TECHNICAL MEMORANDUM
TRANSMISSION PIPELINE ROUTES TO RESERVOIR SITES (TM-P-3)

TO: Ed Brauner (City of Santa Rosa)
Dan Carlson (City of Santa Rosa)
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FROM: Therese Wooding (Parsons ES)
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DATE: 21 September 1995

RE: Santa Rosa Subregional Long-Term Wastewater Project;
Ref. No. 723129.31006

INTRODUCTION

The purpose of this memorandum is to 1) present the approach used to evaluate and select transmission line routes to the subject reservoirs, 2) recommend a preferred route to each of the reservoirs, 3) document how the routes deviate from those shown in the 1993 project maps and 4) indicate cross country portions of the routes.

Using piping layouts shown in the drawing package titled "Santa Rosa Subregional Long-Term Wastewater Project; Alternative Projects Considered Through February 1993" by Harland Bartholomew & Associates Inc. dated October 19, 1993 (1993 project maps) as a starting point, final proposed pipeline routes to the reservoirs have been developed based on the following criteria:

1. Minimize route elevation to reduce pumping head
2. Minimize route length
3. Use existing roadways where possible to simplify obtaining right-of-way
4. Consider cross country route if use of existing roadways causes the route to be grossly inappropriate from an engineering and cost perspective (e.g., circuitous route, increased pumping head, etc.)
5. Minimize crossing rivers, streams, major roads, railroads, major utilities, etc.
6. Consider tunneling to minimize pumping head.

The proposed piping layouts between the treatment plant and the reservoirs are generally consistent with those shown in the 1993 project maps. No major layout changes were made.

Some piping revisions occur in the area immediately around the reservoirs. Alternate layouts were evaluated using present worth economic analyses to assist in the selection of a recommended alignment. In several cases, reduction of the maximum alignment elevation through tunneling or use of an alternate route (which might be longer but have a lesser maximum elevation) proved to be more economical in the long term than a shorter route with a greater maximum elevation. Tunneling was a component of the original (prior to Parsons ES involvement) proposed alignment into Two Rock reservoir. Tunneling is currently recommended at the Sears Point, Tolay C, and Two Rock reservoirs. A description of the tunneling analysis is presented as Technical Memorandum No. TM-P-4.

Note that the present worth costs in the tables are relative costs for comparison purposes only. Flows used in this analysis are based on preliminary estimates which will be refined based on results of the water conservation study and water balance model. Further pipe diameter optimization analysis may be required before final costs can be determined.

ALTERNATE FLOW ROUTES EVALUATED

Map OV-1 shows the overall area, pipeline alignments and reservoir locations relative to the treatment plant. Figures 1 through 30 provide a more detailed layout of the various alternatives initially proposed for each reservoir.

For data management purposes, the transmission lines were broken into segments and numbered. Table 1 contains the transmission line number, length, beginning elevation, ending elevation and maximum elevation. Based on the information in Table 1, it was possible to select a preferred pipeline route for Lakeville, Tolay A and Adobe Road reservoirs. The recommended routes are summarized below. The rationale for the route selection is noted in the right-hand column of Table 1. The alternative route for Lakeville is on a public versus private road and has the added advantage of dual use as an irrigation distribution main. The alternative alignment for Tolay A has a clear benefit in that it uses public right-of-way versus cross-country and private right-of-way. It also reduces the peak elevation, hence the pumping head is reduced. Use of the alternative alignment for Adobe Road also takes advantage of public versus private right-of-way, as well as reducing the peak elevation. For the remaining seven reservoirs, where the tabulated information was not sufficient to select a preferred route, comparative present worth energy analyses were performed.

OVERALL ECONOMIC ANALYSIS

The assumptions used and the results of the overall present worth analysis are shown in Table 2. Assumptions used are shown in boldface type. Flow rates and pipe sizes are preliminary estimates used to calculate the relative cost of each alternative route. Material costs were obtained from recent vendor quotes and the Means cost estimate guide. The recommended pipeline route is that with the least comparative present worth cost. Once the flow rates are confirmed by additional water balance analysis, further analysis may be performed to optimize transmission line sizes and to refine construction and present worth costs.

RECOMMENDED ALIGNMENTS

A summary of the recommended alignment for each reservoir is provided below. With three exceptions, the least cost alternative is the recommended alignment. The least cost alignments for Sears Point and Tolay C pass through existing wetlands and, thus are undesirable from an environmental impact perspective. Thus, alternate alignment A with tunnel is recommended for both reservoirs. At Huntley, the difference in cost between the alignments is not sufficiently significant, at this level of cost estimating, to outweigh the criterion to follow existing roadways. Thus, alternative alignment A is recommended. The routes to each reservoir are summarized below. Table 3 summarizes route characteristics in terms of deviation from routes shown in the 1993 project maps, cross country portions, and tunneling recommendations.

Reservoir	Recommended Alignment
Tolay A	Alternate Alignment
Lakeville	Alternate Alignment
Adobe Road	Alternate Alignment
Tolay C	Alternate Alignment A w/Tunnel
Sears Point	Alternate Alignment A w/Tunnel
Two Rock	Initial Alignment w/ Tunnel
Bloomfield	Initial Alignment
Carroll Road	Alternate Alignment A
Valley Ford	Alternate Alignment A
Huntley	Alternate Alignment A

Table 1

PRELIMINARY SCREENING TO SELECT ROUTES FOR
TRANSMISSION LINES (TL) TO STORAGE

R /oir	TL No.	Length (ft)	Begin El.	End El.	Max El.	Recommendation/Rationale
Alternatives 2A						
Tolay A	TL-1	44,000	80	150	150	Use Alt. alignment
(Initial Align.)	TL-3	37,000	150	30	150	Pro: * makes maximum use of exist.
	TL-4	9,000	30	240	320	roads
		90,000				* Reduces max El. by 50 ft.
Tolay A	TL-1	44,000	80	150	150	Con: * Increases length by 2,000 ft
(Alt. Align.)	TL-3	37,000	150	30	50	--small compared to overall
	TL-4A	11,000	30	240	270	alignment length
		92,000				No tunnel. See note 1
						OK. USE ALT. ALIGNMENT
Alternatives 2B						
Lakeville	TL-1	44,000	80	150	150	Use Alt. Route
(Initial Align.)	TL-3	37,000	150	30	150	Pro: *Can draw off pipe for irrig.
	TL-31	7,000	30	10	30	*Max. el reduced by 30 ft.
	TL-5	7,000	10	20	20	
	TL-6	5,000	20	210	240	
		100,000				Con: *Increases pipe length by 1,500ft
						small compared to total length
Lakeville	TL-1	44,000	80	150	150	
(Alt. Align.)	TL-3	37,000	150	30	150	No tunnel. See note 1
	TL-31	7,000	30	10	20	
	TL-5	7,000	10	20	20	
	TL-6A	6,500	20	100	210	
		101,500				**OK. USE ALT. ALIGNMENT**

Notes:

1. Use of a tunnel to reduce pumping head was NOT considered if the reservoir water surface is the alignment high point

Table 1

PRELIMINARY SCREENING TO SELECT ROUTES FOR
TRANSMISSION LINES (TL) TO STORAGE

R. .voir	TL No.	Length (ft)	Begin El.	End El.	Max El.	Recommendation/Rationale
Alternatives 2B						
Adobe Road	TL-1	44,000	80	150	150	Use Alt. alignment
(Initial Align.)	TL-2	7,000	150	360	360	Pro: * makes maximum use of exist.
		51,000				roads
						* Reduces max El. by 35 ft.
Adobe Road	TL-1	44,000	80	148	150	* No increase in pipe length
(Alt. Align.)	TL-2A	7,000	148	240	325	Con: * None
		51,000				No tunnel. See note 1.
						USE ALT. ALIGNMENT
Alternatives 2C						
Tolay C	TL-1	44,000	80	150	150	Perform Prelim. PW Analysis
(Initial Align.)	TL-3	37,000	150	30	50	Alternative Alignments
	TL-31	7,000	30	10	30	Pro: * makes maximum use of exist.
	TL-32	11,000	10	270	420	roads
		99,000				* Reduces alignment length
						between 2,000 - 2,400 ft
Tolay C	TL-1	44,000	80	150	150	depending on alternative
(Alt. Align. A)	TL-3	37,000	150	30	50	*Tunnel and Alt. B reduce max. el
	TL-31	7,000	30	10	30	by 130 ft. However, there are
	TL-32A	9,000	10	230	420	wetland issues with Alt. B.
		97,000				
						Con: *No apparent best alternative
T C	TL-1	44,000	80	150	150	
(1,900 ft tunnel	TL-3	37,000	150	30	50	
for Alt. Align. A)	TL-31	7,000	30	10	30	
	TL-32A	9,000	10	230	270	
		97,000				
Tolay C	TL-1	44,000	80	150	150	
(Alt. Align. B)	TL-3	37,000	150	30	50	
	TL-4B	15,600	30	240	270	PERFORM PRELIM. PW ANALYSIS
		96,600				See Table 2
Alternatives 2D						
Lakeville	TL-1	44,000	80	150	150	Use Alt. Route
(Initial Align.)	TL-3	37,000	150	30	150	Pro: *Can draw off pipe for irrig.
	TL-31	7,000	30	10	30	*Max. el reduced by 30 ft.
	TL-5	7,000	10	20	20	
	TL-6	5,000	20	210	240	
		100,000				Con: *Increases pipe length by 1,500ft
						small compared to total length
Lakeville	TL-1	44,000	80	150	150	
(Alt. Align.)	TL-3	37,000	150	30	150	No tunnel. See note 1
	TL-31	7,000	30	10	20	
	TL-5	7,000	10	20	20	
	TL-6A	6,500	20	100	210	
		101,500				OK. USE ALT. ALIGNMENT

Notes:

1. Use of a tunnel to reduce pumping head was NOT considered if the reservoir water surface is the alignment high point

Table 1

PRELIMINARY SCREENING TO SELECT ROUTES FOR
TRANSMISSION LINES (TL) TO STORAGE

Reservoir	TL No.	Length (ft)	Begin El.	End El.	Max El.	Recommendation/Rationale
Alternatives 2D						
Sears Point	TL-1	44,000	80	148	150	Perfom Prelim. PW Analysis
(Initial Align.)	TL-3	37,000	148	30	150	Pro: * makes maximum use of exist.
	TL-31	7,000	30	10	30	roads
	TL-32	11,000	10	420	420	*Decreases alignment length
	TL-33	7,000	420	270	420	between 1,000 - 1,500 ft
		106,000				depending on alignment
						*Tunnel and Alt. B decrease max. el
Sears Point	TL-1	44,000	80	150	150	by 350 ft over other two alignments
(Alt. Align. A)	TL-3	37,000	150	30	50	
	TL-31	7,000	30	10	30	Con: *No apparent best alternative
	TL-32A	9,000	10	230	420	
	TL-33A	8,000	230	200	260	
		105,000				
Sears Point	TL-1	44,000	80	150	150	
(1,900 ft. Tunnel for	TL-3	37,000	150	30	50	
Initial Align.)	TL-31	7,000	30	10	30	
	TL-32A	9,000	10	230	270	
	TL-33A	8,000	230	200	260	
		105,000				
Sears Point	TL-1	44,000	80	150	150	
(Alt. Align. B)	TL-3	37,000	150	30	50	
	TL-4B	15,500	30	230	270	
	TL-33A	8,000	230	200	260	
		104,500				**PERFORM PRELIM. PW ANALYSIS**
						See Table 2

Notes:
1. Use of a tunnel to reduce pumping head was NOT considered if the reservoir water surface is the alignment high point

Table 1

PRELIMINARY SCREENING TO SELECT ROUTES FOR
TRANSMISSION LINES (TL) TO STORAGE

Reservoir	TL No.	Length (ft)	Begin El.	End El.	Max El.	Recommendation/Rationale
Alternative 3A						
Two Rock	TL-10	4,000	80	90	120	Recommend further optimization analysis
(Initial Align.)	TL-11	15,000	90	200	204	
	TL-12	2,000	200	200	200	Pro: *max El. reduced by 140 ft using alt.
	TL-20	4,600	200	360	510	alignment A.
		25,600				*Tunnel reduces max El. to 360 ft
Two Rock	TL-10	4,000	80	90	120	Con: *Increase in alignment length
(2,700 ft Tunnel	TL-11	15,000	90	200	204	between 5,400 - 42,400ft
for initial	TL-12	2,000	200	200	200	depending on alternative
align.)	TL-20	4,600	200	360	360	*Tunnel construction cost may be
		25,600				high
Two Rock	TL-10	4,000	80	90	120	
(Alt. Align. A)	TL-11	15,000	90	200	220	
	TL-12	2,000	200	200	204	
	TL-13	25,000	200	84	340	
	TL-20A	22,000	80	170	360	
		68,000				
Two Rock	TL-10	4,000	80	90	120	
(Alt. Align. B)	TL-11	15,000	90	200	204	
	TL-12	2,000	200	200	200	
	TL-20B	10,000	200	360	530	
		31,000				
Two Rock	TL-10	4,000	80	90	120	
(Alt. Align. C)	TL-11	15,000	90	200	204	
	TL-12	2,000	200	200	200	
	TL-20C	24,000	200	360	360	PERFORM PRELIM. PW ANALYSIS
		45,000				See Table 2

Table 1

PRELIMINARY SCREENING TO SELECT ROUTES FOR
TRANSMISSION LINES (TL) TO STORAGE

Reservoir	TL No.	Length (ft)	Begin El.	End El.	Max El.	Recommendation/Rationale
Alternative 3B						
Bloomfield	TL-10	4,000	80	90	120	Recommend further optimization analysis
(Initial Align.)	TL-23	4,000	90	100	250	
	TL-15	25,000	100	375	375	Pro: *max El. reduced by 35 ft using alt.
	TL-19	9,000	375	255	375	alignment.
		42,000				
						Con: *Alignment length increases by
Bloomfield	TL-10	4,000	80	90	120	17,500 ft.
(Alt. Align. A)	TL-11	15,000	90	200	204	
	TL-12	2,000	200	200	200	
	TL-13	25,000	200	84	340	No tunnel.
	TL-15A	8,500	84	40	100	
	TL-19A	5,000	50	100	255	
		59,500				
Bloomfield	TL-10	4,000	80	90	120	
(Alt. Align. B)	TL-23	4,000	90	100	135	
	TL-15	25,000	100	375	375	
	TL-19B	20,400	375	50	375	
	TL-19A	5,000	50	100	255	PERFORM PRELIM. PW ANALYSIS
		58,400				See Table 2

