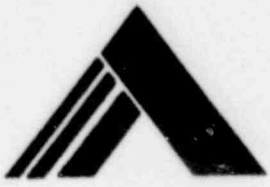
PALO VERDE NUCLEAR GENERATING STATION



UNITS 4 & 5

ENVIRONMENTAL REPORT
CONSTRUCTION PERMIT STAGE

SUPPLEMENT NO. 2
MAY 1979

ARIZONA PUBLIC SERVICE COMPANY
PROJECT MANAGER AND OPERATING AGENT

ARIZONA PUBLIC SERVICE COMPANY
P. O. BOX 21666 · PHOENIX, ARIZONA 85036

June 4, 1979
PVNGS-289-JMA/DBK

Director of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Palo Verde Nuclear Generating Station
Units 4 and 5
File: FF-79-054-026

Docket Nos: STN-50-592/593

Dear Sir:

Arizona Public Service Company (APS) as Project Manager and Operating Agent for Palo Verde Nuclear Generating Station (PVNGS) Units 4 and 5, is submitting herewith for your review 41 copies of Supplement 2 of the PVNGS 4 and 5 Environmental Report pursuant to the requirements of 10CFR50.30.(c).(1).(iv).

This Supplement provides an alternative supplemental water source evaluation.

Respectfully submitted,
Arizona Public Service Co.
By: Edwin E. Van Brunt
Edwin E. Van Brunt, Jr.
APS Vice President
Nuclear Projects
ANPP Project Director

On its own behalf and as agent for all other joint applicants

2354 113

dup 7906050302

State of Arizona)
) ss.
County of Maricopa)

Subscribed and sworn to before me this 11 day of MAY 1979.

Notary Public

My Commission Expires:
My Commission Expires Jan. 23, 1983

cc: (See Attachment)

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cc:

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U. S. Nuclear Regulatory
Commission
Washington, D.C. 20555

Atomic Safety and Licensing
Appeal Board
U. S. Nuclear Regulatory
Commission
Washington, D.C. 20555

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Washington, D.C. 20555

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INSTRUCTION SHEET

The title page for Supplement No. 2 may be discarded. Follow the removal and insertion instructions for the six volumes.

Section	Remove Original Pages	Insert Sup. No. 2 Pages
	Volume I	
Front Matter	---	Supplement No. 2 Letter
	---	Supplement No. 2 Instruction Sheet
	A/B thru M/blank	A/B thru M/N
	xi/xii	xi/xii
Chapter 1	1.1-1/1.1-2	1.1-1/1.1-2
	Volume II	
Front Matter	xi/xii	xi/xii
	Volume III	
Front Matter	xi/xii	xi/xii
	Volume IV	
Front Matter	xi/xii	xi/xii

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INSTRUCTION SHEET

Section	Remove Original Pages	Insert Sup. No. 2 Pages
Chapter 3	Figure 3.9-9	Figure 3.9-9
	Volume V	
Front Matter	xi/xii	xi/xii
Chapter 9	9.2-25/9.2-26	9.2-25/9.2-26
	Figure 9.2-3	Figure 9.2-3
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Chapter 10	10.i/10-ii	10.i/10-ii
	---	Tab 10B
	---	Appendix 10B

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Title	O[a]
Letter (5 pages)	O
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Letter (3 pages)	S-2[c]
Intro 1	O
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3	O
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1.2-11	S-1
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a. Original issue, March 1978.
b. Supplement 1, September 1978
c. Supplement 2, May 1979.

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1-v	S-1
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Table 1.2-7	S-1
Table 1.2-8 (17 sheets)	S-1
Table 1.2-9A (5 sheets)	S-1
Table 1.2-9B (5 sheets)	S-1
Table 1.2-10A (2 sheets)	S-1
Table 1.2-10B (3 sheets)	S-1
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Appendix 1A (34 pages)	S-1
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Appendix 1D (6 pages)	S-1
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Appendix 1I (12 pages)	S-1
Appendix 1J (56 pages)	S-1
Appendix 1K (21 pages)	S-1
Appendix 1L (98 pages)	S-1

Volume III

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v	S-1
vi	S-1
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Appendix 1M (36 pages)	S-1
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Appendix 1T	
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Appendix 1U	
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viii	S-1
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x	S-1
xi	S-1
xii	S-1
2-i	S-1
2-ii	O
2-iii	O
2-iv	O
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Figure 2.1-1	O
Figure 2.1-2	O
2.2-1	O
2.2-2	O
2.2-3	O
2.2-4	O
2.2-5	O
2.2-6	O
2.2-7	O
2.2-8	O
2.2-9	O
2.2-10	O
2.2-11	O
2.2-12	O
Figure 2.2-1	O
Figure 2.2-2	O
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2.3-6	S-1
2.3-7	S-1
2.4-1	O
Figure 2.4-4	O
2.5-1	O
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Figure 2.5-8	O
Figure 2.5-9 (5 sheets)	O

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Page	Issue	Page	Issue
2.6-1	O	2.7-33	O
2.6-2	O	2.7-34	O
2.7-1	O	2.7-35	O
2.7-2	O	2.7-36	O
2.7-3	O	Figure 2.7-1A	O
2.7-4	O	Figure 2.7-2A	O
2.7-5	O	Figure 2.7-3A	O
2.7-6	O	2.8-1	O
2.7-7	O	2.8-2	O
2.7-8	O	2.9-1	O
2.7-9	O	2A-1	O
2.7-10	O	2B-1	O
2.7-11	O	2B-2	O
2.7-12	O	2B-3	O
2.7-13	O	2B-4	O
2.7-14	O	2B-5	O
2.7-15	O	2B-6	O
2.7-16	O	2B-7	O
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2.7-18	O	2B-9	O
2.7-19	O	2B-10	O
2.7-20	O	2C-1	O
2.7-21	O	2D-2	O
2.7-22	O	2E-1	O
2.7-23	O	2E-2	O
2.7-24	O	2F-1	O
2.7-25	O	2F-2	O
2.7-26	O	2G-1	O
2.7-27	O	2G-2	O
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2.7-32	O	3.1-1	O

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Page	Issue	Page	Issue
3.1-2	O	3.5-15	O
Figure 3.1-4	O	3.5-16	O
Figure 3.1-5	O	3.5-17	O
Figure 3.1-6	O	Figure 3.5-6	O
Figure 3.1-8	O	3.6-1	O
Figure 3.1-9	O	3.6-2	O
Figure 3.1-10	O	3.6-3	O
Figure 3.1-11	O	3.6-4	O
Figure 3.1-12	O	3.6-5	O
3.2-1	O	Figure 3.6-1	O
3.3-1	O	Figure 3.6-2	O
Figure 3.3-1		Figure 3.6-3	O
(4 sheets)	O	Figure 3.6-4	O
3.4-1	O	Figure 3.6-5	O
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3.4-4	O	3.7-3	O
3.4-5	O	3.8-1	S-1
Figure 3.4-1	O	3.9-1	S-1
Figure 3.4-2	O	3.9-2	S-1
3.5-1	O	3.9-3	S-1
3.5-2	O	3.9-4	S-1
3.5-3	O	3.9-5	S-1
3.5-4	O	3.9-6	S-1
3.5-5	O	3.9-7	S-1
3.5-6	O	3.9-8	S-1
3.5-7	O	3.9-9	S-1
3.5-8	O	3.9-10	S-1
3.5-9	O	3.9-11	S-1
3.5-10	O	3.9-12	S-1
3.5-11	O	3.9-13	S-1
3.5-12	O	3.9-14	S-1
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3.9-21/3.9-22	S-1
3.9-23/3.9-24	S-1
3.9-25	S-1
3.9-26	S-1
3.9-27	S-1
3.9-28	S-1
3.9-29	S-1
3.9-30	S-1
3.9-31	S-1
3.9-32	S-1
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Figure 3.9-3	S-1
Figure 3.9-4	S-1
Figure 3.9-5	S-1
Figure 3.9-6	S-1
Figure 3.9-7	S-1
Figure 3.9-8	S-1
Figure 3.9-9	S-2
3A-1	O
3A-2	O
3A-3	O
3A-4	O
3A-5	O
3A-6	O
3A-7	O
3A-8	O
3A-9	O
3A-10	O

Volume V

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xi	S-1
xii	S-1
4-i	S-1
4-ii	S-1
4.1-1	O
4.1-2	O
4.1-3	O
4.1-4	O
4.1-5	O
4.1-6	O
4.1-7	O
4.1-8	O
4.1-9	O
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4.1-12	O
4.1-13	O
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LIST OF EFFECTIVE PAGES

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4.2-2	S-1	5.1-5	O
4.2-3	S-1	5.1-6	O
4.2-4	S-1	5.1-7	O
4.2-5	S-1	5.1-8	O
4.2-6	S-1	5.1-9	O
4.2-7	S-1	5.1-10	O
4.2-8	S-1	5.1-11	O
4.2-9	S-1	5.1-12	O
4.2-10	S-1	5.1-13	O
4.2-11	S-1	Figure 5.1-1	O
4.2-12	S-1	Figure 5.1-2	O
4.2-13	S-1	Figure 5.1-3	O
4.2-14	S-1	Figure 5.1-4	O
4.2-15	S-1	Figure 5.1-5	O
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4.2-17	S-1	Figure 5.1-9	O
4.2-18	S-1	Figure 5.1-10	O
4.2-19	S-1	Figure 5.1-11	O
4.2-20	S-1	Figure 5.1-12	O
4.2-21	S-1	Figure 5.1-13	O
4.2-22	S-1	Figure 5.1-14	O
4.2-23	S-1	Figure 5.1-15	O
4.2-24	S-1	Figure 5.1-16	O
4.2-25	S-1	Figure 5.1-17	O
4.2-26	S-1	Figure 5.1-18	O
4.3-1	O	Figure 5.1-19	O
5-i	O	Figure 5.1-20	O
5-ii	O	5.2-1	O
5-iii	O	5.2-2	O
5-iv	O	5.2-3	O
5.1-1	O	5.3-1	O
5.1-2	O	5.3-2	O
5.1-3	O	5.3-3	O
5.1-4	O	5.3-4	O

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Page	Issue	Page	Issue
5.3-5	O	3	O
5.3-6	O	4	O
5.4-1	O	5	O
5.4-2	O	6	O
5.4-3	O	7	O
5.4-4	O	8	O
5.4-5	O	9	O
5.4-6	O	10	O
5.5-1	O	11	O
5.6-1	S-1	12	O
5.6-2	S-1	13	O
5.6-3	S-1	14	O
5.7-1	O	15	O
5.7-2	O	16	O
5.7-3	O	17	O
5.7-4	O	18	O
5.7-5	O	19	O
5.7-6	O	20	O
5.7-7	O	21	O
5.7-8	O	22	O
5.7-9	O	23	O
5.7-10	O	24	O
Figure 5.7-2	O	25	O
5.8-1	O	26	O
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5A-1	O	28	O
5A-2	O	29	O
5B-1	O	30	O
Title Page	O	31	O
Table of Contents	O	32	O
List of Tables	O	33	O
List of Figures	O	34	O
1	O	35	O
2	O	36	O

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37	O	7-i	O
38	O	7-ii	O
39	O	7.1-1	O
40	O	7.1-2	O
41	O	7.1-3	O
6-i	O	7.1-4	O
6-ii	O	7.1-5	O
6.1-1	O	7.1-6	O
6.1-2	O	7.1-7	O
6.1-3	O	7.1-8	O
6.1-4	O	7.1-9	O
6.1-5	O	7.1-10	O
6.1-6	O	7.1-11	O
6.1-7	O	7.1-12	O
6.1-8	O	7.1-13	O
6.1-9	O	7.1-14	O
6.1-10	O	7.1-15	O
6.1-11	O	7.1-16	O
6.1-12	O	7.1-17	O
6.1-13	O	7.1-18	O
6.1-14	O	7.2-1	O
6.1-15	O	7.2-2	O
6.1-16	O	8-i	S-1
6.1-17	O	8-ii	S-1
6.2-1	O	8.1-1	S-1
6.3-1	O	8.1-2	S-1
6.3-2	O	8.1-2a/8.1-2b	S-1
6.3-3	O	8.1-2c	S-1
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6A-2	O	8.1-4	O
6B-1	O	8.1-5	O
6B-2	O	8.1-6	O

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LIST OF EFFECTIVE PAGES

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8.1-10	O	9.1-5	S-1
8.1-11	S-1	9.1-6	S-1
8.1-12	O	9.1-7	S-1
8.1-13	S-1	9.1-8	S-1
8.1-14	S-1	9.2-1	S-1
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8.2-1	S-1	9.2-3	S-1
8.2-2	S-1	9.2-4	S-1
8.2-3	S-1	9.2-5	S-1
8.2-4	O	9.2-6	S-1
8.2-5	O	9.2-7	S-1
8.2-6	O	9.2-8	S-1
8.2-7	O	9.2-9	S-1
8.2-8	O	9.2-10	S-1
8.2-9	O	9.2-11	S-1
8A Title	S-1	9.2-12	S-1
8A-i	S-1	9.2-13	S-1
8A-ii	S-1	9.2-14	S-1
8A-1	S-1	9.2-15	S-1
8A-2	S-1	9.2-16	S-1
8A-3/8A-4	S-1	9.2-17	S-1
8A-5	S-1	9.2-18	S-1
8A-6	S-1	9.2-19	S-1
8A-7	S-1	9.2-20	S-1
8A-8	S-1	9.2-21/9.2-22	S-1
8A-9	S-1	9.2-23	S-1
8A-10	S-1	9.2-24	S-1
9-i	S-1	9.2-25	S-1
9-ii	S-1	9.2-26	S-2
9-iii	S-1	9.2-27/9.2-28	S-1
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9.2-33/9.2-34	S-1
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9.2-37	S-1
9.2-38	S-1
9.2-39	S-1
9.2-40	S-1
9.2-41	S-1
9.2-42	S-1
9.2-43	S-1
9.2-44	S-1
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Figure 9.2-2	S-1
Figure 9.2-3	S-2
Figure 9.2-4	S-1
Figure 9.2-5	S-1
Figure 9.2-6	S-1
9.3-1	S-1
9.3-2	S-1
9.3-3	S-1
9.3-4	S-1
9.3-5	S-1
9.3-6	S-1
9.3-7	S-1
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9.4-2	S-1

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v	S-1

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viii	S-1
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xi	S-1
xii	S-1
10-i	S-1
10-ii	S-2
10-iii	S-1
10-iv	S-1
10-v	S-1
10.1-1	O
10.1-2	O
10.1-3	O
10.1-4	O
10.1-5	O
10.1-6	O
10.1-7	O
10.1-8	O
10.1-9	O
10.1-10	O
10.1-11	O
10.1-12	O
10.1-13	O
10.1-14	O
10.1-15	O
10.1-16	O
10.1-17	O
10.1-18	O
10.1-19	O
10.1-20	O
10.1-21	O
10.1-22	O

LIST OF EFFECTIVE PAGES

Page	Issue	Page	Issue
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1. PURPOSE OF THE PROPOSED FACILITY

1.1 GENERAL INFORMATION

This Environmental Report (ER) is submitted in support of the joint application for construction permits for two nuclear power units. The two units are to be located at Palo Verde Nuclear Generating Station (PVNGS) and are hereinafter referred to as PVNGS-4&5. Each unit is to have a nominal net generating capacity of 1,270 megawatts and is to be a replicate of PVNGS-1,2&3. Units 1,2&3 at PVNGS are now under construction pursuant to Construction Permit numbers CPPR-141, CPPR-142, and CPPR-143, issued in NRC Dockets STN 50-528, STN 50-529, and STN 50-530, respectively. The scheduled dates for commercial operation of all the PVNGS units are as follows:

A. Unit 1 - May 1, 1982
B. Unit 2 - May 1, 1984
C. Unit 3 - May 1, 1986
D. Unit 4 - May 1, 1988
E. Unit 5 - May 1, 1990

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The joint application is filed by Arizona Public Service Company (APS) on its own behalf and as agent for the other joint applicants identified in the application. Subject to the receipt of approvals and authorizations required by law (refer to sections 12.1 and 12.2 of this ER), the joint applicants (sometimes referred to as "participants") will jointly own PVNGS-4&5 as tenants in common with undivided ownership interests in the respective percentages set forth in the joint application.

