

**APPENDIX G**  
**POTENTIAL OFF-STREAM RESERVOIR SITES**  
**FOR PERMIT 15000 FEASIBILITY STUDY**

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## TECHNICAL MEMORANDUM

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TO: Steve Reich DATE: March 9, 2001  
FROM: Allan Richards JOB NO.: 1828  
RE: Potential Off-Stream Reservoir Sites - Camp Pendleton Marine Corps Base

### 1. Introduction

Potential off-stream reservoir sites in the lower Santa Margarita River area were evaluated as part of the Groundwater Recharge and Recovery Enhancement Program (Project) conducted by Stetson Engineers for the Camp Pendleton Marine Corps Base (Camp Pendleton). An off-stream reservoir system would allow for an increase in Santa Margarita River diversions. The Project considered off-stream reservoirs for the purpose of storing surplus river diversions in excess of the storage capacity of Lake O'Neill and in excess of the storage and infiltration capacity of the groundwater recharge pond system. Off-stream reservoirs are included in Project Alternative 4 which also involves increasing the capacity of the existing river diversion system from 100 cubic feet per second (cfs) to 200 cfs, and expanding the groundwater recharge pond system from five ponds to seven ponds.

Potential off-stream reservoir sites were identified in the vicinity of the existing river diversion and groundwater recharge system with the intention to fill the proposed reservoir(s) by pumping water from either Lake O'Neill or from one of the groundwater recharge ponds. Surplus river diversions would be pumped directly from either Lake O'Neill or from one of the recharge ponds when river diversions available to the groundwater recharge system are high. During periods of low river flow and low river diversions, water stored in the off-stream reservoir(s) could be returned to the recharge ponds by gravity to replenish the groundwater aquifer.

This reconnaissance evaluation of potential off-stream reservoir sites was conducted utilizing U.S. Geological Survey (USGS) topographic maps, aerial photographs, and limited field investigations. Geologic assessments, soils investigations, and other site specific studies would be required to develop conceptual dam designs, assess construction feasibility, and refine cost estimates. Although identification of additional uses for off-stream reservoirs were beyond the scope of this study, it should also be noted that the off-stream reservoirs could be included as part of conjunctive use systems with entities located outside of Camp Pendleton.

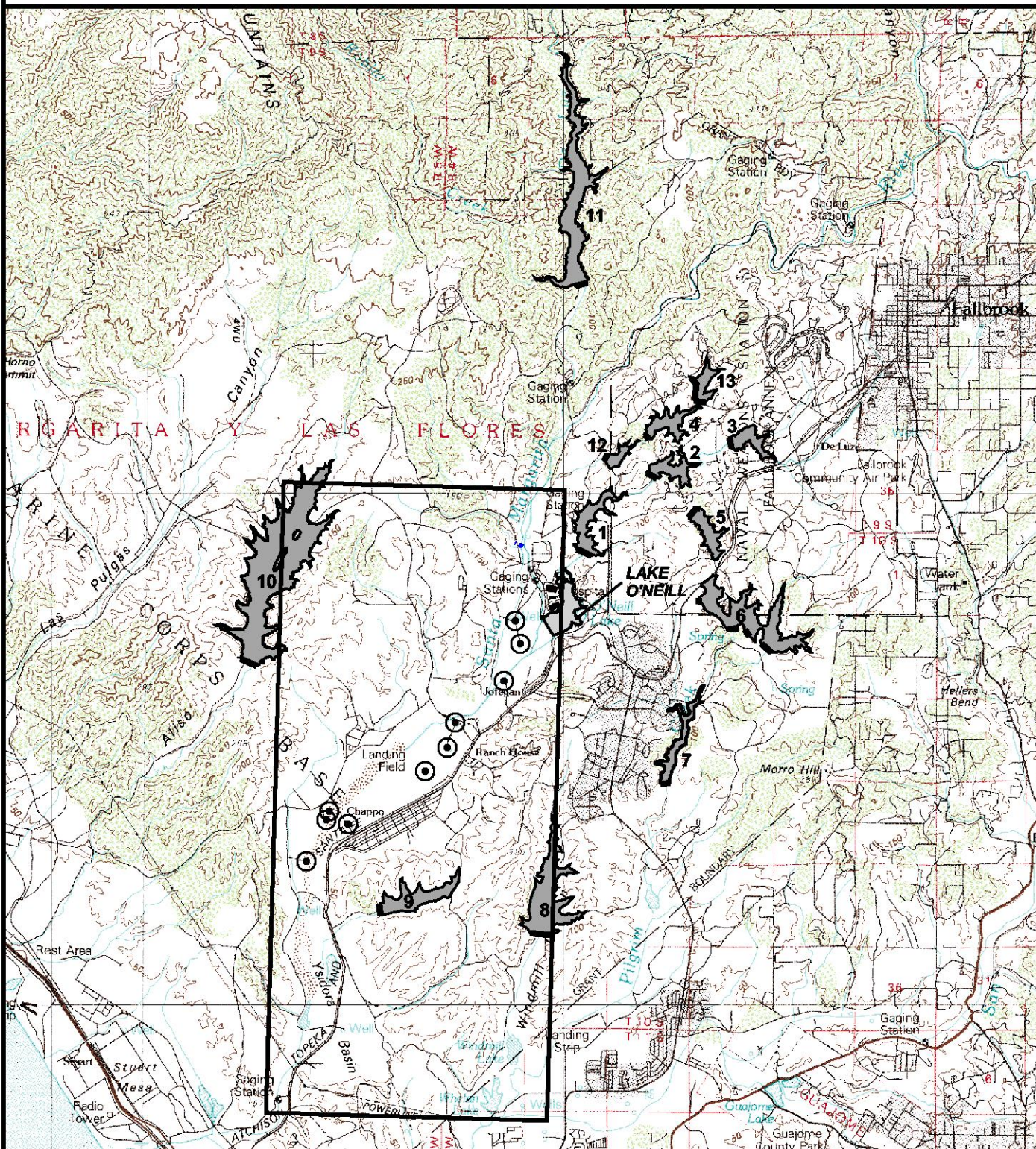
## **2. Potential Off-Stream Reservoir Sites**