Table 1

PRELIMINARY SCREENING TO SELECT ROUTES FOR TRANSMISSION LINES (TL) TO STORAGE

R. .voir	TL No.	Length (ft)	Begin El.	End El.	Max El.	Recommendation/Rationale
Alternative 3C						
Carroll Road	TL-10	4,000	80	90	120	Recommend further optimization analysis
(Initial Align.)	TL-23	4,000	90	100	120	
	TL-15	25,000	100	400	400	Pro:*max El. reduced by 560 ft using alt.
	TL-16	12,000	400	800	900	alignment.
	TL-18	4,000	800	250	800	
		49,000				*Con: *Alignment length increases*
						by 15,500 ft.
Carroll Road	TL-10	4,000	80	90	120	
(Alt. Align. A)	TL-11	15,000	90	200	204	
	TL-12	2,000	200	200	200	
	TL-13	25,000	200	84	340	No tunnel.
	TL-15A	8,500	84	40	100	
	TL-16A	3,000	40	20	40	
	TL-18A	7,000	20	200	250	
		64,500				
Carroll Road	TL-10	4,000	80	90	120	
(Alt. Align. B)	TL-23	4,000	90	100	120	
	TL-15	25,000	100	400	400	
	TL-19B	20,400	375	50	375	
	TL-16A	3,000	40	20	40	
	TL-18A	7,000	20	200	250	PERFORM PRELIM. PW ANALYSIS
		63,400				See Table 2

Table 1

PRELIMINARY SCREENING TO SELECT ROUTES FOR TRANSMISSION LINES (TL) TO STORAGE

Reservoir	TL No.	Length (ft)	Begin El.	End El.	Max El.	Recommendation/Rationale
Alternative 3D						
Valley Ford	TL-10	4,000	80	90	120	Recommend further optimization analysis
	TL-23	4,000	90	100	135	
(Initial Align.)	TL-15	25,000	100	400	400	
	TL-16	12,000	400	800	900	Pro: *max El. reduced by 560 ft using alt.
	TL-17	9,000	800	280	800	alignment A.
	TL-21	3,000	280	90	280	Con:*Alignment length increases by.
		57,000				1,400 ft to 9,500 ft. depending on
Valley Ford	TL-10	4,000	80	90	120	No tunnel.
(Alt. Align. A)	TL-11	15,000	90	200	204	
	TL-12	2,000	200	200	200	
	TL-13	25,000	200	84	340	
	TL-15A	8,500	84	40	100	
	TL-16A	3,000	40	20	40	
	TL-17A	9,000	20	20	135	
		66,500				
Valley Ford	TL-10	4,000	80	90	120	
(Alt. Align. B)	TL-23	4,000	90	100	135	
	TL-15	25,000	100	375	375	
	TL-19B	20,400	375	50	375	
	TL-16A	3,000	40	20	40	
	TL-17A	9,000	20	20	135	**PERFORM PRELIM. PW ANALYSIS**
		65,400				**See Table 2**
Alternitive 3E						
Huntley	TL-10	4,000	80	90	120	Use Alt. Alignment
(Initial Align.)	TL-11	15,000	90	200	204	Pro: * Makes maximum use of exist.
	TL-12	2,000	200	200	200	roads
	TL-13	25,000	200	84	340	* No increase in pipe length
	TL-14	4,000	84	290	355	
		50,000				Con: *Increases max El. by 10 ft
						--Increase does NOT outweigh
Huntley	TL-10	4,000	80	90	120	cost of tunnel or need to keep to
(Alt. Align.)	TL-11	15,000	90	200	204	exist. roads for ROW
	TL-12	2,000	200	200	200	
	TL-13	25,000	200	84	340	No tunnel.
	TL-14A	4,000	84	290	365	**PERFORM PRELIM. PW ANALYSIS**
		50,000				**See Table 2**

PRELIMINARY ENERGY ANALYSIS FOR TRANSMISSION LINES (TL) TO STORAGE
PRELIMINARY SIZING OF PIPES AND PUMP STATION TDH

Tunnel Cost($/LF)
West Co. 1,300
South Co. 1,100

Pump n 0.8
Motor n 0.92

Mat'l & Installation Cost
Pipe ($/LF) 165

PW Factor 12.40
I (%) 7.5
n (years) 30
Pump. Period (yr) 1
Energy ($/KW-hr) 0.1

Reservoir	Length (Feet)	Flow[3] (MGD)	Flow[3] (GPM)	Pipe[3] Diameter	C=120 Unit Loss (ft/100ft)	120 Hf (Feet)	Static Head (Feet)	TDH (Feet)	Total Pump HP	Pipe Cost ($)	Pump Sta.[1,2] ($)	Tunnel ($)	Construction ($)	Energy Use (kW-hr/yr)	Energy Cost ($/yr)	PW Energy ($)	Total PW Cost ($)
Alternative 2C Tolay C (Initial Align.)	99,000	20	13,889	42	0.087	89	340	426	2,028	16,335,000	3,733,000	–	20,068,000	13,262,249	1,326,225	16,449,300	36,517,300
Tolay C (Alt. Align. A)	97,000	20	13,889	42	0.087	84	340	424	2,021	16,005,000	3,695,000	–	19,700,000	13,209,224	1,320,922	16,382,293	36,082,293
Tolay C (Tunnel for Alt. Align. A)	97,000 1,900	20	13,889	42	0.087	84	190	274	1,306	16,005,000	2,964,000	2,090,000	18,969,000	8,537,021	853,702	10,588,563	29,557,563
Tolay C (Alt. Align. B)	96,600	20	13,889	42	0.087	84	190	274	1,306	15,939,000	2,964,000	–	18,903,000	8,526,216	852,622	10,575,152	29,478,152
Alternative 2D Seare Point (Initial Align.)	108,000	20	13,889	42	0.087	92	340	432	2,058	17,490,000	3,789,000	–	21,279,000	13,461,332	1,346,133	16,693,822	37,972,822
Seare Point (Alt. Align. A)	106,000	20	13,889	42	0.087	91	340	431	2,054	17,325,000	3,766,000	–	21,091,000	13,424,320	1,342,432	16,650,319	37,741,319
Seare Point Tunnel for Alt. Align. A)	106,000 1,900	20	13,889	42	0.087	91	190	281	1,338	17,326,000	3,012,000	2,090,000	20,337,000	8,763,117	876,312	10,868,580	31,183,580
Seare Point (Alt. Align. B)	104,600	20	13,889	42	0.087	91	190	281	1,337	17,242,500	3,009,000	–	20,251,500	8,739,611	873,961	10,839,828	31,091,328
Alternative 3A Two Rock (Initial Align.)	26,800	20	13,889	42	0.087	22	430	452	2,166	4,224,000	3,826,000	–	8,050,000	14,082,288	1,408,229	17,466,404	25,516,404
Two Rock (Tunnel for Initial Align.)	26,800 2,700	20	13,889	42	0.087	22	280	302	1,440	4,224,000	3,054,000	3,510,000	7,278,000	9,411,085	941,108	11,672,884	18,950,884
Two Rock (Alt. Align. A)	88,000	20	13,889	42	0.087	69	280	339	1,615	11,220,000	3,264,000	–	14,484,000	10,556,385	1,055,639	13,093,203	27,577,203
Two Rock (Alt. Align. B)	31,000	20	13,889	42	0.087	27	450	477	2,273	5,115,000	3,864,000	–	8,979,000	14,860,980	1,486,098	18,419,820	27,398,820
Two Rock (Alt. Align. C)	46,000	20	13,889	42	0.087	39	280	319	1,520	7,425,000	3,114,000	–	10,539,000	9,935,118	993,512	12,322,627	22,861,627

PRELIMINARY ENERGY ANALYSIS FOR TRANSMISSION LINES (TL) TO STORAGE
PRELIMINARY SIZING OF PIPES AND PUMP STATION TDH

Tunnel Cost($/LF)
West Co. 1,200
South Co. 1,100

Pump n 0.8
Motor n 0.92

Met'l $ Installation Cost
Pipe ($/LF) 165

PW Factor 12.40
i (%) 7.5
n (years) 30
Pump. Period (yr) 1
Energy ($/KW-hr) 0.1

Reservoir	Length (Feet)	Flow[3] (MGD)	Flow[3] (GPM)	Pipe[3] Diameter	120 C=120 Unit Loss (ft/100ft)	Hf (Feet)	Static Head (Feet)	TDH (Feet)	Total Pump HP	Pipe Cost ($)	Pump Sta.[1,2] ($)	Tunnel ($)	Construction ($)	Energy Use (KW-h/yr)	Energy Cost ($/yr)	PW Energy ($)	Total PW Cost ($)
Alternative 3B Bloomfield (Initial Align.)	42,000	20	13,889	42	0.087	36	295	331	1,679	6,930,000	3,245,000	--	10,175,000	10,321,203	1,032,120	12,801,492	22,976,492
Bloomfield (Alt. Align.A)	69,500	20	13,889	42	0.087	52	260	312	1,485	9,817,500	3,057,000	--	12,874,500	9,703,965	970,397	12,035,929	24,910,429
Bloomfield (Alt. Align.B)	68,400	20	13,889	42	0.087	51	295	346	1,647	9,638,000	3,264,000	--	12,900,000	10,764,200	1,076,420	13,350,945	26,250,945
Alternative 3C Carroll Road (Initial Align.)	49,000	20	13,889	42	0.087	43	820	863	4,110	8,085,000	6,102,000	--	13,187,000	26,859,495	2,685,950	33,314,103	46,501,103
Carroll Road (Alt. Align.A)	64,500	20	13,889	42	0.087	56	260	316	1,506	10,642,500	3,069,000	--	13,711,500	9,839,026	983,903	12,203,442	25,914,942
Carroll Road (Alt. Align.B)	63,400	20	13,889	42	0.087	55	295	350	1,668	10,461,000	3,264,000	--	13,726,000	10,899,260	1,089,926	13,519,461	27,245,461
Alternative 3D Valley Ford (Initial Align.)	57,000	20	13,889	42	0.087	49	820	869	4,143	9,405,000	3,076,000	--	12,481,000	27,076,582	2,707,658	33,582,129	46,063,129
Valley Ford (Alt. Align. A)	68,500	20	13,889	42	0.087	59	260	319	1,514	10,972,500	3,228,000	--	14,199,500	9,893,060	989,306	12,270,448	26,468,949
Valley Ford (Alt. Align. B)	65,400	20	13,889	42	0.087	57	295	352	1,678	10,791,000	3,264,000	--	14,055,000	10,953,284	1,095,328	13,585,468	27,640,468
Alternative 3E Huntley (Initial Align.)	50,000	20	13,889	42	0.087	43	276	319	1,517	8,250,000	3,076,000	--	11,326,000	9,914,472	991,447	12,297,016	23,623,016
Huntley (Alt. Align.)	50,000	20	13,889	42	0.087	43	285	328	1,585	8,250,000	3,226,000	--	11,476,000	10,225,896	1,022,589	12,683,288	24,159,288

Notes:
1. Based on conceptual design cost curves from ACWD/USD Water Reuse Survey adjusted for the San Francisco January 16, 1998 ENR cost index of 6525.
2. Installed Hp. Assume installed Hp = calculated Hp + 500Hp for standby pump.
3. Preliminary estimates to assist with route selection.

Route Characteristics Summary Table

Reservoir	Route Change[1]	Tunnel Length	X - Country Route[2]	Description of Cross Country Portion of Route	See Figure
Lakeville	Yes	--	2,500 ft	Private road and unimproved land south of dam embankment	4
Tolay A	Yes	--	3,000 ft	Unimproved land northwest of reservoir	2
Adobe Road	Yes	--	3,500 ft	Private road at dam embankment	6
Tolay C	NA[3]	1,900 ft	6,000 ft	Private road and unimproved land west of reservoir	9
Sears Point	Yes	1,900 ft	16,000 ft	Private road and unimproved land northwest of reservoir	12
Two Rock	No	2,700 ft	4,600 ft	Unimproved land north of reservoir	16
Bloomfield	No	--	4,000 ft	Unimproved land east of reservoir	20
Carroll Road	Yes	--	7,000 ft	Private road south of dam embankment	25
Valley Ford	Yes	--	9,000 ft	Private road south of dam embankment	27
Huntley	Yes	--	4,000 ft	Private road north of reservoir	30

1. Route deviates from "Santa Rosa Subregional Long-Term Wastewater Project;Alternative Projects Considered Through February 1993" drawing set by Harland Bartholomew & Associates
2. Length of route which crosses private property
3. NA = Not Applicable

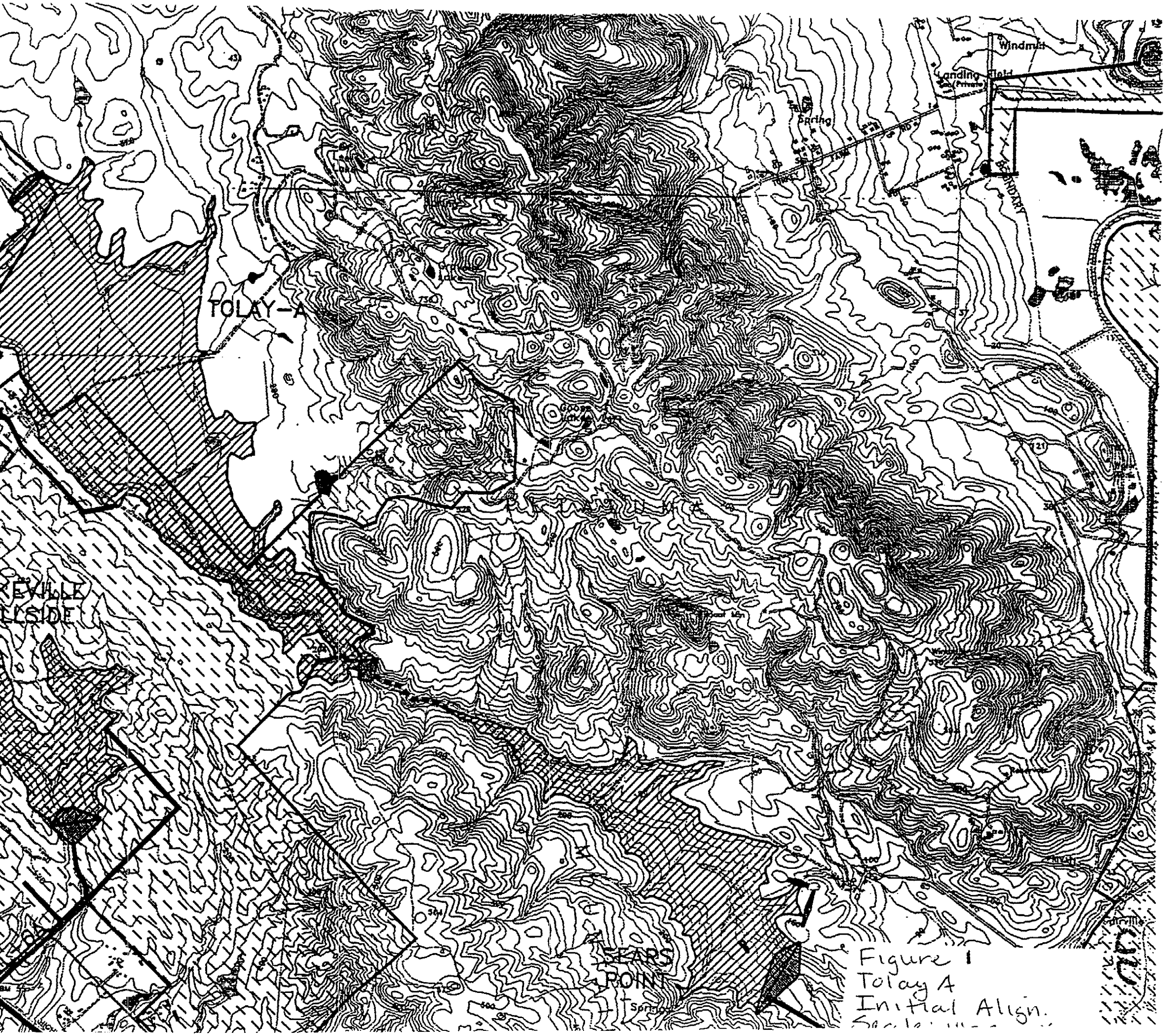


Figure 1
Tolay A
Initial Align.