Pursuant to the Amended PVNGS Replication Agreement, dated as of February 1, 1978, (a copy of which is included with the General Information accompanying the joint application as Appendix 1A to section 1), APS is the Project Manager and Operating Agent of the PVNGS-4&5 project and in such capacities will have the full authority and responsibility to engineer, design, construct, operate and maintain PVNGS-4&5 and to file and prosecute all

applications for licenses, permits, and authorizations necessary therefor.

The PVNGS-4&5 project is neither a corporate entity, a partnership nor a joint venture. It is a jointly owned facility, consisting of all equipment, structures, nuclear fuel, and all other property and rights that are or may be used or useful in the operation and maintenance of the facility. The PVNGS-4&5 project also includes a share of the common facilities to be shared with PVNGS-1,2&3, but excludes all transmission lines. Each joint owner has the sole and exclusive right to a percentage, equal to its ownership interest of the generating capability of each unit of PVNGS-4&5. Accordingly, no sales of power will be made by the project or by APS as agent for other participants in PVNGS-4&5. Instead, all sales of power and energy from each unit of PVNGS-4&5 will be made by the several joint owners, individually, to their respective customers.

Collectively, the PVNGS-4&5 Participants provide, either at retail or wholesale, a substantial portion of the power needed by the public in Arizona, west Texas, southern New Mexico, southern Nevada, and southern California. In addition, APS wholesales power to Mexican utilities for distribution in Mexico; such sales are less than 1 percent of total APS sales.

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C. Three sites located in the Upper Little Colorado River area
   1. St. Johns
   2. Upper Little Colorado River 2
   3. Snowflake.

Detailed literature reviews and field studies at the nine candidate sites were performed. The results of these studies are shown in table 9.2-4.

In the final process, the results of the environmental and economic studies were reviewed. SRP then selected the Snowflake and St. Johns sites for further investigation. This decision was based primarily on economic consideration since these sites were located very close to the coal supply to be used and were considered to be located in the best meteorological area; as a result they ranked higher than any of the other sites in these areas.

SRP subsequently selected the St. Johns site for construction of what is now known as the Coronado Generating Station, the first of three 350-MWe units scheduled for commercial operation in 1979.

In 1976, Arizona Public Service Company used the information collected in the SRP siting study to assist in defining an alternate coal site for use in the late 1980, early 1990 time frame.

The Rainbow and Chino sites identified in the SRP siting study were immediately eliminated due to the air quality findings and the proximity of the Chino site to areas of high terrain. At that time (1976) it was decided that all the remaining alternates in the SRP study were viable, but APS concentrated its preliminary investigations exclusively on the Ranegras site.

The subsequent enactment of the Clean Air Act Amendments of 1977 required the reevaluation of sites identified in the SRP study

as viable alternate coal sites. The Upper Colorado River 2 and Snowflake sites were not considered further because the major portion of the Class I area increment at the Petrified Forest National Park has been allocated by EPA to the Cholla 5 plant.

Another result of the Clean Air Act Amendments has been the designation of Maricopa County, Arizona, as a nonattainment area for carbon monoxide and particulates by the EPA. This designation, if not changed, would make development of coal-fired plants at the Hassayampa site, as well as at the PVNGS or Gillespie Dam sites, impractical. The remaining sites, identified as alternates in the SRP study, are the Sentinel 1 and Sentinel 2 sites and the Ranegras site.

Using the information obtained from the investigations of SRP (see table 9.2-4), the Sentinel 2 site is shown to be slightly more suitable than the Sentinel 1 site, based on evaluations of air quality, meteorology, and ecology (projected impact of proposed roads, railroads and pipelines), the other factors considered in table 9.2-4 being essentially equal. It has been concluded, based on the SRP study and the preliminary investigations by APS, that the two preferable sites for developing an alternative coal plant are the Ranegras and Sentinel 2 sites. Hereinafter these sites will be referred to as the Bouse site and the Sentinel site, respectively.

The Bouse site is located in the Ranegras Plain, as shown in figure 9.2-5. It is situated in the northern portion of Yuma County, Arizona, about 110 miles west-northwest of Phoenix. The Sentinel site is located in western Yuma County, about 90 miles west-southwest of Phoenix, as shown in figure 9.2-5. Based on present knowledge of the Bouse site, it is limited in development to about 1500-MWe. This limitation is founded on two basic restrictions: air quality and limited water availability.

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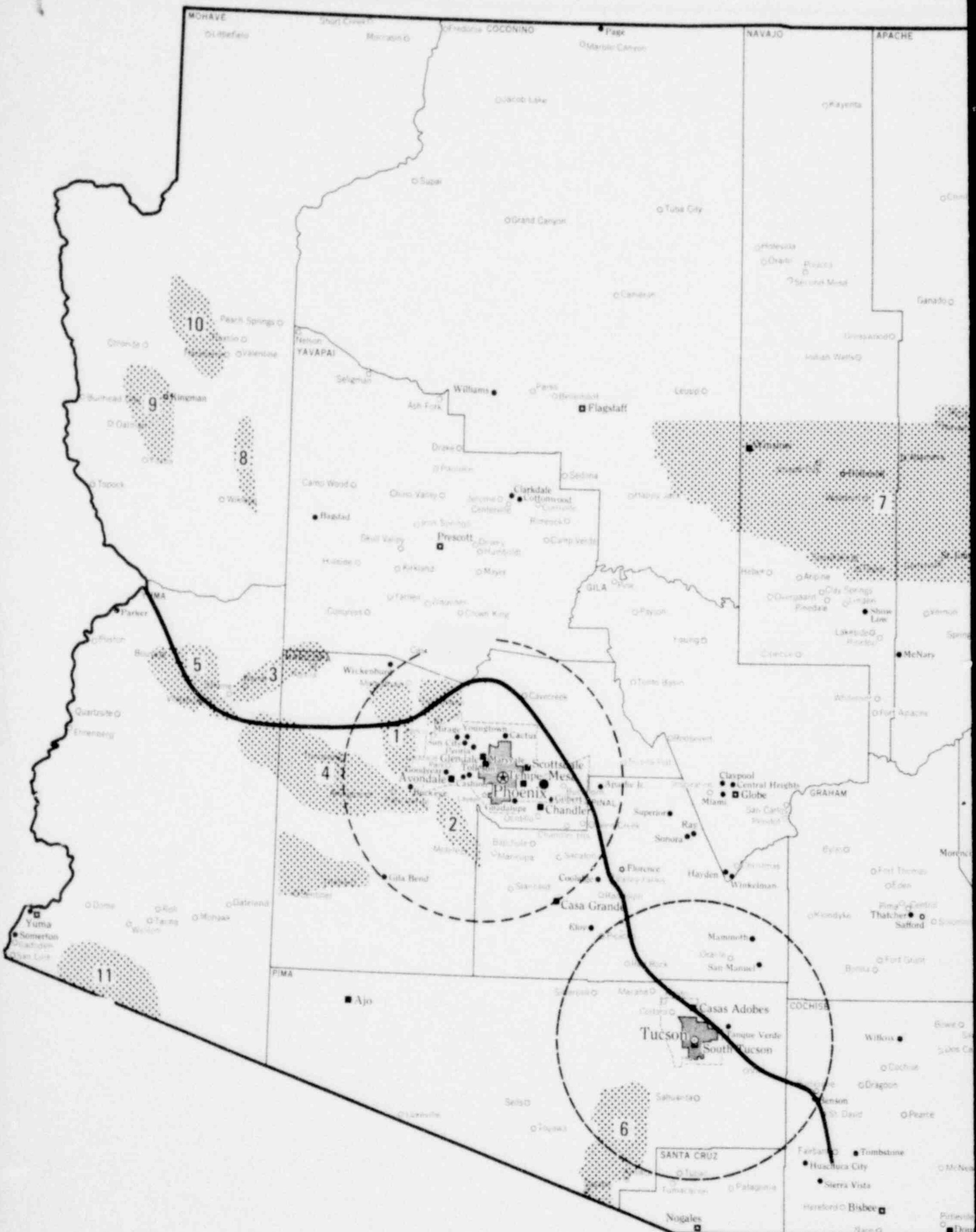

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Cottonwood
Bagdad
Parker
Wickenburg
Phoenix
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Scottsdale
Tempe
Mesa
Chandler
Avondale
Gilbert
Globe
Miami
Claypool
Central Heights
Superior
Ray
Sonora
Hayden
Winkelman
Florence
Coolidge
Casa Grande
Eloy
Gila Bend
Ajo
Yuma
Somerton
Mammoth
San Manuel
Casas Adobes
Tucson
South Tucson
Tanque Verde
Willcox
Benson
Tombstone
Huachuca City
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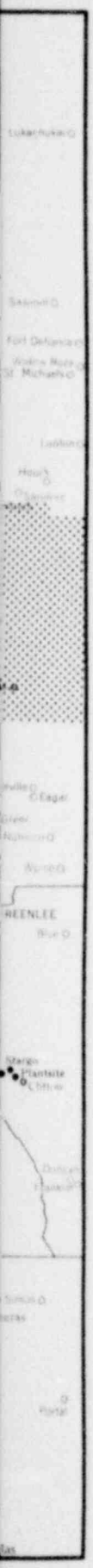

SCALE

0 20 40

Miles

LEGEND:

Areas of Groundwater Availability

1. HASSAYAMPA VALLEY
2. RAINBOW VALLEY
3. McMULLEN VALLEY
4. HARQUAHALA PLAINS
5. RANEGRAS PLAINS
6. ALTAR VALLEY
7. LITTLE COLORADO
8. BIG SANDY VALLEY
9. SACRAMENTO VALLEY
10. HUALAPAI VALLEY
11. YUMA AREA

Sewage Water Supplies 50-Mile Radius

Central Arizona Project

NOTE:
The sewage water supply 50-mile radius for Phoenix is centered on the 91st Avenue Sewage Treatment Plant

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Supplement No. 2
May 1979

Palo Verde Nuclear Generating Station
Units 4 & 5

CANDIDATE AREA LOCATION MAP

Figure 9.2-3

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APPENDIX 10B

ALTERNATIVE SUPPLEMENTAL WATER SOURCE EVALUATION

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Figures

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10B. ALTERNATIVE SUPPLEMENTAL WATER SOURCE EVALUATION

The analyses relating to the use of wastewater effluent from the 91st Avenue Sewage Treatment Plant as the sole or primary source of condenser cooling water for Palo Verde Units 4 and 5 were based on projections prepared by the City of Phoenix Water and Sewer Department of quantities of effluent which would be available for use in the period 1978-2000 at the Palo Verde Nuclear Generating Station (PVNGS) in accordance with the wastewater effluent contract (Agreement No. 13904) between the six municipalities that own the 91st Avenue Plant and Arizona Public Service Company (APS) and Salt River Project. Subsequent to the receipt of such projections, it was brought to the applicants' attention that studies conducted for the Maricopa Association of Governments (MAG) Regional Council for the purpose of developing an areawide wastewater management plan for Maricopa County, pursuant to Section 208 of P.L. 92-500 (Federal Water Pollution Control Act Amendments of 1972), contained conflicting and significantly reduced projections of wastewater effluent from the 91st Avenue Plant.

These studies (hereinafter the MAG 208 Studies), which were conducted by the Corps of Engineers (COE) with various portions being performed by various engineering firms under contracts with MAG and COE, led to the initial identification of 36 areawide alternatives which, through the process of review and selection, were reduced to 20 and then to 7 alternatives. These seven alternatives were then broken into two subregional areas (i.e., eastside and westside) for detailed analysis and consideration by the MAG 208 advisory group structure. The MAG 208 advisory group structure consisted of a citizens' advisory group, a technical advisory group, an agricultural advisory group, a management subcommittee, and an executive committee. After receipt of the initial recommendations of the advisory groups, the MAG Regional Council in July 1978

designated three preferred eastside and three preferred westside alternatives for further study and consideration. During the ensuing process one of the westside alternatives was eliminated and four areawide alternatives were presented to the MAG Regional Council for consideration. In November 1978, the Council selected alternative 2 as the approved regional plan for Maricopa County (hereinafter referred to as the "MAG Approved Plan"). Subsequently, in February 1979, the Arizona State Water Quality Control Council approved the MAG Approved Plan. It was adopted by the Governor and submitted to the Administrator of the Environmental Protection Agency (EPA) for review.

The MAG Approved Plan includes the following:

a. Expansion of the 91st Avenue Plant immediately to increase its capacity by 30 Mgal/d providing a total capacity of 120 Mgal/d (135,000 acre-ft/yr).

b. Later expansion of 91st Avenue Plant to increase capacity to 134.6 Mgal/d (151,000 acre-ft/yr), to serve anticipated requirements through year 2000.

c. Upgrading the City of Phoenix 23rd Avenue Sewage Treatment Plant from a current rating 31 to 40 Mgal/d (44,800 acre-ft/yr).

d. Expansion of the City of Tolleson Sewage Treatment Plant to 7.2 Mgal/d (8000 acre-ft/yr). The outfall from the Tolleson Plant is crossed by the PVNGS effluent pipeline at 91st Avenue.

e. Construction of a new sewage treatment plant at Reems Road near the Gila River with a capacity of 5.4 Mgal/d (6000 acre-ft/yr) to serve the communities of Avondale, Goodyear, and Litchfield Park. The Reems Road Plant is to be located near the Gila River in close proximity to the PVNGS effluent pipeline.

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Refer to figure 10B-1 for the locations of these plants.

Thus, under the MAG Approved Plan the planned capacities by the year 2000 of expanded or new sewage treatment plants situated in proximity to the PVNGS effluent pipeline can be summarized as follows:

	Capacity acre-ft/yr
91st Avenue Plant	151,000
23rd Avenue Plant	44,800
Tolleson Plant	8,000
Reems Road Plant	6,000

Agreement 13904 requires the delivery of up to 140,000 acre-ft/yr of wastewater effluent when available from the 91st Avenue and 23rd Avenue Plants after satisfaction of prior commitments in the total amount of 37,300 acre-ft/yr.

The amount of effluent available in 1990 under Agreement 13904, as projected by the City of Phoenix in 1978, is 44,800 acre-feet from the 23rd Avenue Plant and 122,400 acre-feet from the 91st Avenue Plant, or a total of 167,200 acre-feet. In contrast, the COE in connection with the MAG 208 Studies projected that the total effluent processed at both the 91st and the 23rd Avenue Plants would be about 167,000 acre-feet in 1990 and about 180,000 acre-feet in 1995. Of these total quantities of effluent expected to be processed about 129,000 acre-feet in 1990 and about 142,000 acre-feet in 1995 would be available to satisfy the requirements of Agreement 13904.

