (C-17-15)17ca1, was pumped at a constant discharge of 255 gpm (16 l/s) for five days with a maximum drawdown of 0.96 feet (0.3 m). The drawdown data collected during the pumping and recovery period of the test are erratic and inconclusive. No calculation of transmissivity or storativity has been made.

Lithologic logs for the test wells in Tule Valley indicate that water-table conditions exist in the valley-fill aquifer. Well yields of over 350 gpm (22 l/s) are anticipated from wells in areas of coarse-grained material on the alluvial fans.

The carbonate aquifer is considered to have a moderate potential for water-supply development. Appropriate carbonate hydrostratigraphic units are present, and volcanic and intrusive rocks units are not present in abundance.

2.33.3.3 Water Quality

Water-chemistry data for Tule Valley are presented in Appendix F1-33. Water-quality analyses of samples from 10 springs and eight wells in the valley indicate that all of the waters sampled have TDS concentrations of less than 2000 mg/l and are within the criteria for construction use (Appendix E1-1).

One sample from a well in the north-central portion of the valley (C-16-16)34bcd exceeds the State of Utah Primary Drinking

Water Standards (Appendix E1-3) for sulfate and nitrate. High concentrations of these ions would be expected in water which has flowed through playa and lacustrine deposits, such as those which occur in the northern portion of Tule Valley. Water samples from the Air Force test well in the central part of the Tule Valley (C-17-15)17ca1 also showed levels of sulfate (820 and 910 mg/l) in excess of the Utah Primary Drinking Water Standards for this constituent.

2.33.4 Water-Supply Alternatives

2.33.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of existing water rights is not a viable water-supply alternative for MX construction in Tule Valley. Approved ground-water rights total only 50 acre-ft/yr (0.06 hm^3/yr). A significant amount of approved surface-water rights are available, but the sources are too scattered to be a viable water supply.

2.33.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred water-supply source for MX construction. Only a small portion of the 32,000 acre-ft/yr (39.4 hm^3/yr) has been appropriated, and studies completed to date indicate that the aquifer is capable of supplying water in sufficient quantity and quality necessary to meet the MX requirements.

2.33.4.3 Carbonate Aquifer

The carbonate aquifer in Tule Valley is a viable water-supply alternative but should only be developed if other in-valley sources prove inadequate or unavailable.

2.33.4.4 Interbasin Transfer

Interbasin transfer of water to Tule Valley is a viable water-supply alternative but should be considered low priority. Snake Valley is the potential source valley.

2.33.5 Impacts of Development

2.33.5.1 Intrabasin Effects

MX water withdrawals will be minor compared to the perennial yield of the valley and only a minimal lowering of water levels is anticipated. At the present time, ground-water use in the valley consists of widely separated stock-watering wells. It should be possible to avoid any detrimental impacts on these users by appropriate location of MX production wells.

The MX water withdrawals may slightly reduce ground-water flow to the playa area in the north of the valley and hence decrease water lost by spring discharge and evapotranspiration. The major springs in the valley, however, do not appear to be part of the valley-fill system, and the project should have no effect on their discharge. The springs in the House and Confusion ranges are located above the valley-fill and are derived from local precipitation. The springs in the north-central valley floor discharge water which appears to have moved upward through a fault zone from a deeper aquifer.

2.33.5.2 Interbasin Effects

A small amount of subsurface flow may occur from Tule Valley to Fish Springs Flat. The development of water from the valley-fill aquifer should have little impact on this discharge because of the limited magnitude of MX withdrawals as compared to the valleys perennial yield.

2.34 WAH WAH VALLEY

2.34.1 General Physiography and Hydrology

Wah Wah Valley is a north-south trending basin in Millard and Beaver counties, Utah. It is topographically closed, with the San Francisco Mountains on the east, the Wah Wah Mountains on the west and southwest, the Confusion and House ranges on the north, and a broad, low ridge on the northeast which separates Wah Wah Valley from the Sevier Lake basin. The mountain crests range in elevation from approximately 6000 to 9660 feet (1829 to 2944 m). The average valley-floor elevation is about 4800 feet (1463 m). Wah Wah Valley is approximately 44 miles long (71 km), 21 miles (34 km) across at its widest point, and encompasses 600 mi^2 (1553 km^2).

Precipitation in the drainage basin is estimated to average 290,000 acre-ft/yr (357.6 hm^3/yr). Of this, approximately 97 percent is lost to evapotranspiration and about 7800 acre-ft/yr (9.6 hm^3/yr) occur as surface-water runoff (Stephens, 1974). Ground-water recharge from the infiltration of precipitation is estimated at 7000 acre-ft/yr (8.6 hm^3/yr), and recharge from ground-water inflow from Pine Valley is approximately 3000 acre-ft/yr (3.7 hm^3/yr) (Stephens, 1974). Discharge by evapotranspiration is approximately 40 acre-ft/yr (0.05 hm^3/yr) along stream channels and 600 acre-ft/yr (0.7 hm^3/yr) from the Wah Wah Springs discharge area. Ground-water discharge from wells and springs includes 52 acre-ft/yr (0.06 hm^3/yr) from alluvium and 58 acre-ft/yr (0.07 hm^3/yr) from non-carbonate rocks (Stephens, 1974). Approximately 8500 acre-ft/yr

($10.5\ hm^3/yr$) of ground-water outflow is believed to discharge from Wah Wah Valley to Tule Valley and the Sevier Lake drainage basin in the north (Stephens, 1974).

Wah Wah Springs, located on the west side of the valley ([C-27-15]11aba) are the only large springs which occur. This spring group has been identified as regional. All other springs in the valley are small meteoric springs located along the mountain margins.

