MEMORANDUM

TO: File

FROM: Robin Cort

DATE: December 1, 1995

SUBJECT: Interest Rates for Present Worth Analysis

The following technical memorandum, TM-P4, uses an interest rate of 7.5% for present worth cost comparisons. This memorandum was prepared prior to the project cost estimate, which uses a 6.5% interest rate. Because the present worth analysis in this memorandum is used for internal comparison only, and is not carried forward into the final cost analysis, the difference in the interest rates does not affect the conclusions presented in this memorandum.

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TECHNICAL MEMORANDUM
TM-P-4

TO: Andy Hauge (HBA)
Robin Cort (Parsons ES)

FROM: Therese Wooding (Parsons ES)
Rich Maurer (Parsons ES)

DATE: 21 July 1995

RE: Santa Rosa Subregional Long-Term Wastewater Project, Transmission Pipelines to Storage, Tunnel Length Optimization Analysis
Ref. No. 723129.31006

INTRODUCTION

The purpose of this memorandum is to 1) present the approach used to evaluate the relative economic benefit of tunneling to lower the pumping head into Tolay C, Two Rock, Sears Point, Bloomfield, Carroll Road, Valley Ford, and Huntley reservoirs, and 2) recommend the tunnel length, if appropriate, for use in an overall present worth analysis. Tunneling was not recommended at the other three reservoir sites (Tolay A, Adobe Road and Lakeville) because 1) the transmission line high point is the water surface in the reservoir or 2) the tunnel depth would be less than 50 ft. (See Figures 4 through 13 for pipeline profiles and hydraulic profiles of the tunnels.) Flows used in this analysis are based on those determined in TM-P-6. Pipe material costs are not included in the analysis as they are common to all alternatives.

TUNNELING ECONOMIC ANALYSIS

The pipeline routes used in the tunneling analysis are shown in the attached figures. Map OV-1 shows the overall project area, pipeline alignments and reservoir locations relative to the treatment plant. Figures 1 through 3 provide a more detailed layout of the tunnels' locations. Hydraulic profiles for the recommended alignments are provided in Figures 4 through 13. Assumptions used in the analysis are shown in Table 1 in boldface type. Note that the present worth costs in the tables are relative costs for comparison purposes only. Tunnel length at specific elevations was measured from topographical maps. For example, at Two Rock at a ground elevation of 500 ft. the proposed tunnel length is 250 ft. Assuming an 8-foot tunnel diameter, a construction cost of $1,300/LF, the estimated construction cost of the tunnel would be approximately $325,000.

Material costs were obtained from recent vendor quotes, the Means cost estimate guide and a review of tunnel construction costs from past projects. Present worth assumptions are based on recommendations from the project economist, EPS.

Pumping energy costs were calculated based on static head at specific elevations. At Tolay C, Two Rock, Carroll Road and Valley Ford the static head and tunnel length is based on the reservoir water surface. For example, at Two Rock, for a ground elevation of 500 ft., given that the pump station elevation is 80 ft., the static head is 420 ft. The static head is calculated as the difference between the water surface elevation at the reservoir and the pump station. Energy costs and pump station housepower become larger as the static head increases. The static head will vary depending on the water surface in the reservoir. To be conservative, the maximum water surface in the reservoir was used in the analysis. At Sears Point, Bloomfield, and Huntley the static head and length of the tunnel is limited by the topography around the dam site. At Sears Point for example, the maximum reservoir water surface El. is 140 ft. However, the base of the 420 ft. high ridge occurs at El. 270 ft. The ground then slopes down to the maximum reservoir water surface El of 140 ft. Thus, 270 ft was used as the high point in the static head calculation.

Friction losses between the pump station (at the treatment plant) and the tunnel (alignment high point) are considered common to all alternatives and were not included in the calculations. Between the high point and the reservoirs it is assumed that gravity flow occurs for the no tunnel option and that pumped flow occurs for the tunnel option. Friction losses and related pump station construction and operation costs for the tunnel options are included in the present worth costs. This is conservative as a majority of the tunnel option alignment downstream of the tunnel will most likely be gravity flow.

CONCLUSIONS

Tunnels are recommended for the transmission pipeline to Two Rock, Sears Point and Tolay C reservoirs. Results of the tunneling analysis is shown in Table 1. Graphical results of the analysis are shown on Figures 14 through 20. In general, topographical elevation and tunnel length have a significant impact on the total present worth of each project. A short tunnel which provides a large reduction in pumping head is the most economically feasible configuration. For example, use of a tunnel at Two Rock reservoir lowers the total present worth cost due to the 150 ft. decrease in pumping head and relatively short, 2,700 ft length. However, a tunnel for Valley Ford reservoir is not recommended. In spite of the 165 ft. reduction in pumping head (similar to Two Rock) the cost of the tunnel due to its length (almost 10 times that of Two Rock) outweighs the energy cost savings. Tunneling is not recommended at Huntley because the estimated cost savings is not within the accuracy of the analysis. Also, the tunnel depth is only 50 ft. It may be possible to obtain a reduction in pumping head by trenching and installing the pipe at a greater depth. This possibility should be investigated further should Huntley be the selected alternative.

The longest tunnels shown for Two Rock, Sears Point and Tolay C have been incorporated into an overall relative present worth analysis. The analysis compares the relative present worth costs of all proposed routes into each of the reservoirs and is used to assist in the selection of a recommended transmission line route from the treatment plant to the reservoir. The results of this analysis are presented in Technical Memorandum No. TM-P-3.

Summary

Tunneling recommendations for each of the 10 project reservoirs are presented below.

Reservoir	Recommendation	Figure Nos.
Tolay A	Tunnel not necessary. Based on visual inspection of alignment, provides only minimal reduction in static head which may be achieved by trenching and installing pipe at a greater depth.	4
Adobe Road	Tunnel not necessary. Reservoir is alignment high point.	5
Lakeville	Tunnel not necessary. Reservoir is alignment high point.	6
Tolay C	Use tunnel. Present worth cost reduced by approximately $1.4M	7, 14
Sears Point	Use tunnel. Present worth cost reduced by approximately $1.4M	8, 15
Two Rock	Use tunnel. Present worth cost reduced by approximately $0.12M	9,16
Bloomfield	Do not use tunnel. Present worth increases with tunnel length. Tunnel cost outweighs reduction in pumping cost.	10, 19
Carroll Road	Do not use tunnel. Present worth increases with tunnel length. Tunnel cost outweighs reduction in pumping cost.	11, 18
Valley Ford	Do not use tunnel. Present worth increases with tunnel length. Tunnel cost outweighs reduction in pumping cost.	12, 17
Huntley	Do not use tunnel. Provides only minimal reduction in present worth cost. Reduction in pumping head also minimal, may be achieved by trenching and installing pipe at a greater depth.	13, 20

Table 1 (concluded)

Tunnel Optimization Analysis for Transmission Lines to Reservoirs

Pump Sta. El.	50	Pump Efficiency	0.8	Present Worth Factor	11.81
Hazen-Williams C	120	Motor Efficiency	0.92	i(%)	7.5
				n(years)	30
South Co. Tunnel Cost($/LF)[1]	1,100	Tunnel Dia. (ft)	8	Pump period (years)	0.42
West Co. Tunnel Cost($/LF)[1]	1,300			Energy($/kW-hr)	0.1

Reservoir	Flow (MGD)	Flow (gpm)	Pipe Dia. (in)	Topo El. (ft)	Tunnel Length (ft)	Down Stream Length (ft)	H_f (ft)	Hp	Energy Use (kW-hr/yr)	Energy Cost ($/yr)	Static Head (ft)	Pump Sta. ($)	Tunnel Cost ($)	PW Energy ($)	Total PW Cost ($)
South County Reservoirs															
Tolay C	26	18,056	48	420	0	0	0.00	2,292	6,241,246	624,125	370	3,414,675	0	7,371,152	10,785,827
				400	870	435	0.64	2,172	5,914,681	591,468	350	3,270,899	1,131,000	6,985,467	11,387,366
				360	1,200	600	0.88	1,926	5,244,049	524,405	310	3,055,235	1,560,000	6,193,424	10,808,660
				320	1,600	800	1.18	1,680	4,574,285	457,429	270	2,839,572	2,080,000	5,402,408	10,321,979
				270	1,900	950	1.40	1,372	3,734,598	373,460	220	2,516,076	2,470,000	4,410,705	9,396,781
Sears Point	26	18,056	48	420	0	--	--	2,292	6,241,246	624,125	370	3,414,675	0	7,371,152	10,785,827
				400	870	--	--	2,168	5,903,881	590,388	350	3,270,899	1,131,000	6,972,711	11,374,610
				360	1,200	--	--	1,920	5,229,152	522,915	310	3,055,235	1,560,000	6,175,830	10,791,066
				320	1,600	--	--	1,673	4,554,422	455,442	270	2,839,572	2,080,000	5,378,949	10,298,521
				270	1,900	--	--	1,363	3,711,011	371,101	220	2,516,076	2,470,000	4,382,847	9,368,923
West County Reservoirs															
Two Rock	26	18,056	48	510	0	0	0.00	2,850	7,759,386	775,939	460	3,738,170	0	9,164,135	12,902,305
				500	250	157	0.18	2,789	7,593,808	759,381	450	3,702,226	325,000	8,968,580	12,995,807
				480	600	378	0.44	2,667	7,260,788	726,079	430	3,630,338	780,000	8,575,271	12,985,610
				460	800	504	0.59	2,544	6,925,906	692,591	410	3,594,395	1,040,000	8,179,763	12,814,157
				440	1,100	693	0.81	2,421	6,592,266	659,227	390	3,486,563	1,430,000	7,785,721	12,702,283
				420	1,400	881	1.03	2,299	6,258,626	625,863	370	3,414,675	1,820,000	7,391,679	12,626,353
				400	1,850	1,165	1.36	2,177	5,926,848	592,685	350	3,270,899	2,405,000	6,999,836	12,675,735
				380	2,200	1,385	1.62	2,054	5,593,828	559,383	330	3,234,955	2,860,000	6,606,527	12,701,482
				360	2,700	1,700	1.99	1,933	5,262,670	526,267	310	3,055,235	3,510,000	6,215,417	12,780,652
Bloomfield	26	18,056	48	370	0	0	0.00	1,982	5,397,834	539,783	320	3,127,123	0	6,375,050	9,502,174
				360	500	250	0.37	1,923	5,235,359	523,536	310	3,055,235	650,000	6,183,161	9,888,396
				340	1,500	750	1.10	1,803	4,910,409	491,041	290	2,911,460	1,950,000	5,799,382	10,660,842
				320	2,000	1,000	1.47	1,682	4,579,251	457,925	270	2,839,572	2,600,000	5,408,273	10,847,844
Carroll Road	26	18,056	48	340	0	0	0.00	1,797	4,891,787	489,179	290	2,911,460	0	5,777,369	8,688,849
				320	830	415	0.61	1,676	4,564,726	456,473	270	2,839,572	1,079,000	5,391,118	9,309,690
				300	2,100	1,050	1.55	1,558	4,243,128	424,313	250	2,695,796	2,730,000	5,011,298	10,437,094
				280	3,300	1,650	2.43	1,440	3,920,661	392,066	230	2,587,964	4,290,000	4,630,452	11,508,416

Table 1 (concluded)

Tunnel Optimization Analysis for Transmission Lines to Reservoirs

Pump Sta. El.	50	Pump Efficiency	0.8	Present Worth Factor	11.81
Hazen-Williams C	120	Motor Efficiency	0.92	i(%)	7.5
				n(years)	30
South Co. Tunnel Cost($/LF)[1]	1,100	Tunnel Dia. (ft)	8	Pump period (years)	0.42
West Co. Tunnel Cost($/LF)[1]	1,300			Energy($/kW-hr)	0.1

