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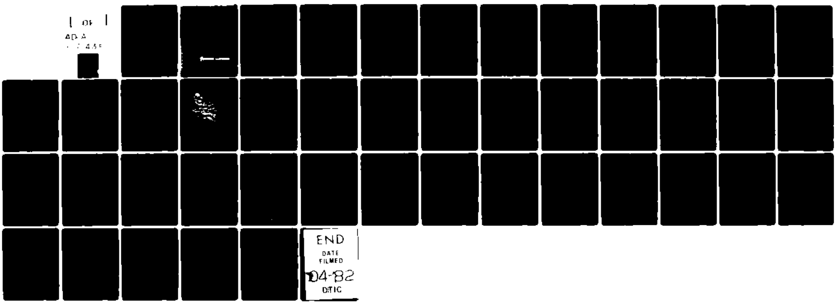

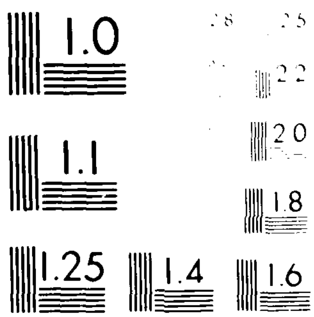
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CONSULTING ENGINEERS AND GEOLOGISTS

MX SITING INVESTIGATION
WATER RESOURCES PROGRAM
PROGRESS REPORT

Prepared for:

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

Prepared by:

Fugro National, Inc.
3777 Long Beach Boulevard
Long Beach, California 90807

13 February 1981

FUGRO NATIONAL, INC.

Current Analysis

TDS
Ca
Mg
Na
K
SO_4
CL
HCO_3
Flouride
Nitrate
Tridium expensive not done
hardness
silica
trace Metals Cu, As Fe Hg Mn Zn

now adding Boron

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER FN-81-FEB-1 ~~E-TR-FEB-81~~	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the status of all Water Resources program activities through approximately first quarter of FY 81 in Nevada and Utah.

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FOREWORD

This report was prepared for the Department of the Air Force, Ballistic Missile Office (BMO), in compliance with Contract Number F04704-80-C-0006, CDRL Item 004A2. It presents the status of all Water Resources Program activities through approximately the first quarter of Fiscal Year 1981 (FY 81) and discusses some preliminary results and conclusions.

This report presents the status of the following:

- Data collection including valley-fill and carbonate aquifer drilling and testing programs, shallow aquifer reconnaissances, and Operational Base (OB) studies;
- Data evaluation including numerical modeling, valley evaluations, and OB studies;
- Water appropriation applications; and
- Water management plan.

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1.0 INTRODUCTION

1.1 BACKGROUND

The MX Water Resources Program was initiated in June 1979 for the purpose of evaluating the availability of water for both the construction and operational phases of the MX project in Nevada and Utah and to assess the effects of these withdrawals on local water users, the environment, and the aquifers. The findings of the Water Resources Program to date have been presented to BMO in a series of technical reports listed below:

- "MX Siting Investigation, Geotechnical Summary, Water Resources Program FY 79," 21 December 1979;
- "MX Siting Investigation, Water Resources Program, Summary for Draft Environmental Impact Statement," 15 May 1980;
- "Overview of Nevada and Utah Water Law: Historical Development and Current Procedures for Rights Acquisition," revised, 2 June 1980;
- "Municipal Water-Supply and Wastewater-Treatment Facilities in Selected Nevada and Utah Communities," dated 20 June 1980 (this report was also submitted to BMO as Volume III of the summary report for the Draft Environmental Impact Statement, 15 May 1980);
- "MX Siting Investigation, Water Resources Program, Industry Activity Inventory, Nevada-Utah," 2 September 1980;
- "MX Siting Investigation, Water Resources Program, Interim Report," 31 October 1980; and
- "MX Siting Investigation, Water Rights Inventory, Nevada-Utah, Water Resources Program FY 80," 19 December 1980.

This report presents the status of Water Resources Program activities, since the interim report of 31 October 1980, through 9 January 1981. It also discusses the preliminary results of field drilling, testing and reconnaissance programs, Operational Base (OB) studies, and computer numerical model simulations of valley-fill aquifers in selected valleys. A glossary of selected hydrogeologic terminology is provided in Appendix A to assist in the understanding of some of the technical terms used in this report.

1.2 SCOPE

The scope of the Water Resources Program involves field and office data collection efforts, data evaluation, and report preparation. The major elements of the Water Resources Program are discussed below.

Existing Data Collection

- o Review existing pertinent publications and data contained in agency files relating to water availability, local water use, regional ground-water flow systems, and aquifer characteristics.
- o Contact state and federal officials knowledgeable about ground-water conditions in Nevada and Utah.

Shallow Aquifer Reconnaissance

- o Perform field studies to identify water users, measure ground-water levels, collect ground-water samples for chemical analysis, measure spring and stream discharges, conduct aquifer tests of existing wells, and examine general hydrogeologic conditions:
  - Measure ground-water levels in selected wells to construct potentiometric maps for identifying ground-water migration patterns and areas of recharge or discharge;
  - Collect ground-water samples from wells and springs for field and laboratory analyses to characterize the water quality and assess its suitability for construction or drinking purposes and to aid in identifying ground-water migration patterns and recharge areas;
  - Measure spring and stream discharges to aid in surface water studies and to provide input to computer model simulations of the ground-water systems in the area; and
  - Conduct aquifer tests in selected existing wells to determine potential well yields and the aquifer's ability to store and transmit water (this information is needed in designing well fields and evaluating impacts).

Valley-fill and Carbonate Aquifer Studies

- Drill and test valley-fill aquifers and carbonate (regional) aquifers. The drilling and testing programs are designed to gather information about aquifer characteristics and its ability to store and transmit water and about regional ground-water flow systems where little data exist. The aquifer test data are needed to determine the effects of pumping on nearby wells and springs to provide information in support of water appropriation applications.

- Evaluate regional and basin structures to better understand regional ground-water flow systems.

Numerical Modeling

- Make computer numerical models of the ground-water system in selected valleys. This will aid in assessing the effects of MX ground-water withdrawals on the local water users and the environment.

Surface-Water Overview

- Investigate the surface-water regime to provide data on the availability of surface water and the rates and amounts of potential recharge to the ground-water systems. The results will be input to the valley computer models to enhance the accuracy of the modeling results.

Municipal Water Resources Study

- Assess municipal water supplies and waste-water treatment facilities for their capacity to handle increased demand and loads due to MX population influx. This study includes towns within and immediately adjacent to the siting area with emphasis on Tonopah, Ely, Caliente, and Pioche in Nevada and Delta, Milford, and Cedar City in Utah. This study was conducted for Fugro National, Inc. by the Desert Research Institute for Nevada and the Utah Water Research Laboratory for Utah. The results of this study were reported to BMO on 20 June 1980.

Water Legal Study

- Review and study Nevada and Utah water laws and permitting procedures and conduct a water rights inventory. This study was conducted for Fugro National, Inc. by the Desert Research Institute, Nevada, and has aided in the filing of water appropriation applications. The results of this study were reported to BMO on 2 June and 19 December 1980.

Industry Activity Inventory

- Compile an industry activity inventory to identify the water requirements of existing and proposed industries in the siting area and determine how these requirements may interact with MX construction and operational activities. This study was conducted for Fugro National, Inc. by the Desert Research Institute for Nevada and the Utah Water Research Laboratory for Utah. The results of this study were reported to BMO on 2 September 1980.

Water Appropriations

- Assess the quantity of water required by MX activities in each valley and submit applications for appropriation. Define points of diversions for ground-water withdrawal and survey diversion sites.