Both the City of Phoenix and the COE projections utilized the same projections of population growth in metropolitan Phoenix as well as the same water usage factors per household in 1977. However, while both projections included an allowance for the

effect of conservation on the use of water, the COE projections assumed significantly larger conservation factors.

It is not clear which of the two projections will prove to be more correct, but in light of the potential that effluent processed at the 91st Avenue Plant will be less than originally anticipated, a review of the alternative supplemental water sources has been conducted and the results of such review are set forth in this Appendix 10B.

In this connection, however, four points should be noted.

1. The MAG Approved Plan does provide sufficient capacity at the 91st and 23rd Avenue Plants to meet the effluent requirements of five units at PVNGS;
2. The projections of the COE do show an adequate supply of effluent for condenser cooling water requirements of PVNGS in 1990 from both 91st and 23rd Avenue Plants;
3. The potential deficiency in the supply of effluent from the 91st Avenue Plant is limited in time.
4. There are several alternative supplemental sources of water for condenser cooling and ample time to consider and select the most prudent alternative before a commitment must be made.

10B.1 PVNGS CONDENSER COOLING WATER REQUIREMENTS

As discussed in section 3.3.1, the per-unit condenser cooling water requirement at the Palo Verde site is 21,350 acre-ft/yr. This requirement is based on the following assumptions:

a. City of Phoenix wastewater effluent is utilized as the source of condenser cooling water.
b. Wastewater effluent is delivered to the 91st Avenue Sewage Treatment Plant.
c. The planned unit capacity factor is 95 percent.

d. Annual average ambient meteorological conditions.
e. No blowdown treatment.
f. Losses as defined in PVNGS-4&5 ER, figure 3.3-1.
g. One month allowed for refueling.

If the source of condenser cooling water is other than wastewater effluent, the water requirements will vary depending on the makeup water quality and blowdown quantities required to maintain proper water chemistry in the cooling towers. In addition, water requirements will vary with meteorological conditions and unit capacity factor. For the purposes of this appendix, 21,350 acre-ft/yr will be assumed as the per-unit water requirement, regardless of source, throughout the life of PVNGS.

As shown in PVNGS-4&5 ER, table 5.7-2, PVNGS water requirements vary by month. The sum of the requirements for each month gives the per-unit requirement of 21,350 acre-ft/yr. Peak water consumption is in the month of August. Peak water requirements are shown in figure 10B-2 as the August requirements times 12. In cases where the peak water requirements are greater than effluent availability, an effluent shortage will exist in 1 or more summer months of that year.

10B.2 SEWAGE EFFLUENT AVAILABILITY

Wastewater effluent is available to PVNGS from several sources. The two major sources are the 23rd Avenue Sewage Treatment Plant and the 91st Avenue Sewage Treatment Plant. The availability of up to 140,000 acre-ft/yr has been assured by a contract with the municipal owners of such plants. Other potential smaller sources of effluent are the Tolleson Sewage Treatment Plant and a planned Reems Road Sewage Treatment Plant. Estimates of effluent quantities from the 23rd and 91st Avenue sources have been made by the City of Phoenix, Water and Sewers Department, and by the COE for the MAG 208

Water Quality Management Program[1]. These estimates vary considerably and are, therefore, presented separately. Estimates of effluent quantities from the Tolleson and Reems Road sources have been made by the COE.

10B.2.1 CITY OF PHOENIX ESTIMATES

Estimates of the wastewater effluent available from the 91st and 23rd Avenue Sewage Treatment Plants, as prepared by the City of Phoenix, Water and Sewers Department,[2] are presented in figure 10B-2.

10B.2.2 MAG ESTIMATES

Estimates of the wastewater effluent available from the 91st and 23rd Avenue Sewage Treatment Plants, as prepared for MAG by the COE, are presented in figure 10B-2.

The Tolleson Sewage Treatment Plant currently processes less than 1000 acre-ft/yr and under the MAG plan will be expanded to 8000 acre-ft/yr by the year 2000. Current wastewater effluent discharge from the Tolleson plant is utilized under contract for Turf Production. The proposed Reems Road facility will be sized for 6000 acre-ft/yr.[1] Effluent from these sources, as predicted by MAG, is presented in figure 10B-3.

The estimates are based on Arizona Department of Economic Security population projections and a per capita effluent production. Allowances for conservation included in the estimate are as follows:

New homes--15 percent reduction beginning in 1980

Existing homes--1 percent/yr reduction from 1980 to 1985

10B.2.3 REFERENCES

1. Maricopa Association of Governments, 208 Water Quality Management Program, Draft Final Plan, December 1978.

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2. Letter from A. F. Vondrick, as Water and Sewers Director, City of Phoenix, Water and Sewers Department, to E. E. Van Brunt, Jr., Vice President, Arizona Public Service Company, August 29, 1978.

10B.3 ADDITIONAL WATER REQUREMENTS

10B.3.1 CITY OF PHOENIX ESTIMATES

Based on the City of Phoenix estimates for the 23rd and 91st Avenue plants, as discussed in Section 10B.2.1, a short-term effluent shortage during the summer months of 1990-1992 could exist when effluent from only the 91st Avenue Plant is utilized. This shortage is discussed in the PVNGS-4&5 ER, sections 10.2.2.1 and 5.7. As shown in figure 10B-2, if effluent from the 23rd Avenue plant is also utilized, no shortage is predicted in any month.

10B.3.2 MAG ESTIMATES

Based on the MAG estimates prepared by the COE, an effluent shortage exists for approximately 20 years when effluent from only the 91st Avenue Plant is utilized (refer to figure 10B-2). If effluent from the 23rd Avenue plant is also utilized, no shortage is predicted.

10B.4 ALTERNATIVE COOLING WATER SOURCES

Section 10.2 discusses alternatives available for condenser cooling water requirements at PVNGS-4&5. Although the discussion presented in section 10.2 is keyed to supplying 100 percent of the cooling water requirements, it does provide useful information in determining the alternatives available for providing the potential water requirements discussed by section 10B.3. Seven alternatives are discussed in section 10.2.

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The alternatives are as follows:

1. Wastewater effluent from the City of Phoenix 91st Avenue Sewage Treatment Plant
2. Offsite groundwater
3. Groundwater from Buckeye Irrigation District (BID) wells supplemented, as necessary, to meet quality requirements for treatment in a water-reclamation facility of similar design to PVNGS-1,2&3, by wastewater effluent from the 91st Avenue Sewage Treatment Plant
4. Groundwater from Roosevelt Irrigation District (RID) wells supplemented, as necessary, to meet quality requirements for treatment in a water-reclamation facility of similar design to PVNGS-1,2&3, by wastewater effluent from the 91st Avenue Sewage Treatment Plant
5. Existing or future water projects (Central Arizona Project, CAP)
6. Agricultural drainage water from the BID supplemented, as necessary, to meet quality requirements for treatment in a water-reclamation facility of similar design to that of PVNGS-1,2&3, by wastewater effluent from the 91st Avenue Sewage Treatment Plant
7. Maximum available agriculture drainage water from the BID supplemented, as necessary, to meet quantity requirements, by wastewater effluent from the 91st Avenue Sewage Treatment Plant

Four additional alternatives, a through d, are discussed in section 10.2 for providing supplemental water requirements based upon City of Phoenix estimates of effluent availability.

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These alternatives are as follows:

a. Negotiate an agreement with BID to lay off a portion of their allotment (30,000 acre-feet) of 91st Avenue

effluent during the summer months of 1990 and 1991. This lay off could then be recaptured during the winter months.

b. Negotiate an agreement with the City of Phoenix to process raw sewage at the 91st Avenue plant that would normally be processed at the 23rd Avenue plant, thereby making additional effluent available at the 91st Avenue plant.

c. Utilize onsite or offsite wells to make up only the effluent cooling water requirements.

d. Use cooling tower blowdown treatment to reduce condenser cooling water requirements.

The viability of these and related alternatives for makeup of an effluent shortage is dependent upon the amount of supplemental water required and, therefore, upon the effluent-availability estimate used.

10B.4.1 CITY OF PHOENIX

Based upon the City of Phoenix estimates (refer to section 10B.2.1) the effluent from the 91st Avenue Plant would be insufficient to meet the peak summer requirements for PVNGS-4&5 during 1990 to 1992. Because the deficiency is small and lasts only a few years, alternatives a, b, c, and d are viable alternatives for obtaining the necessary effluent without acquiring an additional water source.

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10B.4.2 MAG ESTIMATES

Based upon the MAG estimates (refer to section 10B.2.2) the effluent available at the 91st Avenue Plant is not sufficient for PVNGS-4&5. Therefore it may be necessary to develop a supplemental water source. Alternatives 1 through 7 (section 10B.4) represent sources of supplemental water and suggest other sources of supplemental water that, while too small to

provide 100 percent of the condenser cooling water requirements for PVNGS-4&5 as discussed in section 10.2, can provide supplemental water in quantities sufficient to make up shortages predicted using the MAG estimates.

10B.4.2.1 Alternative 1

If sufficient wastewater effluent is not available at the 91st Avenue Plant, additional effluent is available from the 23rd Avenue Plant in quantities sufficient to make up the MAG-estimated shortages at 91st Avenue. This effluent is committed under the existing contract with the City of Phoenix.

In addition to the 23rd Avenue Plant, two other sewage treatment plants are located or will be located such that their wastewater effluent could be reasonably collected and piped to PVNGS. These are the Tolleson and Reems Road plants.

10B.4.2.1.1 23rd Avenue Plant

Under the existing effluent contract up to 140,000 acre-ft/yr of effluent is available for power plant cooling from the 91st and 23rd Avenue Plants. An extension of the ANPP effluent pipeline would be required to make the output of the 23rd Avenue Plant available at PVNGS. This extension would be approximately 10 miles long.

10B.4.2.1.2 Tolleson Plant

The Tolleson plant currently produces less than 1000 acre-ft/yr of effluent. Under the MAG plan the Tolleson facility is estimated to be expanded to 8000 acre-ft/yr capacity by the year 2000.

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Currently, effluent from the Tolleson plant is contractually committed to turf production. Its existing effluent pipeline to the Salt River is in very close proximity to the PVNGS effluent pipeline. To utilize this effluent, a structure would

be required to connect the Tolleson effluent pipeline and the PVNGS effluent pipeline. Utilizing the MAG estimates for plant flow, the Tolleson plant alone will not make up the MAG-estimated effluent shortage at the 91st Avenue Plant (refer to figure 10B-3).

10B.4.2.1.3 Reems Road Plant

The output of the proposed Reems Road plant, as estimated by MAG, is presented in figure 10B-3. It is proposed that the plant be located in the immediate vicinity of the PVNGS effluent pipeline, thereby requiring only a structure to connect the Reems Road plant effluent pipeline with the PVNGS effluent pipeline to make the plant output available to PVNGS.

The estimated flow from the Reems Road plant, by itself or in combination with the Tolleson plant flow, is not sufficient to make up the effluent shortage predicted by MAG at the 91st Avenue Plant.

10B.4.2.2 Alternative 2

Offsite well fields were studied(1) in conjunction with preparation of section 10.2. The study was evaluated for supply of 100 percent of the PVNGS-4&5 condenser cooling water requirements. It was determined to be impractical for offsite well fields to supply that quantity of water at PVNGS.

Subsequent to this study, another study(2) was performed to determine the possibility of making up the MAG-estimated effluent shortage at the 91st Avenue Plant using offsite/well fields. This study proposed three different well fields, all capable of supplying the necessary effluent. Two of the well fields are located north of the PVNGS site (Tonopah). One well field is located south of the PVNGS site (Centennial). During evaluation of these well fields, a fourth well field (South) contiguous with the south boundary of the PVNGS site was developed.

Each of the four well fields is capable of making up the MAG-estimated effluent shortage at the 91st Avenue Plant.

10B.4.2.3 Alternative 3

Groundwater used for irrigation in the BID is sufficient to make up the MAG-estimated effluent shortages at the 91st Avenue Plant. If used in these quantities at PVNGS, this water source is compatible with the existing PVNGS Water Reclamation Facility (WRF) design. However, this alternative was originally conceived based upon the substitution of effluent for groundwater. Estimates by MAG indicate that sufficient effluent for this substitution does not exist in the time frame required. Therefore, this alternative would not be feasible.

10B.4.2.4 Alternative 4

Groundwater used for irrigation in the RID is sufficient to make up the MAG-estimated effluent shortages at the 91st Avenue Plant. If used in these quantities at PVNGS, this water source is compatible with the existing PVNGS Water Reclamation Facility (WRF) design.

However, this alternative was originally conceived based upon the substitution of effluent for groundwater. Estimates by MAG indicate sufficient effluent for this substitution does not exist. Therefore, this alternative would not be feasible.

10B.4.2.5 Alternative 5

As discussed in section 10.2.2.4, use of Central Arizona Project (CAP) water at PVNGS would be a first and only use of this water. Based on the availability of other less valued sources of water, use of CAP water is not considered desirable. Furthermore, the allocation of CAP water recommended by the State of Arizona for power production would not furnish sufficient cooling water for PVNGS-4&5 in the time frame required.(3)

10B.4.2.6 Alternative 6

The quality of the BID agricultural drainage water is such that only 12,600 acre-ft/yr could be utilized in the present WRF design. This quantity is insufficient to make up the MAG-estimated effluent shortage at the 91st Avenue Plant. Therefore, the use of BID drainage water in the existing WRF is not a viable alternative for a supplemental water supply.

10B.4.2.7 Alternative 7

Agricultural drainage water from the BID is currently under contract with the APS in quantities sufficient to make up the MAG-estimated effluent shortage at the 91st Avenue Plant. Use of this drainage water would require a redesign of the WRF.

10B.4.3 ALTERNATIVE SUMMARY

10B.4.3.1 City of Phoenix Estimates

Alternatives a, b, c, and d of section 10B.4 and section 10.2.2.1 remain viable alternatives to make up the small effluent shortages that may exist at the 91st Avenue Plant based on City of Phoenix estimates.

10B.4.3.2 MAG Estimates

As a result of evaluating alternatives 1 through 7 of section 10B.4 and section 10.2, several alternatives appear viable for makeup of the MAG-estimated effluent shortage at the 91st Avenue Plant. These alternatives are evaluated in section 10B.5 to determine the preferred alternative(s). They are different alternatives from the original seven alternatives

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of section 10B.4 by the addition of a superscript. The alternatives to be evaluated are:

1'. Addition of an effluent pipeline from the 23rd Avenue Sewage Treatment Plant to the 91st Avenue Sewage Treatment Plant

2'. Construction of an offsite well field

7'. Use of BID agricultural drainage water and modification of the existing WRF design

10B.4.4 REFERENCES

1. Harshbarger & Associates, Groundwater Development Alternatives, PVNGS 4&5, October 19, 1977.

2. Harshbarger & Associates, Potential Groundwater Development, PVNGS Units 4&5, Tonopah and Centennial Areas, October 27, 1978.

3. Fox, Kel, Chairman, Arizona Water Commission, personal communication to C. B. Andrus, Secretary of the Interior, U.S. Department of the Interior.

10B.5 ALTERNATIVE EVALUATION

As discussed in section 10B.4.3, various alternatives exist for make-up of potential effluent shortages at the 91st Avenue Plant. As the alternatives are dependent on the magnitude and duration of the shortage, i.e., the projected effluent estimates used, the alternatives are evaluated in conjunction with either the City of Phoenix or MAG estimates.

10B.5.1 CITY OF PHOENIX ESTIMATES

As the effluent shortage predicted using the City of Phoenix estimates is small, alternatives a, b, c, and d are all considered viable and essentially equivalent.