Reservoir	Flow (MGD)	Flow (gpm)	Pipe Dia. (in)	Topo El. (ft)	Tunnel Length (ft)	Down Stream Length (ft)	H_f (ft)	Hp	Energy Use (kW-hr/yr)	Energy Cost ($/yr)	Static Head (ft)	Pump Sta. ($)	Tunnel Cost ($)	PW Energy ($)	Total PW Cost ($)
West County Reservoirs (continued)															
Valley Ford	26	18,056	48	340	0	0	0.00	1,797	4,891,787	489,179	290	2,911,460	0	5,777,369	8,688,849
				320	1,000	500	0.74	1,677	4,566,837	456,684	270	2,839,572	1,300,000	5,393,611	9,533,182
				300	2,100	1,050	1.55	1,558	4,243,128	424,313	250	2,695,796	2,730,000	5,011,298	10,437,094
				280	3,200	1,600	2.36	1,439	3,919,419	391,942	230	2,587,964	4,160,000	4,628,985	11,376,949
				260	4,500	2,250	3.31	1,321	3,598,193	359,819	210	2,480,132	5,850,000	4,249,605	12,579,737
				240	5,800	2,900	4.27	1,203	3,276,967	327,697	190	2,336,356	7,540,000	3,870,225	13,746,581
				220	7,400	3,700	5.45	1,087	2,959,466	295,947	170	2,192,581	9,620,000	3,495,243	15,307,824
				200	17,900	8,950	13.17	1,011	2,752,452	275,245	150	2,156,637	23,270,000	3,250,752	28,677,389
				180	20,300	10,150	14.94	898	2,444,882	244,488	130	2,012,861	26,390,000	2,887,500	31,290,361
				175	21,100	10,550	15.53	871	2,370,472	237,047	125	1,940,973	27,430,000	2,799,619	32,170,592
Huntley	26	18,056	48	360	0	0	0.00	1,920	5,229,152	522,915	310	3,055,235	0	6,175,830	9,231,066
				340	600	300	0.44	1,799	4,899,236	489,924	290	2,911,460	780,000	5,786,187	9,477,646
				320	1,000	500	0.74	1,677	4,566,837	456,684	270	2,839,572	1,300,000	5,393,611	9,533,182
				313	1,200	600	0.88	1,635	4,451,242	445,124	263	2,803,628	1,560,000	5,257,089	9,620,717

1) Cost difference due to different geologic characteristics in South and West Counties.

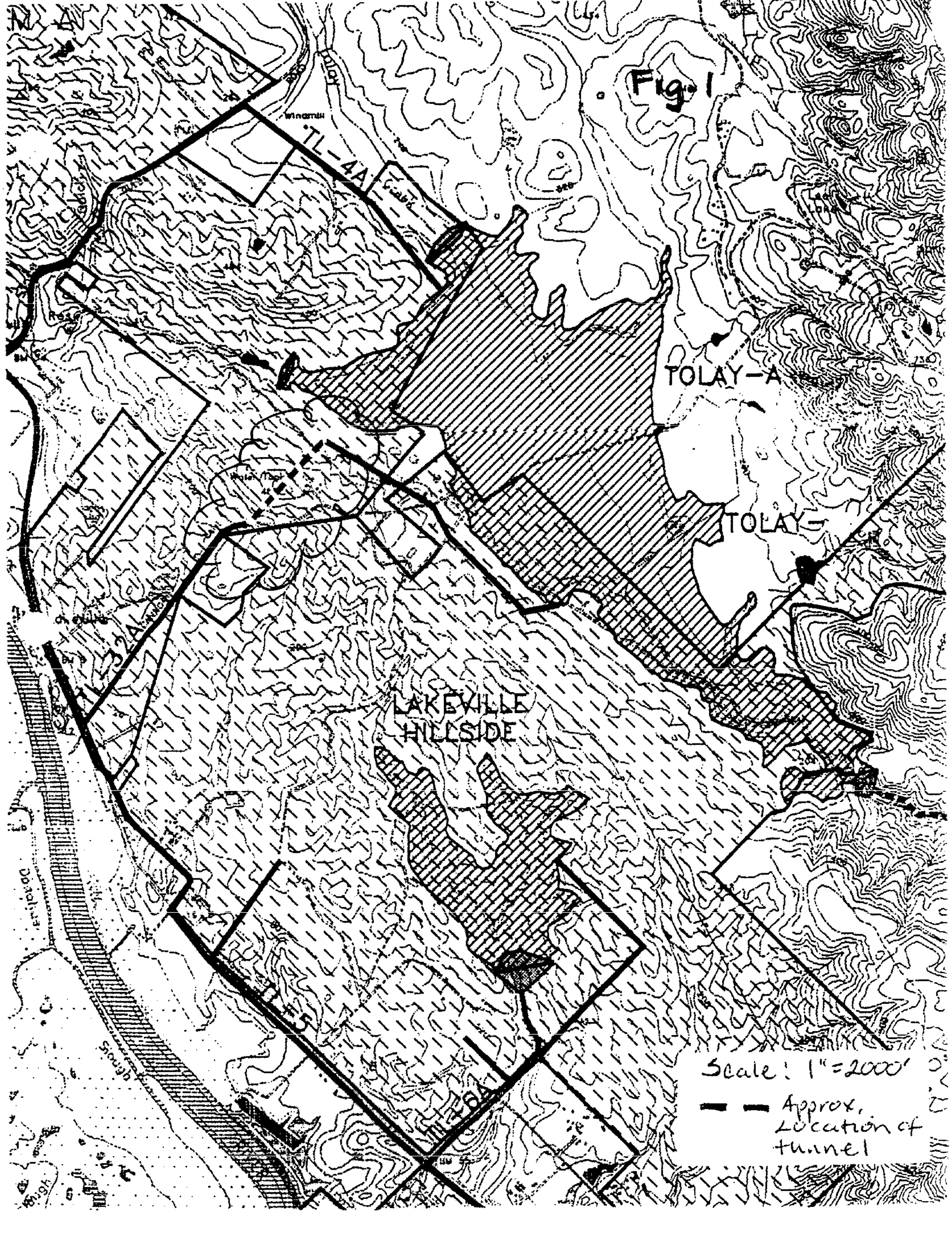

Fig. 1
TL-4A
TOLAY-A
TOLAY-
LAKEVILLE
HILLSIDE
Scale: 1" = 2000'
Approx. Location of tunnel

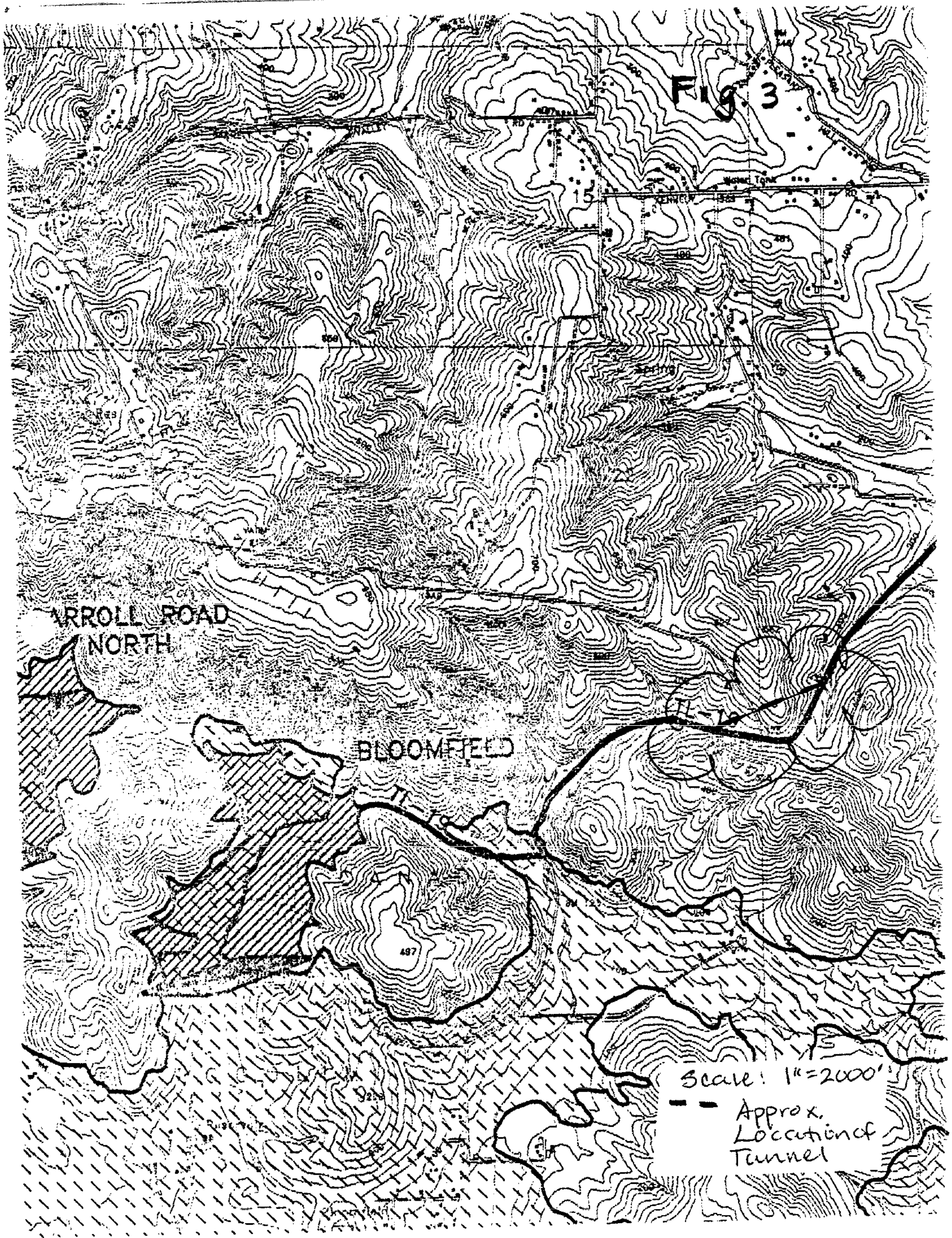

Fig 3
ARROLL ROAD
NORTH
BLOOMFIELD
Spring
Water Tank
Scale: 1" = 2000'
Approx. Location of Tunnel