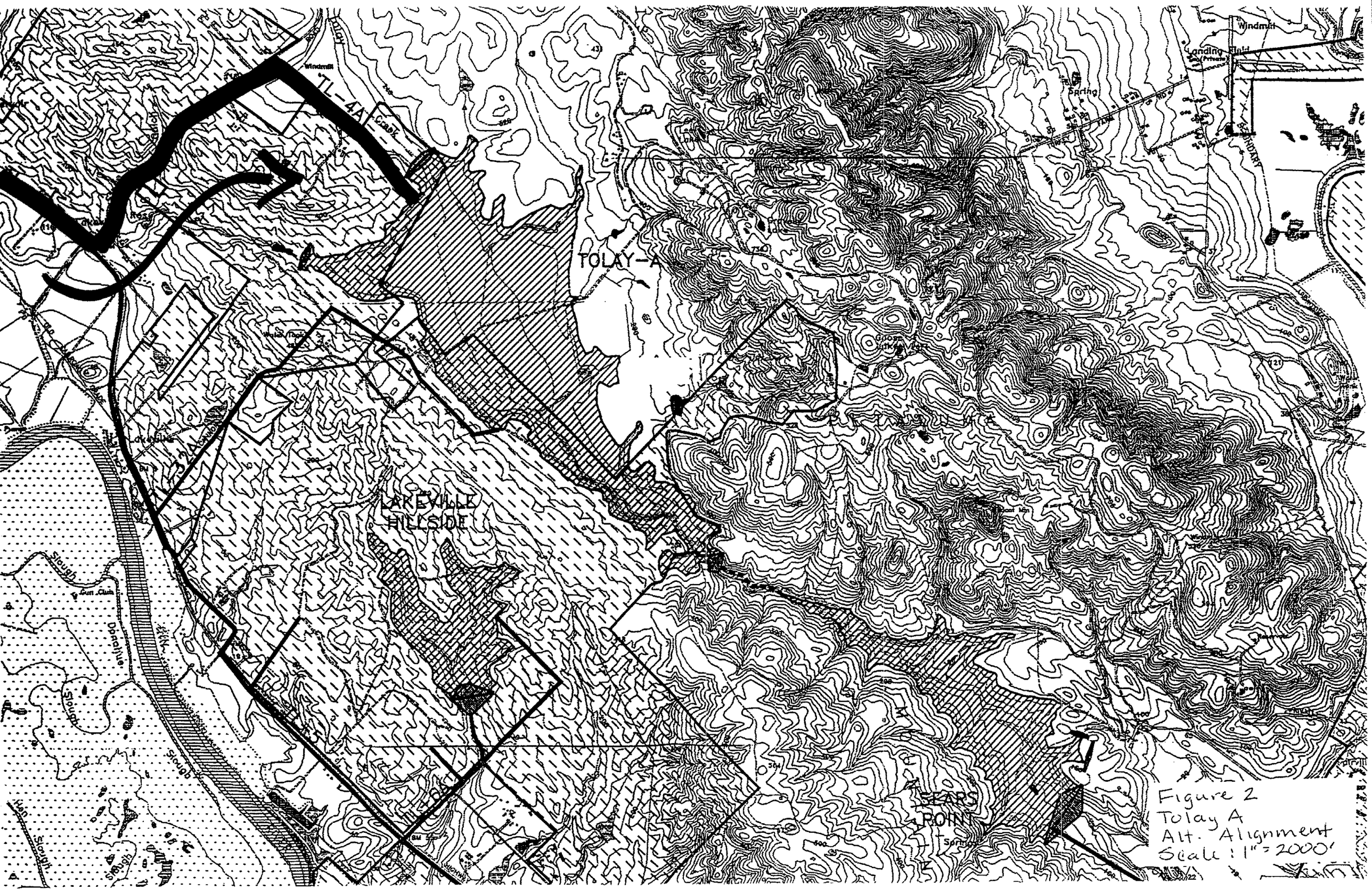


Figure 2
Tolay A
Alt. Alignment
Scale: 1" = 2000'

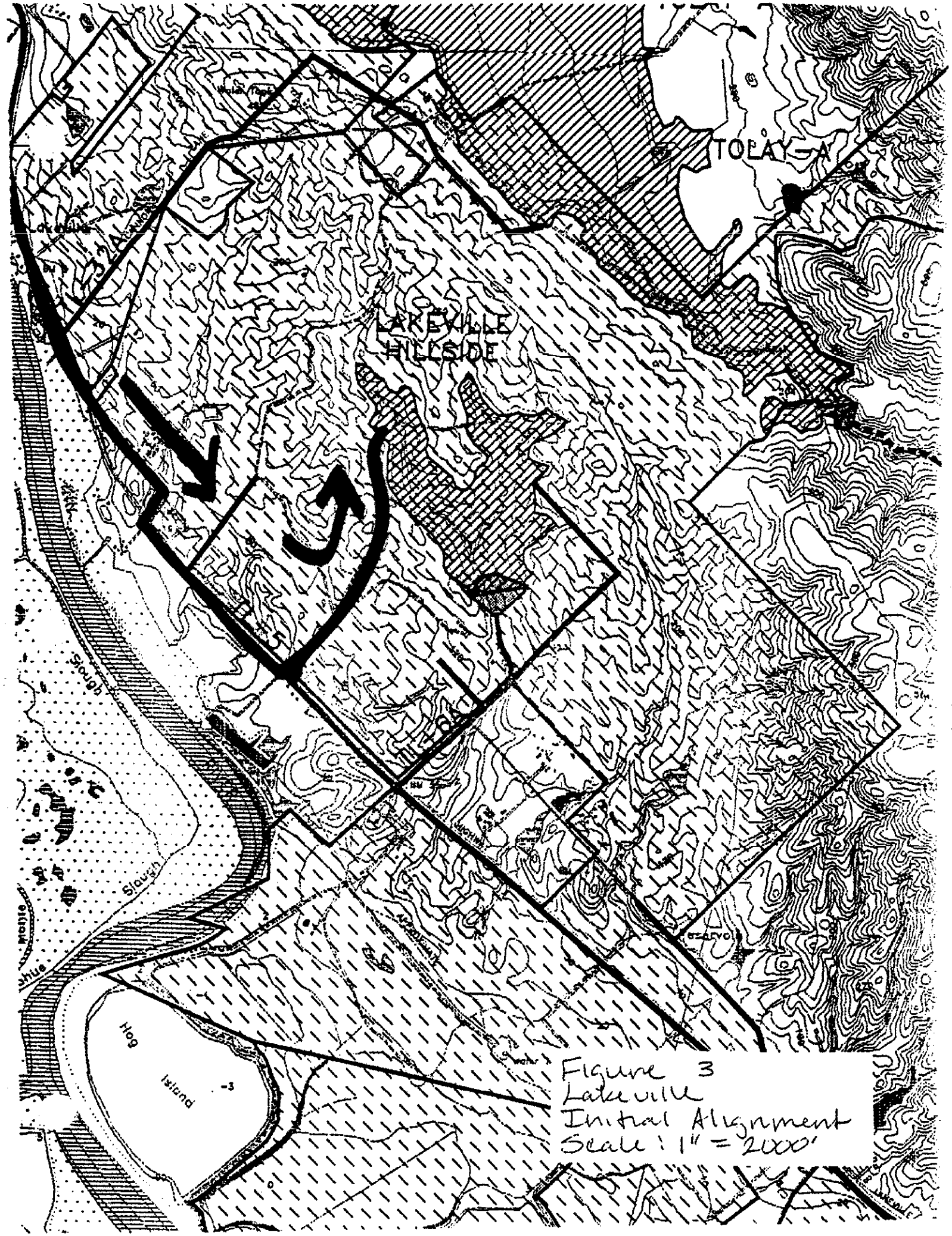


Figure 3
Lakeville
Initial Alignment
Scale: 1" = 2000'

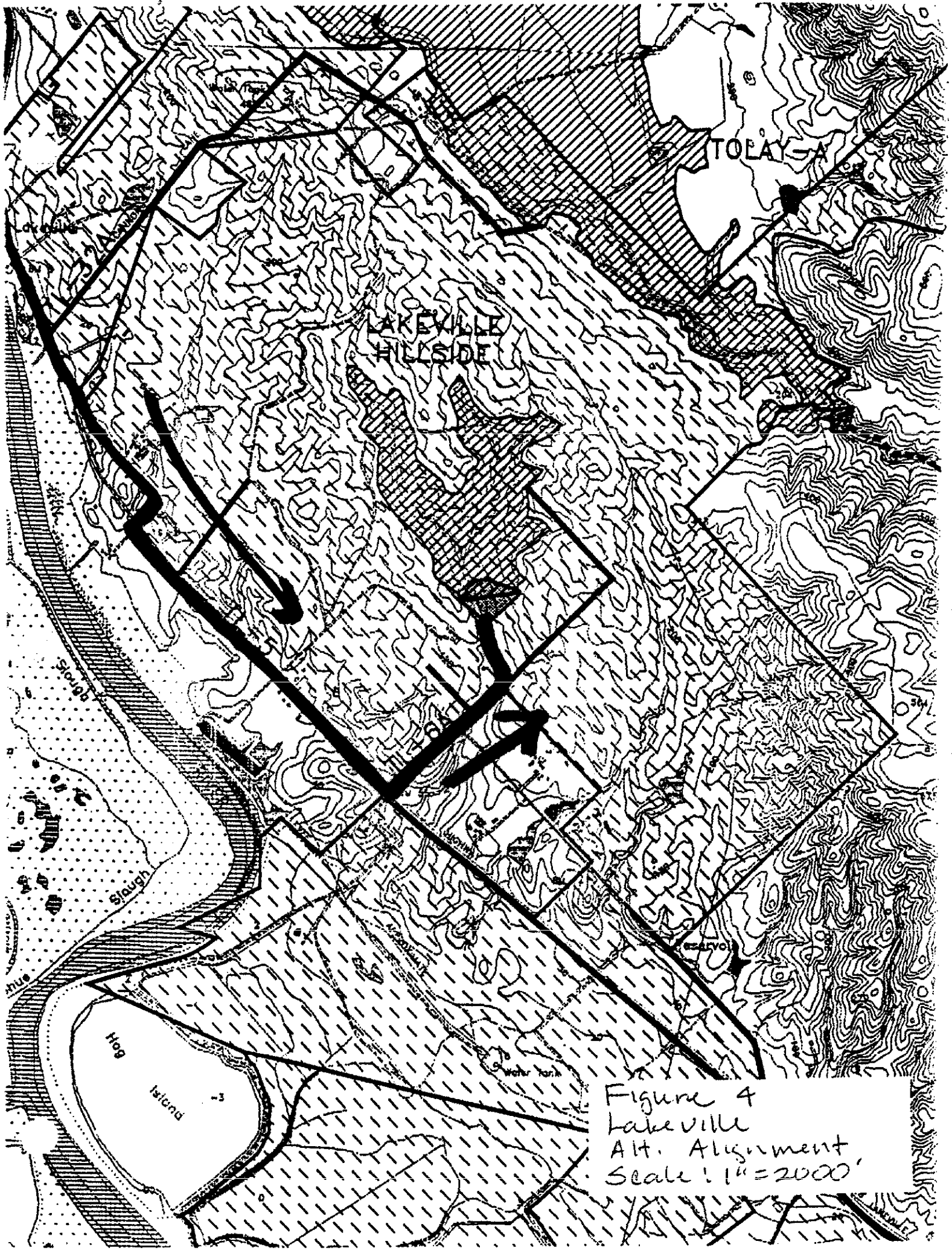


Figure 4
Lakeville
Alt. Alignment
Scale: 1" = 2000'

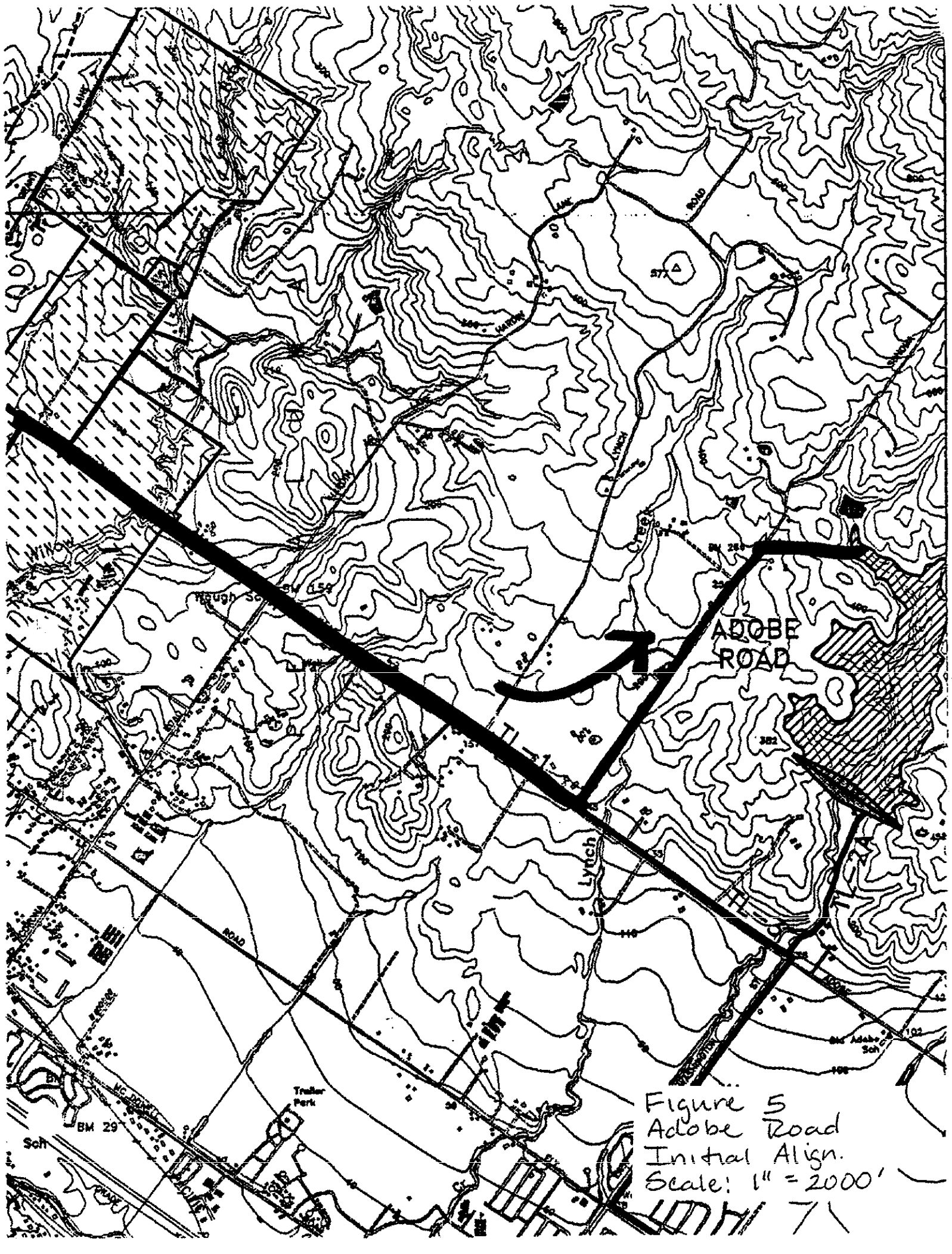


Figure 5
Adobe Road
Initial Align.
Scale: 1" = 2000'