The initial evaluation of potential off-stream reservoirs identified a total of 13 sites in the vicinity of the existing groundwater recharge pond system. USGS topography maps and aerial photographs were reviewed to determine site locations for off-stream reservoirs that conceptually could be constructed with minimal relocations required for roads, utilities, and structures. This preliminary evaluation of reservoir sites assumed earth embankment dam construction and limited crest heights of the proposed dams to 130 feet above the creek or streambeds. The general locations of the 13 potential off-stream reservoir sites are shown relative to Lake O'Neill in Figure G-1. A summary of the preliminary dam and reservoir statistics for each of the 13 sites is given on Table G-1.

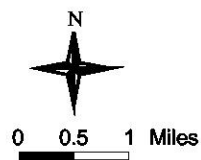
In connection with developing Project Alternative 4, Reservoir Nos. 4, 5, 6, 12, and 13 were selected for additional study as off-stream storage sites. Primarily because of environmental considerations or prohibitive costs for construction and operations, Reservoir Nos. 1, 2, 3, 7, 8, 9, 10, and 11 were eliminated from further consideration. Four alternative systems for pumping river diversions to the off-stream storage locations were developed using the select reservoirs and are described below.



POTENTIAL OFF-STREAM RESERVOIR SITES  
 LOWER SANTA MARGARITA RIVER  
 CAMP PENDLETON MARINE CORPS BASE



- ⊙ PRODUCTION WELL
- DAM
- GROUNDWATER MODEL BOUNDARY
- PROPOSED RESERVOIR





**TABLE G-1**  
**POTENTIAL OFF-STREAM RESERVOIR SITES ON**  
**CAMP PENDLETON MARINE CORPS BASE**

1.       **Reservoir #1**  
 Located 1/4 mile above Lake O'Neill on Fallbrook Creek.  
  
 Normal Water Surface (NWS) elevation = 220 feet  
 Dam crest height above streambed = 85 feet  
 Dam crest length = 1,000 feet  
 Reservoir surface area at NWS = 93.70 acres  
 Approximate storage capacity at NWS = **1,870 acre-feet** (assumes avg. depth = 20 feet)
  
2.       **Reservoir #2**  
 Located on Fallbrook Creek approximately 2.0 river miles above Lake O'Neill.  
  
 NWS elevation = 400 feet  
 Dam crest height above streambed = 130 feet  
 Dam crest length = 750 feet  
 Surface area at NWS = 68.91 acres  
 Approximate storage capacity at NWS = **3,450 acre-feet** (assumes avg. depth = 50 feet)
  
3.       **Reservoir #3**  
 Located approx. 3 river miles above Lake O'Neill.  
  
 NWS elevation = 500 feet  
 Dam crest height above streambed = 60 feet  
 Dam crest length = 700 feet  
 Surface area at NWS = 57.63 acres  
 Approximate storage capacity at NWS = **1,440 acre-feet** (assumes avg. depth = 25 feet)
  
4.       **Reservoir #4**  
 Located on unnamed Santa Margarita tributary approximately 1.75 river miles below De Luz Creek confluence)  
  
 NWS elevation = 400 feet  
 Dam crest height above streambed = 110 feet  
 Dam crest length = 500 feet  
 Surface area at NWS = 71.90 acres  
 Storage capacity at NWS = **2,465 acre-feet**
  
5.       **Reservoir #5**  
 Located approx. 1 mile above Reservoir #1  
  
 NWS elevation = 460 feet  
 Dam crest height above streambed = 100 feet  
 Dam crest length = 1,000 feet  
 Surface area at NWS = 66.80 acres  
 Approximate storage capacity at NWS = **2,000 acre-feet** (assumes avg. depth = 30 feet)