Water Management Plan

- Develop a water management plan to obtain a construction and operation water supply that will minimize or avoid significant impacts to local water users and the environment. Aquifer capabilities, optimum well locations, and water supply alternatives will be considered and recommendations made.

The total number of field activities performed for each deployment valley or operational base site since the initiation of the program is listed in Table 1-1.

VALLEY	DRILLED WELLS[1]	PUMP TESTS[2]	WATER QUALITY ANALYSIS	WATER LEVEL MEASURE-MENTS	DISCHARGE MEASURE-MENTS	WATER TABLE MONITORING WELL
ANTELOPE	0	0	4	16	9	7
BIG SAND SPRINGS	0	0	1	3	4	1
BIG SMOKY	0	2	5	23	2	0
CAVE	2	1	6	13	3	2
COAL	2	0	1	8	1	2
DELAMAR/ DRY LAKE	5	2	6	13	3	0
DUGWAY	2	0	1	7	1	2
FISH SPRINGS FLAT	0	0	2	19	1	9
GARDEN	2	1	11	30	9	9
HOT CREEK	4	2	18	17	13	6
LAKE	0	0	0	23	0	16
LITTLE SMOKY	0	0	4	20	4	3
MULESHOE	0	0	3	1	8	0
PAHROC	0	0	1	5	1	0
PENOYER	0	0	5	16	9	9
PINE	2	1	5	1	1	0
RAILROAD	4	2	11	30	11	19
RALSTON	0	0	2	16	6	3
REVEILLE	0	0	6	6	8	1
SEVIER DESERT	0	1	8	33	0	15
SNAKE/ HAMLIN	2	10	50	110	36	54
SPRING	2	2	17	44	14	13
STONE CABIN	0	0	5	10	8	5
TULE	4	3	8	34	5	17
WAH WAH	3	0	1	7	0	4
WHIRLWIND	2	1	3	32	2	21
WHITE RIVER	1	7	20	66	3	11
STEPTOE	1	1	23	22	31	0
BUTTE	0	0	5	16	5	5
JAKES	0	0	2	3	9	0
KOBEH	0	0	7	33	15	6
LONG	0	0	6	13	3	6
MONITOR	0	0	7	12	13	0
NEWARK	0	1	14	34	16	5
MILFORD O.B.	2	1	13	50	0	0
BERYL O.B.	2	1	32	13	1	0
COYOTE O.B.	3	1	6	12	0	0

NOTE:

1 Includes test and observation wells

2 Includes both drilling and reconnaissance programs

1-9-81

SUMMARY OF WATER RESOURCES PROGRAM ACTIVITIES

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE – BMO

TABLE 1-1

FUGRO NATIONAL, INC.

2.0 PROGRAM STATUS

2.1 DATA COLLECTION

The status of the shallow aquifer reconnaissance, valley-fill and carbonate aquifer drilling and testing programs, and OB studies are shown in Table 2-1. The location of the wells and other field activities are shown in Drawing 2-1. Through 9 January 1981, a total of 45 wells have been drilled into both valley-fill and carbonate aquifers, 40 aquifer (pump) tests have been performed, 319 water quality analyses have been completed, 811 water-level and 255 discharge measurements have been made, and 251 water table monitoring wells have been installed (as part of the Verification program).

Collection of existing data and publications contained in state and federal agency files related to water resources has been an ongoing effort since the initiation of the Water Resources Program. This information, along with data generated from the water resources field activities, are being input to Fugro's computerized data storage and retrieval system for ready reference, easy evaluation, and rapid response to requests for water resources data. The existing data collection effort was expanded in FY 80 to include private industry and other non-public sources. About 130 companies were contacted including oil companies, mining companies, and electric utilities. Of those contacted, over 90 percent responded. Five companies offered data, and 116 companies declined to submit data on the grounds that there were either insufficient data available or that the data were confidential.

WATER RESOURCES

VALLEYS	SHALLOW AQUIFER RECONNAISSANCE: FIELD WORK IN FY 80	SHALLOW AQUIFER RECONNAISSANCE: FIELD WORK IN FY 81	DRILLING AND AQUIFER TESTING – VALLEY FILL – FIELD WORK IN FY 80: DRILLING	DRILLING AND AQUIFER TESTING – VALLEY FILL – FIELD WORK IN FY 80: TESTING	DRILLING AND AQUIFER TESTING – VALLEY FILL – FIELD WORK IN FY 81: DRILLING	DRILLING AND AQUIFER TESTING – VALLEY FILL – FIELD WORK IN FY 81: TESTING	DRILLING AND AQUIFER TESTING – CARBONATE (BEDROCK) – FIELD WORK IN FY 80: DRILLING	DRILLING AND AQUIFER TESTING – CARBONATE (BEDROCK) – FIELD WORK IN FY 80: TESTING	DRILLING AND AQUIFER TESTING – CARBONATE (BEDROCK) – FIELD WORK IN FY 81: DRILLING	DRILLING AND AQUIFER TESTING – CARBONATE (BEDROCK) – FIELD WORK IN FY 81: TESTING
Antelope	●				○	○				
Big Sand Springs	●				○	○				
Big Smoky	●									
Butte		●								
Cave	●		●	●						
Coal	●				⊕	○	●	●		
Delamar	●		●	●						
Dry Lake	●		●	●			●	●		
Dugway	●		●							
Fish Springs Flat	●				○	○				
Garden	●		●	●						
Hamlin	●		●	●						
Hot Creek	●		●	●						
Jakes		●								
Kobeh		●								
Lake	●									
Little Smoky	●				○	○				
Long		●								
Monitor		●								
Muleshoe	●									
Newark		●								
Pahroc	●									
Penoyer	●									
Pine	●		●	●						
Railroad	●		●	●						
Ralston	●									
Reveille	●				○	○				
Sevier	●									
Snake	●									
Spring	●		●	●						
Steptoe	●						●	●		
Stone Cabin	●								○	○
Tule	●		●	●						
Wah Wah	●		●			○				
Whirlwind	●		●	●	○	○			○	○
White River	●		●							
OB AREAS										
Beryl		●			●	●				
Coyote Spring		●			●		●	●		
Delta										
Milford		●			●	●				
Ely										

EXPLANATION

- ○ Work Planned
- ⊕ Work Partially Completed
- ● Work Completed

1-9-81

STATUS OF WATER RESOURCES PROGRAM FIELD ACTIVITIES

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE – BMO

TABLE 2 1

FUGRO NATIONAL, INC.

2.1.1 Shallow Aquifer Reconnaissance

The shallow aquifer reconnaissance program was initiated to gather baseline hydrologic data that would aid in determining ground-water migration patterns, ground-water quality and its distribution, the location of recharge and discharge areas, and aquifer characteristics. This information is required to identify potential sources of water for MX construction and to quantify the expected impacts of their development.

The shallow aquifer reconnaissance includes the measurement of spring and stream discharges, measurement of water-levels in existing wells, water sampling for quality analysis, and aquifer testing of existing wells. By the end of FY 80 field studies, 30 valleys had been completed. In FY 81, six additional valleys, Butte, Jakes, Kobeh, Long, Monitor, and Newark valleys in Nevada, have been completed for the deployment area. The results of these investigations, and all of the valleys studied (12) since the interim report, will be discussed in the July 1981 technical report.

During the reconnaissance of the six valleys, 41 water samples were collected, 111 water-level measurements were made, 61 discharge measurements were made, and one aquifer test was conducted.