The potentiometric surface of the valley-fill aquifer in Wah Wah Valley ranges in elevation from about 4500 feet (1372 m) in the south to about 4460 feet (1559 m) in the north (Appendix Figure B1-34). The hydraulic gradient in the valley is approximately 5 feet/mile (1 m/km) to the north. The depth to ground water in the valley ranges from about 500 feet (152 m) below land surface in the southern end of the valley to about 200 feet (61 m) below land surface in the north.

The valley-fill aquifer has been estimated to be about 2400 feet (732 m) thick (Mower and Cordova, 1974). The valley fill consists of interlayered and interfingered alluvial fan, channel, and lacustrine deposits consisting of gravel, sand, silt, and clay. The deposits are unconsolidated to partly consolidated clastic material of Tertiary to Quaternary age (Stokes, 1964).

The bedrock which crops out in the mountains underlies the valley-fill aquifer. The Wah Wah Mountains are mainly composed of limestone and dolomite of Paleozoic age, with some extrusive igneous rocks of Tertiary age. The San Francisco Mountains are primarily metasedimentary rocks of Precambrian age with some carbonate and sedimentary quartzitic rocks of Paleozoic age in the north and primarily extrusive and intrusive igneous rocks of Tertiary age to the south (Stokes, 1964).

2.34.2 MX Water Requirements

The peak annual demand for water during MX construction is expected to be 3228 acre-feet (4.0 hm^3) in 1984. Construction is projected to begin 1983 and conclude in 1987. In July 1980, the Air Force filed for 3801 acre-ft/yr (4.7 hm^3/ yr) of ground-water appropriations in Wah Wah Valley from seven points of diversion.

2.34.3 Water-Supply Limitations

2.34.3.1 Perennial Yeild, Use, and Appropriations

The perennial yeild of Wah Wah Valley is estimated to be less than 10,000 acre-ft/yr (12.3 hm^3/yr) (Price, 1979). Ground-water use is estimated at 2 acre-ft/yr (0.002 hm^3/yr) for live-stock watering (UWRL, 1980). Possible future ground-water use is estimated at 32 acre-ft/yr (0.04 hm^3/yr) for alunite ore mining and 8180 acre-ft/yr (10.1 hm^3/yr) for alumina processing (UWRL, 1980). There are 34 acre-ft/yr (0.04 hm^3/yr) of approved ground-water appropriations (certificates and proofs) for stock watering in Wah Wah Valley. In addition, there are a total of 32,576 acre-ft/yr (40.2 hm^3/yr) of pending ground-water applications for mining activities (DRI, 1980), however, the consortium which developed plans for producing alumina has broken up and presently there are no plans for a mining and construction phase (UWRL, 1980).

Surface-water use in Wah Wah Valley is 50 acre-ft/yr (0.06 hm^3/yr) for livestock (UWRL, 1980), however, reconnaissance by Ertec indicates that some land is being irrigated near the Wah Wah Range. There are surface-water permits and applications for 903 acre-ft/yr (1.1 hm^3/yr) which includes 875 acre-ft/yr (1.1 hm^3/yr) for irrigation and 28 acre-ft/yr (0.04 hm^3/yr) for stock watering. Certificates for surface water in Wah Wah Valley total 251 acre-ft/yr (0.3 hm^3/yr) which include 168 acre-ft/yr (0.2 hm^3/yr) for irrigation and 83 acre ft/yr (0.1 hm^3/yr) for stock watering.

The quantity of ground water available for MX use, when considering existing water use, is approximately the perennial yield (<10,000 acre-ft/yr [12.3 hm^3/yr]). The amount of groundwater available is less than 9966 acre-ft/yr (12.3 hm^3/yr) when considering approved appropriations.

2.34.3.2 Source Capabilities

Wah Wah Springs, in the southwestern portion of the valley, discharge approximately 800 acre-ft/yr (1.0 hm^3/yr). These springs are the only significant surface-water source in the valley and they do not represent a sufficient water supply to meet MX requirements.

An Air Force valley-fill aquifer test well was drilled in the southern portion of the valley at (C-27-14)28dd1. Test results indicate a transmissivity of 12,000 ft^2/day (1112 m^2/day) and a storativity of 0.1. The well sustained a discharge of 375 gpm (24 l/s) with 194 feet (59 m) of drawdown. The static water level was fairly deep, about 565 feet (172 m). Although pumping lifts in the valley may be greater than other MX candidate valleys, the valley-fill aquifer appears capable of meeting MX requirements.

There are little data on the carbonate aquifer in Wah Wah Valley. The aquifer has an estimated low potential for water-supply development because of the occurrence of significant aquitards within Paleozoic section and the predominance of volcanic and intrusive rocks in certain of the surrounding ranges.

2.34.3.3 Water Quality

Water-chemistry data for Wah Wah Valley are listed in Appendix F1-34. Of the samples available, 10 were from springs, nine were from wells, and two were from mines. Seven of the samples exceeded Primary and Secondary Drinking Water Standards for the State of Utah (Appendix E1-3) as shown in Table 2.34.1. Two of the samples also exceeded recommended criteria for TDS for concrete mixing (Appendix E1-1).