7A

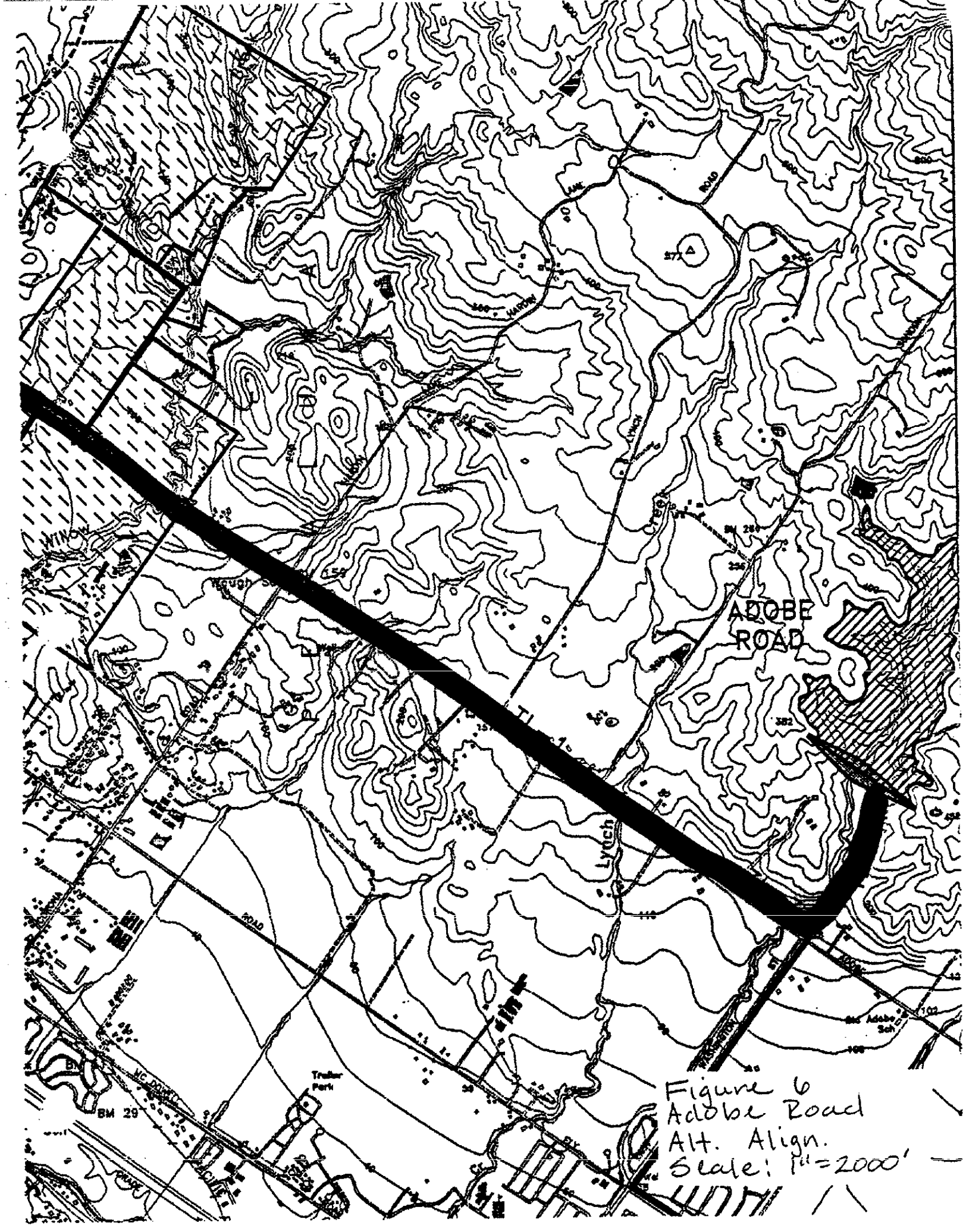
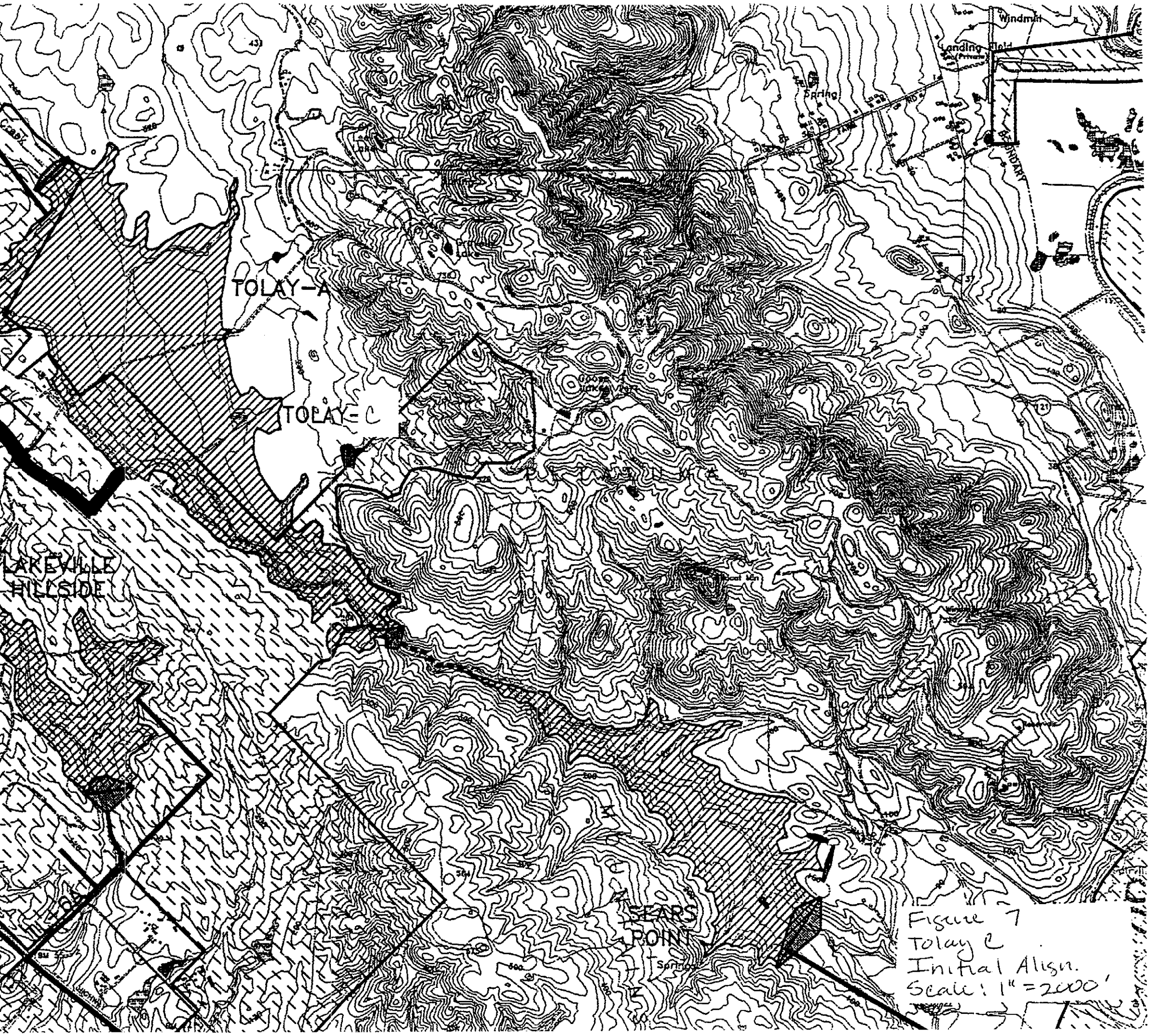
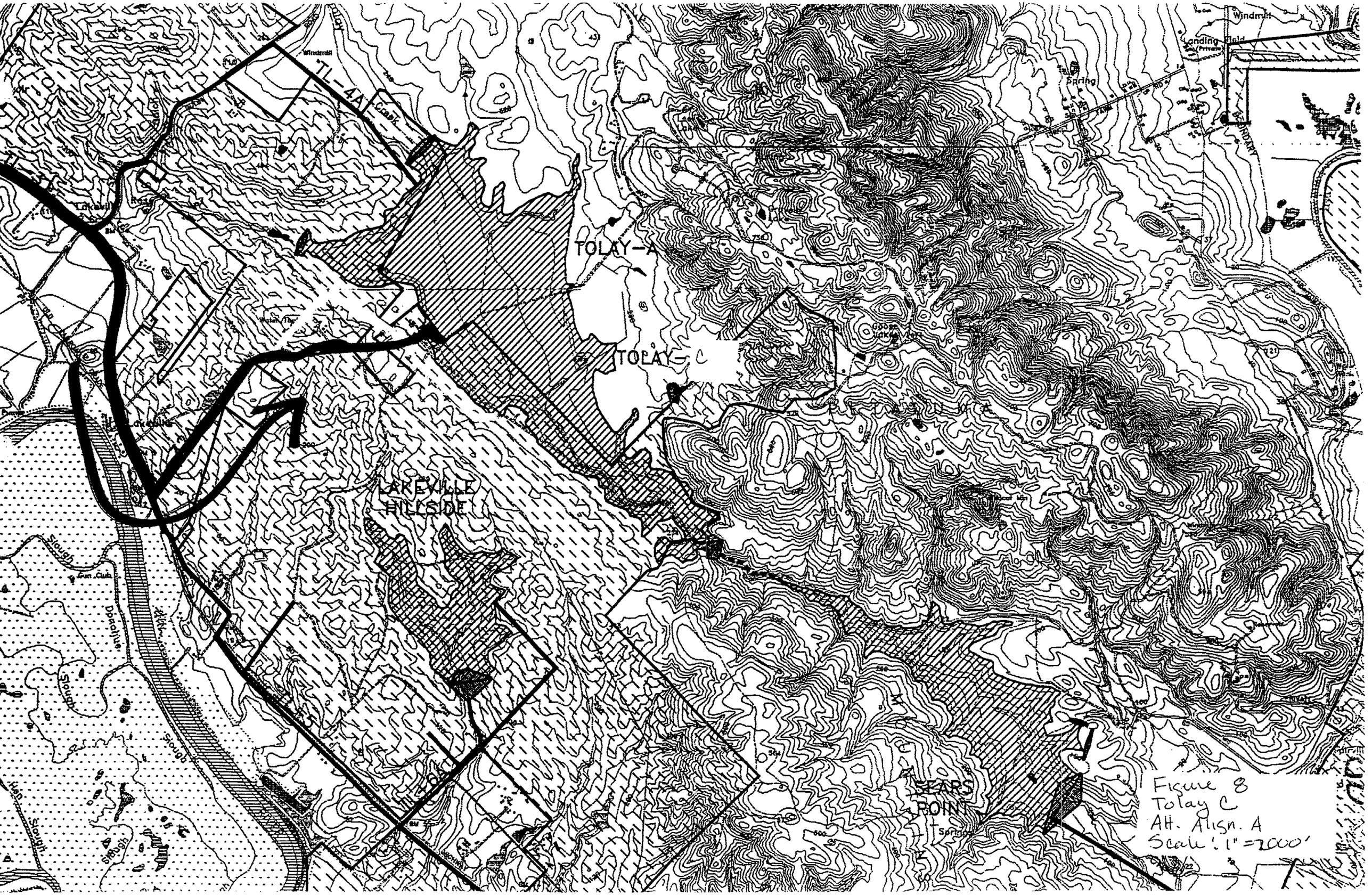


Figure 6
Adobe Road
Alt. Align.
Scale: 1"=2000'


TOLAY-A
TOLAY-C
LAKEVILLE
HILLSIDE
SEARS
POINT
Windmill
Landing
Field
Spring
Figure 7
Tolay 2
Initial Align.
Scale: 1" = 2000'


TL-4A
TOLAY-A
TOLAY-C
LAKEVILLE HILLSIDE
SEARS POINT
Windmill
Landing Field
Spring
Lakeville
Slough
Gun Club
Donahue
Slough
Slough
Slough
Figure 8
Tolay C
Alt. Alisn. A
Scale: 1" = 2000'