10B.5.2 MAG ESTIMATES

Development of a supplemental water source is required to make up the potential effluent shortages predicted by MAG. As

shown in figure 10B-2, this supplemental source must have a peak capacity of at least 2500 acre-ft/mo. Section 10B.4.3.2 summarizes the alternatives available for supplemental water sources.

10B.5.2.1 Alternative 1'

Based upon both the MAG and City of Phoenix estimates, sufficient effluent exists for all five Palo Verde units if wastewater effluent from the 23rd Avenue Sewage Treatment Plant is utilized.

The environmental impacts of this alternative are negligible as (1) the right-of-way used for the pipeline has already been disturbed by agriculture over most of its length and (2) excess effluent is predicted to be available for flow in the reach of the Salt River between 23rd and 91st Avenues to support existing habitat (refer to section 10B.6.1). In addition, the use of effluent for condenser cooling water makeup represents a second use of water.

The estimated cost for the PVNGS-4&5 Water Reclamation Facilities, including this pipeline, is given in table 10B-1.

10.5.2.2 Alternative 2'

Four well fields have been identified that have the capability to make up the potential effluent shortage predicted by MAG. These well fields are significantly smaller than the well field discussed in the PVNGS-4&5 ER, section 10.2.2.1. While there may be some difficulties in securing the land for any of these well fields, they have been selected to minimize acquisition problems and should present fewer acquisition problems than the well field discussed in section 10.2.2.1. The environmental impacts of any of the four well fields are minor. (Refer to section 10B.6.2.)

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Table 10B-1

ALTERNATIVE SUPPLEMENTAL WATER SUPPLIES MONETIZED COSTS(a)
(IN MILLIONS OF DOLLARS)

Item	Effluent From 23rd and 91st Avenue Sewage Treatment Plants (Alternative 1')	Effluent Supplemented by Offsite Wells (Alternative 2')	Effluent Supplemented by Irrigation Drain Water (Alternative 7')
Capital cost	235.4	233	235
Annual operating cost	20.5	20.5	30
Present worth operating cost	173.2	173.2	253.6
Total present worth	408.6	406.2	488.6

a. Costs are for two units, makeup supply piping collection and treatment; discount factor is 0.8981.

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The estimated cost for the PVNGS-4&5 Water Reclamation Facilities, including installation of a well field, is given in table 10B-1.

10B.5.2.3 Alternative 7'

The contractual arrangement between APS and BID do not assure a continuous supply of water.

Two of the six drainage wells required to furnish the contracted 20,000 acre-feet/yr of drainage water are situated in an area designated as a critical groundwater area. It is unclear whether or not the transport of drainage water from these two wells outside the critical area would be permissible. Further, BID has reserved the right to suspend the use of all or any portion of drainage water by PVNGS whenever (1) the flow in the Gila River at the BID headgates is less than 75 ft^3/s for 7 consecutive days (2) static water levels in any well is lower than 40 feet following a cessation of pumping for 72 hours, or (3) pumping levels in any well falls below 60 feet. Since current flows in the Gila River at the BID headgates are primarily dependent upon effluent flows from the 91st Avenue Plant, a shortage of effluent will probably result in reduction in river flows below the stipulated 75 ft^3/s and result in a suspension of drainage water pumping.

The wells required for this alternative are in existence. Therefore, the only construction impacts of this alternative are associated with the collection piping.

The estimated costs for the PVNGS-4&5 Water Reclamation Facilities, including installation of this alternative, are given in table 10B-1.

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10B.5.3 ALTERNATIVES SELECTED

10B.5.3.1 City of Phoenix Estimates

Alternatives a, b, c, and d are equally acceptable for makeup of potential effluent shortages predicted by the City of Phoenix.

10B.5.3.2 MAG Estimates

Alternatives 1' and 2' are comparable in environmental impact and cost. Alternative 1' offers the benefit of reuse of water resources. On the other hand, alternative 2' has the advantage of providing a diverse water source that may enhance water source reliability. These alternatives are considered equivalent at this time. Alternative 7' is less desirable because of its doubtful availability and higher cost. In addition, it offers no advantage over alternative 1' or 2' from an environmental standpoint. Therefore, alternative 7' is not evaluated further at this time. Alternatives 1' and 2' are essentially equivalent, and remain available to make up potential effluent shortages.

10B.6 ASSESSMENT OF SELECTED ALTERNATIVES

An environmental assessment was made of alternative supplemental water sources that would satisfy the potential need for additional cooling water for PVNGS-4&5. As indicated in section 10B.5, two sources (wastewater effluent from the 23rd Avenue Sewage Treatment Plant, and a well field) were considered.

10B.6.1 PIPELINE ROUTE FROM THE 23rd AVENUE SEWAGE TREATMENT PLANT

Five alternative pipeline routes from the 23rd Avenue Sewage Treatment Plant which connect to the 91st Avenue pipeline to PVNGS were evaluated (figure 10B-4).

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10B.6.1.1 Description of Alternative Routes

The five alternate routes have approximately the same lengths (9.3 to 10.3 miles), and the area traversed by all routes is essentially flat. Land use along routes 1, 2, 3, and 4 is mostly agricultural. Route 5 is primarily along the bed of the Salt River, crossing natural vegetation with little cropland along the course of the route.

1. Route 1: From the 23rd Avenue Sewage Treatment Plant, this route parallels Lower Buckeye Road for 2.5 miles west of the plant. The route angles west-southwest for about 1 mile, continues west for 5 miles, and turns south where it then joins with the 91st Avenue pipeline.

   The route crosses mostly cropland (78 percent) and urban-residential areas (22 percent). The route runs along improved roads adjacent to urban-residential properties for approximately 4 miles of its length and crosses cropland for the rest of its length following the right-of-way of an overhead transmission line.

2. Route 2: This route parallels Lower Buckeye Road for 2.5 miles west of the plant, then angles southwest for about 2 miles towards the main channel of the Salt River. It continues along the riverbed to 75th Avenue, then travels west 2 miles to where it joins the 91st Avenue pipeline.

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   This alternative crosses cropland (67 percent) and urban-residential areas (33 percent) and avoids areas of native vegetation. The route runs along an existing irrigation line that is adjacent to the Salt River for approximately half of the route. It would disrupt urban development land during construction along about

one-third of its length and cropland along most of the rest of the route.

3. Route 3: From the 23rd Avenue Sewage Treatment Plant, the route parallels Lower Buckeye Road for 4.25 miles, jogs 1 mile south, then turns west for 3 miles, then south and west again to join with the 91st Avenue pipeline to PVNGS.

   The route crosses cropland (58 percent) and a substantial amount of urban-residential area (42 percent). The route runs along improved roads, which are adjacent to cropland and urban-residential properties for its entire length. The route parallels an existing sewage pipeline route for another 4 miles and a transmission line right-of-way for another 4 miles. Construction activities along this route would disrupt the greatest amount of urban-residential property (almost half the route is adjacent to urban development property).

4. Route 4: This route parallels Lower Buckeye Road for approximately 8.25 miles and turns south for 2 miles, along 91st Avenue, to connect with the 91st Avenue pipeline. The route crosses cropland (91 percent) and urban-residential areas (9 percent).

5. Route 5: This route parallels Lower Buckeye Road for 1.25 miles, then angles southwest into the bed of the Salt River. The route crosses primarily natural habitat and undeveloped riverbed. It also runs through some large active gravel pits. The route traverses sparse saltbush habitat with annuals present in scattered locations (68 percent). The remainder of the route is urban-residential (23 percent) and cropland (9 percent).

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10B.6.1.2 Archaeological Resources

Refer to annex A of appendix 10B for an archaeological assessment of the five alternative pipeline routes. Areas where significant archaeological resources are identified will be mitigated in a manner similar to that used for the PVNGS-4&5 pipeline between the Hassayampa River and the PVNGS site.

10B.6.1.3 Ecological Resources

In order to compare the five routes, recent aerial photography (January 1979) was used to prepare a vegetation resource map of the area traversed by the routes (figure 10B-4). Impact analyses were based on information from recent pertinent literature, contacts with regional authorities, vegetation maps, and a field survey of the pipeline routes.

In order to discriminate among routes, the primary and secondary consequences of developing each route were evaluated. The primary ecological impact of all pipeline routes is the same: the reduction of habitat within the Salt River channel between 23rd and 91st Avenue as a result of reduced effluent flows. Most of the wastewater effluent presently discharged from the 23rd Avenue Sewage Treatment Plant reaches the Salt River via two canals located west-southwest of the plant. Some of the water is diverted for irrigation, but most is contained in a small thread of flow within the channel. This flow supports wetland vegetation that is used by various wildlife species, primarily birds (e.g., doves and waterfowl). Because of periodic flooding, most of the vegetation is composed of scattered annuals. The deep water table in this section of the river limits phreatophyte establishment.(1)

The total amount of vegetation growing in the Salt River between 23rd and 91st Avenues is much less than that found along the Green Belt portion of the Gila River. The section is almost devoid of vegetation because of the lowering of the water table

and extensive gravel mining operations. The limited vegetation is composed of species that provide some food and cover for wildlife. Stagnant pools of water provide breeding habitat for mosquitoes and outbreaks of botulism have occurred here. This area can be considered relatively unimportant to wildlife because erratic flows and periodic flooding make it a limited and undependable wildlife habitat. Human disturbance in the area (e.g., gravel pits, concrete works, and landfill activities) further reduce its value for wildlife.

In addition to the impact of habitat reduction in the Salt River channel, each route would directly affect the areas disturbed by pipeline construction. Only Route 5 affects areas of native vegetation. The remaining four traverse only cropland and urban-residential areas.

None of the routes will impact endangered or threatened species, nor will they disturb areas of unique ecological value. The riparian and wetland habitats in the Salt River channel between 23rd and 91st Avenue have some wildlife value. Because the habitat is largely maintained artificially by wastewater effluent and is intermittently available, the overall adverse ecological impact of reducing it is, therefore, minor.

The four pipeline routes that traverse only cropland and urban-residential areas are slightly preferable to the route that includes portions of the Salt River channel. All of the areas disturbed by pipeline routes would be expected to quickly revert to preconstruction conditions. Therefore, essentially no adverse impact beyond the loss of wildlife habitat is anticipated during actual pipeline construction.

Since development of the 23rd Avenue pipeline will not utilize all of the effluent projected to be available, a portion of the effluent will reach the Salt River and maintain a portion

of the wetland habitat. Therefore, the adverse impact of water diversion would be reduced or eliminated.

10B.6.1.4 Summary

No serious adverse ecological or land-use impacts would result from the construction of any of the five routes being considered. The loss of wildlife habitat in the Salt River channel is minor and may be partially mitigated by excess wastewater effluent from the 23rd Avenue Sewage Treatment Plant flowing in the river channel. The four routes that do not impact native vegetation (routes 1 through 4) are slightly preferable to route 5 which crosses 6.8 miles of sparse saltbush habitat.

Routes 3 and 4 were eliminated from further consideration because they pass through areas of high archaeological sensitivity. (Refer to annex A.)

Neither Routes 1 nor 2 was found to have significantly less environmental impact than the other. Therefore, Route 1 was selected as the preferred pipeline route on the basis of engineering considerations. (Refer to figure 10B-5.)

10B.6.2 WELL FIELDS

Four well field locations were evaluated. Two areas are near Tonopah (north and west of PVNGS) and two are between Centennial Wash and the PVNGS site (south of PVNGS). Brief descriptions of the well field alternatives follow:

1. North Tonopah. This well field encompasses sections 19, 20, 21, 28, and 29 in T2.N, R6.W. Topographic relief is low and the area is crossed by several intermittent stream channels (including Winter's Wash) bordered with desert riparian habitat (figure 10B-6).

Most of the area is either active agriculture or creosote scrub vegetation (table 10B-2).

2. South Tonopah. This well field includes section 31, 32, and 33 in T2.N, R6.W and sections 4 and 5 in T1.N, R6.W. This well field is generally similar to the North Tonopah well field (figure 10B-7). Native vegetation types present are desert scrub types and desert riparian (table 10B-2).

3. South. This well field is adjacent to PVNGS and extends south and east of it. It encompasses sections 11, 12, 13, 14, 15, 23, and 24 in T1.S, R6.W (figure 10B-8). Desert scrub vegetation types (creosote bush and saltbush) dominate the areas of native vegetation with desert riparian along intermittent stream channels (table 10B-2). Topographic relief is generally low and human occupation is sparse.

4. Centennial. This well field is immediately south of the South well field area and includes sections 21, 22, 23, 24, 25, 26, and 27 in T1.S, R6.W. The South and Centennial well fields overlap (sections 23 and 24). The topographic relief in this area is also relatively low. Much of the area is in active agriculture (table 10B-2), but includes desert scrub and desert riparian types in areas of native vegetation (figure 10B-9).

10B.6.2.1 Land Use

A minimal amount of land would be disturbed by the development of any of the four well fields and this disturbance would primarily be only during construction. Only the well head locations and associated access road would occupy surface land during operations. The land areas involved on this relatively

Table 10B-2

VEGETATIVE COVER IN ALTERNATIVE WELL FIELD LOCATIONS

Vegetation Type	Vegetative Cover (percent)			
	North Tonopah	South Tonopah	South	Centennial
Active agriculture	28	47	27	47
Abandoned agriculture	1	--	8	7
Creosote bush	57	34	25	24
Mixed creosote bush/saltbush	4	2	37	17
Saltbush	--	8	--	--
Desert riparian	10	9	2	5
Creosote bush/cactus	--	--	1	--

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permanent basis are basically the same for the four well fields. The two Tonopah area well fields would disrupt approximately the same amount of natural vegetation land. A greater amount of intensive agricultural land would be traversed by the North Tonopah well field as compared with the South Tonopah well field. The two areas are very similar, the area to the south being preferable because of its greater proximity to the PVNGS site.

Nearly half of the South and Centennial well field areas are under intensive agriculture. The majority of the cultivated farmland is in the Centennial area. The South well field area is covered by mixed natural desert vegetation and has the least amount of developed property. This area is the closest to the PVNGS site.

10B.6.2.2 Archaeological Assessment

Refer to annex A of appendix 10B for an archaeological assessment of the four alternative well fields. It is anticipated that by proper selection of well and collection piping locations any significant impacts to archaeological resources can be eliminated.

10B.6.2.3 Ecological Resources

To compare the four well fields, vegetation resource maps were prepared from 1978 and 1979 color aerial photography. A description of the well fields based on the percent of resource types and wildlife species composition in each area was then prepared. The well fields were then evaluated for ecological impact (based on proposed well field configurations) and subsequently compared.(2) Impact analyses were based on information obtained from vegetation resource maps, recent pertinent literature, contacts with regional authorities, and a field survey of each alternative location.

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Vegetation in the vicinity of well fields includes crops, creosote bush scrub, mixed creosote bush-saltbush scrub, and desert riparian types (figures 10B-6 through 10B-9). Desert riparian (wash) vegetation in the Tonopah area is composed chiefly of palo verde and mesquite. In the Centennial area, riparian vegetation is predominately tamarisk with scattered mesquite and very little palo verde present. Information on vegetation types in the Centennial and Tonopah well field areas is summarized in table 10B-2.

The areas of native vegetation (noncropland) provide habitat for a variety of wildlife species. Desert riparian vegetation is most important because wildlife is generally more diverse and abundant in it and because it provides habitat for several small game species. Cropland areas, because of their lack of diversity, are of limited wildlife value. They do provide some forage for quail and doves. No endangered or threatened species inhabit the region, including the Tonopah well fields.