Figure 4

Tolay A Reservoir Transmission Line Profile

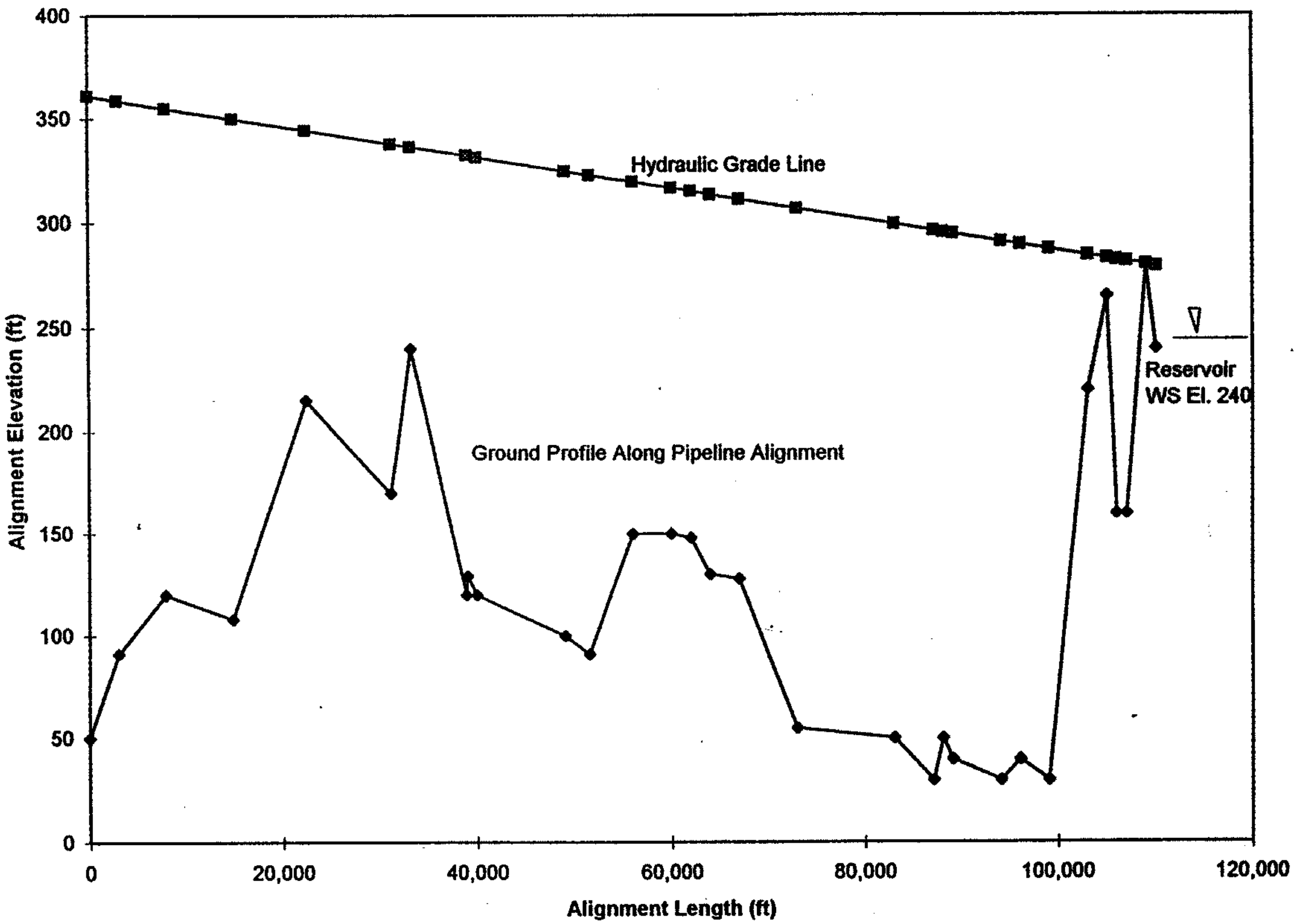

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Figure 5

Adobe Road Reservoir Transmission Line Profile

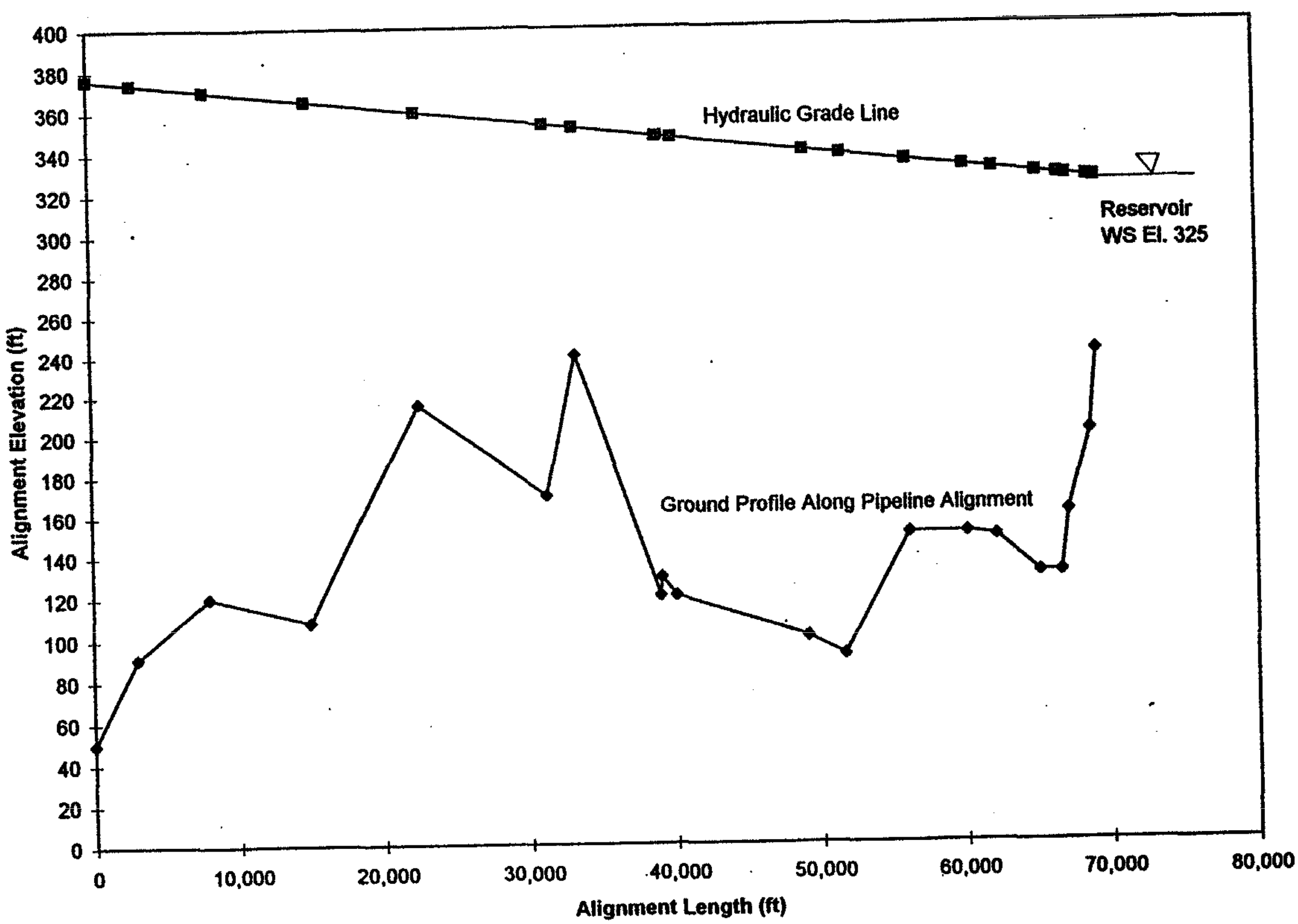

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Figure 6

Lakeville Reservoir Transmission Line Profile

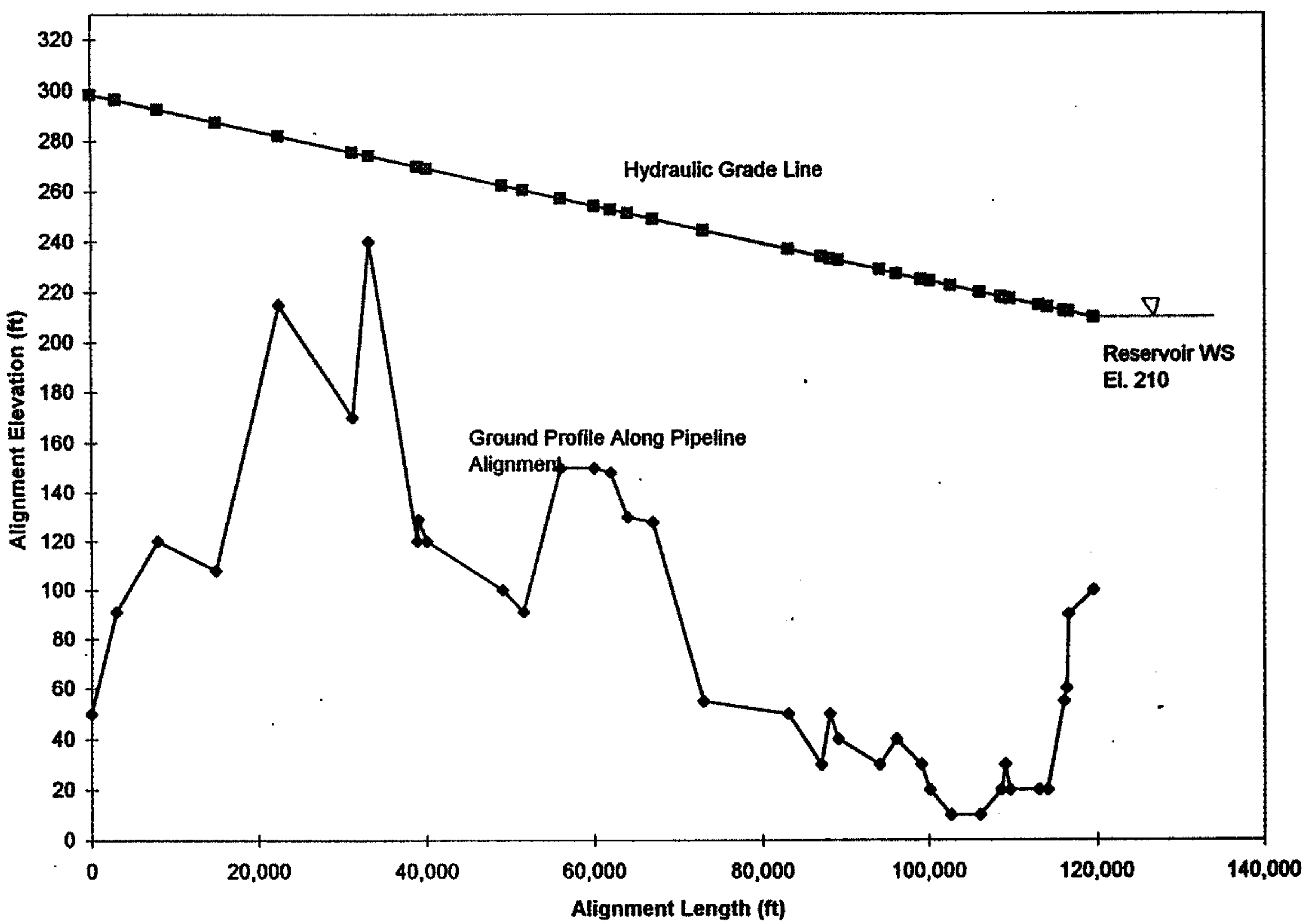