Only one sample from the valley-fill aquifer in the northern portion of the valley was analyzed (well [C-24-13]34ccb1) and it exceeded the recommended TDS level for concrete and the Utah Secondary Drinking Water Standard for chloride. The water which exceeded drinking water standards in the southern half of the valley was primarily from igneous rocks in the southeast and at

TABLE 2.34.1 SAMPLE LOCATIONS IN WAH WAH VALLEY THAT EXCEED WATER-QUALITY CRITERIA

LOCATION	SOURCE	PRIMARY STANDARD EXCEEDED	SECONDARY STANDARD EXCEEDED	CONSTRUCTION STANDARD EXCEEDED
(C-24-13)34ccb1	Well	TDS (1600mg/l*)	Chloride (670 mg/l)	
(C-27-13)9aba	Mine Drain	Sulfate (1600 mg/l*) TDS (3240 mg/l)	Chloride (600 mg/l)	TDS (3240 mg/l)
(C-27-13)14dcd	Mine	Nitrate (73 mg/l) TDS (1650 mg/l*)	Iron (.45 mg/l) Manganese (.19 mg/l) Chloride (420 mg/l)	
(C-27-13)26caa	Spring	Nitrate (11 mg/l)	Chloride (300 mg/l)	
(C-28-13)18adb	Spring	Nitrate (10 mg/l)	Iron (.35 mg/l) Manganese (.05 mg/l)	
(C-28-15)25ccc	Spring	Sulfate (710 mg/l) TDS (4550 mg/l)	Manganese (.30 mg/l) Chloride (2100 mg/l)	TDS (4550 mg/l)
(C-29-15)2dad	Spring	TDS (1170 mg/l*)	Manganese (.20 mg/l) Chloride (360 mg/l)	

* If TDS is greater than 1000 mg/l, the supplier shall show to the state that no better water is available. The state shall not allow the use of an inferior source of water if a better source is available (Utah State Bureau of Environmental Health).

the extreme southern end of the valley. Water samples from the valley-fill aquifer in the southern portion of the valley are within criteria for construction and domestic use.

2.34.4 Water Supply Alternatives

2.34.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of existing water rights is not a viable water-supply alternative for MX construction in Wah Wah Valley. Approved appropriations for ground and surface water are only 34 acre-ft/yr (0.04 hm^3/yr) and 251 acre-ft/yr (0.3 hm^3/yr), respectively.

2.34.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred water-supply source for MX construction and operation. Aquifer tests conducted indicate that it is capable of supplying water at the rate necessary and in sufficient quantities to meet MX requirements. Sufficient ground water is available for appropriation considering the perennial yield and existing use or approved appropriations.

2.34.4.3 Carbonate Aquifer

The carbonate aquifer in Wah Wah Valley has an estimated low potential for water-supply development and is not considered a viable water-supply alternative.

2.34.4.4 Interbasin Transfer

Interbasin transfer of water from Snake Valley into Wah Wah Valley is a viable water-supply alternative. This alternative should be pursued only if supply sources in Wah Wah Valley are not available.

2.34.5 Impacts of Development

2.34.5.1 Intrabasin Effects

Computer simulation of MX pumping in Wah Wah Valley for a five-year construction period has been completed. Seven wells were pumped at maximum rates of 265 gpm (17 l/s). Maximum drawdown occurred at the end of the fourth year and was less than 1 foot (0.3 m) at a distance of 1 mile (2 km) from any individual well. A transmissivity of 12,000 ft^2/day (112 m^2/day) and a storativity of 0.05 were used in the model.

There should be little effect on spring discharge in Wah Wah Valley because the majority of the springs are locally derived and occur above the valley-fill aquifer. Wah Wah Springs are the only regional springs in the valley. MX wells should be located a minimum of 3 miles (5 km) from these springs to avoid any adverse impacts.

2.34.5.2 Interbasin Effects

Water levels and spring discharge could be affected in Tule Valley because it is downgradient and receives underflow from Wah Wah Valley. There are not enough data available to quantify what, if any, the effects will be.

2.35 WHIRLWIND VALLEY

2.35.1 General Physiography and Hydrology

Whirlwind Valley is located in Millard County, Utah. The valley is open to the Sevier Desert to the southeast and is separated by a low topographic divide from Fish Springs Flat and Dugway Valley to the north. The valley is 25 miles (40 km) long, 33 miles (53 km) across at its widest point, and encompasses 792 mi^2 (2050 km^2). Whirlwind Valley is bounded on the east by Sevier Desert, on the northeast by Little Drum and Drum Mountains, and on the west by the Swasey Mountains and the House Range. The average elevations in the mountains range between 6000 and 8000 feet (1829 and 2438 m). The average elevation of the valley floor is 5000 feet (1524 m).

There are no perennial streams in Whirlwind Valley. Surface runoff is rapidly lost to infiltration on alluvial fans and the valley floor. Local springs issue from the clastic rocks of Paleozoic age and from the volcanic rocks of Tertiary age in the mountainous areas. No springs occur on the valley floor.

Ground-water recharge is derived from infiltration of runoff and subsurface flow through the southern portion of the study area from the Sevier Desert. Ground-water discharge is primarily from pumping wells, evapotranspiration, and discharge from springs. The depth to water varies from more than 250 feet (76 m) along the axis of the valley to less than 25 feet (8 m) in the northeastern portion of the study area (Appendix Figure B1-35).

The valley fill is composed of consolidated to unconsolidated deposits of clay, silt, and gravel deposited under subaerial and lacustrine conditions during Tertiary and Pleistocene time. Lake Bonneville shoreline deposits, terraces, and cliffs are present on the lower alluvial slopes (Mower and Feltis, 1968). Gravity surveys conducted by Ertec indicate that the valley-fill deposits are more than 2000 feet (610 m) thick in Whirlwind Valley on the western edge of the Sevier Desert.

The mountains bordering Whirlwind Valley are composed of undifferentiated sedimentary and metamorphic rocks of Precambrian to Cretaceous age. Volcanic rocks of Tertiary age are also exposed in the Little Drum and Drum mountains (Mower and Feltis, 1968).