Wildlife species typical of the native habitats in the area include mourning dove, Gambel's quail, marsh hawk, road runner, black-tailed jack rabbit, desert cottontail, and a variety of lizards and snakes. The desert tortoise occurs north of the proposed Tonopah well field area, but is not known to occur in it. Only small game species are present, and the area does not support important wildlife habitat.

The impact on wildlife is generally proportional to the amount of suitable habitat (native vegetation) affected by route development. Less natural vegetation may be disturbed by the South and Centennial well fields than by the North Tonopah or South Tonopah well fields, but some wash (desert riparian) vegetation might be affected. The Tonopah well fields contain a larger percentage of wash habitat than either the South or

Centennial well fields (table 10B-2). Since wash habitat is more important to wildlife than other habitats present, the impact of South or Centennial well field development on wildlife is probably less than the impact of development in the Tonopah area.(4)

The same wildlife species are present in the South and Centennial area as those that are typical of the Tonopah area. Mule deer may occasionally visit the wash areas, but are not permanent residents. No endangered or threatened species inhabit the region comprising the Centennial well field area.(3)

10B.6.2.4 Summary

In a regional context, none of the well fields would result in major adverse ecological or land-use impacts. The region, including all well fields, is already disturbed and considerably affected by existing development as is the region including the pipeline routes. The native vegetation types present are common throughout southwestern Arizona.

None of the project well fields will adversely affect endangered or threatened species, nor will they disturb areas of unique ecological value. The impacts of developing any of the well fields are considered to be of minor importance to wildlife.

Development of the South well field, south of and contiguous to the PVNGS site, would be slightly more desirable than the other well fields because there is less native vegetation present and a lower probability of disturbing desert riparian habitat. Because of the proximity of the South well field to the PVNGS site, less area would be impacted by pipeline development from this well field than from the Centennial or either of the Tonopah well fields. The South well field was

therefore selected as the preferred well field (refer to figure 10B-8).

10B.6.3 REFERENCES

1. Halpenny, L. (Hydrologist), Water Development Corporation, Tucson, personal communication to W. J. Clark, NUS Corporation, Sherman Oaks, California, October 6, 1978.
2. Harshbarger and Associates, Inc., Potential Groundwater Development PVNGS Units 4&5 Tonopah and Centennial areas, 1978.
3. U.S. Fish and Wildlife Service, "List of Endangered and Threatened Wildlife and Plants," Federal Register 43(238); pp. 58030-58048, 1978.
4. Lowe, C. H., The Vertebrates of Arizona, The University of Arizona Press, Tucson, 1964.

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ANNEX A

APPENDIX 10B

A PRELIMINARY ARCHAEOLOGICAL ASSESSMENT OF FIVE ALTERNATIVE PIPELINE ROUTES AND FOUR ALTERNATIVE WELLFIELDS

ARIZONA NUCLEAR POWER PROJECT
PALO VERDE NUCLEAR GENERATING STATION

MUSEUM OF NORTHERN ARIZONA
DEPARTMENT OF ANTHROPOLOGY

A PRELIMINARY ARCHAEOLOGICAL ASSESSMENT

OF

FIVE ALTERNATIVE PIPELINE ROUTES

AND

FOUR ALTERNATIVE WELLFIELDS

ARIZONA NUCLEAR POWER PROJECT

PALO VERDE NUCLEAR GENERATING STATION

A-77-120

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March 16, 1979

Two projects are under consideration as supplementary water supplies for the Arizona Nuclear Power Project (ANPP) Palo Verde Nuclear Generating Station (PVNGS).

The first, in Phoenix, is a pipeline from the 23rd Avenue sewage treatment plant to the 91st Avenue sewage treatment plant, the present origin of a pipeline to the plant site west of Phoenix. Five alternative routes have been proposed.

The second, near the plant site, is a well field of 5-7 mi^2. Four alternative locations have been proposed.

On 6 March 1979 Mr. John Mann of Arizona Public Service Company (APS) requested an assessment of the archaeological sensitivity of the proposed project areas. One day each was spent in records search, field inspection, and report preparation. A complete literature and file search was premature, and would be more appropriate once an alternative location is selected.

ARCHAEOLOGICAL SENSITIVITY (Stein 1977)

In this report, levels of archaeological sensitivity are defined by the relative probabilities of encountering archaeological sites in specific localities. The relative probabilities, in turn, are estimated from the presence or absence in the localities of environmental factors which are believed to have influenced the location of archaeological sites, and from the degree of modern agricultural development.

The finer the subdivision of an area into units of potential differential site density, the more precise the prediction of sensitivity can become. A sensitivity rating is not an absolute measure of site occurrence, but rather a probability statement based on a knowledge of factors influencing the location of prehistoric sites.

The levels of sensitivity used in this report are high, moderate, and low.

High Sensitivity:

This category applies to known and potential areas of dense prehistoric population or intensive utilization. The destruction of such areas would mean a significant loss of information concerning the cultural resource base.

Moderate Sensitivity:

These are localities where site density is moderate and the mitigation of impacts are negotiable in terms of costs and public values.

It is often feasible to avoid specific archaeological resources within areas of moderate sensitivity.

Low Sensitivity:

This category refers to archaeological localities where either the known or probable site density is low. Areas of low site density often correspond with regions which lack resources conducive to exploitation. A low sensitivity rating, however, does not necessarily reflect the importance of individual sites within these areas.

Pipeline:

The principal sources of information concerning archaeological resources in the area of the proposed pipeline are the records compiled and maps prepared by Omar Turney and Frank Midvale. Figure 1 displays the 5 alternative pipeline routes, superimposed on Midvale's map of prehistoric sites and canals in the area. Turney's map is comparable, generally showing more detail in the site areas and less detail in the canal systems. The 2 major prehistoric sites in the proposed project area are Pueblo del Alamo and Pueblo del Rio, concerning which Turney (1929:91-92) reported:

> ueblo del Alamo. Village of the Open Park, is but a memory; it stood on a slight rise of ground, and thus was protected from the flood waters which must occasionally have come down the canal. A few shards only have been preserved; but the owner of the adjoining land has stated that on some years his father sold enough axes and carved stone articles to pay his taxes: so perhaps someone, somewhere, has things which he calls "curios from out West." We found a fire pit made of clay baked in place in the ground, where probably a house had stood. These are frequently found in room floors; a foot across and 5 to 8 inches deep; they seem to have been used only for the purpose of keeping coals over

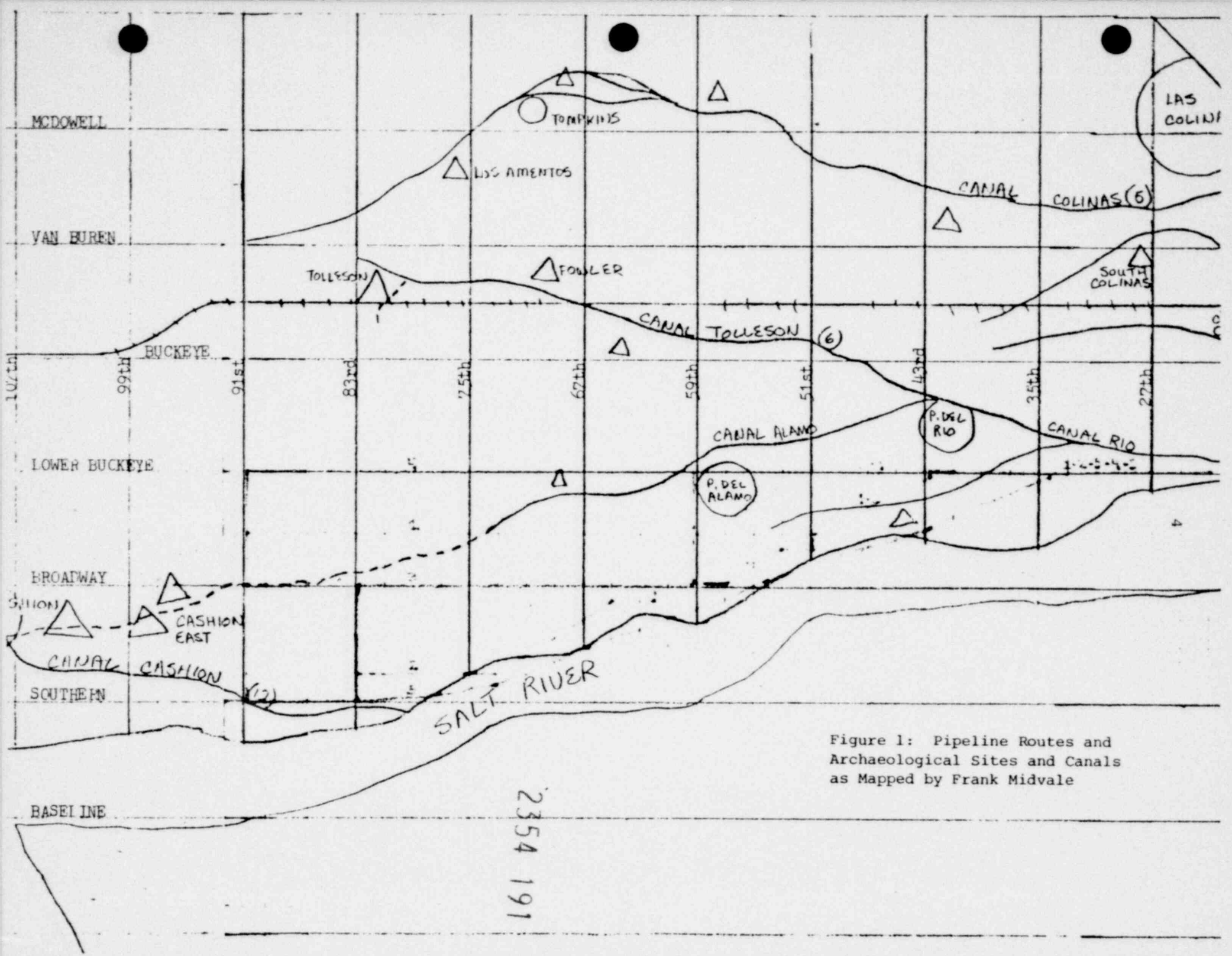

Figure 1: Pipeline Routes and Archaeological Sites and Canals as Mapped by Frank Midvale

night, as little or no ashes are found in or around them. Frequently in room walls are found niches a few inches wide, yet running down two feet deep, which are filled with solid cores of ashes; seemingly some form of a fire place.

Pueblo del Rio. Village of the River, has been stripped of its top stories to build a roadway across the western borrow pit and to fill part of the pit to the north. Apparently it was 260 ft north and south and 130 ft wide, and well oriented. Its denuded top rises 15 ft above the bottom of the borrow pits. In grading the pits, red-on-buff pottery was destroyed, but among the articles saved was the finest example of representative carving which the writer has ever seen in this valley. We place it among the medico-religious articles of that people. The stone has the color of catlinite, but it had received a higher polish than is possible to give to the hardest catlinite. It was a normal size membrum virile et testes homini which formed part of a cup, the latter from its form and position would not permit the object to be construed as pure art but as a crucible, in which the medicine man may have prepared medicines supposed to influence the functions symbolized.

Dr. Eliza A. Ingalls found a phallic cup forty-three years ago in these ruins, a fine grained, hard granite, elaborately detailed. Similar carvings, but without the cup, have been found in such numbers as to strongly indicate phallic worhsip. There need be no surprise that such worship existed; it is in evidence in the ruins of Central America; we believe that the germ of culture and perhaps an actual migration came to the valley of the Salt from the South. Farthermore, let no one disdain the primitive American for his religious beliefs, but first of all examine the primitive religion of every race living in tropical lands the world around-, perhaps we have forgotten the religious significance of some of the ceremonies of our own Caucasian ancestors.

At this ruin the borrow pits were on the west, north and east of the building; we believe the burial ground lies on the south, although burials have been found east of the eastern borrow pit. The ground to the south would have been dry and well located for burials. One colossal breccia was found in a burial and our finest example of an armlet carved from pectunculus shell and bearing at the hinge a beautifully formed frog came from the north edge of the ruin.

Table 1 enumerates areas of archaeological sensitivity along the pipeline routes, and evaluates the relative sensitivity of remains along each route.

TABLE 1

Pipeline

	Relative Sensitivity	Route 4	3	1	2	5
AREAS OF HIGH SENSITIVITY						
1) Pueblo del Alamo and canal ½ mi east, west, or south of 59th Ave. and Lower Buckeye Rd.	7	x	x			
2) unnamed small ruin SW of 67th Ave and Lower Buckeye Rd.	3	x				
AREAS OF MODERATE SENSITIVITY						
3) periphery of Pueblo del Rio 43rd Ave. and Lower Buckeye Rd.	2	x	x	x	x	
4) periphery of Cashion Ruin and possible canal 91st Ave. and Broadway Rd.	2	x		x		
5) unnamed small ruin west of 43rd Ave.	1			x	x	x
6) Cashion Canal 91st Ave. and Southern Ave.	1	x	x	x	x	x
7) Alamo Canal east of 75th Ave.	1			x		
8) unnamed canal Lower Buckeye Rd. between 35th and 43rd Ave.	1	x	x	x	x	
9) same canal between 43rd and 51st Ave.	1				x	x
AREAS OF LOW SENSITIVITY						
all other areas						
OVERALL SENSITIVITY OF INDIVIDUAL ROUTES		16	11	9	6	2

COMMENTS

1) According to Turney, the center of Pueblo del Alamo was located NE of the intersection of 59th Ave. and Lower Buckeye Rd.; according to Midvale, it was SE of the intersection and a compound was bisected by Lower Buckeye Rd. Turney did not indicate the canal mapped by Midvale, a canal which possibly extended to the Cashion Ruin. At the present time the site area is agricultural fields. On the grounds of the Orme 230 KV Rec. Sta. SW of the intersection were noted a few surface artifacts, including redware sherds.

2) The small ruin shown by Midvale SW of the intersection of 67th Ave. and Lower Buckeye Rd. was shown by Turney in all directions from the intersection. At the present time there are no surface indications of archaeological remains and it is likely that most of the site has been disturbed by agricultural development and/or buried beneath the community of Santa Maria.

3) Turney's and Midvale's maps agree on the location of Pueblo del Rio, and both indicate that the site did not extend as far south as Lower Buckeye Rd. At the present time there is an area of rolling ground, with some old building foundations and trash dumping, 0.3 mi north of Lower Buckeye Rd. on the east side of 43rd Ave, at the approximate center of the site. At that location Midvale recorded, sketch and photographed, a compound, approximately 200 ft N-S x 120 ft E-W, with farm buildings atop it. At the present time there is also construction on the NE corner of the intersection of 43rd Ave. and Lower Buckeye Rd.

4) Current investigations at the Cashion Ruin (Antieau in press) have not extended east of 99th Ave., as no site was recorded in Section 28, and have failed to locate the large prehistoric canal mapped by Turney as Canal Twelve and by Midvale as Canal Cashion.

5) The small ruin west of 43rd Ave. is not shown on Turney's map, nor is the branch canal. At the present time there are pastures and fields from Lower Buckeye Rd. south to the Salt River bottom, a distance of about 0.6 mi. A modern ditch crosses 43rd Ave. and may follow the course of the prehistoric canal mapped by Midvale.