2.1.2 Valley-fill Aquifer Drilling and Testing

The valley-fill aquifer drilling and testing program was initiated to provide detailed information about aquifer characteristics in areas where it could not be obtained through the shallow aquifer reconnaissance. The program has been designed to provide information on the effects of MX ground-water withdrawals on current users and the environment, to aid in well field design, and to provide information in support of water appropriation applications.

By the end of FY 80, 33 valley-fill test and observation wells have been drilled, and 14 wells have been tested. Wells have been drilled in White River, Dry Lake, Delamar, Hamlin, Hot Creek, Railroad, Garden, Cave, and Spring valleys in Nevada and Dugway, Tule, Pine, Wah Wah, and Whirlwind valleys in Utah. Generally, these wells were drilled as a set consisting of an observation well drilled approximately 500 feet (152 m) from a test well so that the storage coefficient could be obtained from test results.

Aquifer tests of the wells were completed in 11 valleys including Dry Lake, Delamar, Hamlin, Hot Creek, Railroad, Garden, Cave, and Spring valleys in Nevada, and Tule, Pine, and Whirlwind valleys in Utah. Aquifer tests were not conducted in White River Valley because the well did not penetrate suitable deeper valley-fill aquifers that were the focus of studies in that valley. The two wells drilled in Dugway Valley did not penetrate any significant saturated zones in the valley-fill before encountering rock, so no testing was conducted. The well in Wah Wah Valley will be tested in FY 81. The depth of the test and observation wells drilled in each valley, the dates the wells were constructed, the depth to the static water level, and some aquifer test information are provided in Table 2-2, Valley-fill Aquifer Drilling and Testing Information.

In the remainder of FY 81, seven valley-fill test and observations wells are scheduled to be constructed in the following deployment area valleys: Antelope, Big Sand Springs, Coal, Fish Springs Flat, Little Smoky, Reveille, and Whirlwind. Drilling of the observation well in Coal Valley is in progress, and the schedule for the other wells is shown in Figure 2-1. Additional drilling in data-deficient areas and in areas where the water resources and projected impacts need further clarification is anticipated in FY 82.

2.1.3 Carbonate (Regional) Aquifer Drilling and Testing

The carbonate drilling and testing program assists in the regional evaluation of the ground-water flow systems in both Utah and Nevada. This program aids in evaluating the relationship of valley-fill aquifers to carbonate aquifers and explores alternate water supplies in areas where the valley-fill aquifers may not supply adequate amounts of water for MX needs.

The basic elements, which have entered into selection of the carbonate aquifer well locations and sites, are listed below:

- o Limited valley-fill water available in a valley - the need for other aquifers to serve as an alternate source of water for MX;
- o Distribution of data in a regional carbonate aquifer system;
- o Stratigraphic relationships - those formations which are most likely to yield significant quantities of water;
- o Structural relationships - those areas where considerable structural activity has occurred (faults, shear zones, deformation);

VALLEY (LOCATION)	DRILLING RESULTS: TEST WELL: DEPTH (FEET)	CASING DIAMETER (INCHES)	DRILLING DATES: START	DRILLING DATES: END	OBSERVATION WELL: DEPTH (FEET)	PIEZOMETERS: NUMBER	PIEZOMETERS: SIZE (INCHES)	PIEZOMETERS: DEPTH (FEET)	DRILLING DATES: START	DRILLING DATES: END	AQUIFER TEST RESULTS*: DEPTH TO WATER (FEET)	DISCHARGE (GPM)	TRANSMISSIVITY (GPD/FT)	STORAGE COEFFICIENT	TESTING DATES: START	TESTING DATES: END	COMMENTS
White River 8N 61E-27dc	N/A	N/A	N/A	N/A	1300	2	2	200 & 400	11/20/79	12/19/79	42**	None	N/A		None	None	No test well drilled
Dry Lake 3S 64E-12ca	1012	10	1/26/80	2/12/80	1305	2	2	195 & 1290	1/03/80	1/24/80	396***	500	45,000		4/03/80	4/27/80	
Delamar 6S 63E-12a	1215	10	2/29/80	3/12/80	1012	2	2	630 & 971	2/15/80	2/23/80	871***	85	5,000		5/03/80	5/13/80	
Tule #1 20S/14W-6dd	624	10	7/08/80	7/15/80	624	1	1	620	7/20/80	7/21/80	90***	75	5,100		7/28/80	8/15/80	
Tule #2 17S/15W-17ca	409	10	7/08/80	7/16/80	311	1	2	296	7/21/80	7/22/80	47***	345	50,000		8/01/80	8/15/80	
Dugway #1 12S 10W-31cc	402	10	7/28/80	8/03/80	None	None	None	N/A	N/A	N/A	Dry	None	N/A		None	None	No observation well drilled
Dugway #2 11S/10W-19bb	None	None	7/28/80	8/02/80	178	1	2	174	7/28/80	7/31/80	Dry	None	N/A		None	None	
Spring 9N 68E-30ab	710	10	8/03/80	8/07/80	710	2	2	247 & 700	8/09/80	8/11/80	231***	600	430,000		9/09/80	9/22/80	
Hamlin 8N 69E-35dc	480	10	8/18/80	8/24/80	522	1	2	435	8/06/80	8/07/80	158***	155	12,100		9/09/80	8/14/80	
Railroad #1 3N/52E-2dd	484	10	8/01/80	8/10/80	495	1	2	495	8/14/80	8/15/80	233***	740	70,000		8/12/80	9/29/80	
Hot Creek #1 7N 51E-10aa	540	10 & 7	8/26/80	8/29/80	500	1	2	480	9/02/80	9/08/80	237***	300	86,000		9/26/80	10/9/80	

DATE

*PRELIMINARY DATA

** Measurement made in January 1980

***Measurement made on the same day of the aquifer test

VALLEY FILL AQUIFER DRILLING AND TESTING INFORMATION

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE 22
1 of 3

FUGRO NATIONAL, INC.

VALLEY (LOCATION)	DRILLING RESULTS										AQUIFER TEST RESULTS*						COMMENTS
	TEST WELL				OBSERVATION WELL												
			DRILLING DATES			PIEZOMETERS			DRILLING DATES						TESTING DATES		
	DEPTH (FEET)	CASING DIAMETER (INCHES)	START	END	DEPTH (FEET)	NUMBER	SIZE (INCHES)	DEPTH (FEET)	START	END	DEPTH TO WATER (FEET)	DISCHARGE (GPM)	TRANSMISSIVITY (GPD/FT)	STORAGE COEFFICIENT	START	END	
Hot Creek #2 6N/50E-27ac	505	10	8/27/80	8/30/80	455	1	2	455	9/06/80	9/07/80	291***	375	13,200		9/26/80	10/06/80	
Railroad #2 10N/58E-17bd	600	10	9/15/80	9/29/80	600	2	2	220 & 600	9/20/80	9/21/80	281***	700			10/19/80	11/30/80	
Pine 26S/17W-10aa	951	10	7/08/80	7/12/80	1157	1	2	882	6/08/80	7/10/80	443***	75	2,500		7/20/80	8/10/80	
Cave 7N/63E-14ab	462	10	9/11/80	9/25/80	458	2	2	273 & 422	8/23/80	9/10/80	230***	223	11,100		10/13/80	10/25/80	
Wah Wah 26S/14W-25ab	N/A	N/A	N/A	N/A	1251	1	2	1135	7/07/80	7/30/80	335	None	N/A		N/A	N/A	Alternate site selected in Wah Wah Valley due to low yield potential
Garden 2N/57E-15bd	1065	10	9/11/80	10/24/80	1099	2	2	315 & 1033	8/07/80	8/16/80	421***	500*	88,000		11/09/80	12/09/80	
Whirlwind 15S/12W-19ad	1033	10	10/20/80	11/10/80	1220	1	2	1170	9/15/80	10/13/80	740	7			12/13/80	12/17/80	
Wah Wah 27S/14W-28dd	1350	10	10/23/80	12/10/80	1399	1	2	1399	7/27/80	8/27/80							

DATE

*PRELIMINARY DATA

***Measurement made on the same day of the aquifer test

VALLEY FILL AQUIFER DRILLING AND TESTING INFORMATION

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE - BMO

TABLE 22 2 of 2

FUGRO NATIONAL, INC.