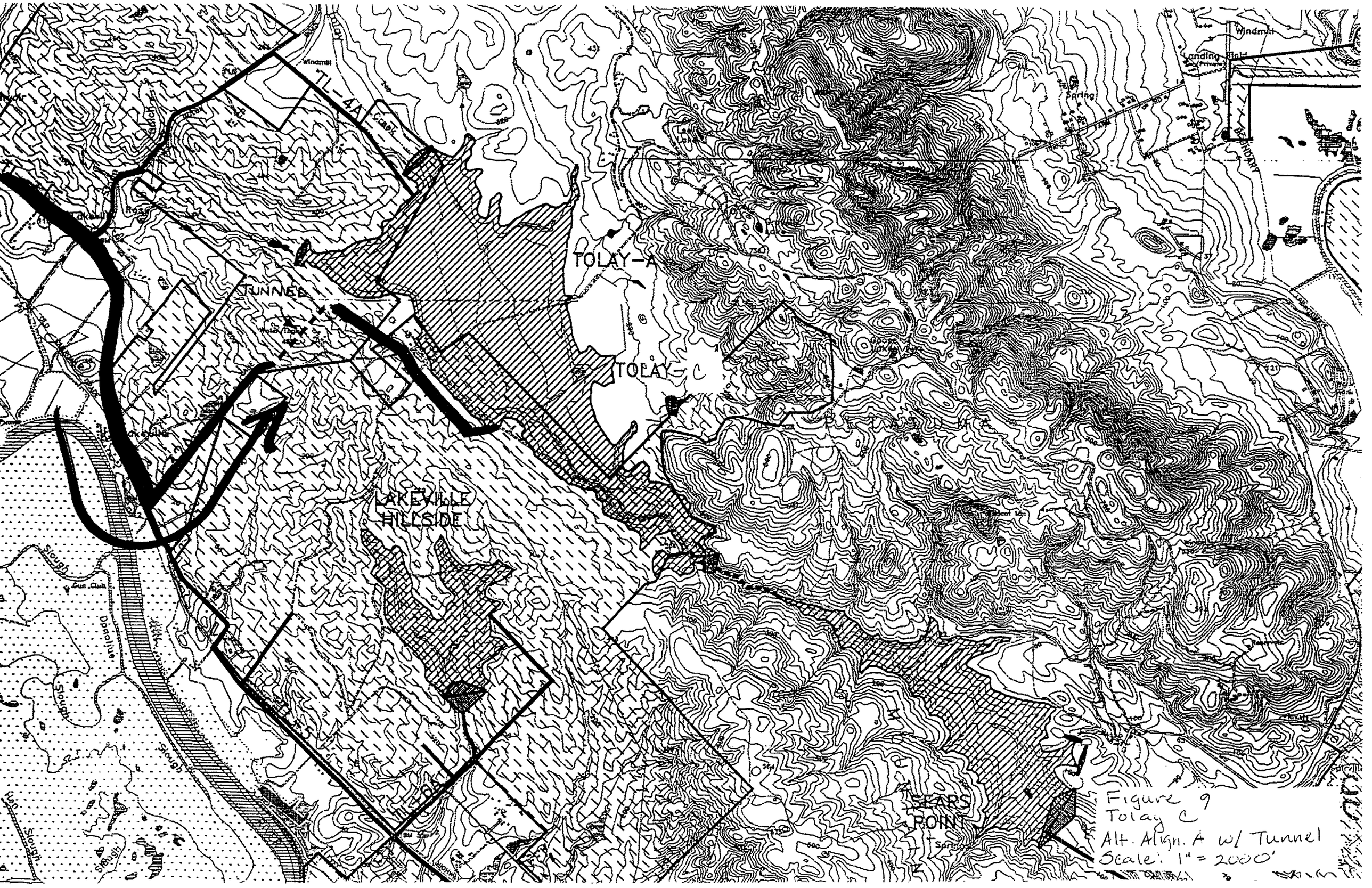
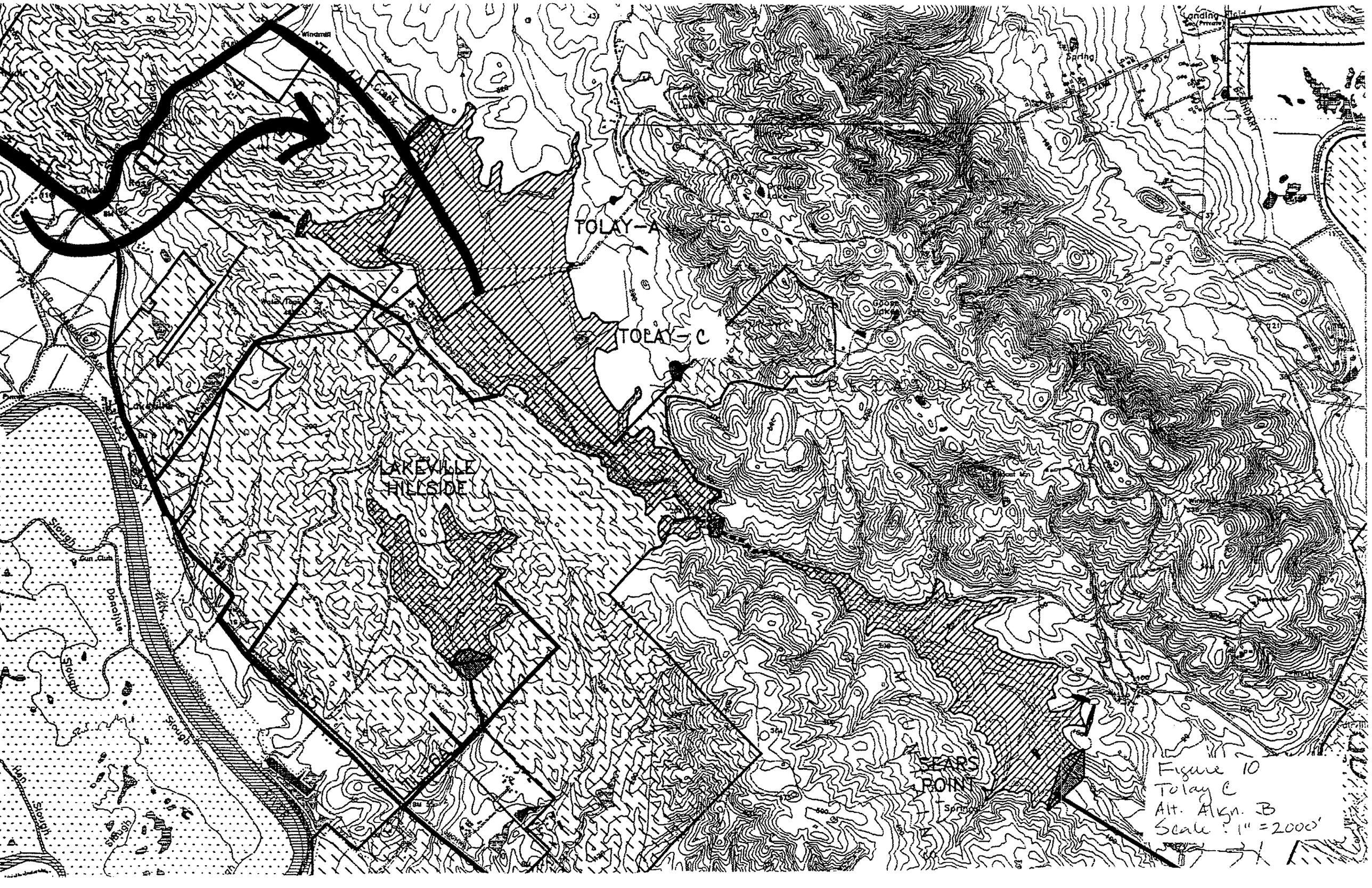


Figure 9
Tolay C
Alt. Align. A w/ Tunnel
Scale: 1" = 2000'


TOLAY-A
TOLAY-C
LAKEVILLE HILLSIDE
SEARS POINT
Landing Field (Private)
Spring
Windmill
Slough
Gun Club
Diversion
Figure 10
Tolay C
Alt. Algn. B
Scale: 1" = 2000'

TOLAY

LAKEVILLE HILLSIDE

SEARS POINT

Slough

Slough

Hog Island

Legend

Buried Pipe

Natural Drainage

Figure 11
Sears Point
Initial Align.
Scale: 1" = 2000'

TOLAY-A

LAKEVILLE HILLSIDE

SEARS POINT

Hog Island

Slough

Water Tank

Legend

Buried Pipe

Natural Drainage

Figure 12
Sears Point
Alt. Alignment A
Scale: 1" = 2000'

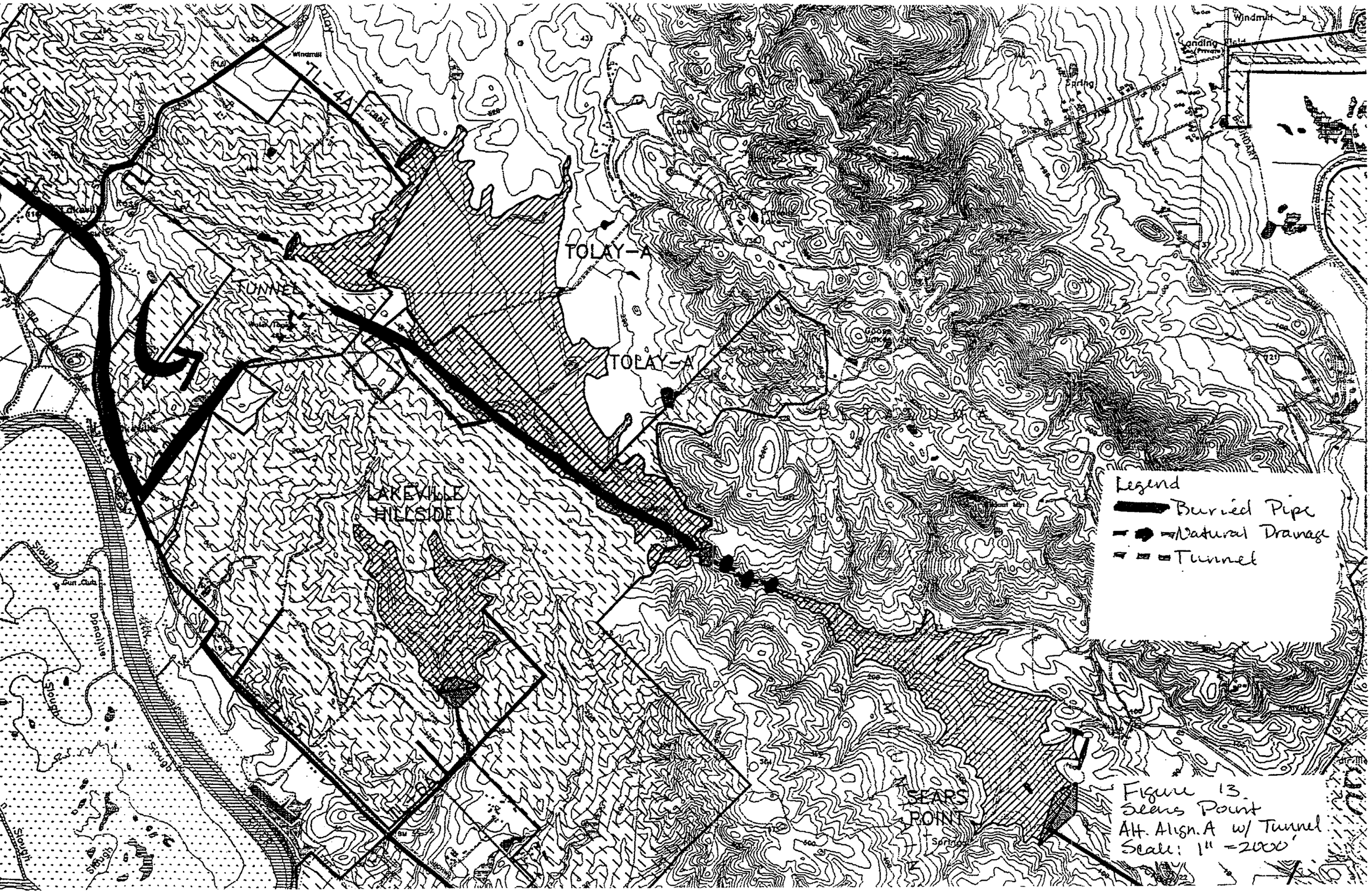


Figure 13
Sears Point
Alt. Align. A w/ Tunnel
Scale: 1" = 2000'

TOLAY-A

TOLAY-A

LAKEVILLE HILLSIDE

SEARS POINT

Legend

Buried Pipe

Natural Drainage

Figure 14
Sears Point
Alt. Align. B
Scale: 1" = 2000'

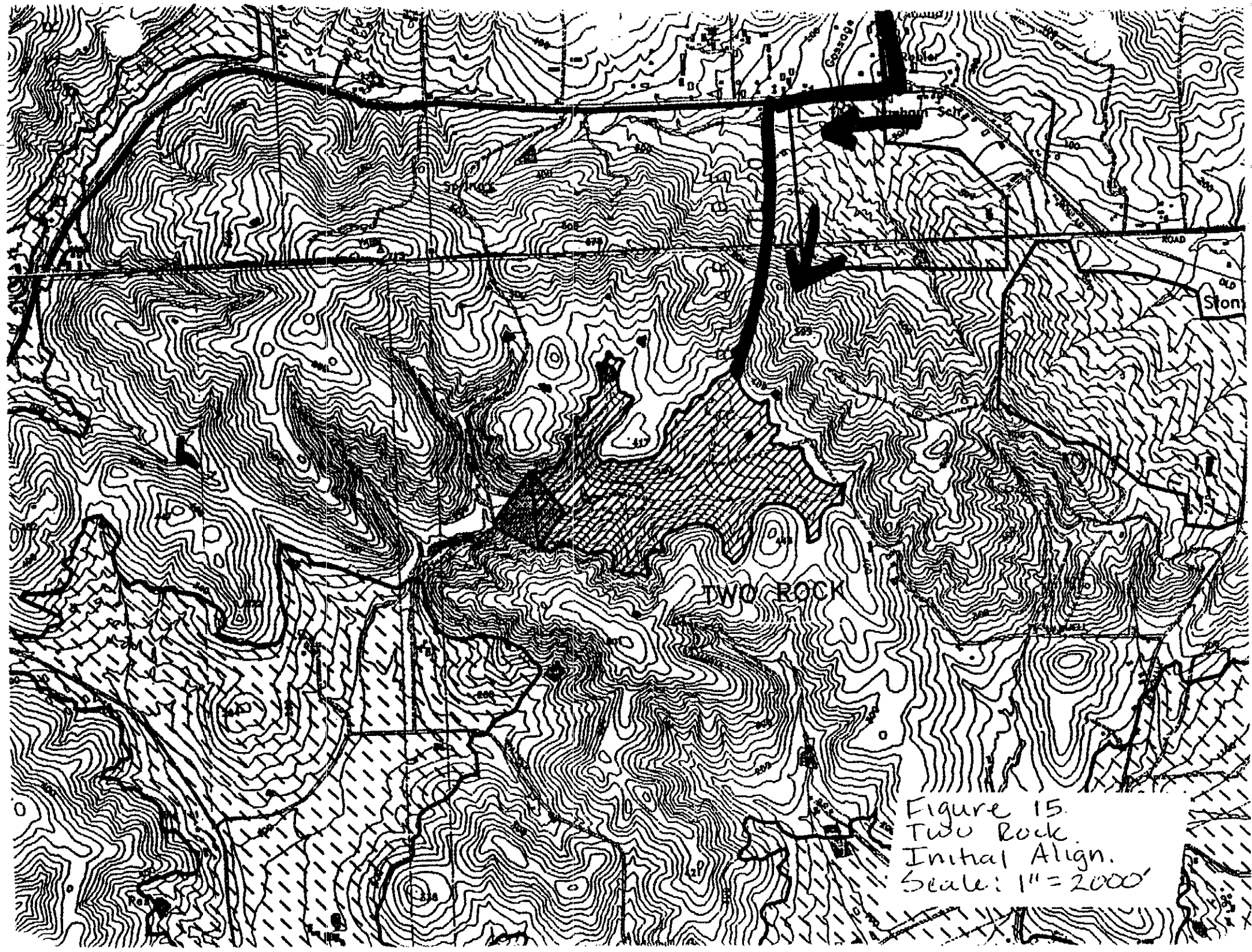


Figure 15
Two Rock
Initial Align.
Scale: 1" = 2000'