**TABLE G-1 (CONTINUED)**  
**POTENTIAL OFF-STREAM RESERVOIR SITES ON**  
**CAMP PENDLETON MARINE CORPS BASE**

- 6. Reservoir #6**  
Located upper Pilgrim Creek watershed.
- NWS elevation = 460 feet  
Dam crest height above streambed = 100 feet (max of 4 dams)  
Dam crest length = 2,500 feet (total of 4 dams)  
Surface area at NWS = 251.78 acres  
Storage capacity at NWS = **7,307 acre-feet**
- 7. Reservoir #7**  
Located lower Pilgrim Creek watershed.
- NWS elevation = 260 feet  
Dam crest height above streambed = 80 feet  
Dam crest length = 700 feet  
Surface area at NWS = 78.54 acres  
Approximate storage capacity at NWS = **1,570 acre-feet** (assumes avg. depth = 20 feet)
- 8. Reservoir #8**  
Located in Windmill Canyon.
- NWS elevation = 240 feet  
Dam crest height above streambed = 110 feet  
Dam crest length = 1,300 feet  
Surface area at NWS = 225.63 acres  
Approximate storage capacity at NWS = **11,280 acre-feet** (assumes avg. depth = 50 feet)
- 9. Reservoir #9**  
Located in Pueblitos Canyon.
- NWS elevation = 180 feet  
Dam crest height above streambed = 95 feet  
Dam crest length = 700 feet  
Surface area at NWS = 117.04 acres  
Approximate storage capacity at NWS = **5,270 acre-feet** (assumes avg. depth = 45 feet)
- 10. Reservoir #10 (Aliso Canyon Reservoir)**  
Located in Aliso Canyon (Aliso Creek) approximately 5.5 river miles from ocean.
- NWS elevation = 440 feet  
Dam crest height above streambed = 100 feet  
Dam crest length = 1,200 feet  
Surface area at NWS = 658.85 acres  
Approximate storage capacity at NWS = **26,350 acre-feet** (assumes avg. depth = 40 feet)

**TABLE G-1 (CONTINUED)**  
**POTENTIAL OFF-STREAM RESERVOIR SITES ON**  
**CAMP PENDLETON MARINE CORPS BASE**

**11. Reservoir # 11 (De Luz Creek Reservoir)**

Located on De Luz Creek approximately 2.0 river miles above confluence with Santa Margarita River.

NWS elevation = 300 feet

Dam crest height above streambed = 120 feet

Dam crest length = 800 feet

Surface area at NWS = 294.12 acres

Approximate storage capacity at NWS = **17,650 acre-feet** (assumes avg. depth = 60 feet)

**12. Reservoir #12**

Located below Reservoir # 4

NWS elevation = 280 feet

Dam crest height above streambed = 60 feet

Dam crest length = 500 feet

Surface area at NWS = 29.34 acres

Storage capacity at NWS = **611 acre-feet**

**13. Reservoir #13**

Located above Reservoir # 4

NWS elevation = 440 feet

Dam crest height above streambed = 20 feet

Dam crest length = 2,000 feet (raise existing levee)

Surface area at NWS = 47.70 acres

Storage capacity at NWS = **477 acre-feet**

### **3. Selected Off-Stream Reservoir Sites**

Using the select Reservoir Nos. 4, 5, 6, 12, and 13, four alternative systems (Alternatives A, B, C, and D) for off-stream storage were initially studied in connection with developing Project Alternative 4. The conceptual plan and facilities associated with off-stream reservoir Alternatives A, B, C, and D are shown in Figures G-2, G-3, G-4, and G-5, respectively, attached to the end of this memorandum. Each of the four off-stream reservoir alternatives are described below.



### **Off-Stream Reservoir Alternative A**

Off-stream reservoir Alternative A includes the system of Reservoir Nos. 5 (2,000 acre-feet) and 6 (7,307 acre-feet) aligned in series. The total storage capacity of the two-reservoir system is 9,307 acre-feet. Alternative A involves a pump station to lift surplus river diversions directly from proposed recharge Pond No. 6 to Reservoir Nos. 5 and 6. A booster pump station would also be required to transfer water from Reservoir No. 5 back into Reservoir No. 6.

For the purpose of preparing a preliminary cost estimate for the three-reservoir system described as Alternative A, it was estimated that a 40 cfs pump station and a 25 cfs booster pump station would be required to fulfill average annual pumping requirements. The cost estimate for Alternative A also included approximately 3.3 miles of 36-inch diameter pipeline to deliver water from the main pump station to the reservoirs. The total cost estimate for constructing the Alternative A reservoirs and appurtenant facilities, including planning, design, and contingencies, is \$88.6 million. The basis for the Alternative A cost estimate is shown on Table G-2.

### **Off-Stream Reservoir Alternative B**

Off-stream reservoir Alternative B includes the system of Reservoir Nos. 12 (611 acre-feet), 4 (2,465 acre-feet), and 13 (477 acre-feet) aligned in series. The total storage capacity of the three-reservoir system is 3,553 acre-feet. Alternative B involves a pump station to lift surplus river diversions directly from proposed recharge Pond No. 6 to Reservoir Nos. 12 or 4. A booster pump station would also be required to transfer water from Reservoir No. 4 into Reservoir No. 13.

For the purpose of preparing a preliminary cost estimate for the three-reservoir system described as Alternative B, it was estimated that a 40 cfs pump station and a 10 cfs booster pump station would be required to fulfill average annual pumping requirements. The cost estimate for Alternative B also included approximately 3.3 miles of 36-inch diameter pipeline to deliver water

**TABLE G-2**  
**COST ESTIMATE FOR**  
**OFF-STREAM RESERVOIR STORAGE**  
**Alternative A**

<b>Item</b>	<b>Cost</b>
Mobilization and Demobilization	\$2,700,000
Dam No. 5 Construction	15,000,000
Dam No. 6 Construction	30,000,000
Pump Station ( 40 cfs)	1,700,000
Pump Station ( 25 cfs)	1,100,000
Pipeline ( 36-inch @ \$230 per foot)	4,000,000
Pipeline ( 24-inch @ \$168 per foot)	1,200,000
Appurtenant Facilities <sup>1</sup>	1,000,000
Contingencies and Unlisted Items @ 25%	14,200,000
<b>Subtotal</b>	<b>\$70,900,000</b>
Planning, Engineering, and Design @ 15%	10,600,000
Project Management and Administration @ 10%	7,100,000
<b>Total Estimated Capital Cost</b>	<b>\$88,600,000</b>
Amortized Capital Cost <sup>2</sup>	7,900,000
Annual Operation and Maintenance Cost <sup>3</sup>	104,000
<b>Total Estimated Annual Cost</b>	<b>\$8,004,000</b>
<b>Unit Cost<sup>4</sup></b>	<b>\$860 /acre-foot</b>