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Figure 7

Tolay C Reservoir Transmission Line Profile

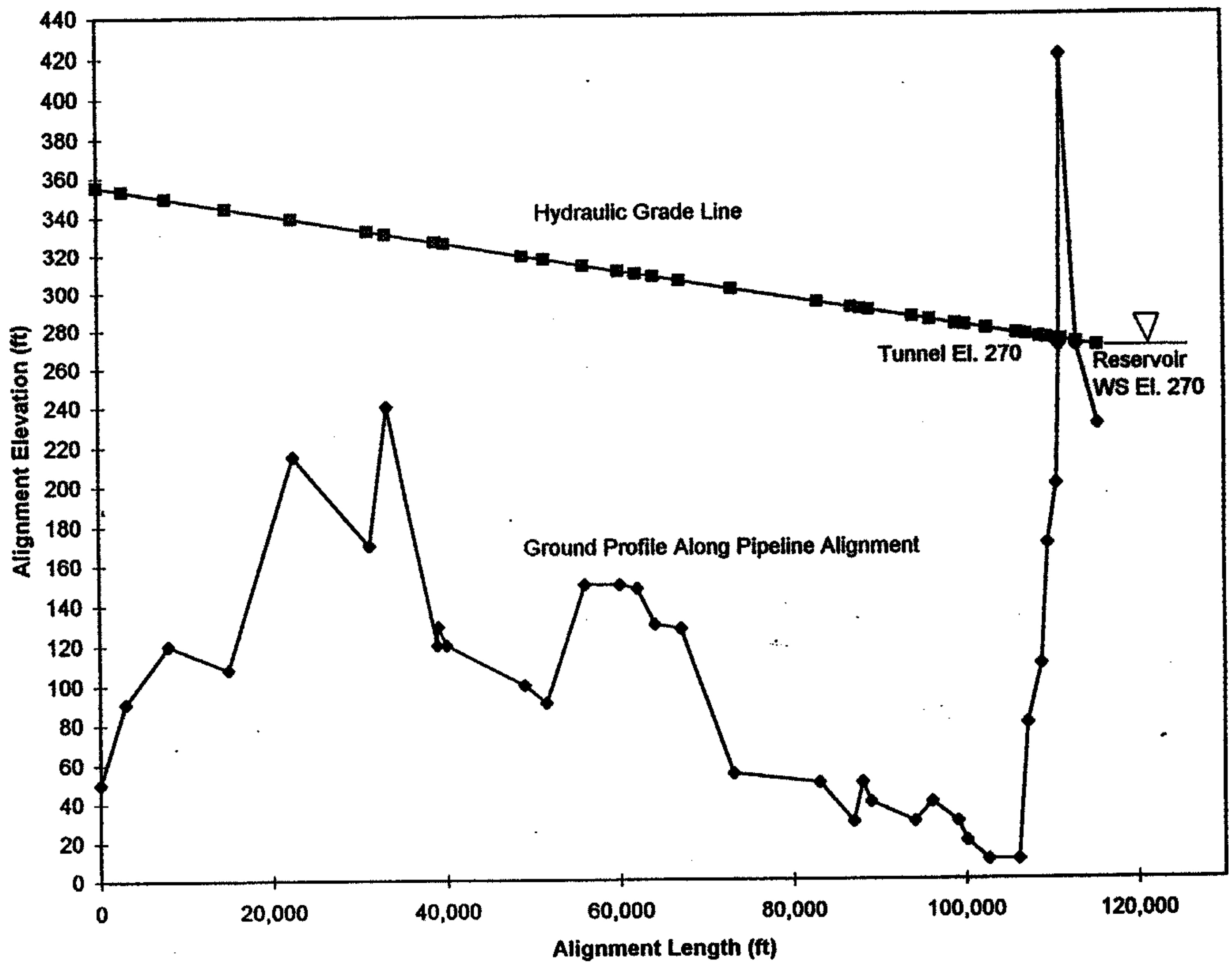

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Figure 8

Sears Point Reservoir Transmission Line Profile

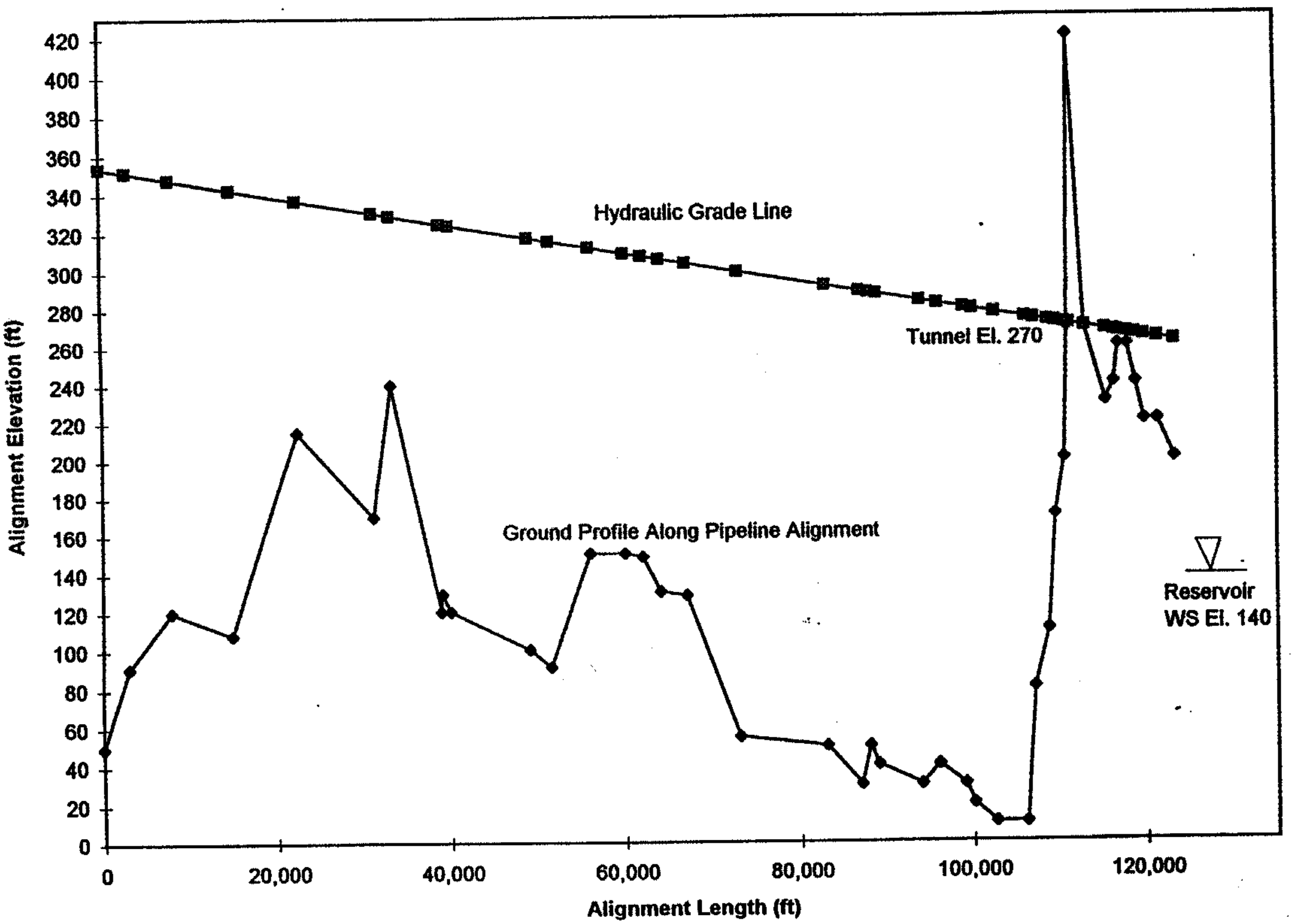

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Figure 9