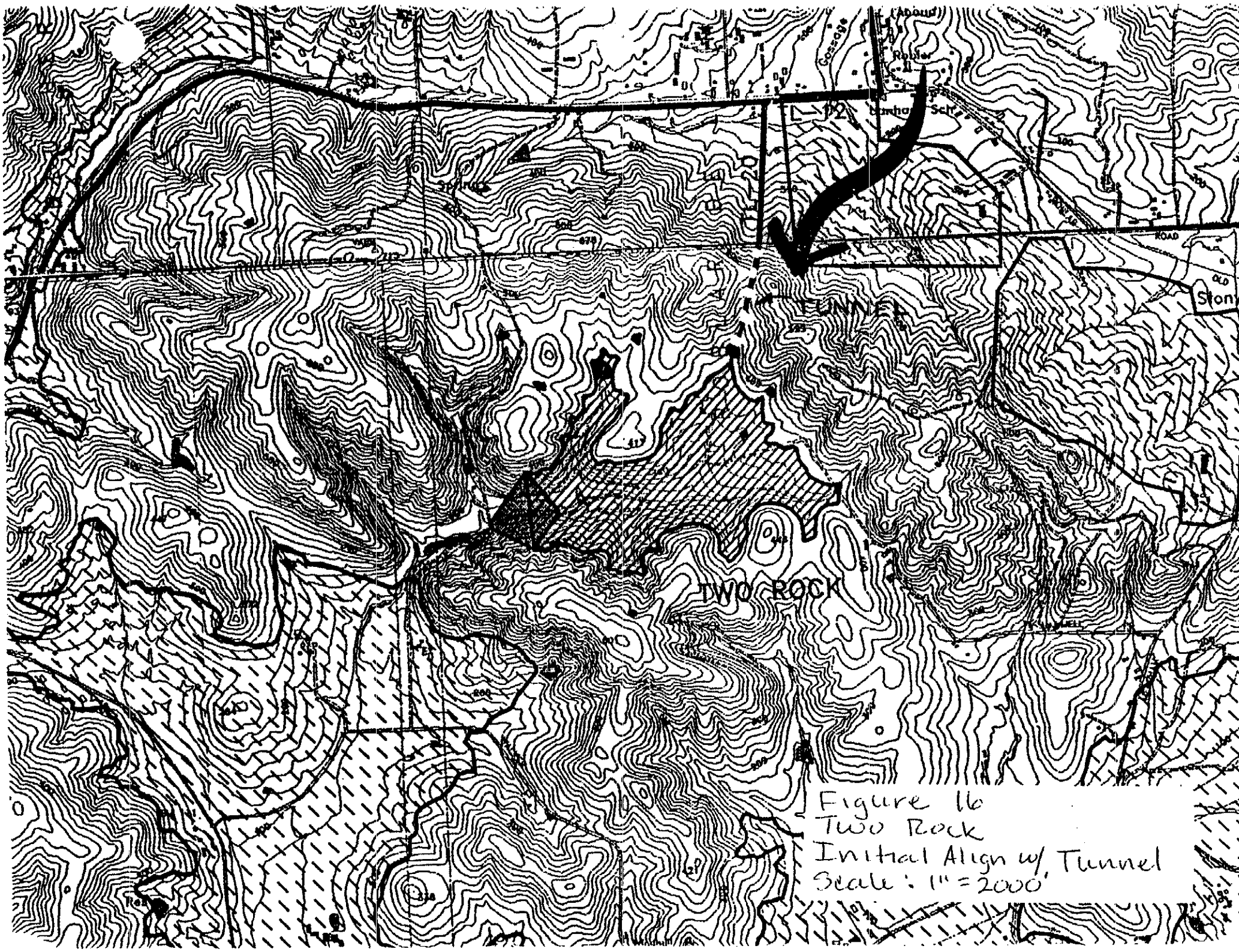


Figure 16
Two Rock
Initial Align w/ Tunnel
Scale: 1" = 2000'

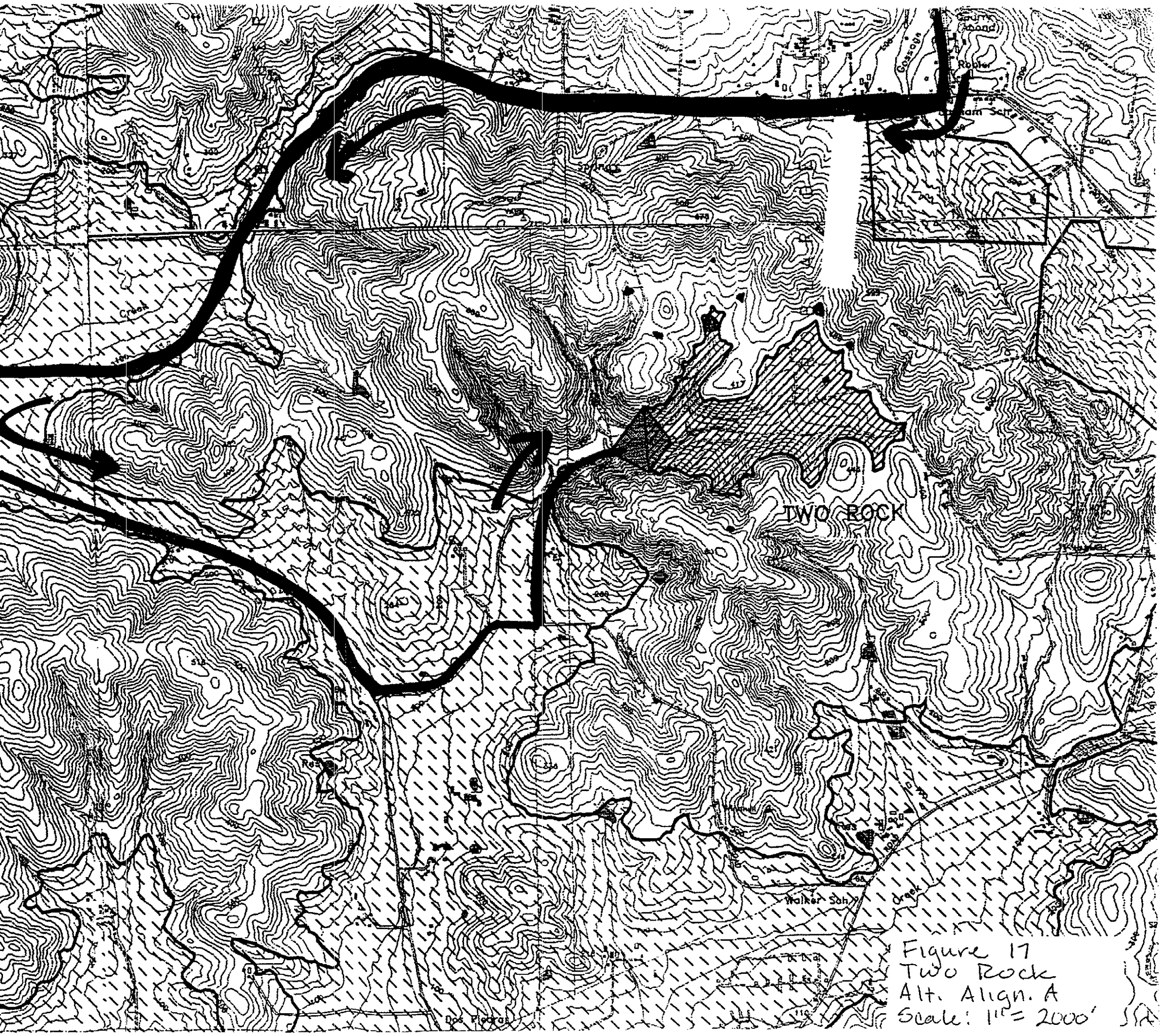


Figure 17
Two Rock
Alt. Align. A
Scale: 1" = 2000'

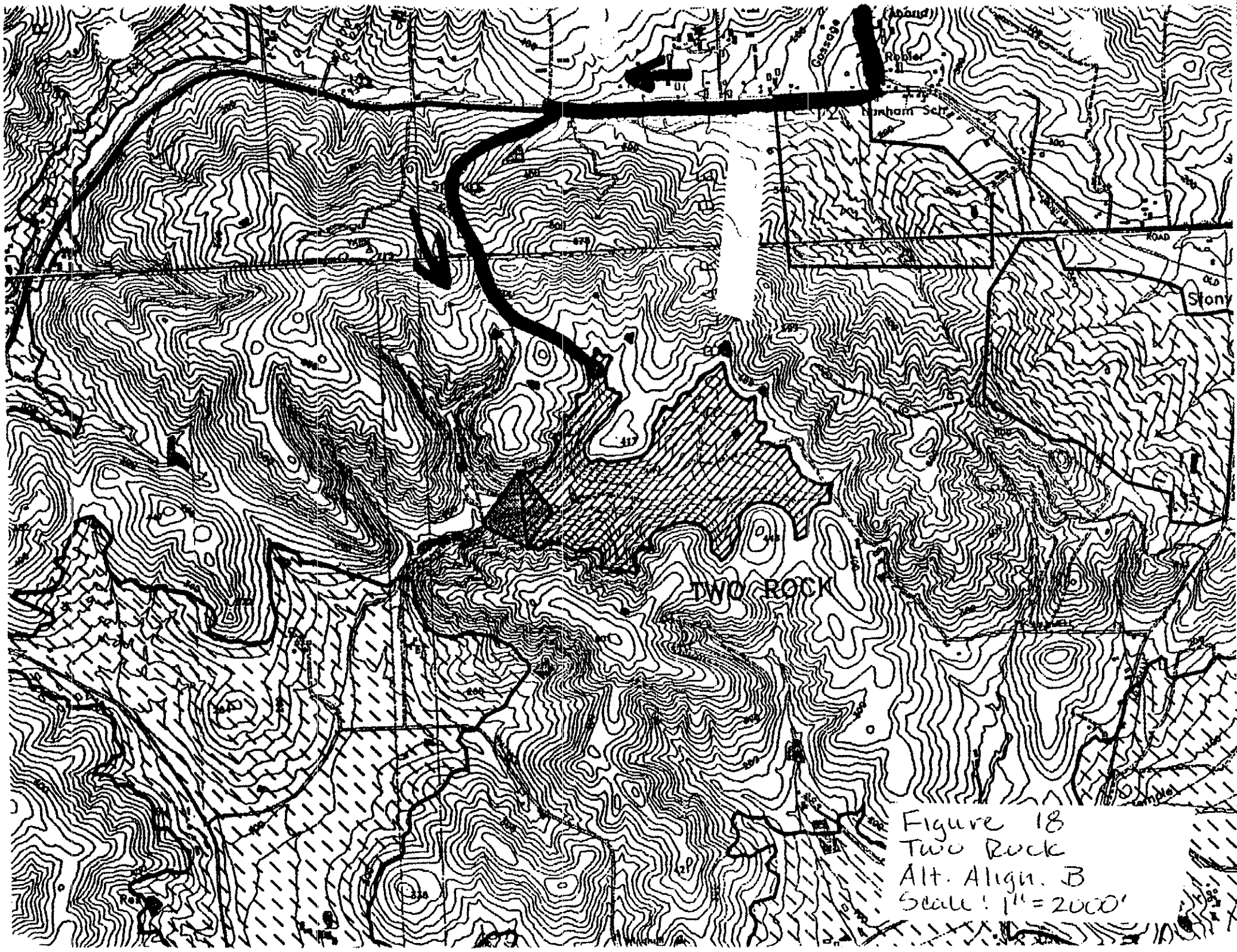
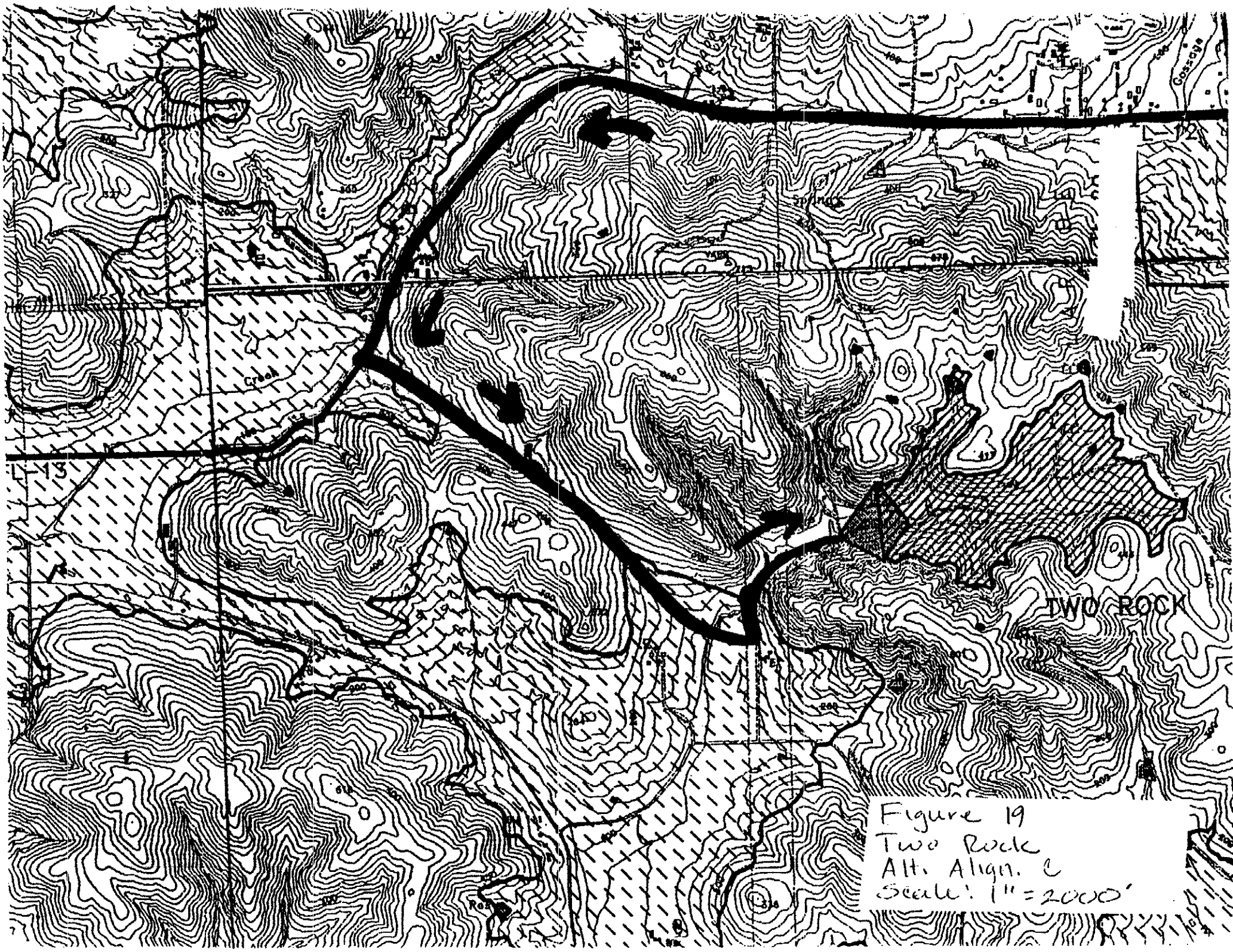


Figure 18
Two Rock
Alt. Align. B
Scale: 1" = 2000'


L-12
L-13
TWO ROCK
Figure 19
Two Rock
Alt. Align. C
Scale: 1" = 2000'