1. Appurtenant facilities include road construction, valves, and meters.

2. Capital costs amortized over 30 years at 8 percent interest.

3. Annual Operation and Maintenance costs based on \$4,000 for power and salary at \$100,000.

4. Unit cost based on total reservoir storage capacity of 9,307 acre-feet.

from the main pump station to the reservoirs. The total cost estimate for constructing the Alternative B reservoirs and appurtenant facilities, including planning, design, and contingencies, is \$46.4 million. The basis for the Alternative B cost estimate is shown on Table G-3.

### **Off-Stream Reservoir Alternative C**

Off-stream reservoir Alternative C includes the combination of the two systems of reservoirs described in Alternatives A and B. The total storage capacity of the off-stream reservoir Alternative C is 12,860 acre-feet. Alternative C also involves pumping surplus river diversions directly from proposed recharge Pond No. 6 to Reservoir Nos. 5 and 6, or to Reservoir Nos. 12 and 4. The booster pump stations and conveyance pipelines utilized for off-stream reservoir Alternatives A and B would also be necessary for Alternative C. The total cost estimate for constructing the Alternative C reservoirs and appurtenant facilities, including planning, design, and contingencies, is \$132.1 million. The basis for the Alternative C cost estimate is shown in Table G-4.

### **Off-Stream Reservoir Alternative D**

Off-stream reservoir Alternative D includes only Reservoir No. 6, reduced in size from 7,307 acre-feet (Alternatives A and C) to 4,800 acre-feet. The storage capacity requirement for Alternative D was developed from refined surface and groundwater model results. The model results determined the amount of surplus river diversions that would actually be available for off-stream storage, and the average annual reservoir yield for the Alternative D off-stream reservoir system. Based on records of historical stream flow, the surface and groundwater modeling results indicated that a pump station having a capacity of approximately 40 cfs would be required to deliver a maximum of 4,800 acre-feet and an average annual yield of 1,050 acre-feet to Reservoir No. 6. The total cost estimate for constructing the Alternative D reservoir and appurtenant facilities, including planning, design, and contingencies, is \$42.3 million. The basis for the Alternative D cost estimate is shown on Table G-5.



**TABLE G-3**  
**COST ESTIMATE FOR**  
**OFF-STREAM RESERVOIR STORAGE**  
**Alternative B**

<b>Item</b>	<b>Cost</b>
Mobilization and Demobilization	\$1,400,000
Dam No. 4 Construction	12,100,000
Dam No. 12 Construction	7,500,000
Dam No. 13 Construction	1,500,000
Pump Station ( 40 cfs)	1,700,000
Booster Pump Station (10 cfs)	460,000
Pipeline ( 36-inch @ \$230 per foot)	4,000,000
Appurtenant Facilities <sup>1</sup>	1,000,000
Contingencies and Unlisted Items @ 25 %	7,400,000
<b>Subtotal</b>	<b>\$37,060,000</b>
Planning, Engineering, and Design @ 15%	5,600,000
Project Management and Administration @ 10%	3,700,000
<b>Total Estimated Capital Cost</b>	<b>\$46,360,000</b>
Amortized Capital Cost <sup>2</sup>	4,100,000
Annual Operation and Maintenance Cost <sup>3</sup>	100,000
<b>Total Estimated Annual Cost</b>	<b>\$4,200,000</b>
<b>Unit Cost<sup>4</sup></b>	<b>\$1,182 /acre-foot</b>

1. Appurtenant facilities include road construction, valves, and meters.

2. Capital costs amortized over 30 years at 8 percent interest.

3. Annual Operation and Maintenance costs based on \$4,000 for power and salary at \$100,000.

4. Unit cost based on total reservoir storage capacity of 3,553 acre-feet.

**TABLE G-4**  
**COST ESTIMATE FOR**  
**OFF-STREAM RESERVOIR STORAGE**  
**Alternative C**

<b>Item</b>	<b>Cost</b>
Mobilization and Demobilization	\$4,000,000
Dam No. 4 Construction	12,100,000
Dam No. 5 Construction	15,000,000
Dam No. 6 Construction	30,000,000
Dam No. 12 Construction	7,500,000
Dam No. 13 Construction	1,500,000
Pump Station ( 40 cfs)	1,700,000
Pump Station ( 25 cfs)	1,100,000
Booster Pump Station (10 cfs)	460,000
Pipeline ( 36-inch @ \$230 per foot)	8,000,000
Pipeline ( 24-inch @ \$168 per foot)	1,200,000
Appurtenant Facilities <sup>1</sup>	2,000,000
Contingencies and Unlisted Items @ 25%	21,100,000
<b>Subtotal</b>	<b>\$105,660,000</b>
Planning, Engineering, and Design @ 15%	15,800,000
Project Management and Administration @ 10%	10,600,000
<b>Total Estimated Capital Cost</b>	<b>\$132,060,000</b>
Amortized Capital Cost <sup>2</sup>	11,700,000
Annual Operation and Maintenance Cost <sup>3</sup>	156,000
<b>Total Estimated Annual Cost</b>	<b>\$11,856,000</b>
<b>Unit Cost<sup>4</sup></b>	<b>\$922 /acre-foot</b>