Two Rock Reservoir Transmission Line Profile

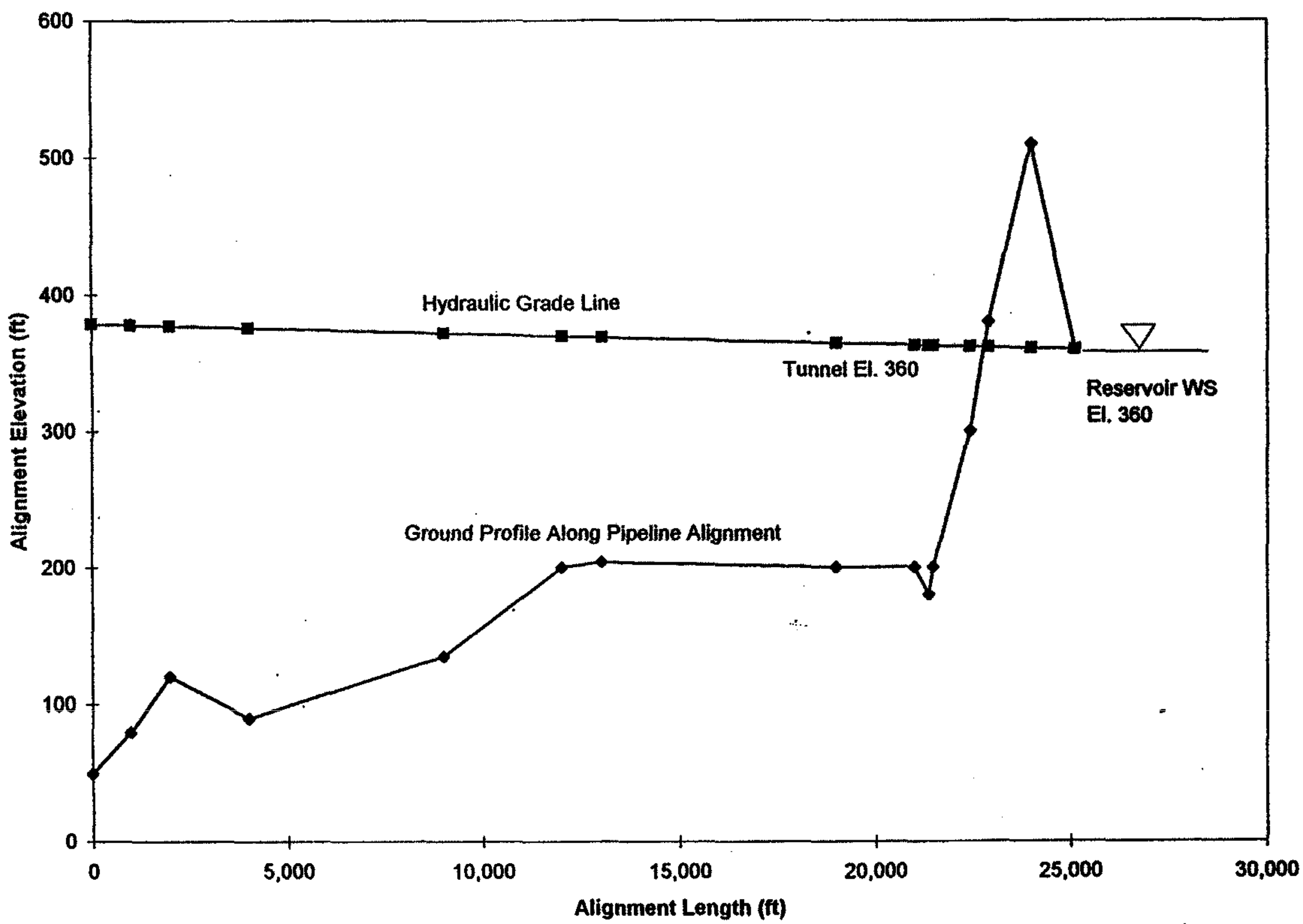

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Figure 10

Bloomfield Reservoir Transmission Line Profile

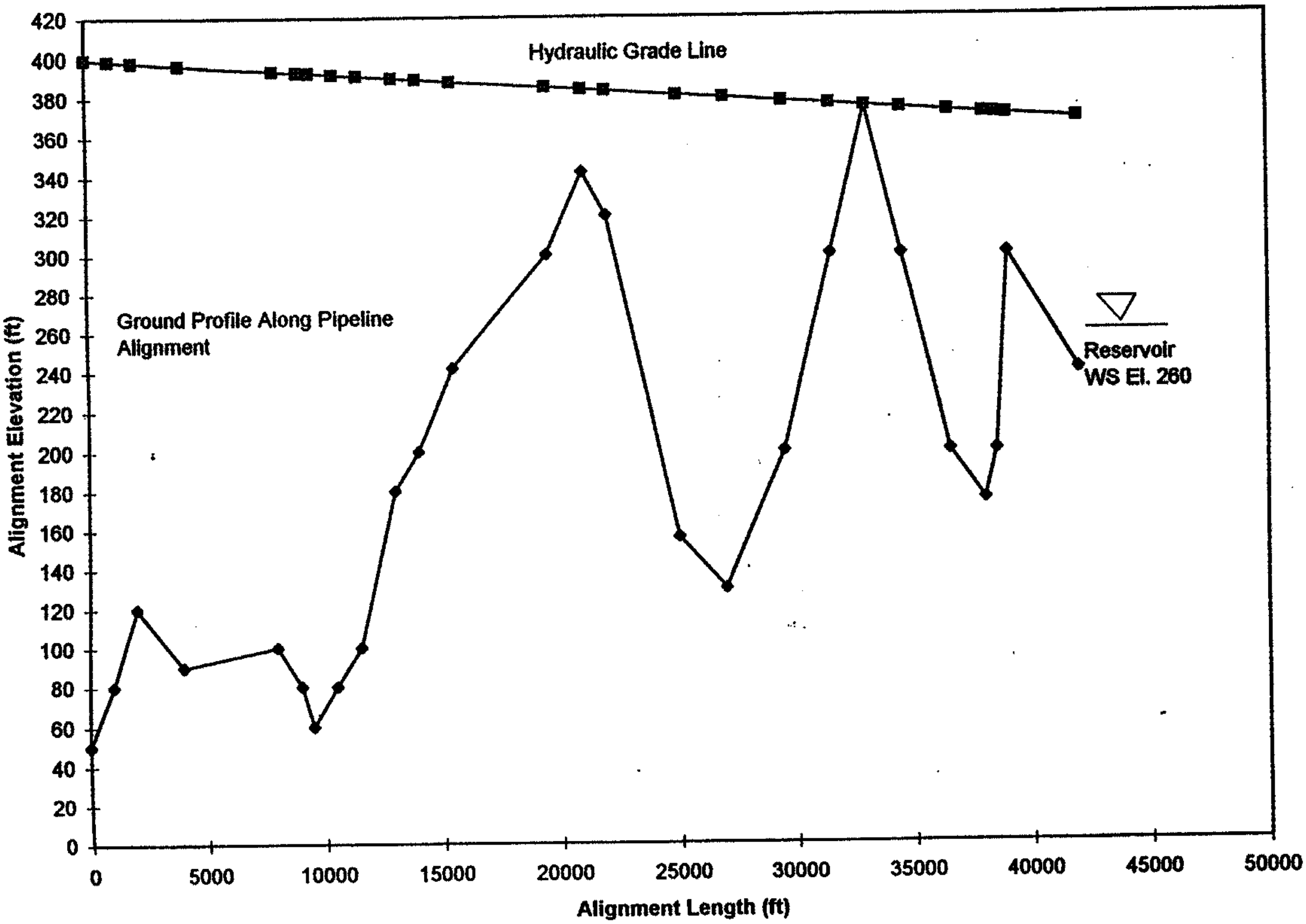

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Figure 11

Carroll Road Reservoir Transmission Line Profile