2.35.2 MX Requirements

The peak annual demand for water during MX construction is expected to be 2712 acre-feet (3.3 hm^3) in 1984. Construction is projected to begin in 1983 and conclude in 1989. The Air Force has filed applications for appropriation of 3685 acre-ft/yr (4.5 hm^3/yr) of ground water from eight points of diversion.

2.35.3 Water-Supply Limitations

2.35.3.1 Perennial Yield, Use, and Appropriations

Perennial yield has not been estimated for Whirlwind Valley. The valley is included within the Sevier Desert area for which Ertec estimated the perennial yield to be 24,500 acre-ft/yr (30.2 hm^3/yr). Present water use in Whirlwind Valley is primarily for stock watering and domestic purposes. Surface-water use is estimated to be 4 acre-ft/yr (0.005 hm^3/yr) while ground water use is 24 acre-ft/yr (.03 hm^3/yr) (UWRL, 1980). No information is available at this time on water rights in the study area. Since this area is considered part of the larger Sevier Desert ground-water basin, the present use in Sevier Desert must be considered when determining water availability. Existing use in the Sevier Desert ground-water basin exceeds the estimate for the perennial yield and the Utah State Engineer is not allowing further appropriation of ground water.

2.35.3.2 Source Capabilities

Surface flows from ephemeral streams and small springs in Whirlwind Valley cannot be considered a dependable source of water for MX use. Most of the springs sources are appropriated and diverted by local users.

Based on existing wells, the valley-fill aquifer can be considered a reliable source of water in those portions of the Whirlwind Valley study area that border Sevier Lake and Sevier Desert. An Air Force valley-fill aquifer test well was drilled in the northern part of Whirlwind Valley ([C-15-12]19ad). Results of testing indicate a very low transmissivity in that area. The test well was only able to sustain a discharge of 7 gpm (0.4 l/s) with 101 feet (31 m) of drawdown. The static water level in the well was 797 feet (243 m).

The carbonate aquifer in Whirlwind Valley is considered to have a low to moderate potential for development as a water-supply source. Appropriate carbonate hydrostratigraphic units are present, but only in limited amounts.

2.35.3.3 Water Quality

Water-chemistry data for Whirlwind Valley are presented in Appendix F1-35. Chemical analyses of samples collected from two springs and one well in the area indicate that the quality of ground water is within acceptable limits for construction use and Utah State Primary and Secondary Drinking Water Standards (Appendices E1-1 and E1-3). These samples were collected in the northern area of the valley. Mower and Feltis (1968) reported that ground water from two wells in Whirlwind Valley had TDS concentrations in excess of 2000 mg/l and one well had a TDS of 1960 mg/l. One well was located in the center of the area in Soap Wash while the other two wells were in the northern portion of the study area.

2.35.4 Water-Supply Alternatives

2.35.4.1 Lease or Purchase of Existing Water Rights

Lease or purchase of existing water rights is the preferred water-supply source for MX construction in Whirlwind Valley. Whirlwind Valley is considered to be part of the Sevier Desert basin and, as such, is subject to any restrictions on that basin. At present, the Utah State Engineer considers both surface- and ground-water sources to be fully appropriated.

2.35.4.2 Valley-Fill Aquifer

The valley-fill aquifer is a viable water-supply source for MX construction and operation only if the Utah State Engineer allows temporary appropriations in excess of perennial yield. Previous data indicate that the valley-fill aquifer of the

Sevier Desert basin in southern Whirlwind Valley is capable of producing water at the rates required for MX purposes. The northern portion of the valley should be avoided. Water quality may be a localized constraint in any part of the valley.

2.35.4.3 Carbonate Aquifer

The carbonate aquifer in Whirlwind Valley is a viable water-supply alternative but should only be considered if no other source of water is available.

2.35.4.4 Interbasin Transfer

Interbasin transfer of water from adjacent basins can be considered a viable alternative since some of those basins, such as Fish Springs and Dugway to the north, are not considered water-short areas and have more than enough ground-water resources to meet current demands in those areas. However, it will probably not be necessary to use this alternative because the valley-fill aquifer in the Sevier Desert basin is capable of delivering sufficient water to meet MX requirements.

2.35.5 Impacts of Development

2.35.5.1 Intrabasin Effects

It is anticipated that about six wells pumping at 300 gpm (19 l/s) would be required to deliver the necessary quantity of water for MX construction. Existing data on the valley-fill aquifer in Whirlwind Valley are not sufficient to permit quantification of the drawdown that would result from MX production wells. If MX water supplies are obtained by lease or purchase of existing water rights, overall impact to the hydrologic system would not be increased.

2.35.5.2 Interbasin Effects

No additional impacts to valleys receiving underflow from Whirlwind Valley will occur if MX water requirements are met through the lease or purchase of existing water rights.

2.36 WHITE RIVER VALLEY

2.36.1 Generaly Physiography and Hydrology

White River Valley is a north-south trending basin in Nye, Lincoln, and White Pine counties, Nevada. The valley is approximately 100 miles (161 km) long and 35 miles (56 km) across at the widest point. White River Valley has an area of 1607 mi^2 (4161 km^2). The average elevation of the valley floor is about 5400 feet (1646 m).

White River, the major drainage in the valley, is perennial north of Lund, Nevada, as the result of runoff from the surrounding mountains and discharge from springs. A number of other ephemeral and intermittent streams derived from similar sources are also present in the valley.

Springs are present in both the surrounding mountains and on the valley floor. All of the springs are believed to be derived from either carbonate or volcanic rocks. Many of valley springs have significant discharge. A number of these springs (Mormon Hot Spring, 9N/61E-32dba; Moon River Spring, 6N/60E-25acb; Hot Creek Spring, 6N/61E18da, etc.) have been classified on the basis of discharge, temperature, and water chemistry as regional springs. These springs are believed to be discharge points for the White River regional ground-water flow system (Kellogg, 1964).