Well Fields

Figures 2 and 3 display the 4 alternative proposed well fields near the PVNGS, as well as archaeological sites in the vicinity recorded by Trott (1974). Prehistoric sites included trails, rock enclosures, gravel clearings, and petroglyphs, all on the eastern flanks of the Palo Verde Hills, and surface scatters of sherds and lithics, mainly on the creosote-covered alluvial plains. Historic sites included early 20th century homesteads and labor camps. Other recent work in the area (Kemrer, Schultz and Dodge 1972; Burton 1975; Antieau 1976; Antieau 1977) has demonstrated a similar patterning of prehistoric sites, with lithic quarries, trails, and collecting loci along the south flanks of the Big Horn Mountains to the north of the project area, and artifact scatters interpreted as food processing loci and small habitation sites on the alluvial plain, especially near Centennial Wash.

Except for the NW corner of well field 3, where sites are recorded, the well fields are devoid of rock outcrops and hills upon and adjacent to which were recorded the majority of the prehistoric sites. In addition, much of the alluvial plain has been subject to agricultural development, probably obliterating surface artifacts scatters. Site classes to be expected in the well fields include artifact scatters and processing and small habitation sites in undisturbed portions of the alluvial plain, and historic sites throughout.

Table 2 displays the archaeological sensitivity, by section, of each of the alternative proposed well fields.

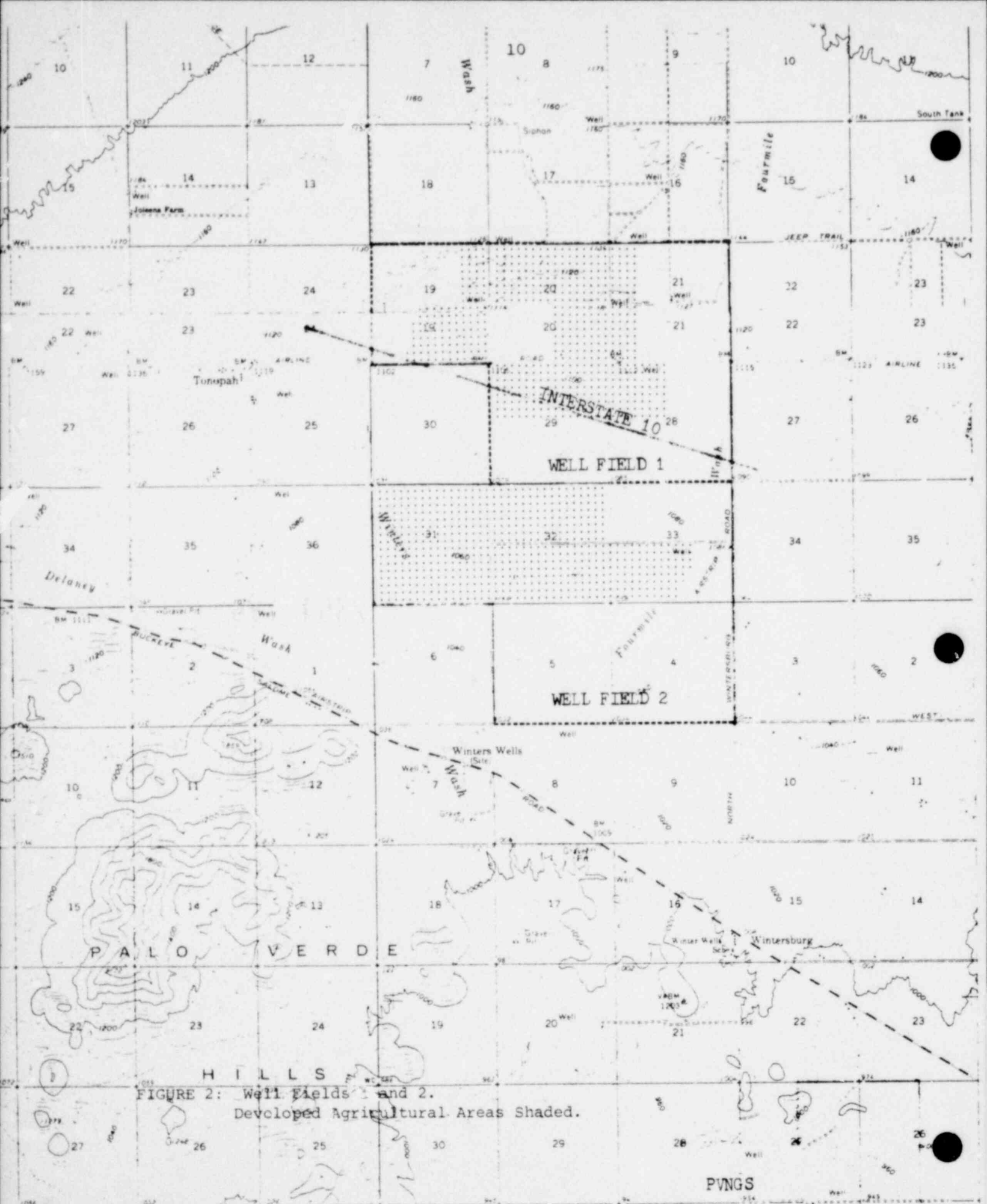

FIGURE 2: Well Fields 1 and 2.
Developed Agricultural Areas Shaded.

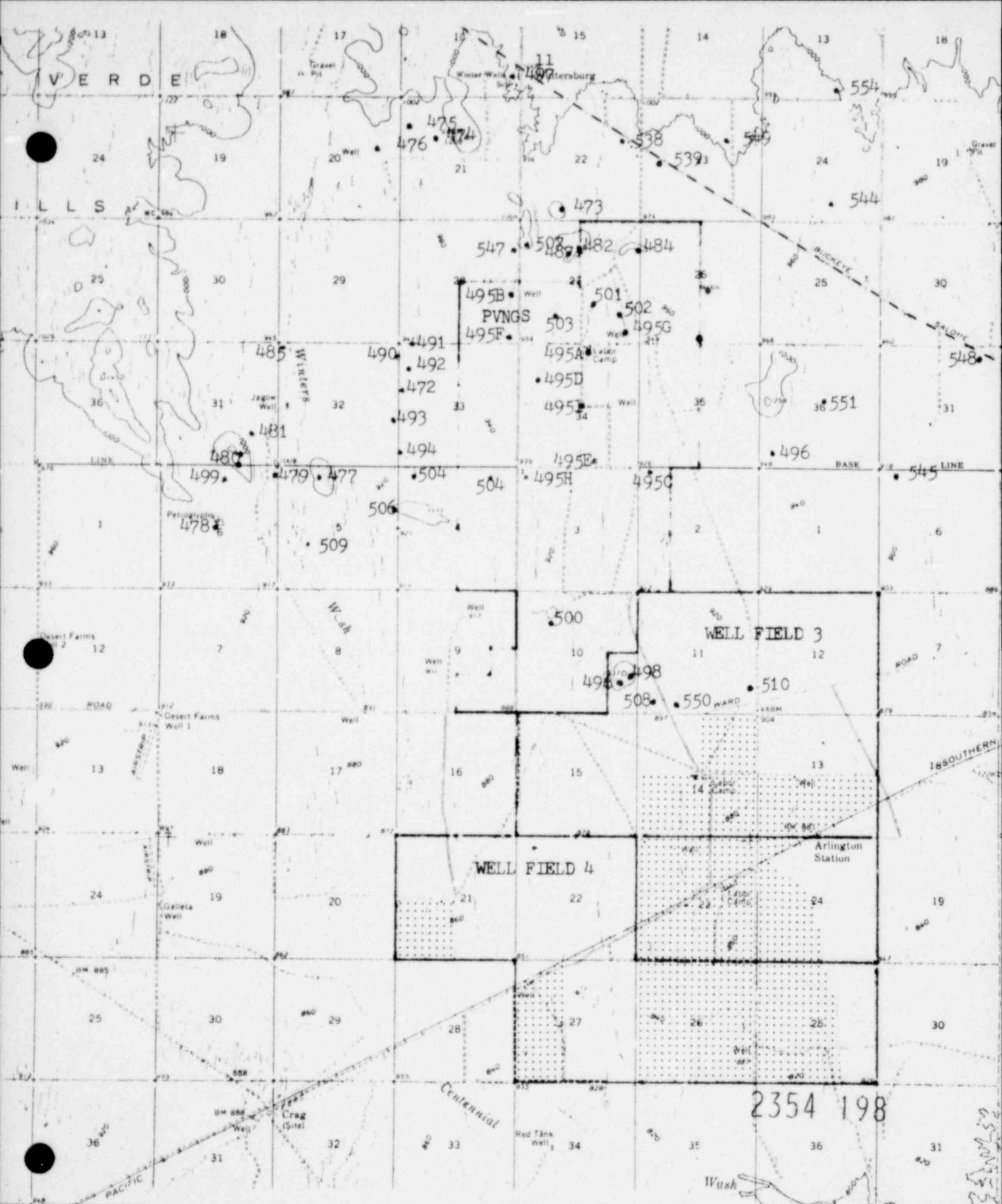

Figure 3: Well Fields 3 and 4, and Archaeological Sites Recorded by Trott (1974) (all site designations prefixed by NA12,). Developed Agricultural Areas Shaded.

TABLE 2

Wellfields

	Section	Sensitivity
PROPOSED WELLFIELD 1 T2N, R6W	19	moderate along Winters Wash, low elsewhere
	20	low, mostly agricultural
	21	moderate, mostly undeveloped
	28	low for NW¼, moderate elsewhere
OVERALL SENSITIVITY: LOW	29	Moderate for S½, low elsewhere
PROPOSED WELLFIELD 2 T1-2N, R6W	31	low, agricultural
	32	low, agricultural
	33	moderate for N½, low for S½
	4	moderate, high along Fourmile Wash
OVERALL SENSITIVITY: MODERATE	5	moderate, high along unnamed wash
PROPOSED WELLFIELD 3 T1S, R6W	10	high, hill with petroglyphs (NA12,496, NA12,498)
	11	high, petroglyphs and historic remains (NA12,508, NA12,550, NA12,510)
	12	moderate, undisturbed, but no substantial drainage
OVERALL SENSITIVITY: MODERATE	13	moderate for N½, Low for S½
	14	moderate for NW¼, low elsewhere
	15	moderate, high along unnamed wash
	23	low, agricultural
	24	low for W½, moderate elsewhere
PROPOSED WELLFIELD 4 T1S, R6W	21	low for SW¼, moderate elsewhere
	22	moderate, high along washes, undeveloped except for PVNGS RR
	23	low, agricultural
OVERALL SENSITIVITY: LOW	24	low for W½, moderate elsewhere
	25	moderate for E½, low elsewhere, agricultural
	26	low, agricultural
	27	low, agricultural, brush, and trash dumping

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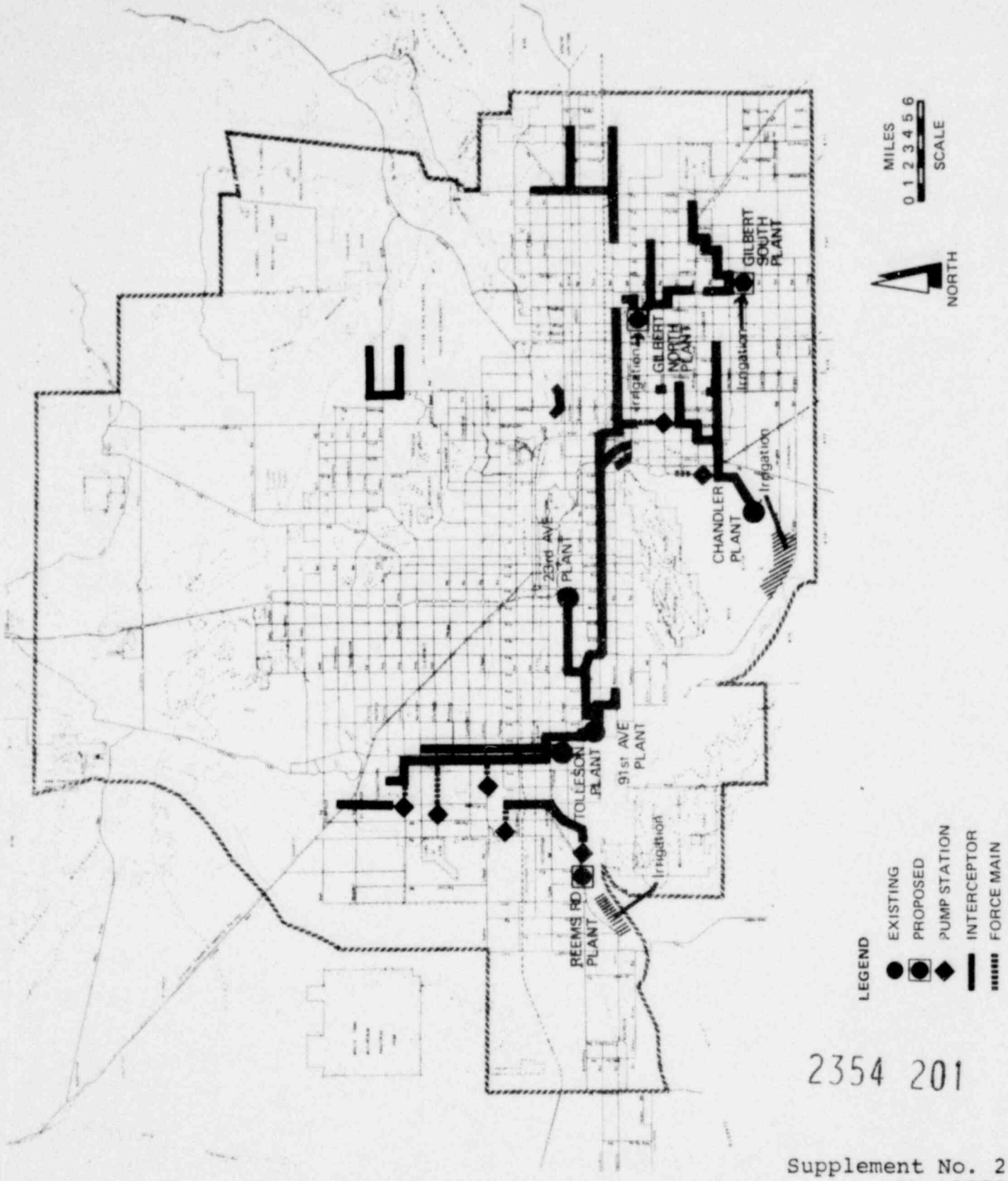