1. Appurtenant facilities include road construction, valves, and meters.

2. Capital costs amortized over 30 years at 8 percent interest.

3. Annual Operation and Maintenance costs based on \$6,000 for power and salary at \$150,000.

4. Unit cost based on total reservoir storage capacity of 12,860 acre-feet.

**TABLE G-5**

**COST ESTIMATE FOR  
OFF-STREAM RESERVOIR STORAGE  
Alternative D (4,800 AF maximum storage)**

<b>Item</b>	<b>Cost</b>
Mobilization and Demobilization	\$1,300,000
Dam No. 6 Construction	19,000,000
Pump Station ( 40 cfs)	1,700,000
Pipeline ( 36-inch @ \$230 per foot)	4,000,000
Appurtenant Facilities <sup>1</sup>	1,000,000
Contingencies and Unlisted Items @ 25%	6,800,000
<b>Subtotal</b>	<b>\$33,800,000</b>
Planning, Engineering, and Design @ 15%	5,100,000
Project Management and Administration @ 10%	3,400,000
<b>Total Estimated Capital Cost</b>	<b>\$42,300,000</b>
Amortized Capital Cost <sup>2</sup>	3,800,000
Annual Operation and Maintenance Cost <sup>3</sup>	88,000
<b>Total Estimated Annual Cost</b>	<b>\$3,888,000</b>
<b>Unit Cost<sup>4</sup></b>	<b>\$810 /acre-foot</b>

1. Appurtenant facilities include road construction, valves, and meters.

2. Capital costs amortized over 30 years at 8 percent interest.

3. Annual Operation and Maintenance costs based on \$3000 for power and labor at \$85,000.

4. Unit cost based on total reservoir storage capacity of 4,800 acre-feet.



Table G-6 below summarizes the cost estimates that were prepared for the off-stream reservoir alternatives.

**TABLE G-6**  
**SUMMARY OF COST ESTIMATES FOR**  
**OFF-STREAM RESERVOIR STORAGE ALTERNATIVES**







ALTERNATIVE	ESTIMATED CAPITAL COST (MILLION \$)	ESTIMATED ANNUAL COST <sup>1</sup> (MILLION \$)	TOTAL RESERVOIR STORAGE CAPACITY <sup>2</sup> (AF)	ANNUAL UNIT COST <sup>3</sup> (\$/AF)
A	88.6	8.0	9,307	860
B	46.4	4.2	3,553	1,182
C	132.1	11.8	12,860	922
D	42.3	3.9	4,800	810

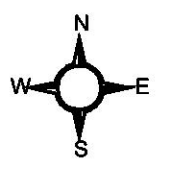
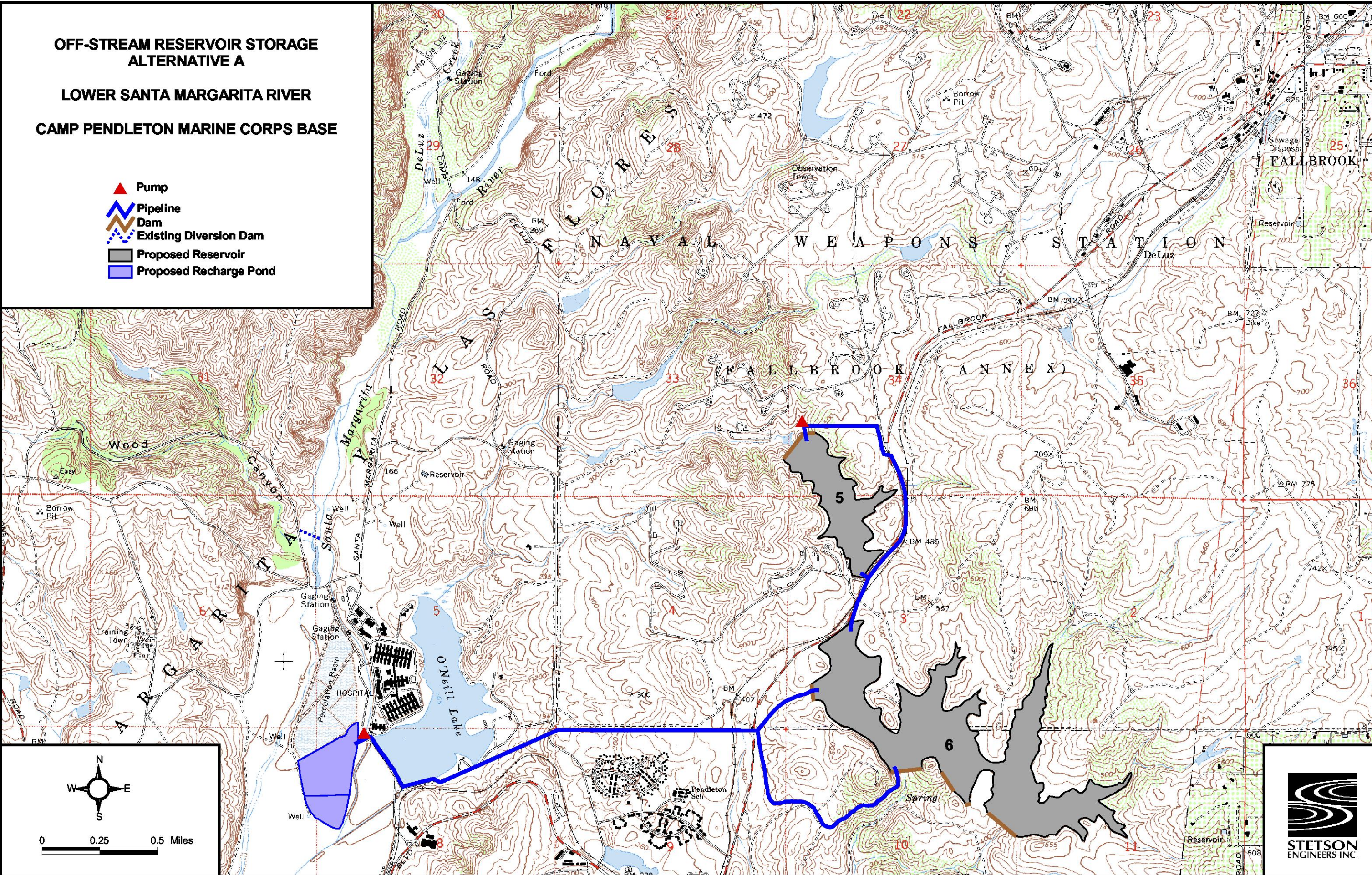
- 1) Annual cost estimated as sum of capital costs amortized over 30 years at 8 percent interest plus power and labor to maintain and operate the facilities.
- 2) Alternative A Storage Capacity = 2,000 AF (Reservoir #5) + 7,307 AF (Reservoir #6).  
Alternative B Storage Capacity = 2,465 AF (Reservoir #4) + 611 AF (Reservoir #12) + 477 AF (Reservoir #13).  
Alternative C Storage Capacity = Alternative A storage capacity + Alternative B storage capacity.  
Alternative D Storage Capacity = 4,800 AF (Reservoir #6 reduced in size).
- 3) Unit cost based on total reservoir storage capacity and estimated annual cost.