Ground water in White River Valley is found in both the valley-fill and carbonate bedrock. Ground-water recharge is estimated to be 38,000 acre-ft/yr (46.9 hm^3/yr) from the infiltration of precipitation into the valley-fill and 39,000 acre-ft/yr (48.1 hm^3/yr) by underflow from Long, Jakes, and Cave valleys through the regional carbonate aquifer (Nevada State Engineer, 1971). Ground-water discharge is estimated to be 37,000 acre-ft/yr (45.6 hm^3/yr) by evapotranspiration and 40,000 acre-ft/yr (49.3 hm^3/yr) by underflow southward to Pahranagat Valley through the carbonate aquifer (Nevada State Engineer, 1971).

The depth to ground water in White River Valley ranges from about 10 to 150 feet (3 to 46 m) below land surface, with the shallowest depths found along the valley axis. Ground water is found at depths of less than 50 feet (15 m) in approximately 40 percent of the valley.

The potentiometric surface of the valley-fill aquifer in White River Valley ranges from 5800 feet (1768 m) in the north to 5000 feet (1524 m) in the south (Appendix Figure B1-36). Ground-water flow in White River Valley is southerly, with a hydraulic gradient of approximately 11 feet/mile (2 m/km).

The valley-fill aquifer in White River Valley consists of lacustrine deposits of late Tertiary age, recent stream-channel deposits, and intermediate and younger age alluvial fans. The lacustrine deposits are concentrated along the valley axis, occupying 50 percent of the valley's surface area. The permeability of these deposits is generally very low. The intermediate alluvial fans are found along the valley margins and occupy about one-sixth of the valley. Because these sediments consist mainly of poorly sorted, gravelly sand, the permeability of the intermediate alluvial fans is also low. The younger alluvial fans and modern stream-channel deposits have the highest permeability in White River Valley. These deposits are downslope from the intermediate fans and occupy about one-third of the valley.

Carbonate rocks of Paleozoic age, which exceed a thickness of 30,000 feet (9144 m), are believed to underlie much of the valley fill in White River Valley (Kellogg, 1963). Carbonate rocks of Devonian age have been identified as the regional aquifer in the White River flow system. These rocks are believed to be in excess of 8200 feet (2499 m) thick and have the highest capabilities of all the carbonates of Paleozoic age to transmit water.

2.36.2 MX Water Requirements

The peak annual water demand for MX construction in White River Valley is expected to be 2384 acre-feet (2.9 hm^3) in 1984. Construction is projected to occur from 1983 to 1988. The Air Force has applied for 3810 acre-ft/yr (4.7 hm^3/yr) of groundwater rights to meet the needs of MX construction and operation.

2.36.3 Water-Supply Limitations

2.36.3.1 Perennial Yield, Use, and Appropriations

The perennial yield of White River Valley has been estimated to be 37,000 acre-ft/yr (45.6 hm^3/yr) by the Nevada State Engineer (1971). Total water use in the valley is estimated to be 29,795 acre-ft/yr (36.7 hm^3/yr) of which 24,523 acre-ft/yr

(30.2 hm^3/yr) are surface water and 5272 acre-ft/yr (6.5 hm^3/yr) are ground water (DRI, 1980).

Surface-water use is divided into 54 acre-ft/yr (0.07 hm^3/yr) for domestic purposes, 101 acre-ft/yr (0.1 hm^3/yr) for stock watering, 14,740 acre-ft/yr (18.2 hm^3/yr) for irrigation, 2172 acre-ft/yr (2.7 hm^3/yr) for energy, and 7456 acre-ft/yr (9.2 hm^3/yr) for recreation and wildlife (DRI, 1980). At the present time, there are 45,291 acre-ft/yr (55.8 hm^3/yr) of surface-water certificates and proofs (DRI, 1980). An additional 8061 acre-ft/yr (9.9 hm^3/yr) of permitted rights and applications for appropriations also exist (DRI, 1980).

Ground-water use in White River Valley is estimated at 4 acre-ft/yr (0.005 hm^3/yr) for domestic purposes, 8 acre-ft/yr (0.01 hm^3/yr) for stock watering, and 5260 acre-ft/yr (6.5 hm^3/yr) for irrigation (DRI, 1980). Ground-water rights in White River Valley are divided into 16,183 acre-ft/yr (20.0 hm^3/yr) of certificates and proofs, 4964 acre-ft/yr (6.1 hm^3/yr) of permits, and an additional 144,382 acre-ft/yr (178.0 hm^3/yr) of pending applications for ground-water appropriations (Woodburn and others, 1981).

Based on the values of total ground-water use (14,540 acre-ft/yr [17.9 hm^3/yr]) and the perennial yield (37,000 acre-ft/yr [45.6 hm^3/yr]), approximately 22,460 acre-ft/yr (27.7 hm^3/yr) of ground water are not being utilized in the valley. The amount of ground water available based on perennial yield and approved appropriations is 15,853 acre-ft/yr (19.5 hm^3/yr).

2.36.3.2 Source Capabilities

Many perennial and intermittent streams are present in White River Valley. Most of this streamflow is appropriated. The springs present on both the valley floor and along the surrounding mountains represent a significant water-supply source in White River Valley. Because of the large quantity of surface-water rights that exist, spring discharge is assumed to be entirely appropriated and used in White River Valley.