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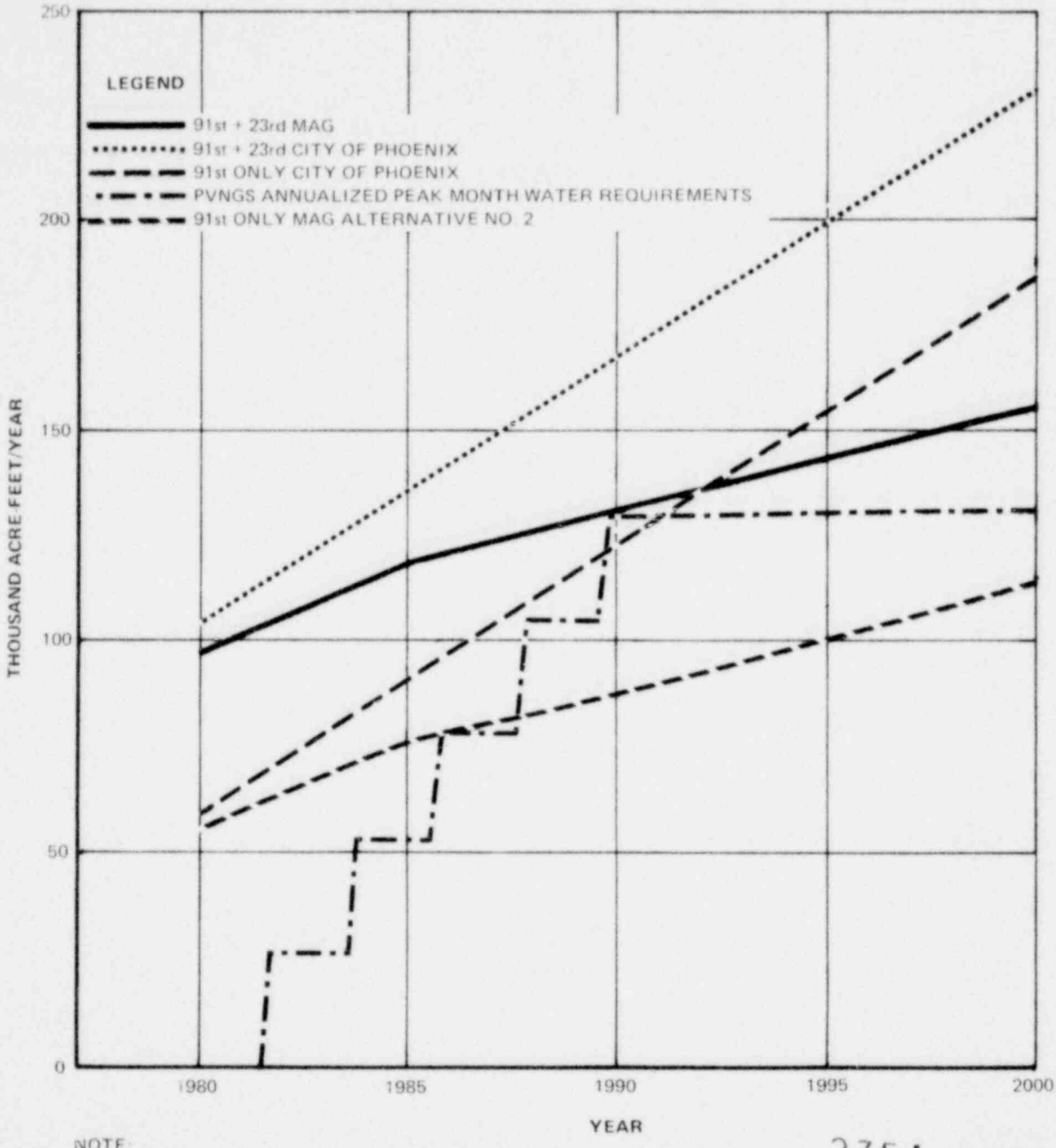
WASTEWATER TREATMENT PLANTS

Figure 10B-1



NOTE:

QUANTITIES AVAILABLE IN EXCESS OF PRIOR COMMITMENTS TO OTHERS IN THE AMOUNT OF 37,300 ACRE-FEET/YEAR.

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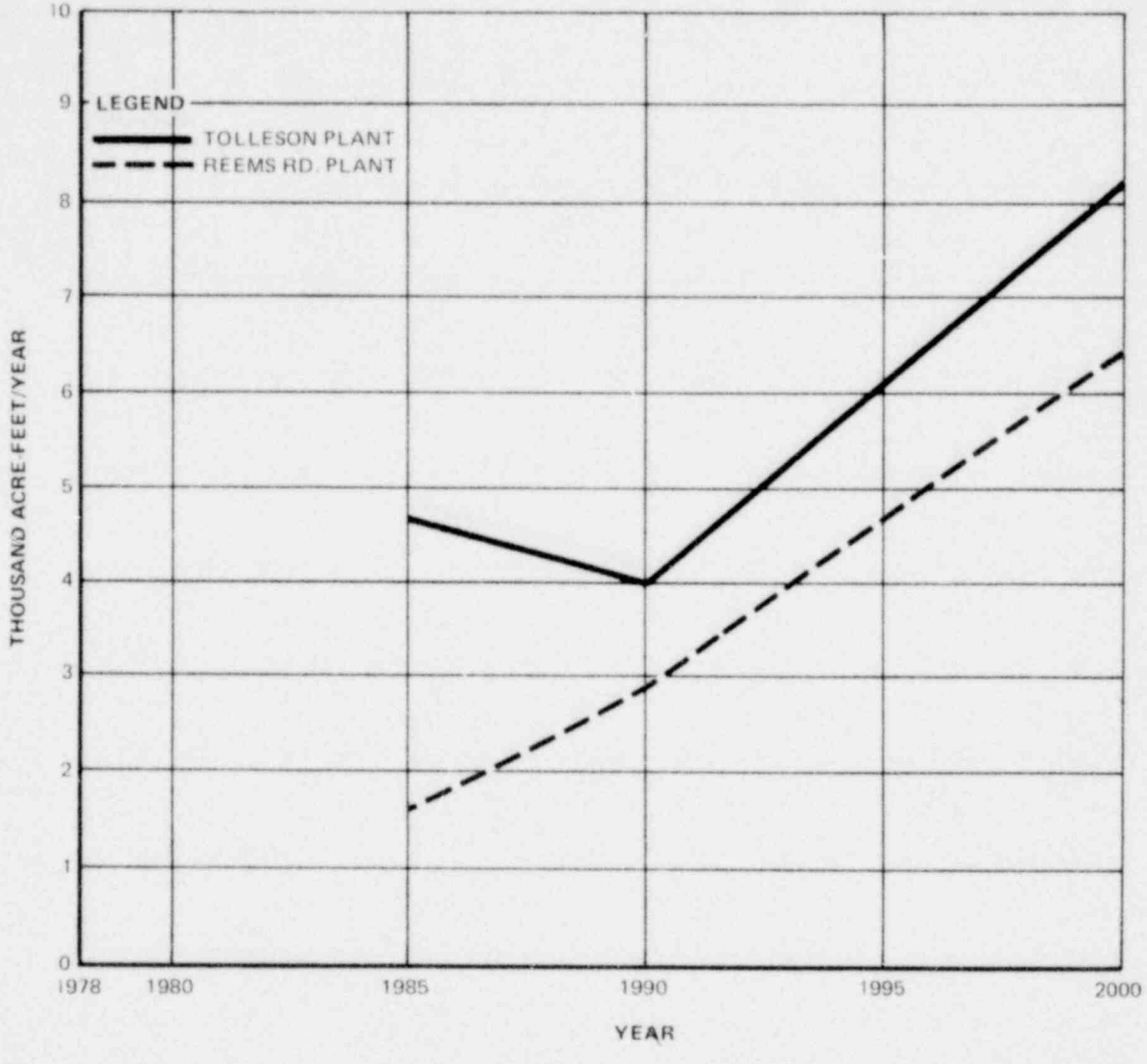
PVNGS PEAK WATER REQUIREMENTS AND AVAILABLE EFFLUENT UNDER CONTRACT

Figure 10B-2



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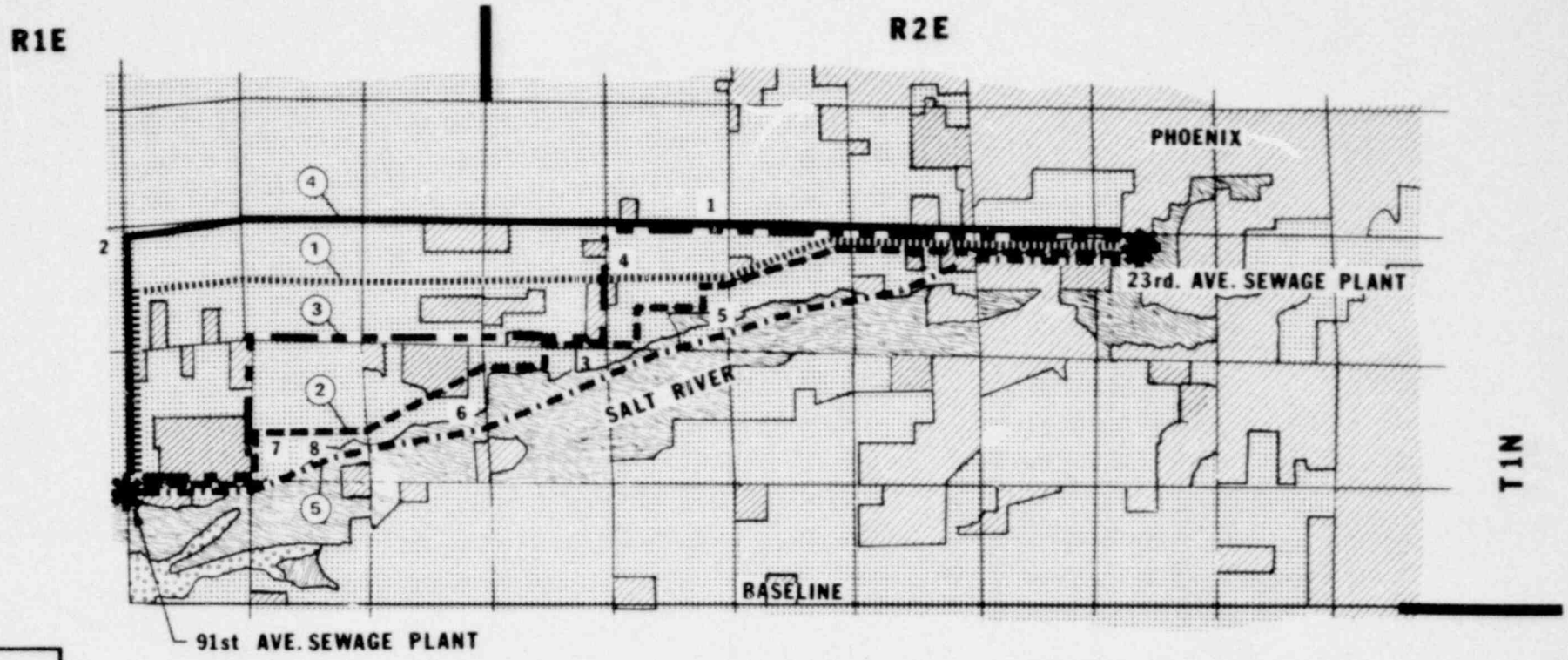
MAG ESTIMATED EFFLUENT AVAILABLE BY YEAR FOR TOLLESON AND REEMS ROAD SEWAGE TREATMENT PLANTS

Figure 10B-3



LEGEND

- TAMARISK
- SALTBUSH THREEAWN
- AGRICULTURAL LANDS
- RESIDENTIAL, INDUSTRIAL AND COMMERCIAL

- LINK (1)
- LINK (2)
- LINK (3)
- LINK (4)
- LINK (5)

ALTERNATIVE ROUTES, 23rd AVENUE EFFLUENT PIPELINE

1-8 SAMPLING STATIONS

NORTH

MILES 1 0 1 2

SCALE

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CORRIDOR VEGETATION MAP OF THE WATER CONVEYANCE ROUTES

Figure 10B-4

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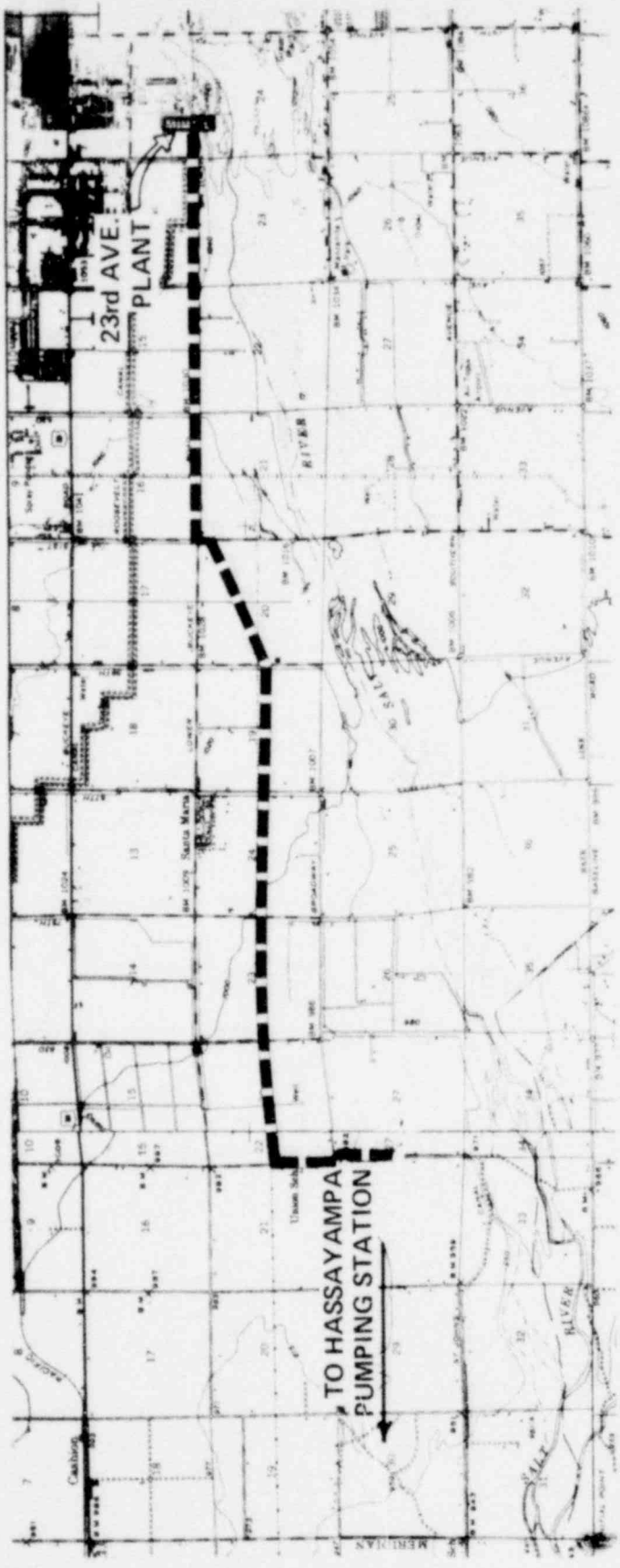