The cost summary shown in Table G-6 includes annual costs for each alternative and unit costs in terms of total reservoir capacity. Annual costs were estimated as the sum of capital costs amortized over 30 years at 8 percent interest plus power and labor to maintain and operate the facilities. It is important to note that the unit costs are provided for comparison purposes only and are based on the total storage capacity of each alternative. The expected average annual reservoir yield for each alternative was not determined. Unit costs based on expected average annual reservoir yields would be significantly higher than the unit costs shown above.



**OFF-STREAM RESERVOIR STORAGE  
ALTERNATIVE A**  
**LOWER SANTA MARGARITA RIVER**  
**CAMP PENDLETON MARINE CORPS BASE**

-  Pump
-  Pipeline
-  Dam
-  Existing Diversion Dam
-  Proposed Reservoir
-  Proposed Recharge Pond



0 0.25 0.5 Miles









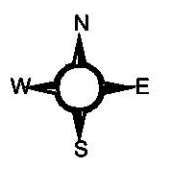
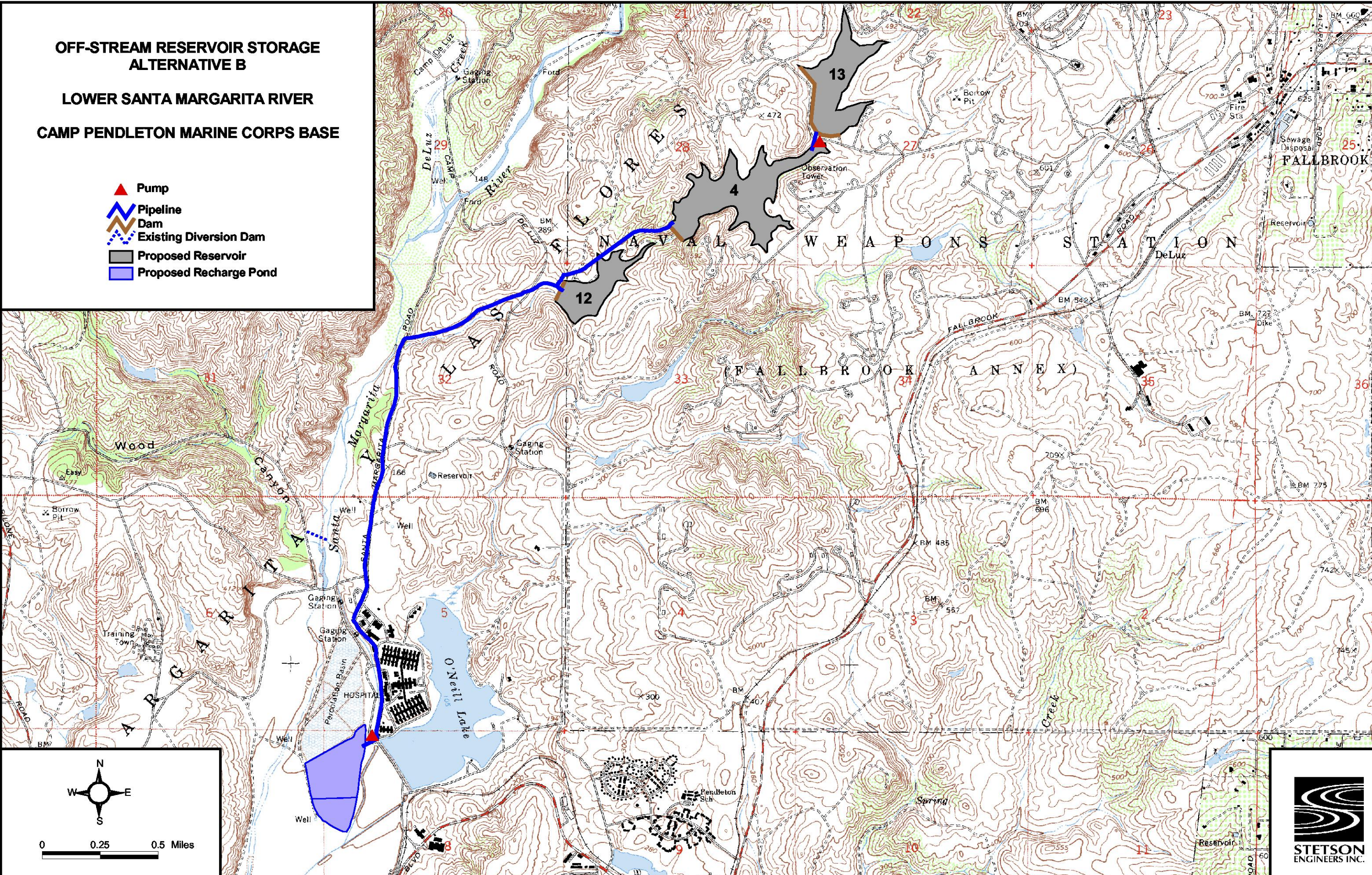