Specific capacity tests performed on existing wells in White River Valley indicated transmissivities of 250 to 8000 ft^2/day (23 to 744 m^2/day). The areas that exhibit higher transmissivity values seem to correspond with the younger alluvial and modern stream-channel deposits discussed in Section 2.36.1. Because poorly sorted materials are found along the valley margins and fine-grained materials are found along the axis, the area between these zones is best suited for MX ground-water withdrawals. Based on interpretation of the lithology of the basin, the valley-fill aquifer is believed to be unconfined. The relatively shallow depth to ground water and the transmissive characteristics of the aquifer indicate that a substantial water supply can be developed from the valley fill.

White River Valley is a major discharge location for the regional carbonate aquifer. The presence of regional springs on the valley floor and water chemistry data indicate that ground water discharges upward from the carbonates into the valley fill. The regional carbonate aquifer is considered to have a high potential for water-supply development.

2.36.3.3 Water Quality

Water-chemistry data for White River Valley are presented in Appendix F1-36. All ground water sampling sites in the valley meet the criteria for water used for construction (Appendix E1-1) except for one well (5N/60E-24d). Nevada Primary Drinking Water Standards (Appendix E1-2) are also exceeded in this well for TDS, chloride, sulfate, and fluoride. Based on the available data, ground water in White River Valley is believed to be generally of suitable quality for construction and drinking water use.

2.36.4 Water-Supply Alternatives

2.36.4.1 Lease or Purchase of Existing Water Rights

The lease or purchase of existing water rights is a viable water-supply alternative for the MX project in White River Valley. Approved surface- and ground-water rights are 45,291 acre-ft/yr (55.8 hm^3/yr) and 16,183 acre-ft/yr (20.0 hm^3/yr), respectively.

2.36.4.2 Valley-Fill Aquifer

The valley-fill aquifer is the preferred source of water for the MX project. The relatively shallow depth to ground water and high transmissivity in much of the valley indicate that substantial quantities of water can be withdrawn from the valley fill. A total of 15,853 acre-ft/yr (19.5 hm^3/yr) of ground water in White River Valley is not subject to approved appropriation. The quantity is more than sufficient to meet MX water requirements for construction and operation.

2.36.4.3 Carbonate Aquifer

The carbonate aquifer in White River Valley is a viable water-supply alternative because of its high potential for water-supply development. The occurrence of several regional springs on the valley floor suggests some degree of communication between the valley-fill and carbonate aquifers.

2.36.4.4 Interbasin Transfer

The interbasin transfer of water into White River Valley is a viable alternative for obtaining water for the MX project but should be given a low priority. Railroad Valley adjoins White River Valley to the west and is a potential source for importation.

2.36.5 Impacts of Development

2.36.5.1 Intrabasin Effects

Development of MX water supplies from the valley-fill aquifer will require six wells pumping continuously at 250 gpm (16 l/s) to achieve the peak-year, ground-water demand (2384 acre-feet [2.9 hm^3]) in 1984. Drawdowns asssociated with MX production wells cannot be accurately assessed at this time because of the lack of specific aquifer test data and a completed numerical model of the ground-water system.

The lease or purchase of existing water rights will minimize MX ground-water withdrawals from the valley-fill or carbonate aquifers. The lease/purchase approach may, however, affect land use in White River Valley. Ground-water currently being utilized for other purposes, such as agriculture, may be diverted to the MX project. Some agricultural lands may be retired, resulting in economic and other changes in the valley. These secondary type of impacts will occur only if water that is currently being used is leased or purchased. If the Air Force acquires unused but appropriated water, there should be no retirement of land.

The effects of MX ground-water withdrawals on springs in White River Valley are expected to be minor. Many of these springs are derived from the carbonate aquifer and therefore are not expected to be severely affected by pumping from the valley fill. MX production wells should be setback a minimum of 3 miles (5 km) from any regional spring to minimize the potential for impact.

2.36.5.2 Interbasin Effects

The interbasin impacts of ground-water withdrawals in White River Valley for the MX project are expected to be minimal. The Nevada State Engineer (1971) has indicated that about 40,000 acre-ft/yr (49.3 hm^3/yr) of ground water discharge from White River Valley to Pahranagat Valley via the carbonate aquifer. Ground-water pumping from the valley-fill aquifer should have minimal, if any, impact on this regional flow. There are, however, insufficient data to quantitatively evaluate the degree of hydraulic connection between the valley-fill and carbonate aquifers.

REFERENCES CITED

Amselmo Mine Company, 1980, Personal communication.

Anatec Laboratories, Inc., 1979, Water quality sampling in the Schell ES area, White Pine County - Nevada, unpublished report submitted to Nevada State Office, Bureau of Land Management, Reno, Nevada.

Bateman, R. L., 1976, Inventory and chemical quality of ground water in the White River - Muddy River - Meadow Valley Wash area, Southwestern Nevada, Desert Research Institute, Project Report No. 40.

Blankennagel, P. K., and Weir, J. E., Jr., 1979, Geohydrology of the eastern part of Pahute Mesa, Nevada Test Site, Nye County, Nevada, U.S. Geological Survey Professional Paper 712-B.

Bolke, E. L., and Sumsion, C. T., 1978, Hydrologic reconnaissance of the Fish Springs Flat area, Tooele, Juab, and Millard counties, Utah, Utah Department of Natural Resources, Technical Publication No. 64.

Bureau of Land Management, 1980, Personal communication, Ely District Office, Nevada.

Bureau of Land Management, 1980, Personal communication, Fillmore District Office, Utah.

Carpenter, E., 1915, Ground water in southeastern Nevada, U.S. Geological Survey, Water-Supply Paper No. 365.

Cooper, H. H., and Jacob, C. E., 1946, "A generalized graphical method of evaluating formation constants and summarizing well field history", American Geophysical Union Transactions, v. 27.

Desert Research Institute, 1980 (Revised 1981), Water rights in Nevada and Utah: An inventory within the MX area.