VALLEY (LOCATION)	DRILLING RESULTS										AQUIFER TEST RESULTS*						COMMENTS
	TEST WELL				OBSERVATION WELL												
	DEPTH (FEET)	CASING DIAMETER (INCHES)	DRILLING DATES		DEPTH (FEET)	PIEZOMETERS			DRILLING DATES		DEPTH TO WATER (FEET)	DISCHARGE (GPM)	TRANSMISSIVITY (GPD/FT)	STORAGE COEFFICIENT	TESTING DATES		
			START	END		NUMBER	SIZE (INCHES)	DEPTH (FEET)	START	END					START	END	
Milford O.B. 31S-13W-5bb	600	10	11/05/80	11/17/80	342	2	2	138 & 342	11/22/80	11/22/80	28	350	40,000		12/07/80	12/17/80	No suitable valley-fill aquifer found. Test well drilling is in progress into bedrock at 856 feet.
Beryl O.B. 33S/17W-21dd	353	10	12/1/80	12/11/80	504	2	2	23[illegible] & 322	12/2/80	12/03/80	236 & 332						
Coyote O.B. 12S-63E-29db					714	2	2	470 & 620	11/13/80	11/22/80	470 & 620						
Coal Valley 1S/59E-34cb					1452	1	2	1452	12/16/80	12/19/80	861						

DATE 9 January 1981

*PRELIMINARY DATA

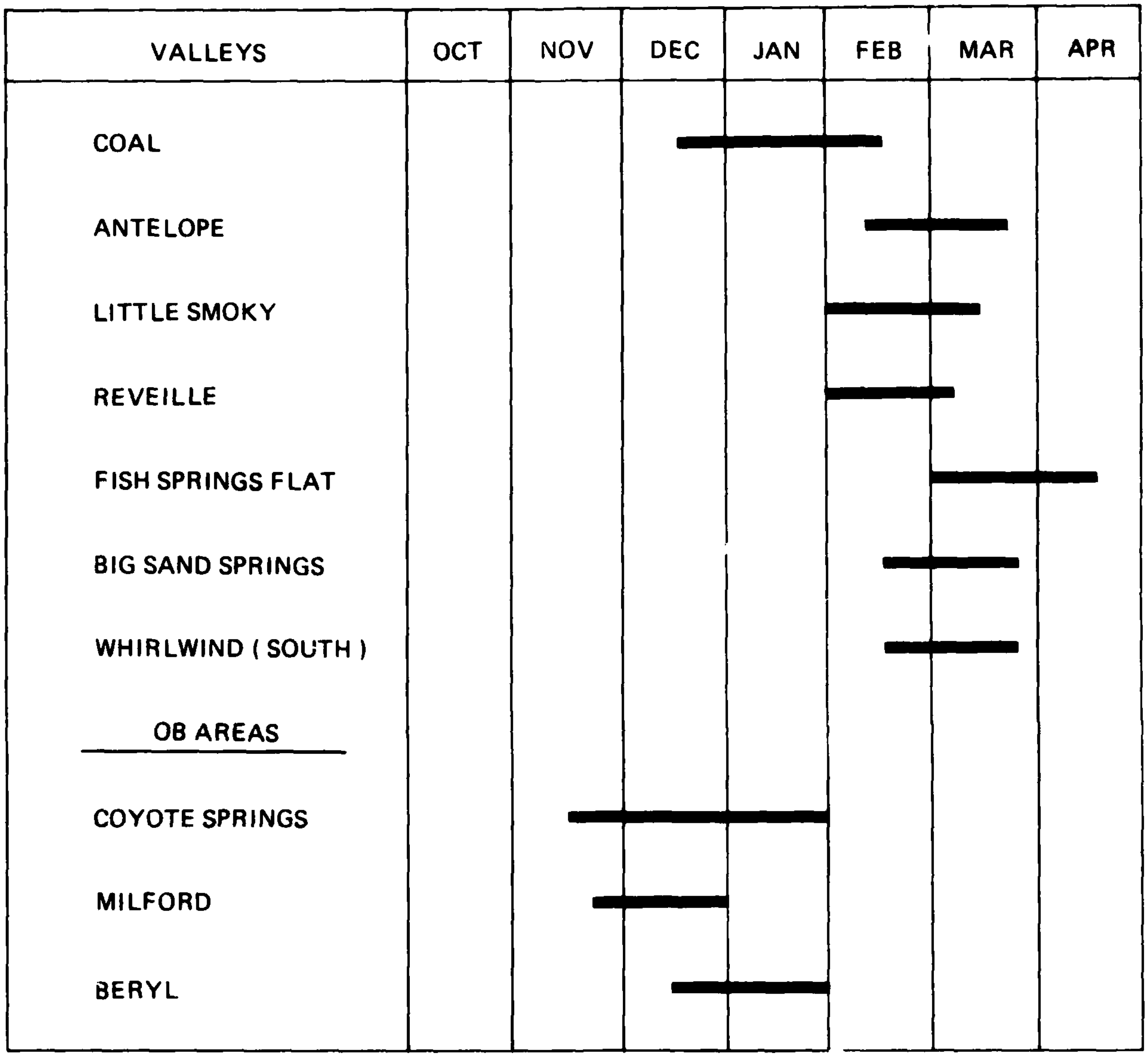
VALLEY FILL AQUIFER DRILLING AND TESTING INFORMATION

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE - BMO

TABLE 22

FUGRO NATIONAL, INC.



COMPLETION SCHEDULE
OF VALLEY-FILL DRILLING
AND TESTING FOR FY81

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE – BMO

FIGURE 2 1

FUGRO NATIONAL, INC.

- o Site accessibility; and
- o Bureau of Land Management permitting limitations - wilderness areas, national forests, etc.
- o Environmentally sensitive area;

In FY 80, three test wells were drilled into carbonate aquifers in or near the White River carbonate flow system in eastern Nevada, not including those drilled for OB studies. The White River carbonate flow system encompasses an area from Long Valley in the north to Coyote Spring Valley in the south, and several wildlife refuges and farming and ranching communities derive their water from regional carbonate springs which are part of this system. The test wells were drilled to depths ranging from 1832 feet (558 m) to 2450 feet (747 m) below ground surface and are located in northwestern Coal Valley, southwestern Steptoe Valley, and northwestern Dry Lake Valley in Nevada. The testing of the Dry Lake well has been completed, and testing of the other two wells is in progress. Four carbonate wells were scheduled to be completed in FY 80, as part of the deployment area data collection, but one of the four wells was diverted to evaluation of the Coyote Spring OB site (discussed in section 2.1.4, Operational Base (OB) Studies). The depth of the test and observation wells drilled in each valley, the dates the wells were constructed, the depth to the static water level, and some aquifer test information are provided in Table 2-3, Carbonate Aquifer Drilling and Testing Information.