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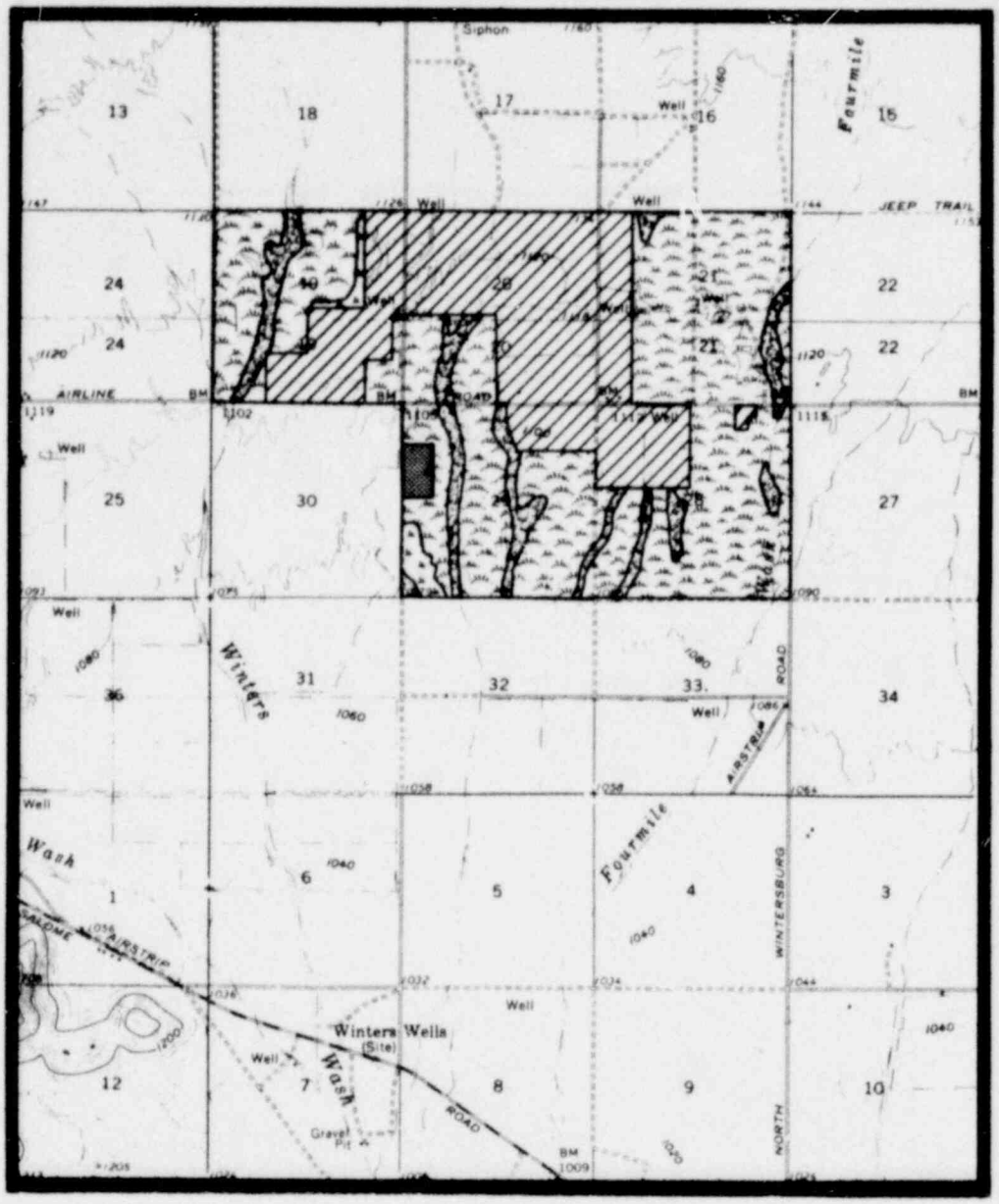
SUPPLEMENTAL WATER
CONVEYANCE PIPELINE

Figure 10B-5



LEGEND

- ACTIVE AGRICULTURE
- ABANDONED AGRICULTURE
- CREOSOTE BUSH
- MIXED CREOSOTE BUSH/SALTBUSH
- DESERT RIPARIAN

NORTH

MILES
0 ½ 1 2 3
SCALE

2354 206

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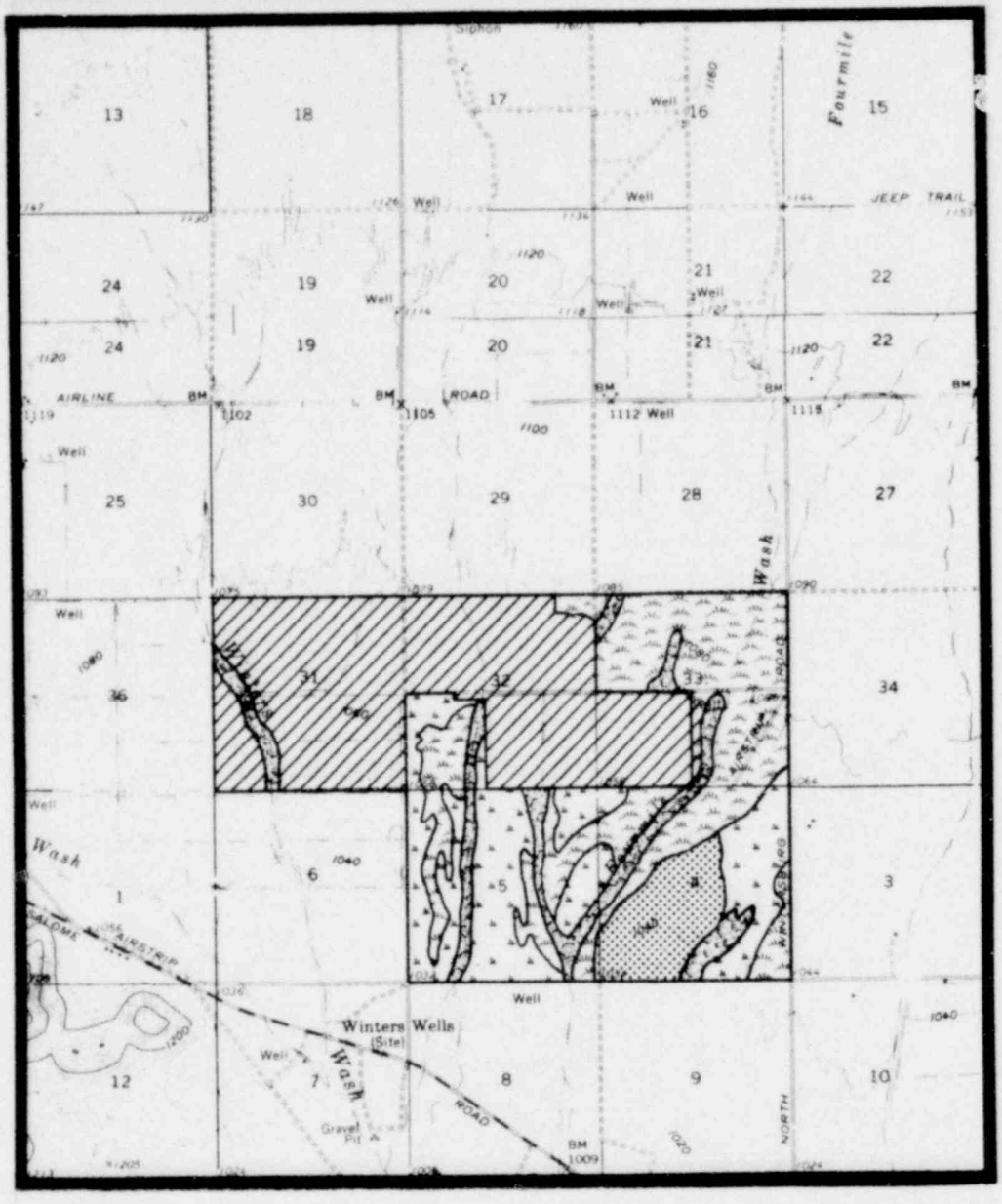
NORTH TONOPAH WELL FIELD

Figure 10B-6



LEGEND

- ACTIVE AGRICULTURE
- CREOSOTE BUSH
- MIXED CREOSOTE BUSH/SALTBUSH
- DESERT RIPARIAN
- SALTBUSH

NORTH

0 ½ 1 MILES 2 3

SCALE

2354 207

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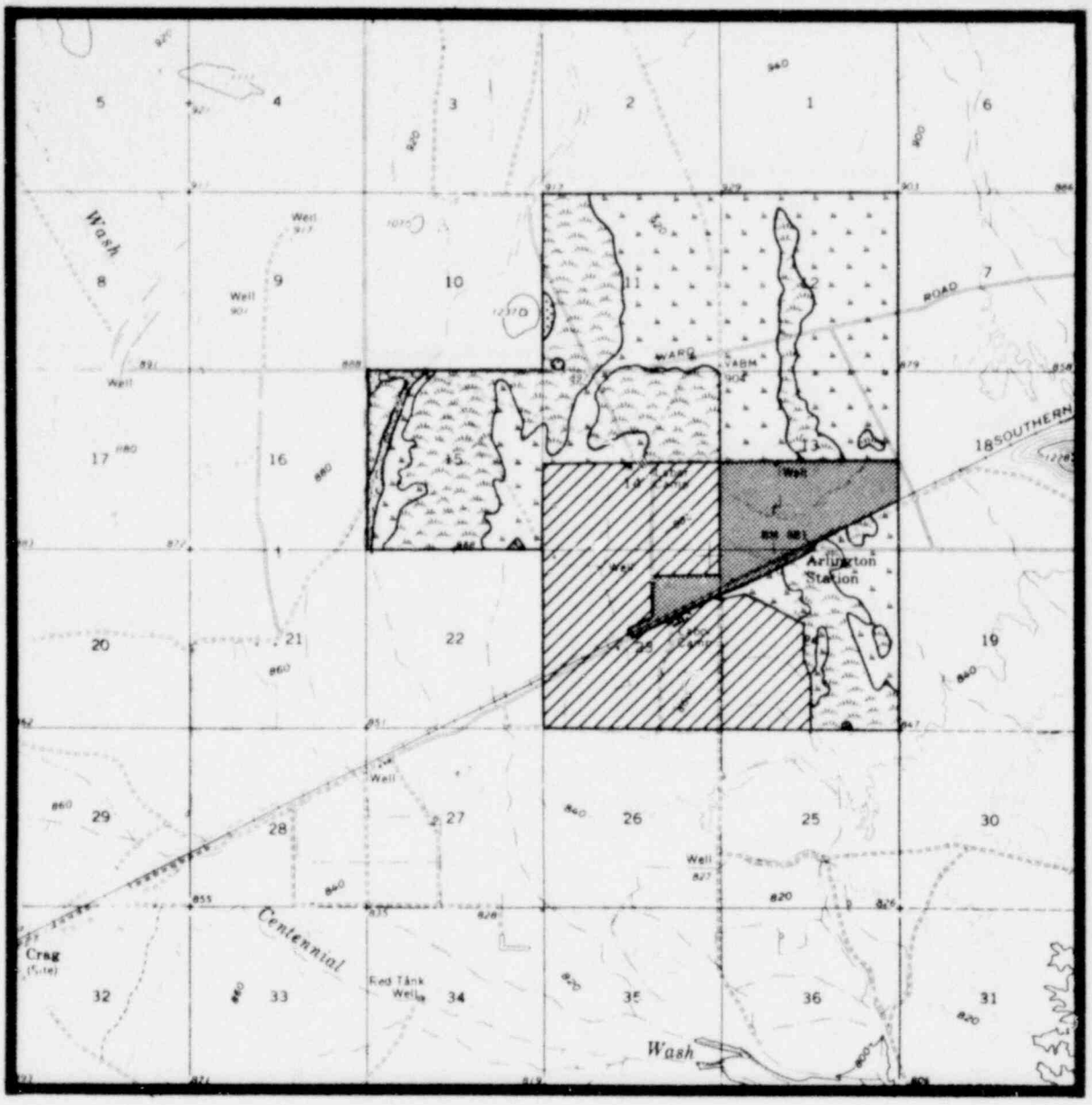
SOUTH TONOPAH WELL FIELD

Figure 10B-7



2354 208

LEGEND

- ACTIVE AGRICULTURE
- ABANDONED AGRICULTURE
- CREOSOTE BUSH/DESERT PAVEMENT
- MIXED CREOSOTE BUSH/SALTBUSH
- DESERT RIPARIAN
- CREOSOTE BUSH/CACTI

NORTH

0 ½ 1 MILES 2 3

SCALE

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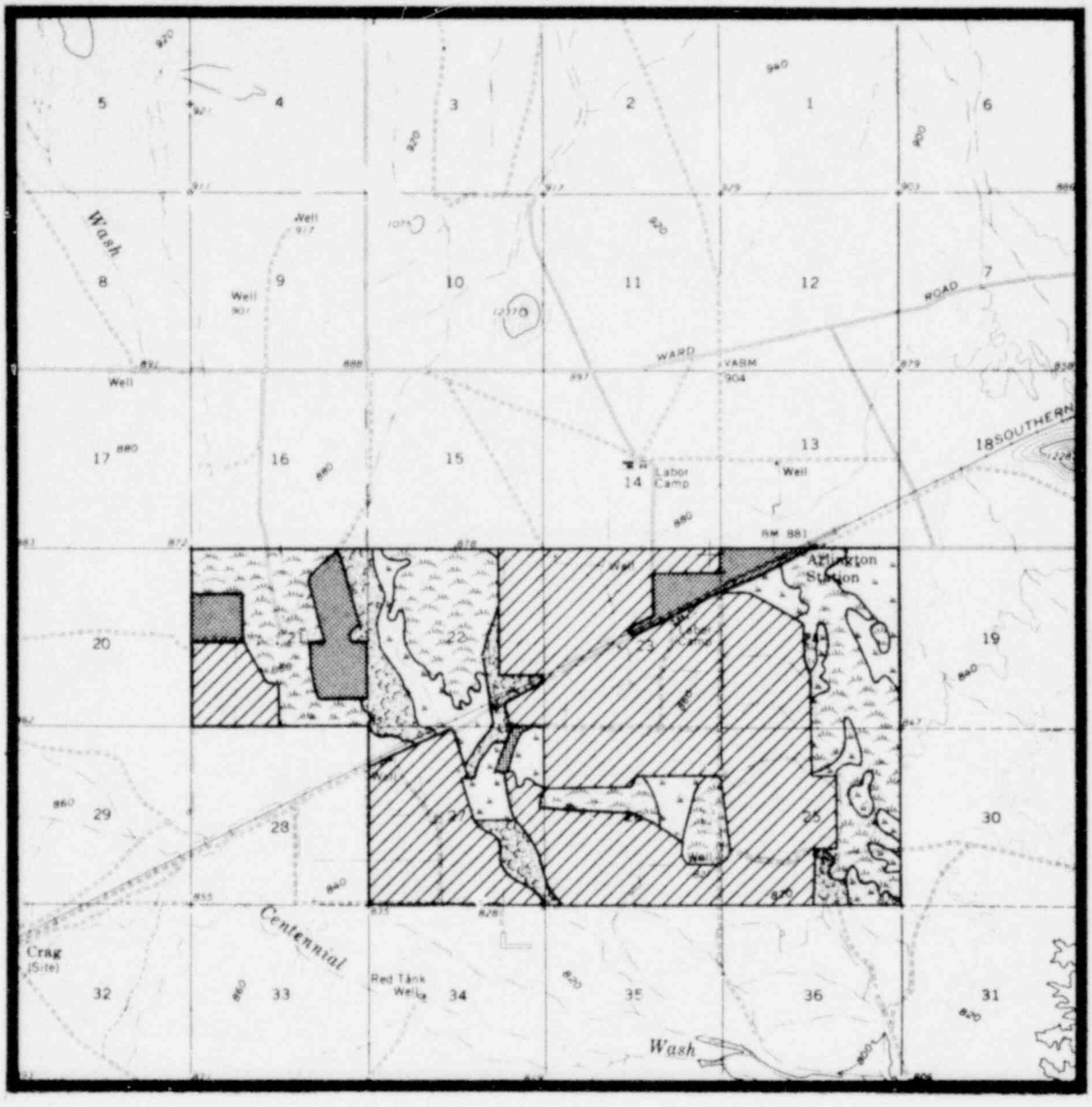
SOUTH WELL FIELD
Figure 10B-8



2354 209

LEGEND

- ACTIVE AGRICULTURE
- ABANDONED AGRICULTURE
- CREOSOTE BUSH/DESERT PAVEMENT
- MIXED CREOSOTE BUSH/SALTBUSH
- DESERT RIPARIAN

NORTH

0 ½ 1 2 3 MILES

SCALE

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CENTENNIAL WELL FIELD

Figure 10B-9