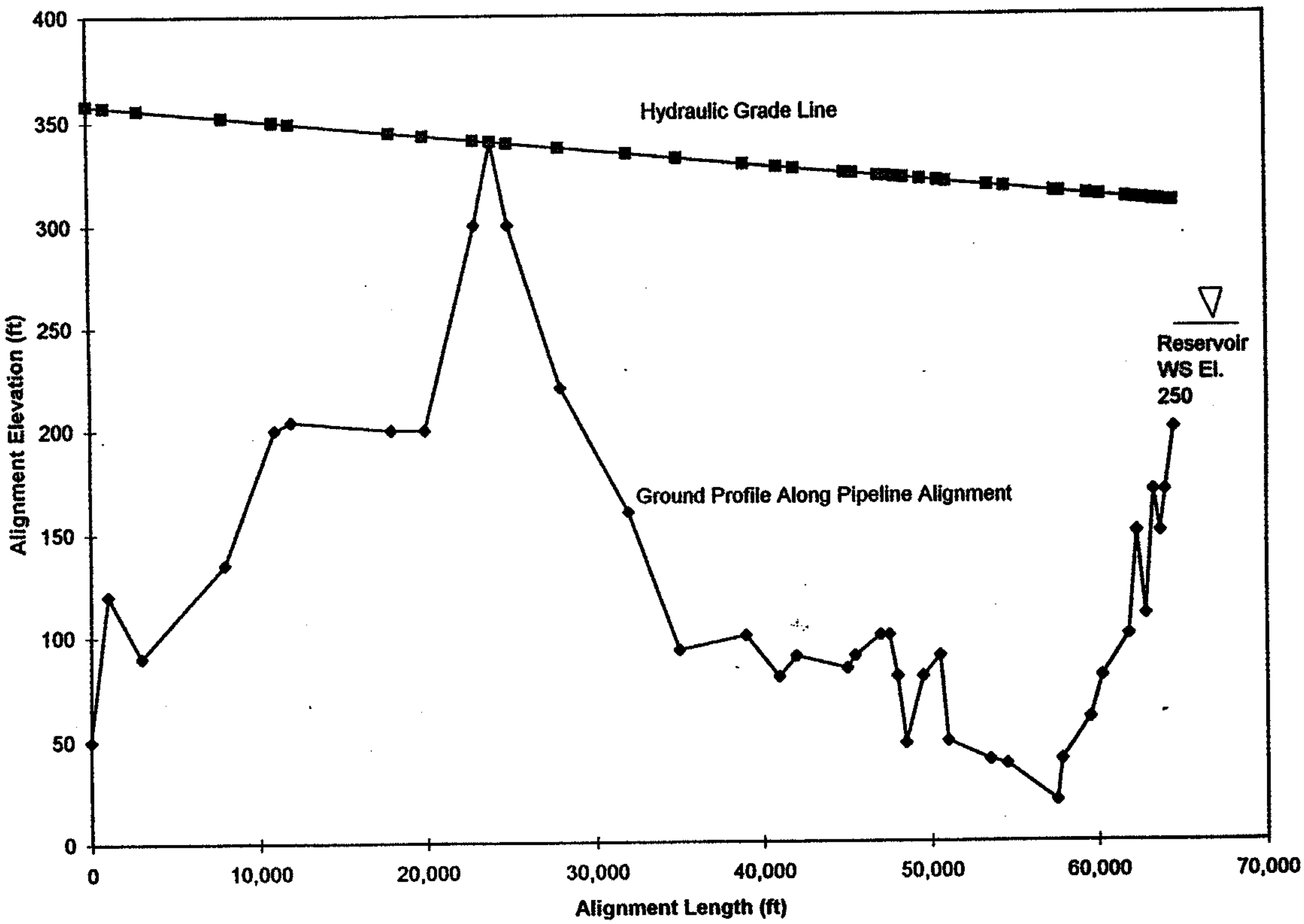

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Figure 12

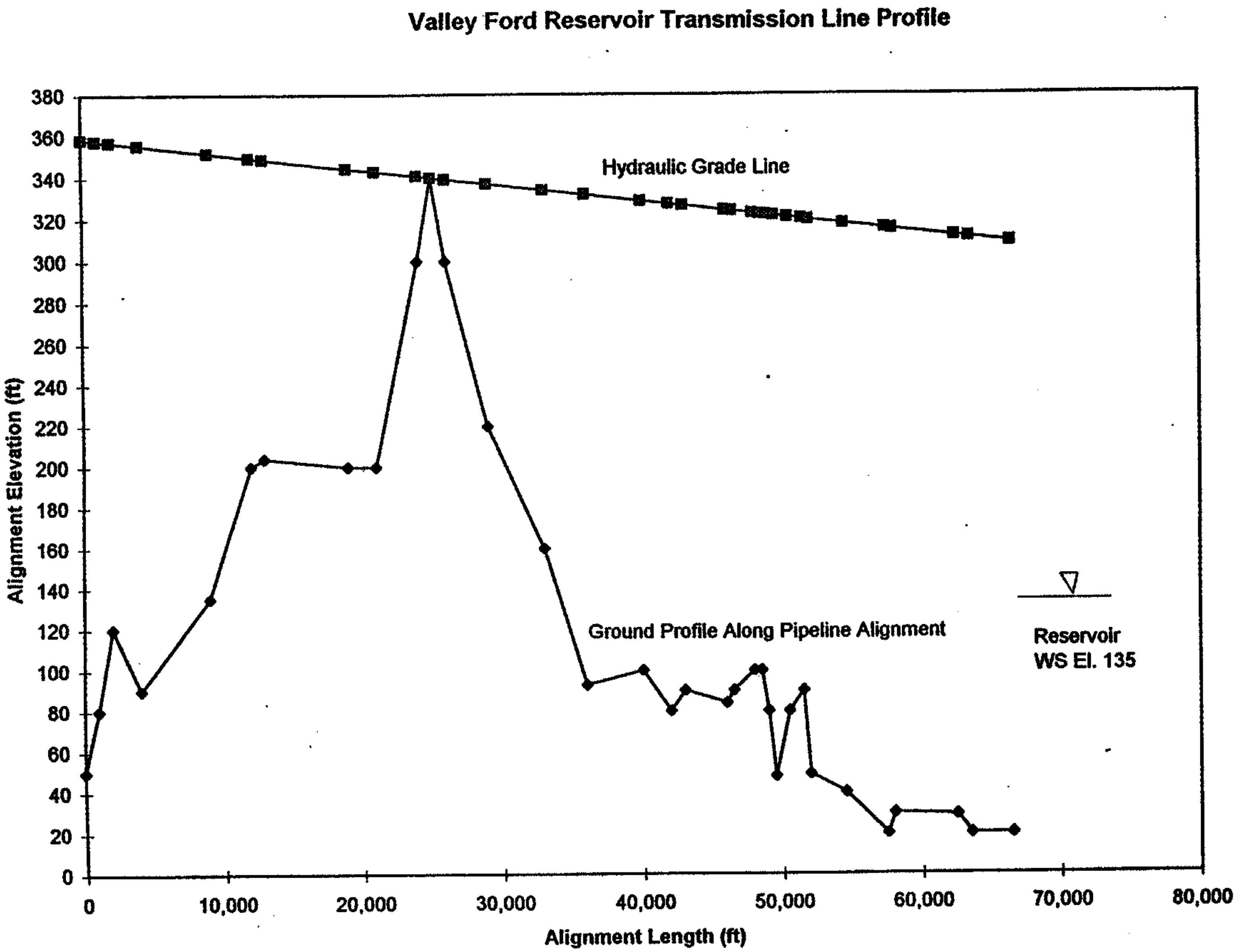

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Figure 13

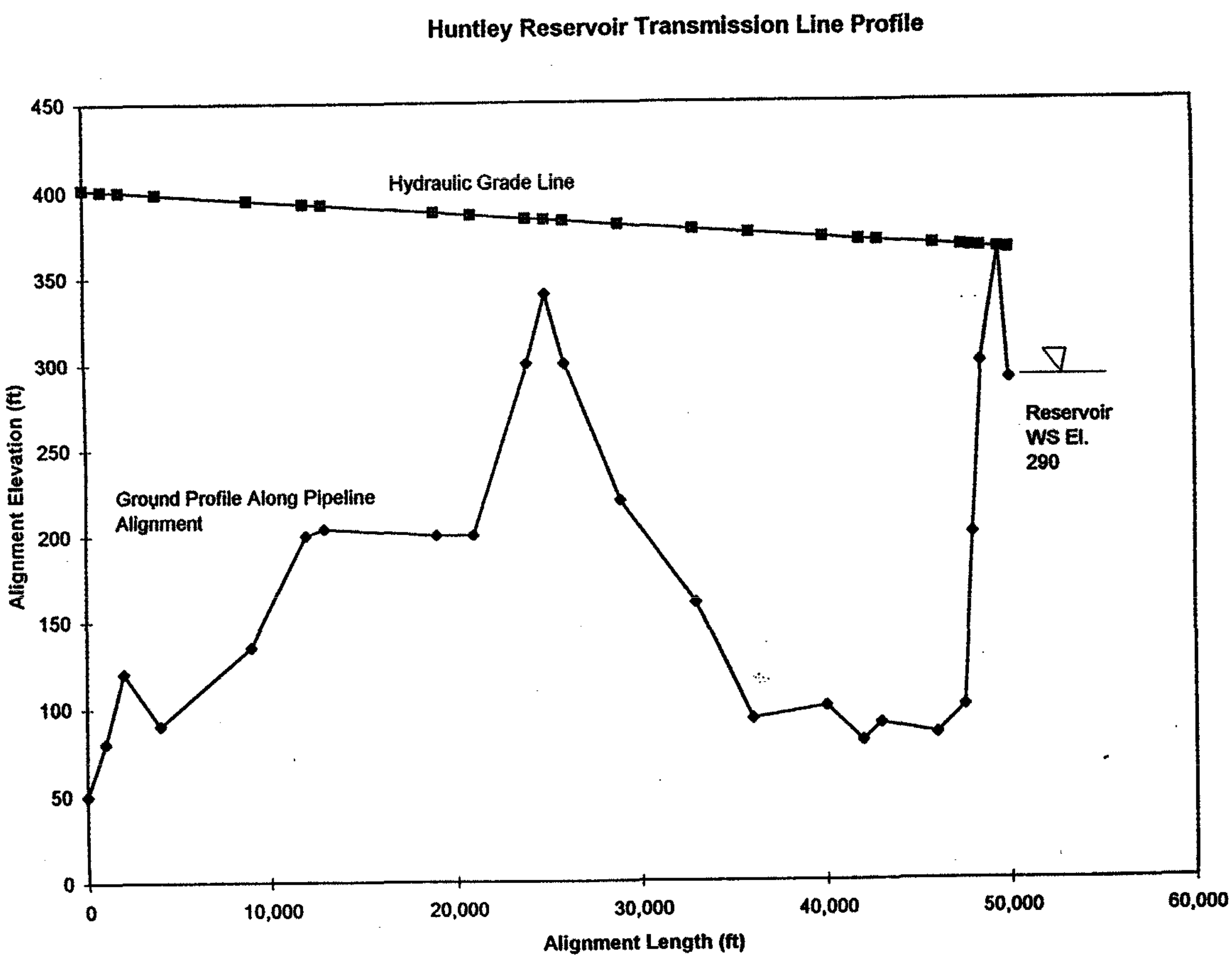

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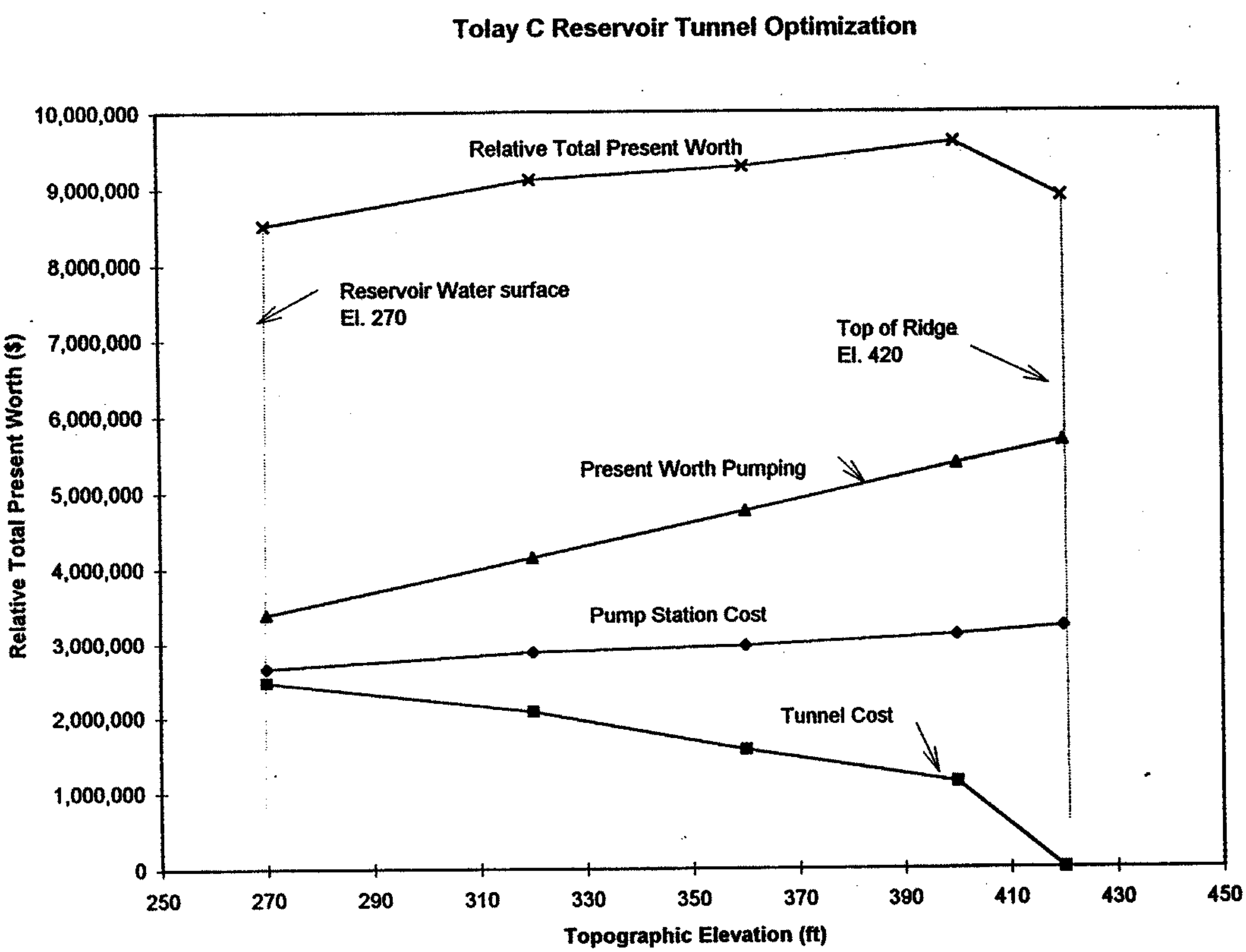
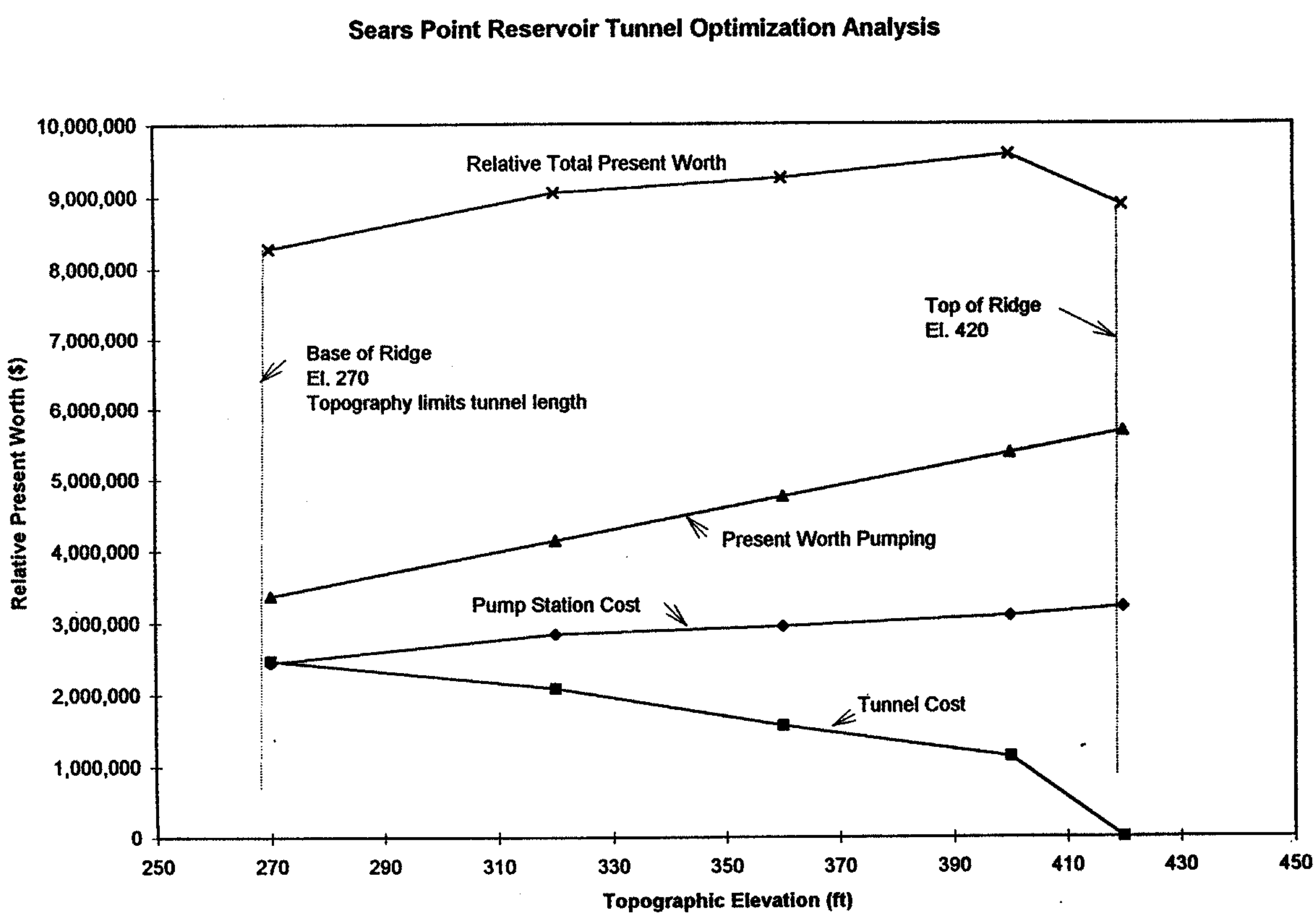
Figure 14