In FY 81, two carbonate aquifer test wells are scheduled to be drilled and tested. Sites are currently being evaluated for

VALLEY (LOCATION)	DRILLING RESULTS											AQUIFER TEST RESULTS*						COMMENTS
	TEST WELL				OBSERVATION WELL													
	DEPTH (FEET)	CASING DIAMETER (INCHES)	DRILLING DATES START	DRILLING DATES END	DEPTH (FEET)	PIEZOMETERS NUMBER	PIEZOMETERS SIZE (INCHES)	PIEZOMETERS DEPTH (FEET)	DRILLING DATES START	DRILLING DATES END	DEPTH TO WATER (FEET)	DISCHARGE (GPM)	TRANSMISSIVITY (GPD/FT)	STORAGE COEFFICIENT	TESTING DATES START	TESTING DATES END	
Coal/Garden 3N/59E-10	1832		8/17/80	12/09/80	N/A	N/A	N/A	N/A	N/A	N/A	563						
Steptoe 12N/63E-12ba	2450		8/28/80	10/13/80	N/A	N/A	N/A	N/A	N/A	N/A	427				11/3/80	In Progress	Casing Perforated 12/19/80- 500-543 feet and 7[illegible]-950 Feet below ground-surface
Dry Lake 3N/63E-27	2395		10/23/80	11/21/80	N/A	N/A	N/A	N/A	N/A	N/A	853	106			12/07/80	12/12/80	
Coyote O.B. 13S/63E-23ddd	665		11/20/80	12/10/80	N/A	N/A	N/A	N/A	N/A	N/A	153	504			12/18/80	12/23/80	

DATE [illegible]

*PRELIMINARY DATA

CARBONATE AQUIFER DRILLING AND TESTING INFORMATION

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE 2.3

FUGRO NATIONAL, INC.

their potential to yield significant quantities of water and for their importance relative to Air Force water supply needs and environmental concerns. The most likely locations for the two carbonate wells are the Whirlwind Valley area, Utah, and the Stone Cabin Valley area, Nevada, where valley-fill water supply problems have been identified. These locations are shown in Drawing 2-1.

2.1.4 Operational Base (OB) Studies

The OB studies were initiated to:

- Assess the potential impacts on nearby ground-water users and the environment resulting from sustained ground-water withdrawals for MX use;
- Determine the characteristics, properties, and interrelationship of various ground-water aquifers in the area; and
- Identify and confirm the viability of alternative ground-water sources of supply in proximity to the OB sites.

From the above activities, recommendations can be made as to the water supply alternatives and the course of action to obtain water for the OB.

In FY 80, a shallow aquifer reconnaissance of Sevier Desert in Utah and Steptoe Valley in Nevada was conducted. These reconnaissances included the Delta and Ely OB sites, respectively. In August 1980, drilling was initiated on a carbonate aquifer well in southern Steptoe Valley near the Ely OB site, as part of the carbonate aquifer drilling program. The activities, conducted in FY 80 in the Delta and Ely OB areas, were primarily a part of the basic deployment area studies. No additional studies of these two OB sites are presently schedule for FY 81.

OB field studies were scheduled in FY 81 for only the Coyote Spring, Milford, and Beryl OB sites. The studies included: 1) shallow aquifer reconnaissances, 2) the drilling of three test and observation wells in the valley fill near the proposed OBs, and 3) the drilling of one carbonate well in or near the Coyote Spring OB site. The status of the OB field studies is shown in Table 2-1 and discussed below.

The shallow aquifer reconnaissance of the Coyote Spring, Milford, and Beryl OB areas was completed in October and November 1980.

One valley-fill well set (one observation and one test well) has been drilled and tested at the Milford OB site. The test and observation wells were completed to depths of 360 feet (110 m) and 340 feet (104 m) below ground surface, respectively. One valley-fill well set has been drilled and tested at the Beryl OB site. The test and observation wells were completed to 350 feet (107 m) and 340 feet (104 m) below ground surface, respectively. A valley-fill observation well was drilled to a depth of 714 feet (218 m) below ground surface in the Coyote Spring OB area. Very little water-bearing aquifer materials were penetrated in the valley-fill. A test well was drilled nearby to test for possible deeper valley-fill aquifers, but rock was penetrated at 856 feet (261 m) below ground surface. The test well was deepened and modified as a carbonate aquifer well.

Near the Coyote Spring OB site in southern Coyote Spring Valley, a carbonate aquifer well has been drilled to a depth of 665 feet

(203 m) below ground surface and tested. The rock that was penetrated was so cavernous that water circulation for the drilling operation could not be maintained without adding casing, and the hole was terminated at 665 (203 m) feet. The well was test pumped at 504 gallons per minute (gpm) (1908 liters per minute [l/m]) and only drew down 4.2 feet (1.3 m). The specific capacity data indicate that the transmissivity might be about 286,000 gallons per day per foot (gpd/ft) (3552 meters squared per day [m^2/day]).

All OB field activities will be completed by the end of March 1981.

2.2 DATA EVALUATION

Data evaluation is in progress in four areas: 1) valley studies, 2) regional carbonate aquifer studies, 3) OB studies, and 4) computer numerical modeling simulations of aquifers which are associated with the first three studies. A summary of water-related issues and solutions and summary of the results of the valley and carbonate aquifer studies will be presented in the Technical Summary Report covering all valleys in the deployment area on 30 July 1981. The results of the OB water resources studies will be presented in a report on 28 May 1981. Detailed documentation and evaluation will be incorporated in subsequent technical reports on each valley as part of the ongoing effort in support of water appropriation. The computer modeling results will be incorporated into the above.

2.2.1 Valley Studies

Evaluation of data from data collection efforts and published reports for each valley in the deployment area is in progress. The intent of valley studies is to summarize the data, characterize the conditions, assess withdrawals, analyze impacts, and present the results so that the data can be used efficiently in water management planning and appropriations. The evaluations of valleys previously reported to BMO will focus on summarizing the results and updating with new data more recent findings and consideration of the interconnection of valley and regional ground-water flow systems.

2.2.2 Regional Carbonate Aquifer Studies

The regional carbonate aquifer studies have focused on the White River carbonate flow system which includes 13 valleys, most of which lie within the MX deployment area. The White River flow system encompasses many water users and several environmentally sensitive areas dependent upon the regional carbonate springs.

The carbonate aquifer field program was initiated in late July 1980. Field drilling and testing operations are scheduled for completion in April 1981. Evaluation of data from the drilling program and a regional overview of all the individual valley data is in progress. The initial data evaluation phase of the carbonate program will be completed 30 June 1980.

The USGS Water Resources Division in Carson City has been involved in water quality, age dating, and migration analyses associated with the carbonate aquifer program. The USGS is analyzing water samples from the carbonate aquifer for oxygen, hydrogen, and chlorine isotopes and $carbon^{14}$ in an effort to determine relative and absolute age dates which will aid in water migration evaluations. Also Dr. Glen Thompson from the University of Arizona has been involved in the relative age dating of water on the program through evaluation of the Freon content of the carbonate water samples. The USGS and Dr. Thompson will continue to be involved and consulted in the evaluation process until completion of the program.

2.2.3 Operational Base Studies

Results of preliminary studies of the Coyote Spring, Milford, Ely, Delta, and Beryl OB sites, utilizing existing data, were presented to BMO on 27 February, 10 March, 31 March, 15 May, and 13 June 1980, respectively. The more extensive evaluation for the Coyote Spring, Milford, and Beryl OB sites, utilizing the results of recently conducted field investigations, is in progress and is scheduled for completion 1 May 1981. The results of the studies of the three OB sites will be presented in an OB report on 28 May 1981. Further evaluations and reporting for the Delta and Ely OB sites are presently not scheduled.