# OFF-STREAM RESERVOIR STORAGE ALTERNATIVE B

## LOWER SANTA MARGARITA RIVER

### CAMP PENDLETON MARINE CORPS BASE

-  Pump
-  Pipeline
-  Dam
-  Existing Diversion Dam
-  Proposed Reservoir
-  Proposed Recharge Pond



0 0.25 0.5 Miles









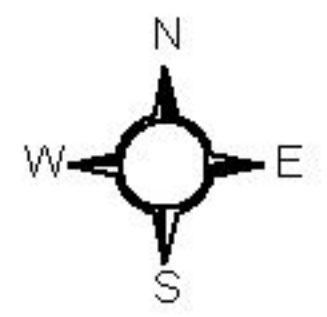
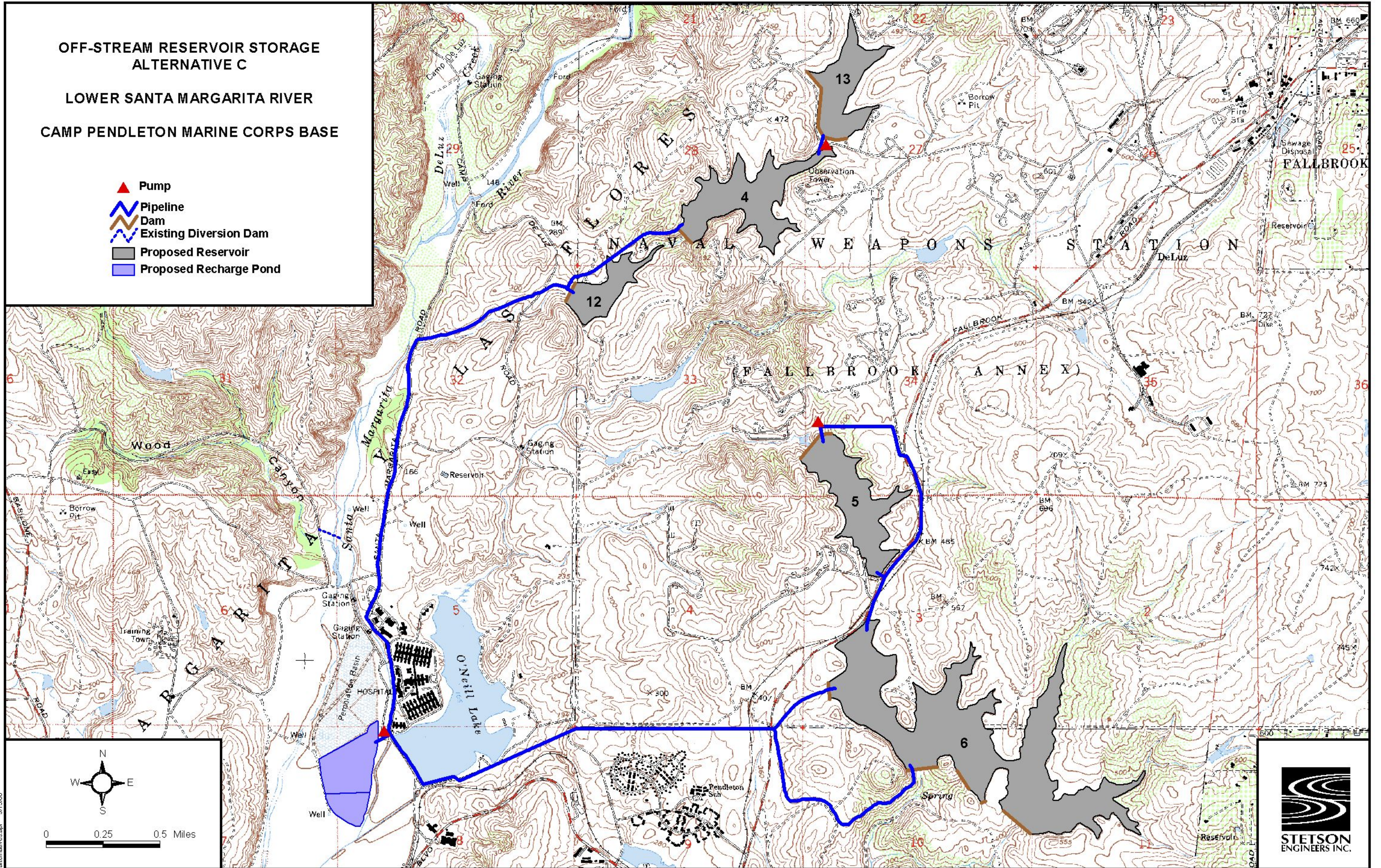
STETSON ENGINEERS INC.