Dinwiddie, G. A., and Schroder, L. J., 1971, Summary of hydraulic testing in and chemical analyses of water samples from deep exploratory holes in Little Fish Lake, Monitor, Hot Creek, and Little Smoky valleys, Nevada, U.S. Geological Survey, Open-File Report 474-90.

Eakin, T. E., 1964, Ground-water appraisal of Coyote Spring and Kane Spring valleys and Muddy River Springs area, Lincoln and Clark counties, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources-Reconnaissance Series Report No. 25.

Eakin, T. E., 1961, Ground-water appraisal of Long Valley, White Pine and Elko counties, Nevada, Nevada Department of Conservation and Natural Resources, Water-Resources Reconnaissance Series Report No. 3.

__________, 1962a, Ground-water appraisal of Ralston and Stone Cabin valleys, Nye County, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report No. 12.

__________, 1962b, Ground-water appraisal of Cave Valley in Lincoln and White Pine counties, Nevada, Nevada Department of Conservation and Natural Resources, Ground Water Resources Reconnaissance Series Report No. 13.

__________, 1963a, Ground-water appraisal of Dry Lake and Delamar valleys, Lincoln County, Nevada, Nevada Department of Conservation and Natural Resource Water Resources Reconnaissance Series Report No. 16.

__________, 1963b, Ground-water appraisal of Garden and Coal valleys, Lincoln and Nye counties, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report No. 18.

__________, 1963c, Ground-water appraisal of Pahranagat and Pahroc valleys, Lincoln and Nye counties, Nevada, Nevada Department of Conservation of Natural Resources, Water Resources Reconnaissance Series Report No. 21.

__________, 1966, A regional interbasin ground-water system in the White River area, southeastern Nevada, Nevada Department of Conservation and Natural Resources, Water Resources Bulletin No. 33.

Eakin, T. E., Hughes, J. L., and Moore, D. O., 1967, Water resources appraisal of Steptoe Valley, White Pine and Elko counties, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report No. 42.

Eakin, T. E., Maxey, G. B., Robinson, T. W., Fredericks, J. C., and Loeltz, O. J., 1951, Contributions to the hydrology of eastern Nevada, Nevada State Engineer's Office, Water Resources Bulletin No. 12.

Eakin, T. E., Price, D., and Harrill, J. R., 1976, Summary appraisals of the nation's ground-water resources - Great Basin Region, U.S. Geological Survey Professional Paper 813-G.

Fiero, G. M., Jr., Mindling, A. L., and Illian, J. R., 1968, Regional groundwater flow system of central Nevada, Desert Research Institute, University of Nevada, Reno, Publication No. 5.

Fugro National, Inc., 1980, MX siting investigation, survey - Dry Lake Valley, Nevada, FN-TR-33-DL, unp report, 30 January 1980.

_________, 1980, MX siting investigation, gravity survey - Hot Creek Valley, Nevada, FN-TR-33-HC, unpublished report, 7 February 1980.

Garside, L. J., and Schilling, J. H., 1979, Thermal waters of Nevada, Nevada Bureau of Mines and Geology, Bulletin No. 91.

Gates, J. S., ed., 1978, Developing a state water plan, ground-water conditions in Utah, spring of 1978, Utah Division of Water Resources, Cooperative Investigation Report No. 17.

Glancy, P. A., 1968, Water-resources appraisal of Butte Valley, Elko and White Pine counties, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report No. 49.

Hess, J. W., and Mifflin, M. D., 1978, A feasibility study of water production from deep carbonate aquifers in Nevada, Water Resources Center, Desert Research Institute, University of Nevada, Publication No. 41054.

Hood, J. W., and Rush, F. E., 1965, Water resources appraisal of the Snake Valley area, Utah and Nevada, Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report No. 34.

Howard, E. L., 1978, Geologic map of the eastern Great Basin, Nevada and Utah, Denver, Colorado, Terra Scan Group Ltd., scale 1:250,000.

Huntley, D., 1981, Numerical model of the Snake Valley Area, Utah and Nevada.

Kellogg, H. E., 1964, Cenozoic stratigraphy and structure of the southern Egan Range, Nevada, Geological Society of America Bulletin, v. 75, no. 10.

Marion, J., 1980, Personal communication, Eureka county agent, Nevada.

Maxey, G. B., and Eakin, T. E., 1949, Ground-water in White River Valley, White Pine, Nye, and Lincoln counties, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources Bulletin No. 8.

Maxey, G. D., and Mifflin, M. D., 1966, Occurrence and movement of ground water in carbonate rocks of Nevada, National Speleological Society Bulletin, v. 28, no. 3, July 1966.

Mifflin, M. D., 1968, Delineation of ground-water flow systems in Nevada, University of Nevada, Reno, Desert Research Institute, Technical Report Series H-W, Hydrology and Water Resources Publication No. 4.

Mower, R. W., and Feltis, R. D., 1968, Ground-water hydrology of the Sevier Desert, Utah, U.S. Geological Survey Water Supply Paper No. 1854.

Mower, R. W., and Feltis, R. D., 1964, Ground-water data Sevier Desert, Utah, U.S. Geological Survey in cooperation with the Utah State Engineer, Basic Data Report No.9.

Nevada State Engineer, 1971, Water from Nevada, Nevada Water Resources Report No. 3.

Nevada State Engineers Office, 1979, Available well logs and driller's reports to the State Engineer of Nevada.

Pinder, G. F., 1970, A digital model for aquifer evaluation, U.S. Geological Survey Technical Water-Resources Investigations, Book 7, Chapter C1.

Portland Cement Association, 1966, "Mixing water for concrete," Portland Cement Association Pamphlet.