2.2.4 Numerical Modeling

Computer numerical modeling is being or is scheduled to be conducted for the ground-water system in selected valleys, the regional White River flow system and the Coyote Spring, Milford, and Beryl OB sites. The status of the numerical modeling program and the valleys being modeled are shown in Table 2-4.

VALLEYS	Valley-Fill Aquifer Modeling* in FY80	Valley-Fill Aquifer Modeling* in FY81	Carbonate (Regional) Aquifer Modeling in FY81**
MULESHOE	⊕		○
WHITE RIVER	⊕		○
RAILROAD	⊕		
HAMLIN	⊕		
SNAKE	⊕		
DRY LAKE	⊕		○
SPRING		⊕	
LAKE		⊕	
LONG		⊕	○
PENOYER		○	
STONE CABIN		○	
DELAMAR		○	○
WAH WAH	⊕	●	
PINE	⊕		
CAVE			○
GARDEN			○
COAL			○
PAHROC			○
PAHRANAGAT			○
JAKES			○
O. B. AREAS			
COYOTE SPRING***		○	○
MILFORD		⊕	
BERYL		⊕	

EXPLANATION

○ Modeling Planned

⊕ Modeling Partially Completed

● Modeling Completed

* Preliminary models completed in FY80 are being revised and updated in FY81

** Valleys listed are all part of regional White River flow system which will be modeled.

*** Includes Kane Springs Valley

STATUS OF WATER RESOURCES PROGRAM
NUMERICAL MODELING

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE – BMO

TABLE 2-4

FUGRO NATIONAL, INC.

1-9-81

Eight valleys were modeled in FY 80 and are currently being updated and revised in FY 81. Ten additional models are planned for FY 81 including the regional model of the White River carbonate flow system, Coyote Spring, Milford, and Beryl OB areas, and six deployment area valleys. The preliminary results and conclusions of the numerical modeling are discussed in Section 3.0, and the final results will be presented in the 30 July 1981 Technical Summary Report.

2.3 APPROPRIATIONS

The process to acquire the necessary water rights for construction and operation of the MX project began in October 1979 with the filing of a water appropriation application for Snake Valley in Nevada. In January 1980, applications were filed for water rights in three additional valleys: Dry Lake, Delamar, and White River valleys. These four valleys represent locations in which it was intended to initiate the drilling program, and water rights applications were filed for the planned drill sites.

In July 1980, applications were filed for an additional 25 valleys making a total of 94 water rights applications in Nevada and Utah. To complete the filing process, applications for the six northern valleys (Kobeh, Butte, Jakes, Long, Newark, and Monitor) and OB sites at Ely, Delta, and Coyote Spring Valley were filed in November and December 1980. Current status of all applications filed to date is shown in Table 2-5.

VALLEY	FILE WATER RIGHTS APPLICATION	QUANTITY OF GRND WATER REQUESTED (ACRE FT/YR)	WATER RIGHTS SURVEY	BEGIN PUBLICATION PERIOD*	CLOSE PROTEST PERIOD**	APPLICATIONS PROTESTED***
SITING VALLEYS:						
ANTELOPE	●	3805	●	12-4-80	2-6-81	
BIG SAND SPRINGS	●	2076	●	12-5-80	2-6-81	
BIG SMOKY	●	4146	●	12-5&12-80	2-6&13-81	
CAVE	●	2076	●	12-4-80	2-6-81	X
COAL	●	3456	●	12-5-80	2-6-81	
DELAMAR	●	1585	●	8-7-80	10-13-80	X
DRY LAKE	●	3810	●	8-7-80	10-13-80	X
DUGWAY	●	3111	N/A	11-6-80	12-22-80	X
FISH SPRINGS FLAT	●	2537	N/A	11-6-80	12-22-80	X
GARDEN	●	3456	●	12-4-80	2-6-81	X
HAMLIN, NEVADA	●	2100	●			X
HAMLIN, UTAH	●	1364	N/A	11-6-80	12-22-80	X
HOT CREEK	●	3115	●			
LAKE	●	3805	●	12-4&5-80	2-6-81	X
LITTLE SMOKY	●	2076	●	12-4&12-80	2-6&13-81	
MULESHOE	●	1731	●	12-4-80	2-6-81	X
PAHROC	●	1388	●	12-4-80	2-6-81	
PENOYER	●	2422	●			
PINE	●	2421	N/A	11-6-80	12-22-80	X
RAILROAD	●	4148	●	12-4-80	2-6-81	
RALSTON	●	4152	●			
REVEILLE	●	2770	●	12-4&12-80	2-6&13-81	
SEVIER	●	2076	N/A	11-6-80	12-22-80	X
SNAKE, NEVADA	●	1905	●	8-7-80	10-13-80	X
SNAKE, UTAH	●	3782	N/A	11-6-80	12-22-80	X
SPRING	●	2425	●	12-4-80	2-6-81	X
STONE CABIN	●	4152	●			X
TULE	●	4146	N/A	11-6-80	12-22-80	X
WAH WAH	●	3801	N/A	11-6-80	12-22-80	X
WHITE RIVER	●	3810	●	8-7-80	10-13-80	X
WHIRLWIND	●	3685	N/A	11-6-80	12-22-80	X
BUTTE	●	2464	O			
JAKES	●	1758	O			
KOBEH	●	3530	O			
LONG	●	1404	O			
MONITOR	●	2112	O			
NEWARK	●	1404	O			
OB SITES: COYOTE/KANE	●	7000	O			
SEVIER-DELTA	●	7000	O			
STEPTOE-ELY	●	7000	O			

● WORK COMPLETED O WORK PLANNED
N/A NOT APPLICABLE
*DATE NOTICE TRANSMITTED TO LOCAL NEWSPAPERS BY STATE ENGINEER
**DATE SHOWN IS APPROXIMATE, ACTUAL DATE DEPENDANT UPON DATE OF FIRST PUBLICATION BY LOCAL NEWSPAPER
***PROTESTS FILED AS OF 1-9-81

STATUS OF WATER APPROPRIATIONS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE – BMO

TABLE 2-5

FUGRO NATIONAL, INC.

The table shows that all applications filed in Utah have been published in local newspapers, the protest period has closed, and all applications have been protested. In Nevada, all applications except those in Hamlin, Hot Creek, Penoyer, Ralston, and Stone Cabin valleys have been published. It is anticipated that those valleys will be published by the end of January 1981. All applications in which the protest period in Nevada has closed have been protested. It is anticipated that all applications in Nevada will be protested.

In March and April 1980, meetings were held with the state engineers of Nevada and Utah to begin discussing the water appropriation procedures and processes leading to the granting of a permit to divert and beneficially use ground water. Since those initial meetings, periodic meetings have been held with each state engineer and their representatives to ensure that applications are receiving timely consideration and that the filings have been in accordance with state law. It is probable that all applications will be protested and field investigations and/or public hearings will likely be held for each application. It is our understanding that public hearings will not be held on any application until after the public review period for the Draft Environmental Impact Statement is closed. Therefore, formal hearings will not begin until after May or June 1981.

In many cases, the state engineer schedules a field investigation prior to the public hearing. Field investigations are held at the proposed point of diversion with the applicant, his representatives, and those protesting in attendance. Purposes of the field investigation are to identify in the field points of diversion and places of use, discuss purposes and conditions of the proposed diversions, discuss reasons for the protest, and discuss with the protestor potential mitigating measures. For a given application, field investigations will be held prior to the public hearing. They will begin approximately one month before the initiation of hearings.

In November 1980, a meeting was held with the law firm representing the Air Force in Nevada to discuss strategy and procedures in preparation for the field investigations and public hearings. Periodic meetings have taken place since that initial meeting. Later in November, a representative from Fugro and the Nevada law firm attended a typical field investigation near Lovelock to become familiar with procedures and approaches used during an investigation. For the same reason, a representative from Fugro attended a typical public hearing in Reno in December 1980.