FIGURE G-4

OFF-STREAM RESERVOIR STORAGE  
ALTERNATIVE C  
LOWER SANTA MARGARITA RIVER  
CAMP PENDLETON MARINE CORPS BASE

-  Pump
-  Pipeline
-  Dam
-  Existing Diversion Dam
-  Proposed Reservoir
-  Proposed Recharge Pond



0 0.25 0.5 Miles

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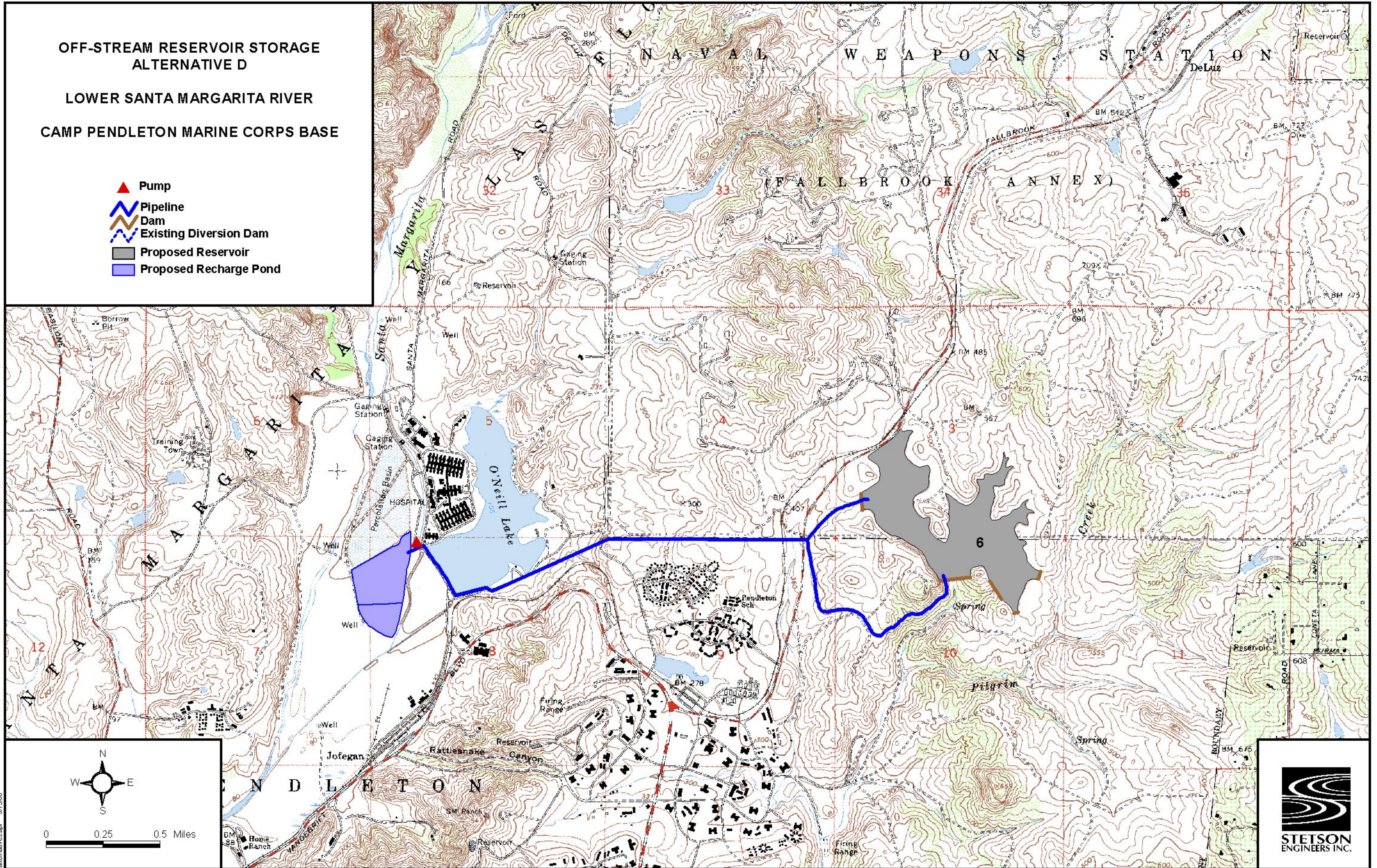


**OFF-STREAM RESERVOIR STORAGE  
ALTERNATIVE D**

**LOWER SANTA MARGARITA RIVER**

**CAMP PENDLETON MARINE CORPS BASE**

-  Pump
-  Pipeline
-  Dam
-  Existing Diversion Dam
-  Proposed Reservoir
-  Proposed Recharge Pond



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