Price, D., 1979a, Summary appraisal of the water resources of the Great Basin, in 1979 Basin and Range Symposium and Great Basin Field Conference, Rocky Mountain Association of Geologists and Utah Geologists Association.

Price, D., ed., 1979b, Developing a state water plan, ground-water conditions in Utah, spring of 1978, Utah Division of Water Resources, Cooperative Investigation Report No. 18.

Prickett, T. A., and Lonnquist, C. G., 1971, Selected digital computer techniques for groundwater resource evaluation, Illinois State Water Survey, Bulletin No. 55.

Robinson, B. P., Thordarson, W., and Beetem, W. A., 1967, Hydraulic and chemical data for wells, springs, and streams in central Nevada, Tps. 1-21 N. and Rs. 41-57 E., U.S. Geological Survey, Open-File Report TEI-87i.

Rush, F. E., 1964, Ground-water appraisal of the Meadow Valley area, Lincoln and Clark counties, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report No. 27.

__________, 1968a, Water-resources appraisal of Clayton Valley - Stonewall Flat area, Nevada and California, Nevada Department of Conservation and Natural Resources, Water Resources - Reconnaissance Series Report No. 45.

Rush, F. E., and Eakin, T. E., 1963, Ground-water appraisal of Lake Valley in Lincoln and White Pine Counties, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources - Reconnaissance Series Report No. 24.

Rush, F. E., and Everett, D. E., 1964, Ground-water appraisal of Monitor, Antelope and Kobeh valleys, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report No. 38.

__________, 1966, Water-resources appraisal of Little Fish Lake, Hot Creek, and Little Smoky valleys, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report No. 38.

Rush, F. E., and Kazmi, S. A. T., 1965, Water-resources appraisal of Spring Valley, White Pine and Lincoln counties, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources - Reconnaissance Series Report No. 33.

Rush, F. E., and Schroer, C. V., 1970, Water Resources of Big Smoky Valley, Lander, Nye, and Esmeralda counties, Nevada, Nevada Department of Conservation and Natural Resources, Water Resources Bulletin No. 41.

Snyder, C. T., 1963, Hydrology of stock-water development on the public domain basin, Millard, Beaver, and Iron counties, Utah, Utah Department of Natural Resources, Technical Publication No. 47.

Soil Conservation Service, Ely, Nevada, Mr. Melvin Cheney, Oral Communication, 1980.

Stephens, J. C., 1974, Hydrologic reconnaissance of the Wah Wah Valley drainage basin, Milford, Beaver, and Iron counties, Utah, Utah Department of Natural Resources, Technical Publication No. 47.

__________, 1976, Hydrologic reconnaissance of the Pine Valley drainage basin, Millard, Beaver, and Iron counties, Utah, Utah Department of Natural Resources, Technical Publication No. 51.

__________, 1977, Hydrologic reconnaissance of the Tule Valley drainage basin, Juab and Millard counties, Utah, Utah Department of Natural Resources, Technical Publication No. 56.

Stephens, J. C., and Sumsion, C. T., 1978, Hydrologic reconnaissance of the Dugway Valley - Government Creek area, West-Central Utah, Utah Department of Natural Resources, Technical Publication No. 59.

Stewart, J. H., and Carlson, J. E., 1978, Geologic map of Nevada, U.S. Geological Survey, scale 1:500,000.

Stokes, W. L., ed., 1964, Geologic map of Utah, Utah University, scale 1:250,000.

Theis, C. V., 1935, "The relation between the lowering of the piezometric surface and the rate and duration of a well using groundwater storage", American Geophysical Union Transactions, v. 16.

Thordarson, W., and Robinson, B. P., 1971, Wells and springs in California and Nevada within 100 miles of the point 37 degrees and 15 minutes North, 116 degrees and 25 minutes West, on Nevada Test Site, U.S. Geological Survey Open-File Report 474-85 (NTS-227).

Todd, D. K., 1959, Groundwater hydrology, second edition, New York: John Wiley and Sons.

Tonopah Public Utilities, 1980, David Hamilton, County Planner: written communication.

Trescott, P.C., Pinder, G. F., and Larson, S. P., 1976, Finite-difference model for aquifer simulation in two dimensions with results of numerical experiments, Techniques of Water-Resources Investigations of the U.S. Geological Survey, Chapter C1, Book 7, Automated Data Processing and Computations.

Tschanz, C. M., and Pampeyan, E. H., 1961, Preliminary geologic map of Lincoln County, Nevada, U.S. Geological Survey Mineral Inventory Field Studies Map MF-206.

U.S. Army Corps of Engineers, 1981, MX Water Demands, Unpublished memo.

U.S. Geological Survey, 1979, Ground-water site inventory, U.S. Geological Survey compilation of data files (computer listing).

__________, 1979, Ground-water site inventory, U.S. Geological Survey compilation of data files (computer listing).

__________, 1980, Water resources data for Nevada, Water Year 1979, U.S. Geological Survey Water-Data Report NV-79-1.

Utah State Engineers Office, 1979, Available well logs and drillers' reports to the State Engineer of Utah.

Utah Water Research Laboratory, 1980 (updated), Industry activity inventory and water use in the are potentially impacted by MX missile complex in Utah, unpublished report, July 1980.

Van Denburgh, A., and Rush, F. E., 1974, Water resources appraisal of Railroad and Penoyer valleys, east-central Nevada, Nevada Department of Conservation and Natural Resources, Water Resources - Reconnaissance Series Report No. 60.

Winograd, I. J., Thordarson, W., 1975, Hydrogeologic and hydrochemical framework, south-central Great Basin, Nevada-California, with special reference to the Nevada Test Site, U.S. Geological Survey Professional Paper No. 712-C.