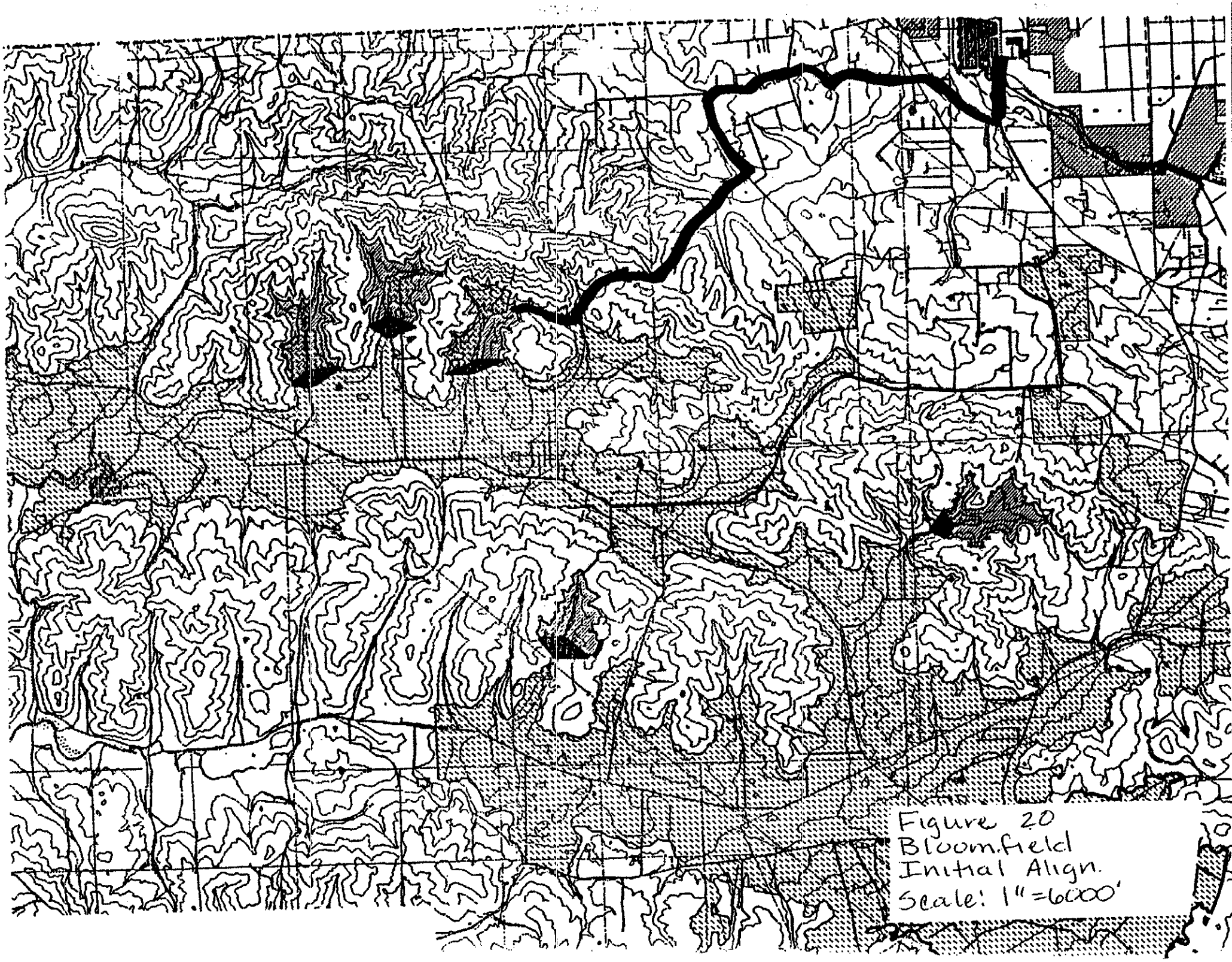


Figure 20
Bloomfield
Initial Align.
Scale: 1"=6000'

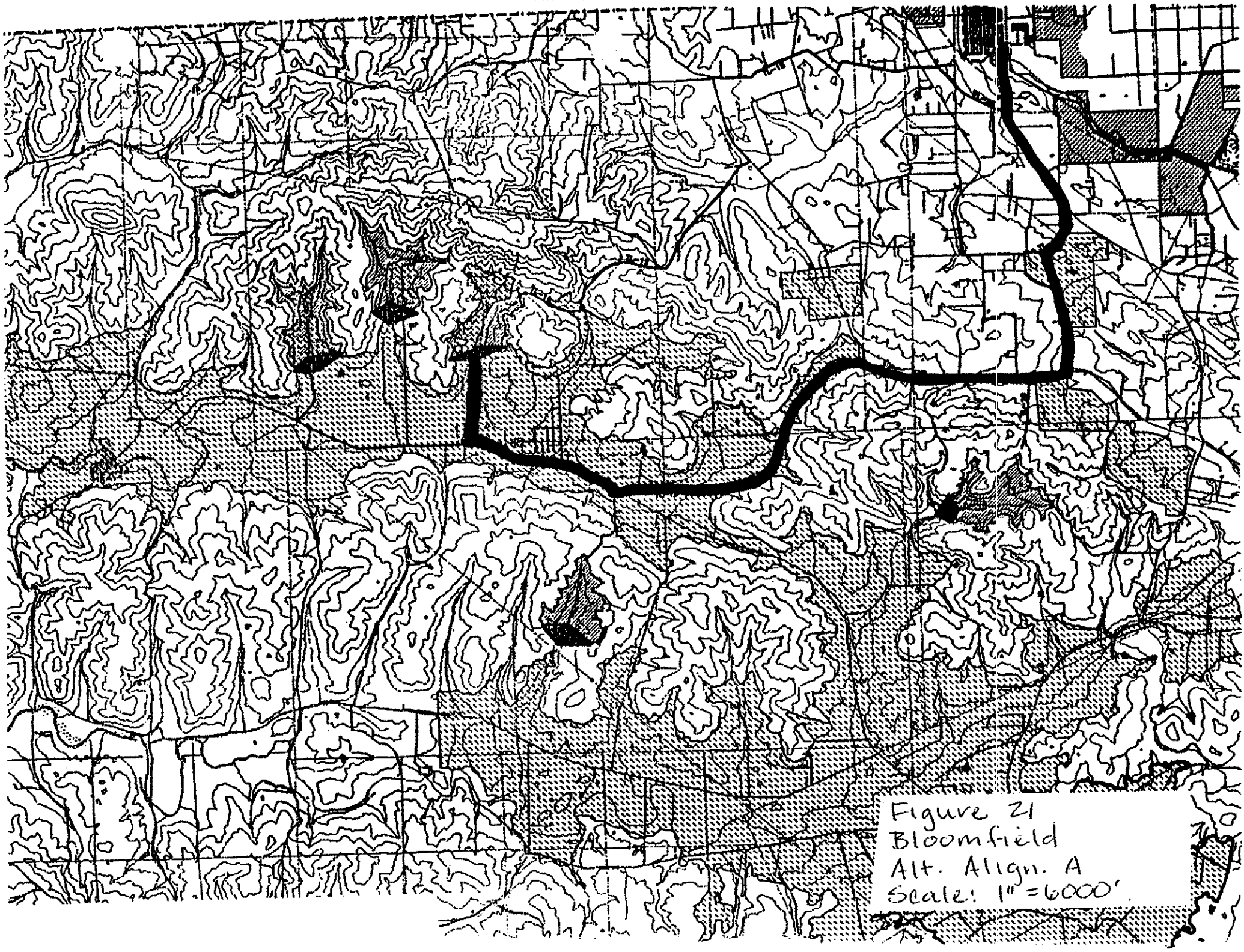


Figure 21
Bloomfield
Alt. Align. A
Scale: 1" = 6000'

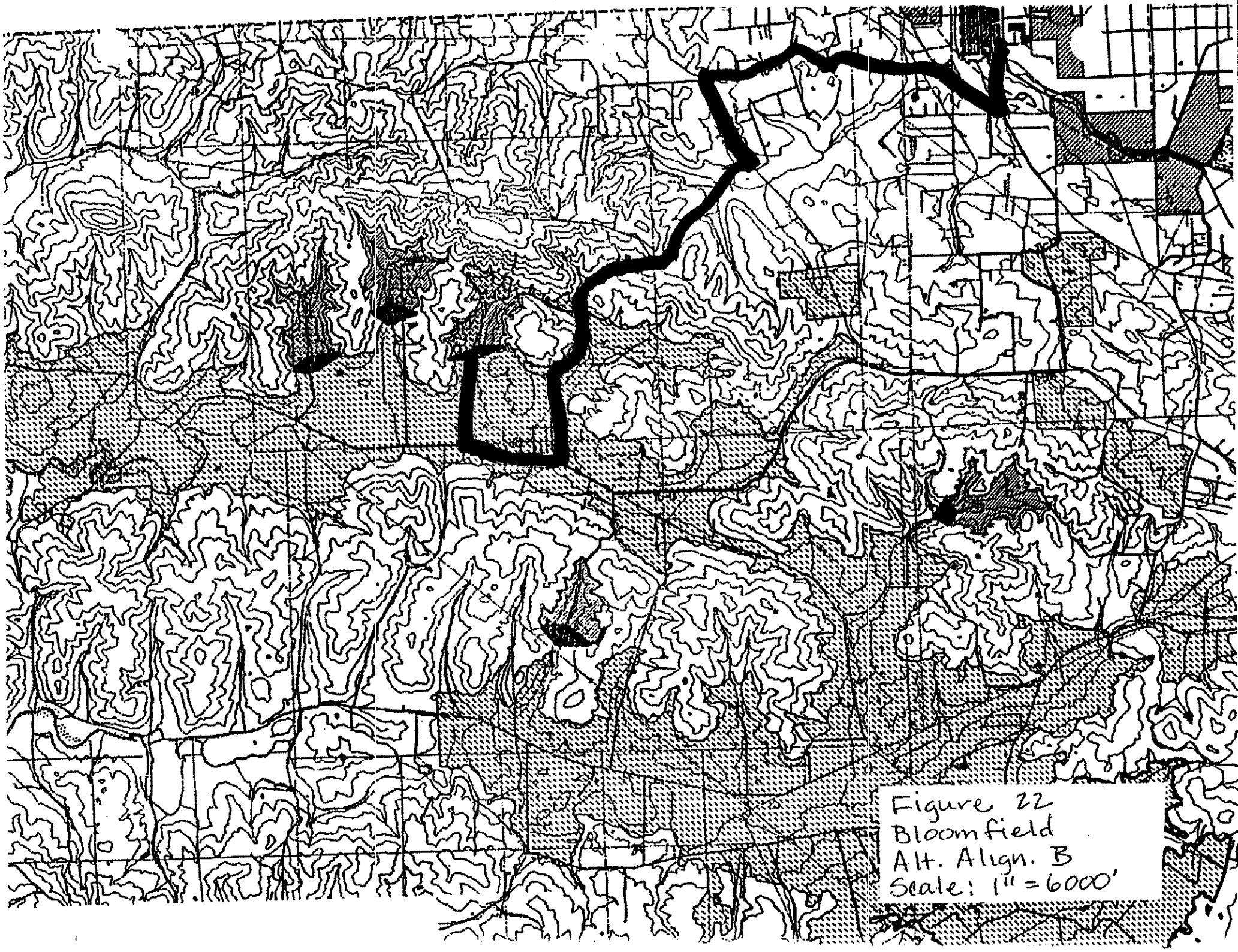


Figure 22
Bloomfield
Alt. Align. B
Scale: 1" = 6000'

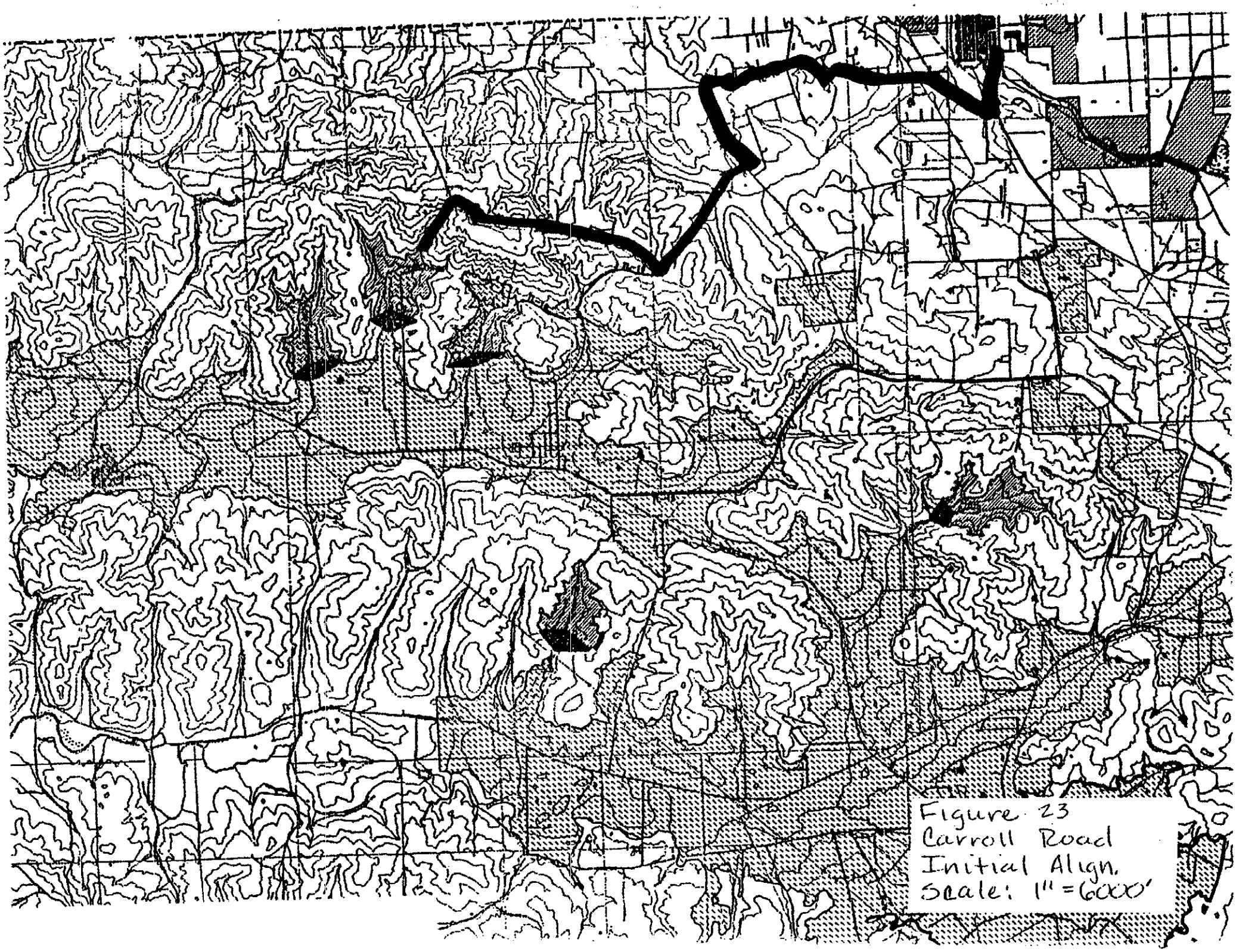


Figure 23
Carroll Road
Initial Align.
Scale: 1" = 6000'