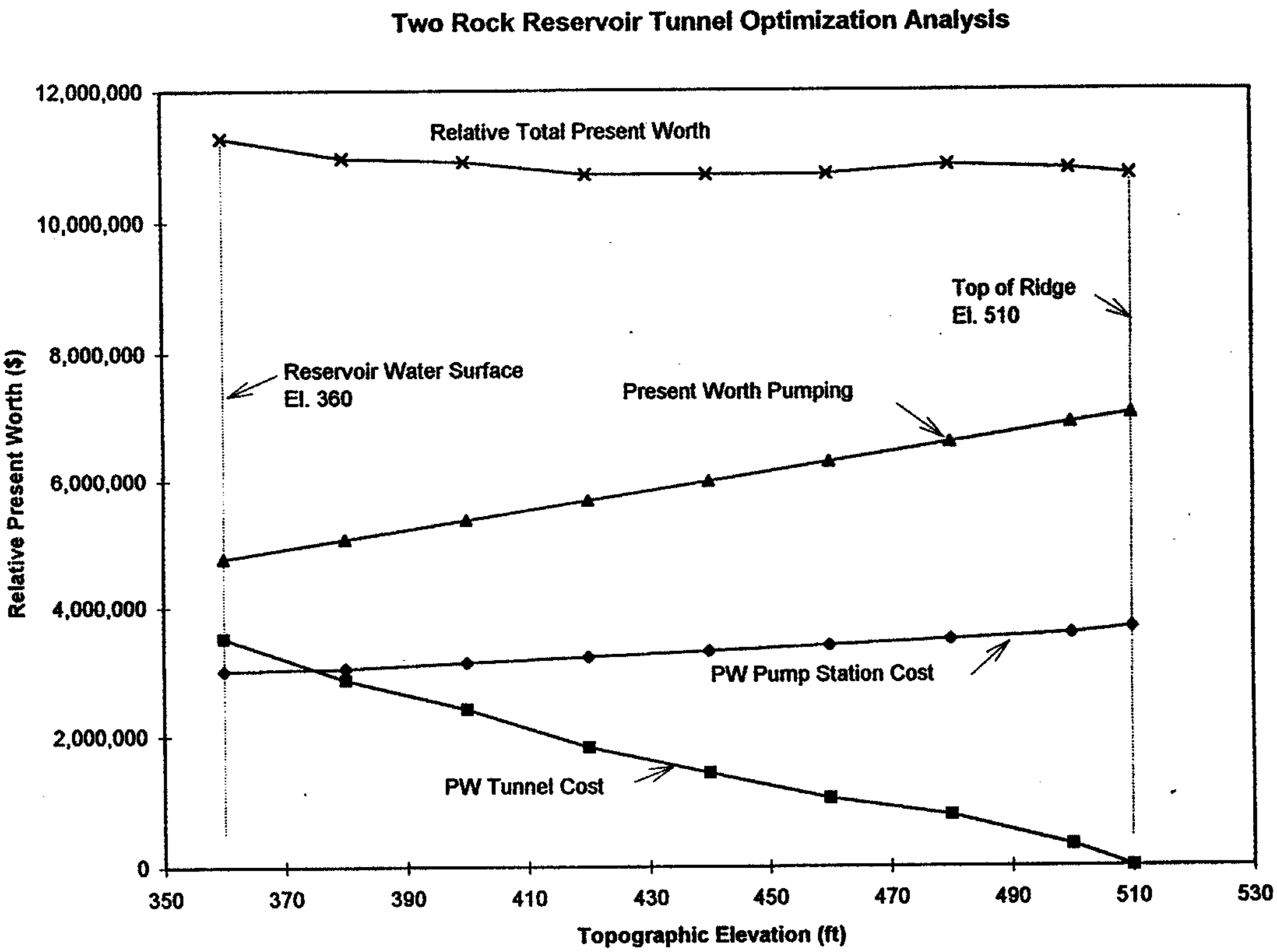
TUNNEL.XLS

Figure 15



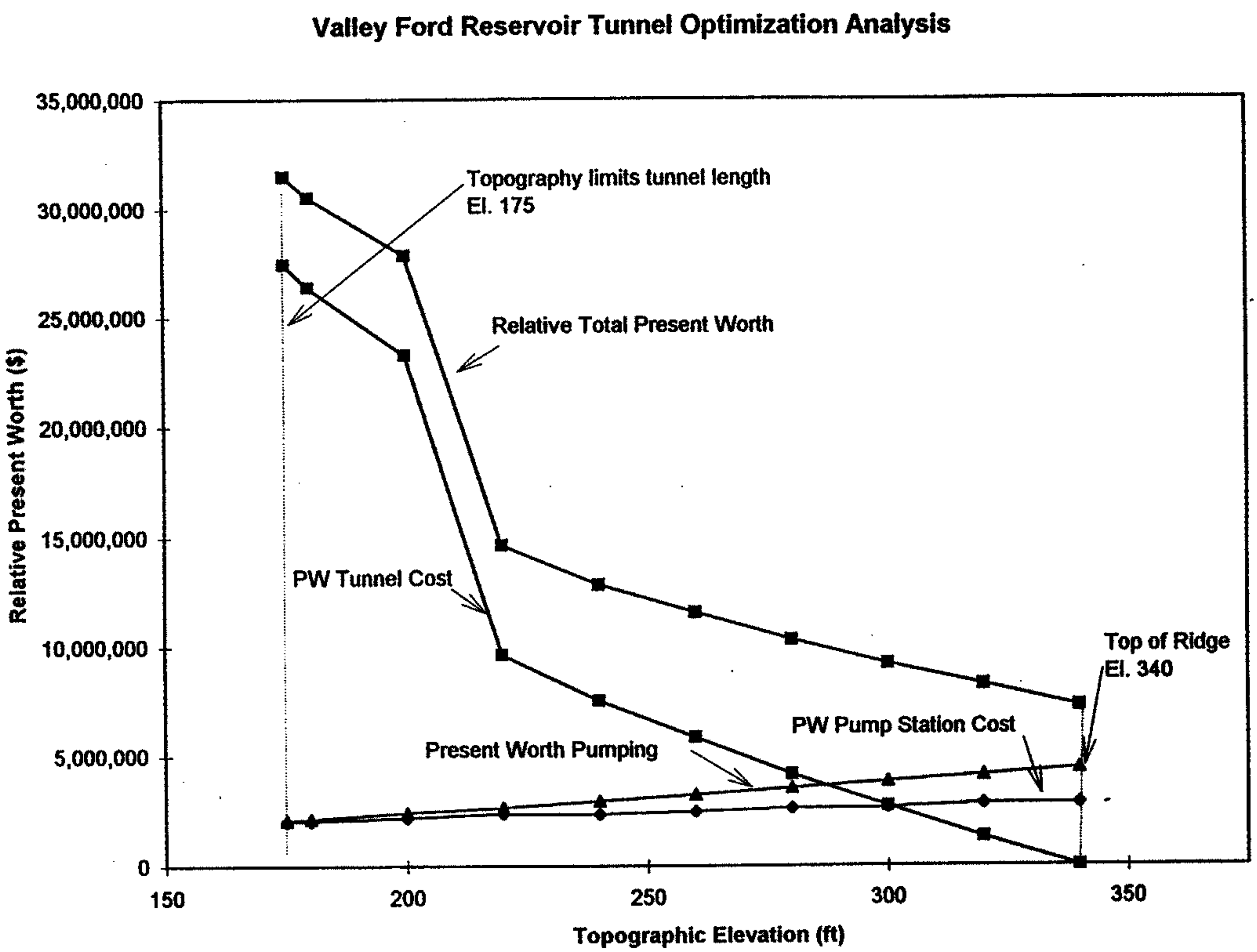
TUNNEL.XLS

Figure 16



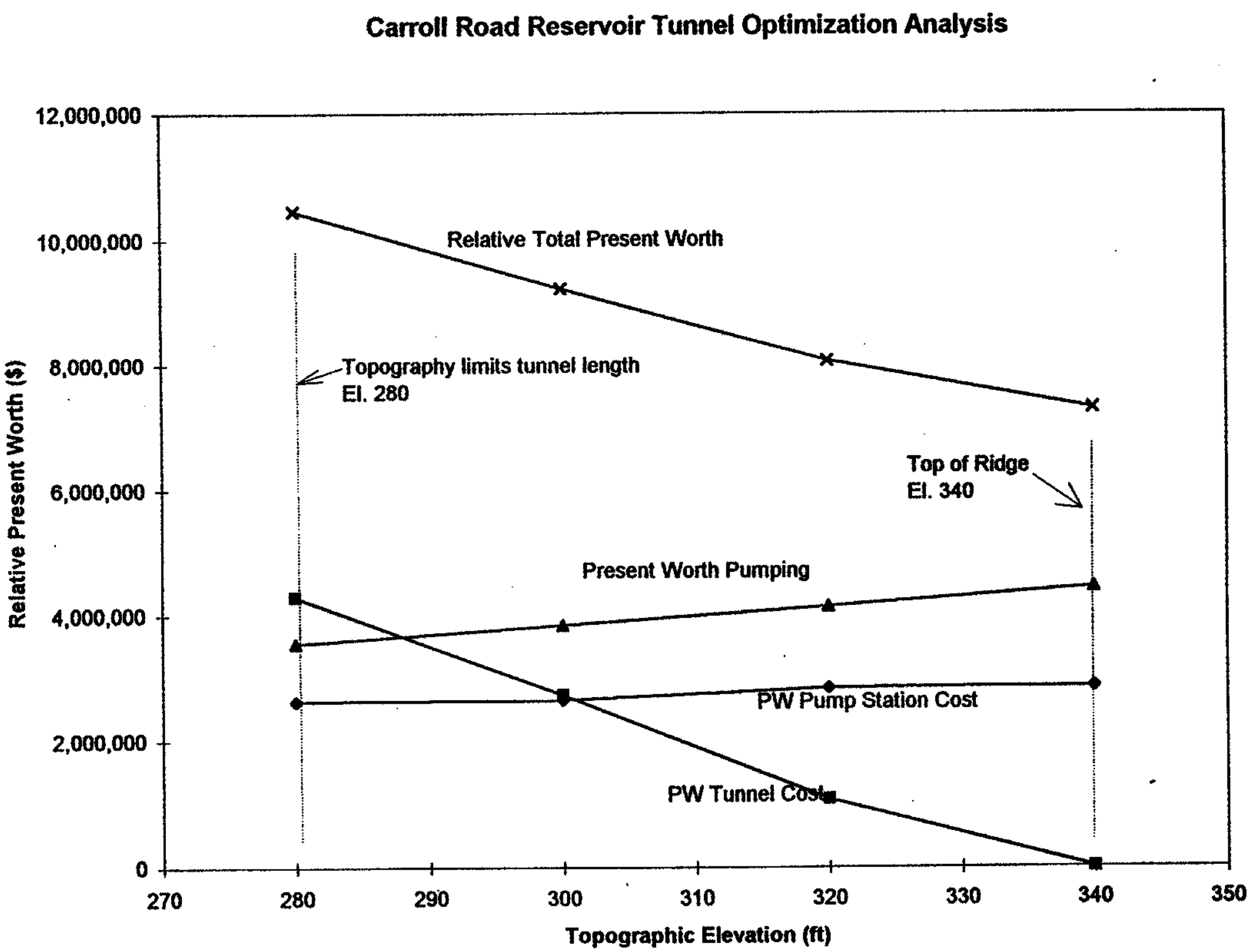
TUNNEL.XLS

Figure 17



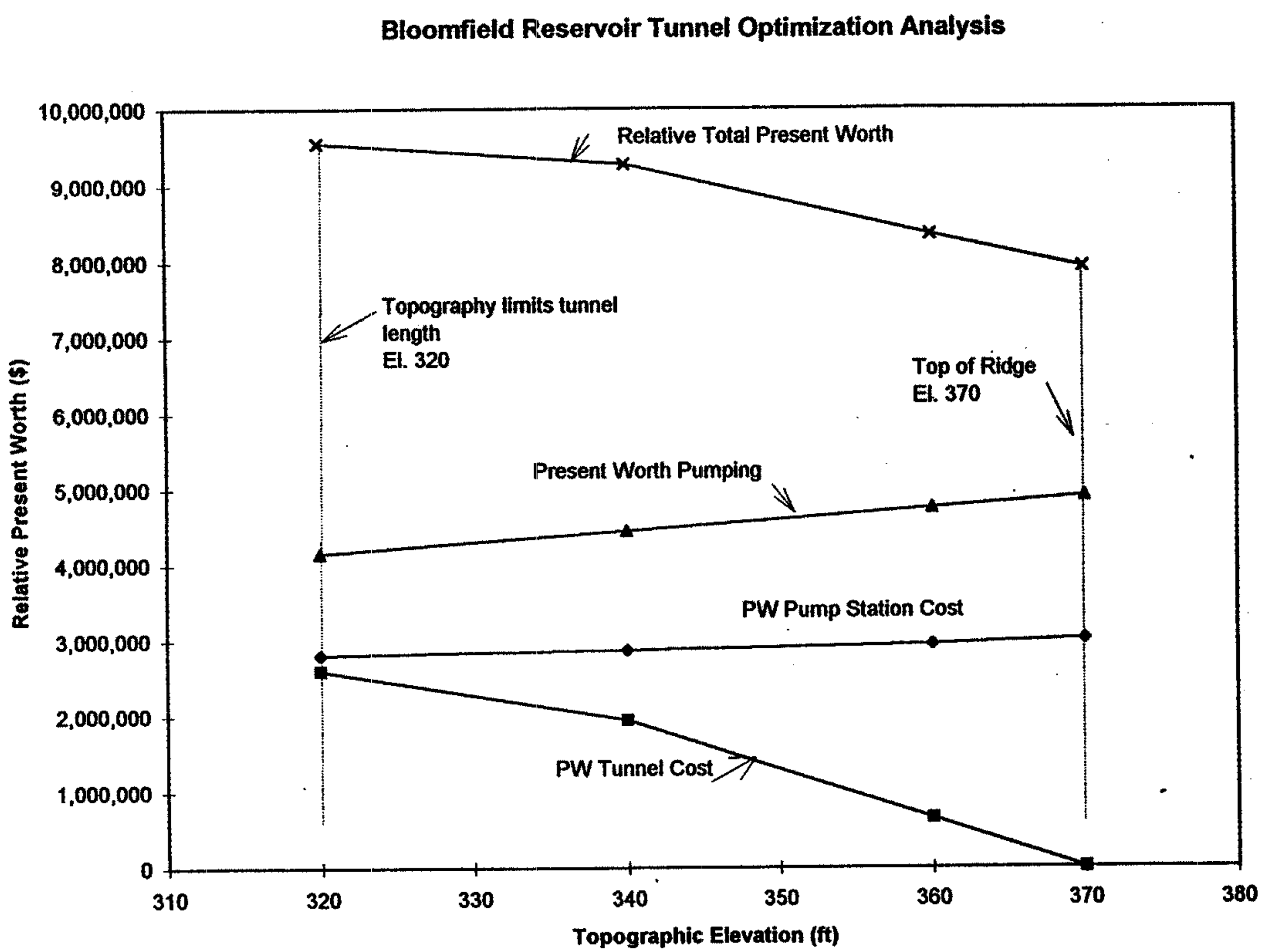
TUNNEL.XLS

Figure 18



TUNNEL.XLS

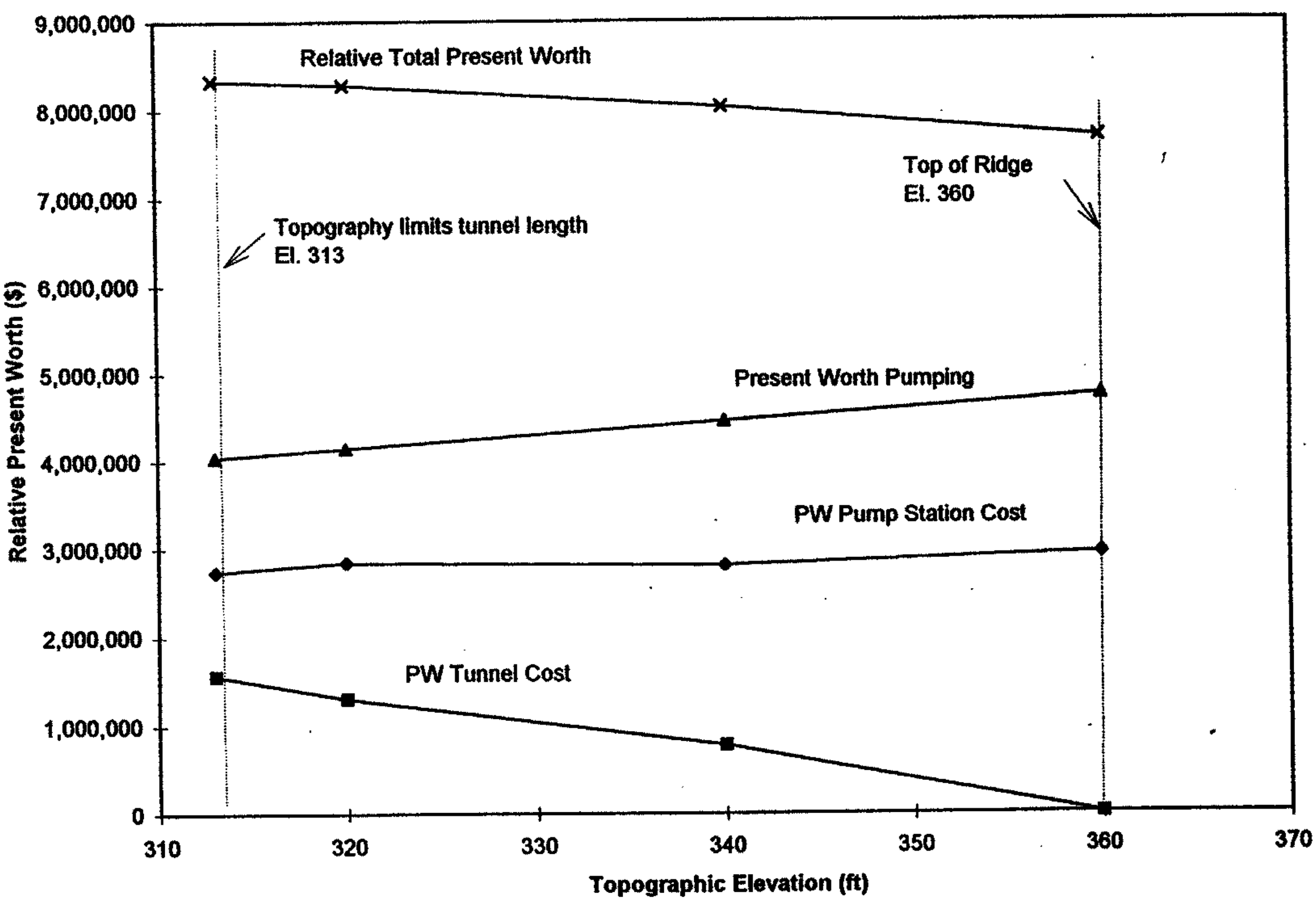
Figure 19



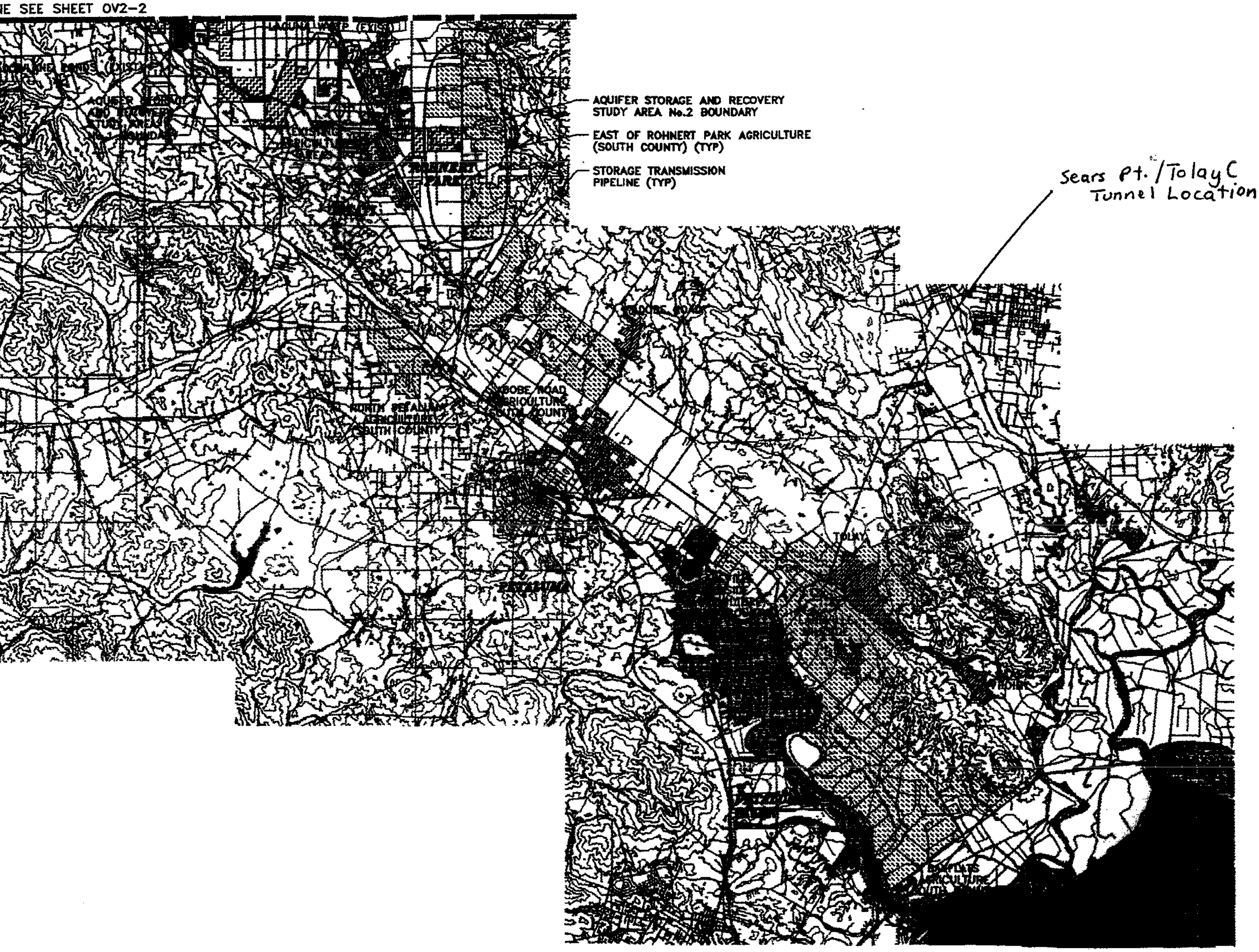
Bloomfield Reservoir Tunnel Optimization Analysis
Relative Total Present Worth
Topography limits tunnel length El. 320
Top of Ridge El. 370
Present Worth Pumping
PW Pump Station Cost
PW Tunnel Cost
Relative Present Worth ($)
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
310
320
330
340
350
360
370
380
Topographic Elevation (ft)

Figure 20