On 8 January 1981, a representative from the Air Force and the Nevada law firm met with representatives from Fugro to begin formulating strategy for upcoming field investigations and public hearings. At that meeting, it was agreed that personal contacts would be made with individual protestors in Snake and White River valleys to attempt to resolve their protests. Those contacts are scheduled to be made in February 1981. If successful, this approach will be used in other protested valleys.

It is anticipated that similar meetings will be held with the law firm representing the Air Force in Utah and the Utah State Engineer in early February 1981. Additional meetings will be held as necessary to ensure that all preparations are completed for field investigations and public hearings in Utah as well as Nevada.

2.4 WATER MANAGEMENT PLAN

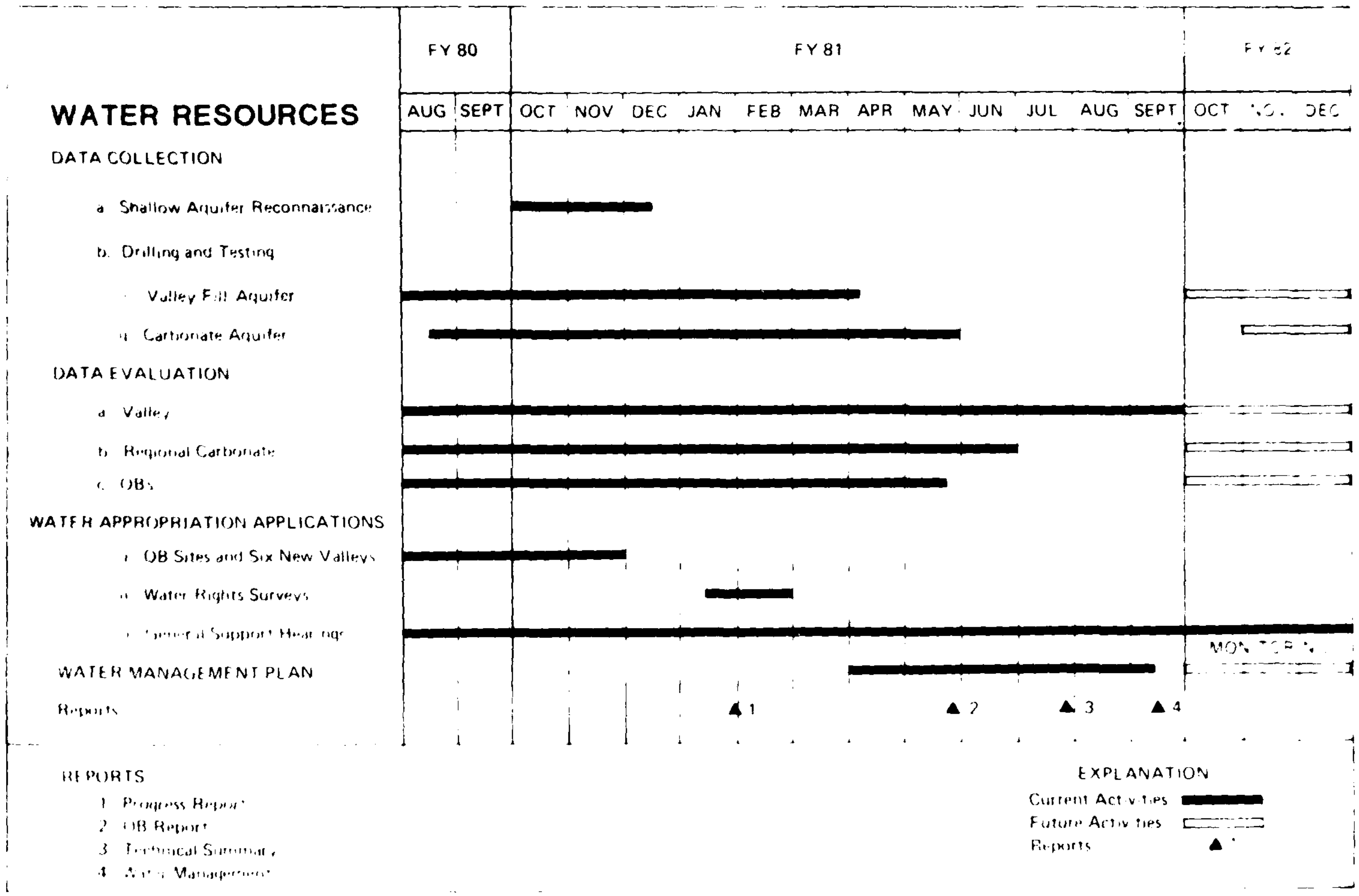
A preliminary water management plan is scheduled for completion in FY 81, and a Water Management Report will be presented to BMO on 10 September 1981. The water management program will evaluate and identify the various water supply options available for MX construction and operation and will suggest the optimal water supply system for each deployment valley. The plan will consider comparative costs for all viable alternatives and the timeliness of their development and implementation. Such water supply alternatives are:

- o Valley-fill aquifer;
- o Carbonate aquifer;
- o Lease or purchase of existing water rights; and
- o Importation of water from valleys where it is more plentiful.

The design of a water-level and water-quality monitoring program for periods before, during, and after MX construction will be presented. The details of a data evaluation program to ensure that any significant effects that MX ground-water withdrawals may have on the local ground-water systems will be evaluated and identified rapidly so that corrective measures can be implemented at the earliest possible time.

The water management planning will be initiated the beginning of April and will continue to approximately the end of FY 81.

The overall schedule of the Water Resources Program activities for FY 81, including data collection, data evaluation, appropriations, water management planning, and reports is shown in Figure 2-2.



FY81 SCHEDULE
WATER RESOURCES
PROGRAM

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE BMO

FIGURE 2 2

FUGRO NATIONAL, INC.

1-9-81

3.0 PRELIMINARY RESULTS AND CONCLUSIONS

At the time of this report, field work has been completed for most water resources subtasks. However, data reduction and analysis is in progress and in various stages of completion for all tasks. Therefore, the results and conclusions listed here are only preliminary and will be refined and expanded as additional data are received and/or evaluated. The following is a summary of the results and conclusions through approximately the first quarter of FY 81:

- Ground water is generally obtainable from valley-fill aquifers in most valleys.

- Twenty-one valleys contain an area where the depth to ground water in the valley fill aquifer is less than 200 feet (61 m); however, in some cases the density of current development might preclude additional development of water by the Air Force in these areas.

- The ground water in valley-fill aquifers is generally potable within the MX siting area, but small areas with ground water that exceeds EPA drinking standards have been identified. Areas of exceedingly poor water quality generally correspond to urban areas with septic tanks, mines, or discharging playas.

- Well yields measured during valley-fill aquifer testing (reconnaissance and drilling programs) have ranged from 7 gpm (about 10 acre-feet per year [acre-ft/yr]) in Whirlwind Valley to 2200 gpm (8327 l/m) (about 3500 acre-ft/yr [4.3 hm^3/yr]) in Snake Valley.

- High yields from wells tapping valley-fill materials (greater than 500 gpm or about 800 acre-ft/yr) (1893 l/m or about 1.0 hm^3/yr) occur in Dry Lake, Spring, Railroad, White River, Snake, Garden, northern Little Smoky, northern Hamlin, Steptoe, Penoyer, and Big Smoky valleys. This suggests that the valley-fill aquifers in these areas are capable of supplying the water for MX construction.

- Moderate yields from wells tapping valley-fill materials (ranging from 100 gpm to 500 gpm or about 160 to 800 acre-ft/yr) (379 l/m to 1893 l/m or 0.2 to 1.0 hm^3/yr) occur in northern Tule, southern Hamlin, southern Wah Wah, Hot Creek, and Cave valleys and at the Milford OB site. This suggests that the valley-fill aquifers in these areas are generally capable of supplying water for MX constructio but some local water supply difficulties may occur.

- Low yields from wells tapping valley-fill materials (less than 100 gpm or about 160 acre-ft/yr) (379 l/m or 0.2 hm^3/yr) occur in southern Tule, northern Pine, Delamar, and Whirlwind valleys and at the Coyote Spring OB site. This suggests that development of valley-fill aquifers for MX construction in these areas may require many wells and may be difficult or may not be feasible.

- The two valley-fill wells drilled in Dugway Valley penetrated rock at about 360 feet (110 m) and 155 feet (47 m) below ground surface, respectively, and no ground water was detected in the wells. This suggests that development of a valley-fill aquifer in Dugway Valley for a source of construction water supply may not be feasible. This, in combination with the very low well yield (7 gpm) (26.5 l/m) in Whirlwind Valley and the presence of the Fish Springs National Wildlife Refuge in Fish Springs Flat, indicates that the northeastern portion of the deployment area may pose a water supply problem for MX. Water may have to be imported from the Sevier Desert or Snake Valley.

- The drawdown of water levels in existing wells or springs and alteration of spring discharge has not been detected during aquifer testing.

- Through careful well-field design, significant effects on local water users and the environment can be minimized or avoided.

- Limestones and dolomites (carbonates) of Devonian age appear to be the major regional aquifers which hydrologically connect many valleys in the siting area. The upper Cambrian carbonates also appear to have potential as significant regional aquifers.

- The Chainman Shale in Nevada (Carboniferous age) appears to be a major confining unit separating local carbonate aquifers from underlying regional ones in most of the areas tested.

- The carbonate well drilled in southern Coyote Spring Valley near the OB site penetrated cavernous carbonate rocks of Carboniferous age. That well had a high well yield (504 gpm) from testing with about 4 feet (1.2 m) of drawdown. A very high transmissivity of 286,000 gpd/ft (3552 m^2/day) is estimated for the carbonate aquifer which suggests very high potential well yields (>1500 gpm) (>5678 l/m). The carbonate unit tested may be the same unit that provides the source of water for Moapa Springs which lies about 20 miles (32 km) to the southeast.

- The low yielding valley-fill aquifer in Coyote Spring Valley, suggesting that additional evaulation of the carbonate aquifers as a source of water for an OB, may be required.

- The yield of the test well at the Dry Lake Valley carbonate aquifer site was only 106 gpm (401 l/m), but because of a very small water-level drawdown, a high transmissivity (100,000 gpd/ft) (1242 m^2/day) is estimated.

- The water temperatures in the test wells tapping the regional carbonate aquifer ranged from 78°F at Coal Valley to 97°F at Coyote Spring Valley. The Steptoe test well topped local carbonate rocks as the ground-water temperature was 53 °F.

- Seven valleys in the MX siting area have been designated as critical ground-water basins by the Nevada State Engineer. In four of these valleys (Big Smoky, Lake, Penoyer, and Stone Cabin), permitted and certificated ground-water rights already exceed the perennial yield. In two of the three remaining designated valleys (Ralston and Steptoe), pending applications total more than the available ground water and may be granted prior to the hearing of the Air Force applications. In the seventh designated valley (Antelope), pending applications and permitted and certificated ground-water rights total less than the perennial yield.

- The Utah State Engineer is not accepting additional applications for the appropriation of ground water in the Milford and Beryl areas of the Escalante Desert. Any ground water used for construction and operation of an operational base in either of these areas will have to be purchased and/or leased or imported.

- In many other Nevada and Utah siting valleys, prioritized pending applications may be granted the available ground water prior to the hearing of the Air Force applications.

- Surface-water rights are nearly or totally appropriated in all valleys.

- Preliminary results from the numerical modeling of selected valleys suggest that equilibrium of the ground-water system will be reached within 18 months of the initiation of Air Force withdrawals. No significant further drawdown of the water table would occur, and water would be salvaged from the perennial yield of the valley.

- Using realistic aquifer characteristics, no more than 5 feet (1.5 m) and usually less than 1 foot (0.3 m) of water-level decline is projected at a distance of 1 mile (1.6 km) from a MX pumping well.

- Using the location of water appropriations points of diversion and drilling program sites, less than 1 foot (0.3 m) of water-level decline in the vicinity of a spring is projected. It should be noted that a water-level decline in the valley-fill aquifer surrounding a spring does not mean that there would be an equivalent decline in the spring unless the spring was solely derived from the aquifer being tapped.

- Preliminary results from the numerical modeling suggest that after the cessation of MX pumping, water levels will return to about 90 percent of their natural level within 90 days, and to their natural level within about two years.

APPENDIX A

Glossary of Selected Hydrogeologic Terminology

GLOSSARY OF SELECTED HYDROGEOLOGIC TERMINOLOGY

AQUIFER. A body of rock or sediments that contains sufficient saturated, permeable material to yield economically significant quantities of ground water to wells and springs.

Confined Aquifer. An aquifer bounded above and below by beds of distinctly lower permeability than that of the aquifer itself.

Carbonate Aquifer. A aquifer, contained in limestone or dolomite rock, which occurs beneath the unconsolidated valley-fill sediments and in the mountain ranges. Flow is believed to be primarily through fracture and solution openings rather than through normal intergranular flow.

Perched Aquifer. An unconfined aquifer separated from an underlying main body of ground water by a material of low permeability and an unsaturated zone.

Valley-fill Aquifer. An aquifer contained within unconsolidated sediments that have filled in the area between bounding mountain ranges or topographic features. These are usually local aquifers limited to the extent of a geographic valley.

DRAWDOWN. The reduction of the water level in a well or the reduction of the pressure head in or near a well as a result of the withdrawal of ground water.

EVAPOTRANSPIRATION. The process by which ground water becomes atmospheric water either by evaporation from a surface or by transpiration by plants. No effort is made to distinguish between the two.

PERENNIAL YIELD. The amount of water that can be withdrawn on a continuous basis without causing an undesirable result. The term "undesirable result" is not defined, but may include intrusion of water of undesirable quality, reduction of head below an economic pumping level, or environmental effects such as destruction of marshy wildlife habitat or destruction of useful phreatophytes. Perennial yield cannot be computed until a management decision has been made on the definition of an undesirable result. Perennial yield in this report refers to state and federal estimates. Those estimates are not accompanied by a quantification or definition of undesirable effects.

PHREATOPHYTE. A plant which takes water directly from the water table through roots which penetrate to the saturated zone. In the MX siting area, these are primarily greasewood, rabbitbrush, saltgrass, and pickleweed.

POTENTIOMETRIC SURFACE. An imaginary surface representing the total head of water in an aquifer. It is the level at which water will stand in a properly constructed well. Ground water flows from higher to lower potential and perpendicular to lines of equal potential elevation.

STORAGE COEFFICIENT. The amount of water added to or removed from storage per unit of surface area of an aquifer per unit of change in head normal to that surface. Expressed as a decimal ratio.

TRANSMISSIVITY. The amount of water flowing through a unit width of an aquifer in response to a unit gradient. It is a measure of the ability of an aquifer to transmit water. It is numerically equal to the hydraulic conductivity times the aquifer thickness. Commonly expressed in gallons per day per foot (meters squared per day).

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