Huntley Reservoir Tunnel Optimization Analysis



TUNNEL.XLS



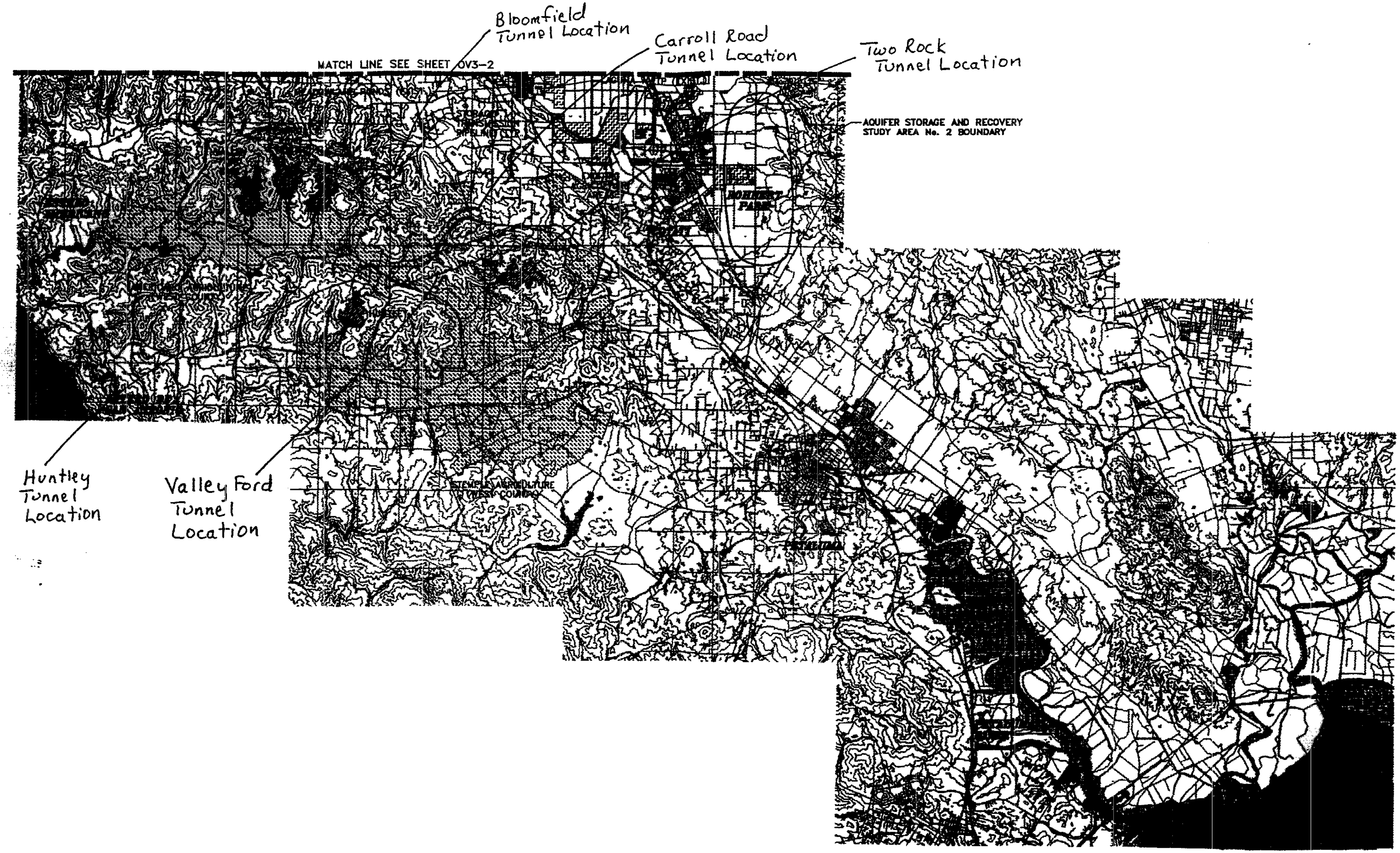
ND BARTHOLOMEW AND ASSOCIATES
PARSONS ENGINEERING SCIENCE
ARSONS
OFFICES IN PRINCIPAL CITIES

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT

PROJECT ALTERNATIVE No.2: SOUTH COUNTY

PROJECT OVERVIEW MAP SOUTH

SCALE 1" = 6000'
SHEET NO. OV2-1
SHEET OF



NO.	DATE	REVISIONS	BY

		DATE
PROJECT NO.	723129	
DESIGNED BY:	J. HAKE	8/95
DRAWN BY:	L. FLUKER	8/95
CHECKED BY:	R. MAURER	8/95

HARLAND BARTHOLOMEW AND ASSOCIATES
PARSONS ENGINEERING SCIENCE
PARSONS
OFFICES IN PRINCIPAL CITIES

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT

PROJECT ALTERNATIVE No.3: WEST COUNTY

PROJECT OVERVIEW MAP SOUTH

SCALE 1" = 6000'
SHEET NO. OV3-1
SHEET OF