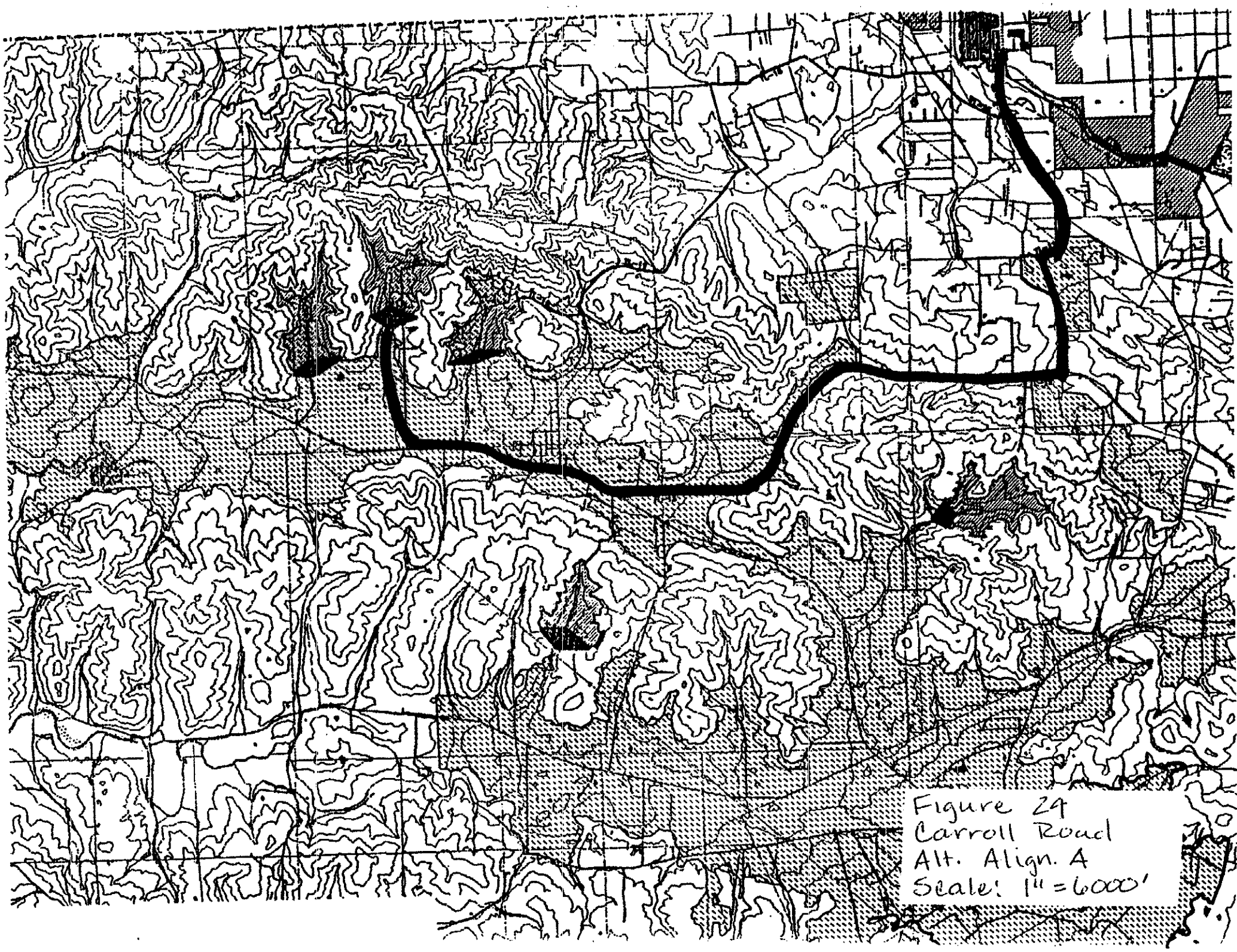


Figure 24
Carroll Road
Alt. Align. A
Scale: 1" = 6000'

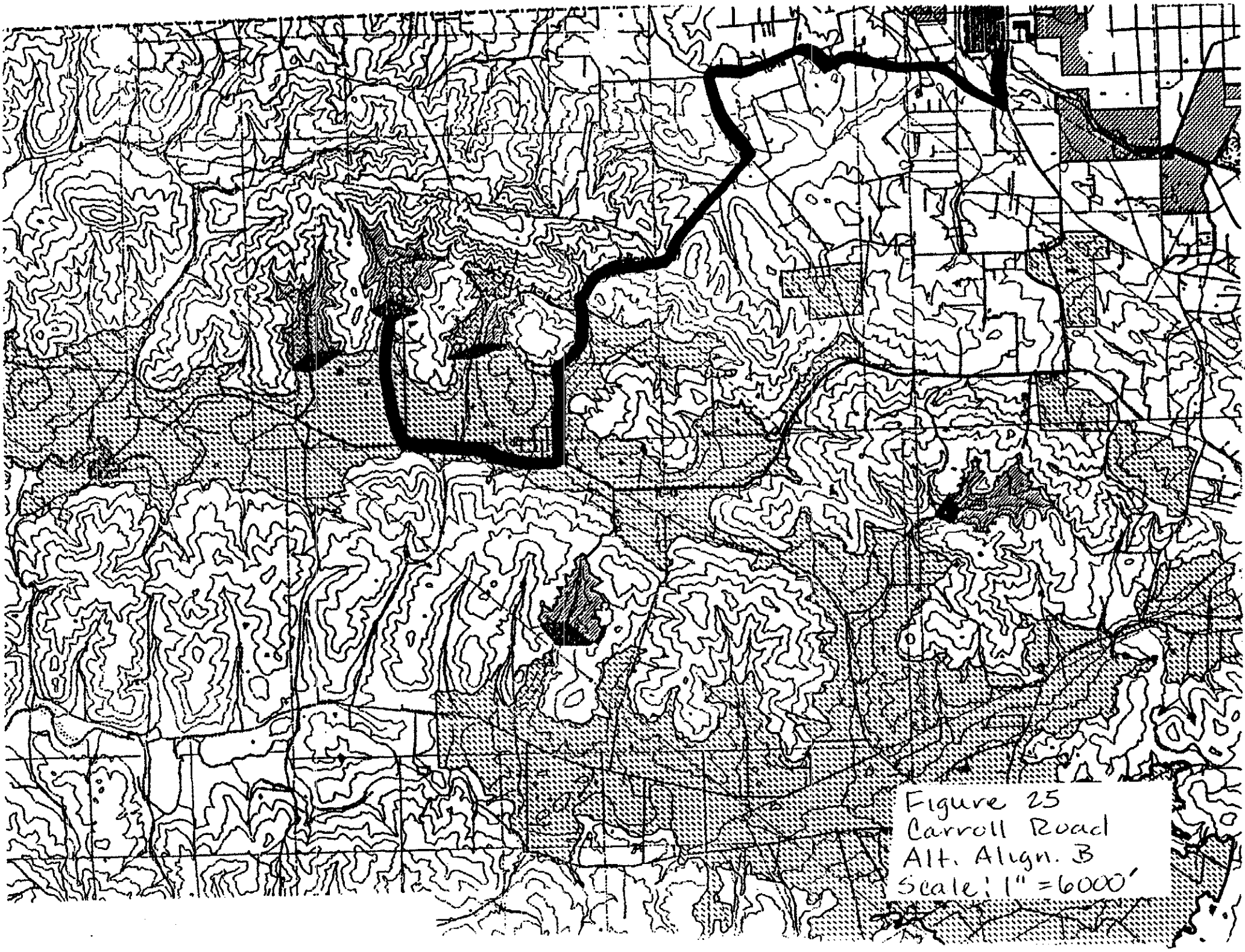


Figure 25
Carroll Road
Alt. Align. B
Scale: 1" = 6000'

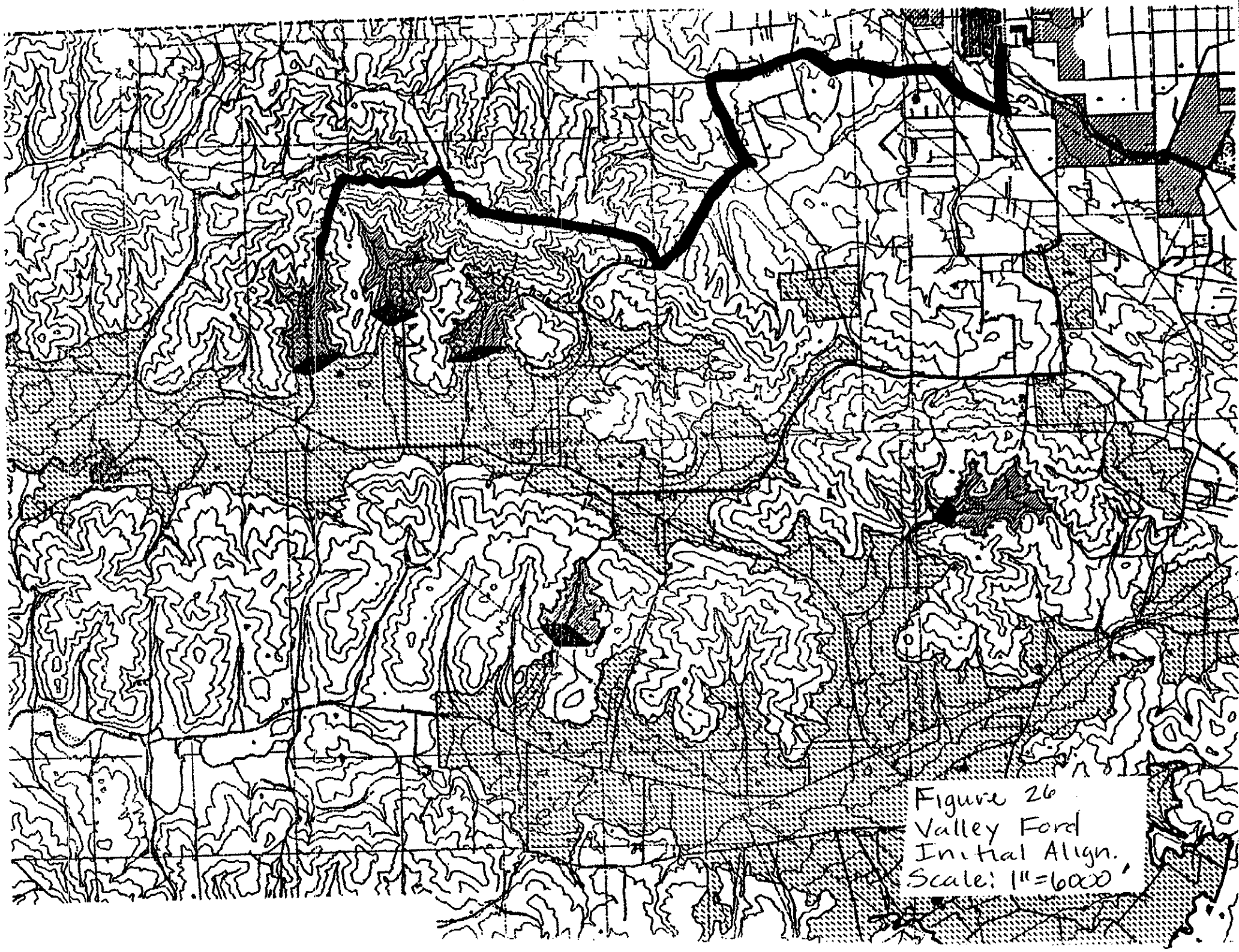


Figure 26
Valley Ford
Initial Align.
Scale: 1"=6000'

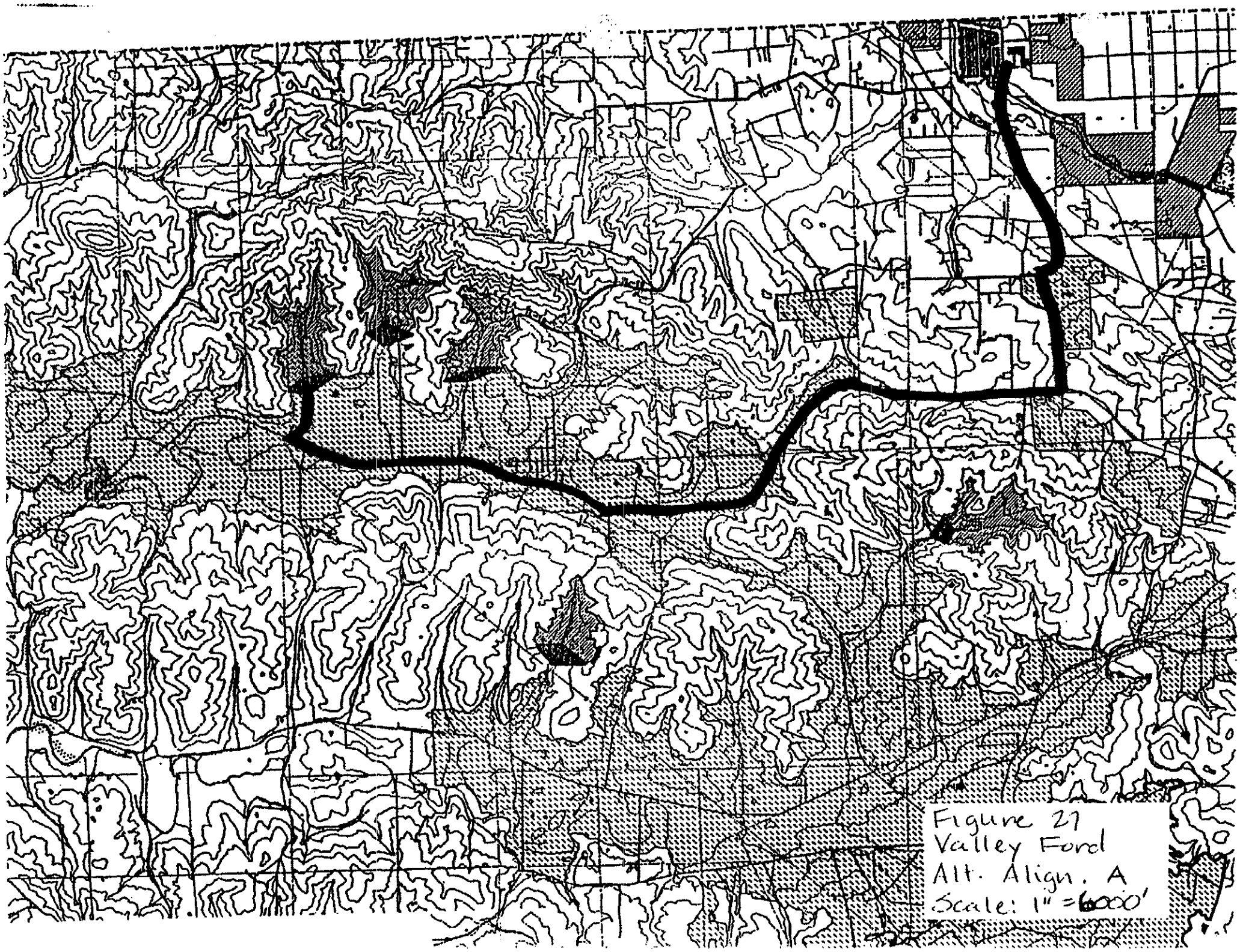


Figure 27
Valley Ford
Alt. Align. A
Scale: 1" = 6000'

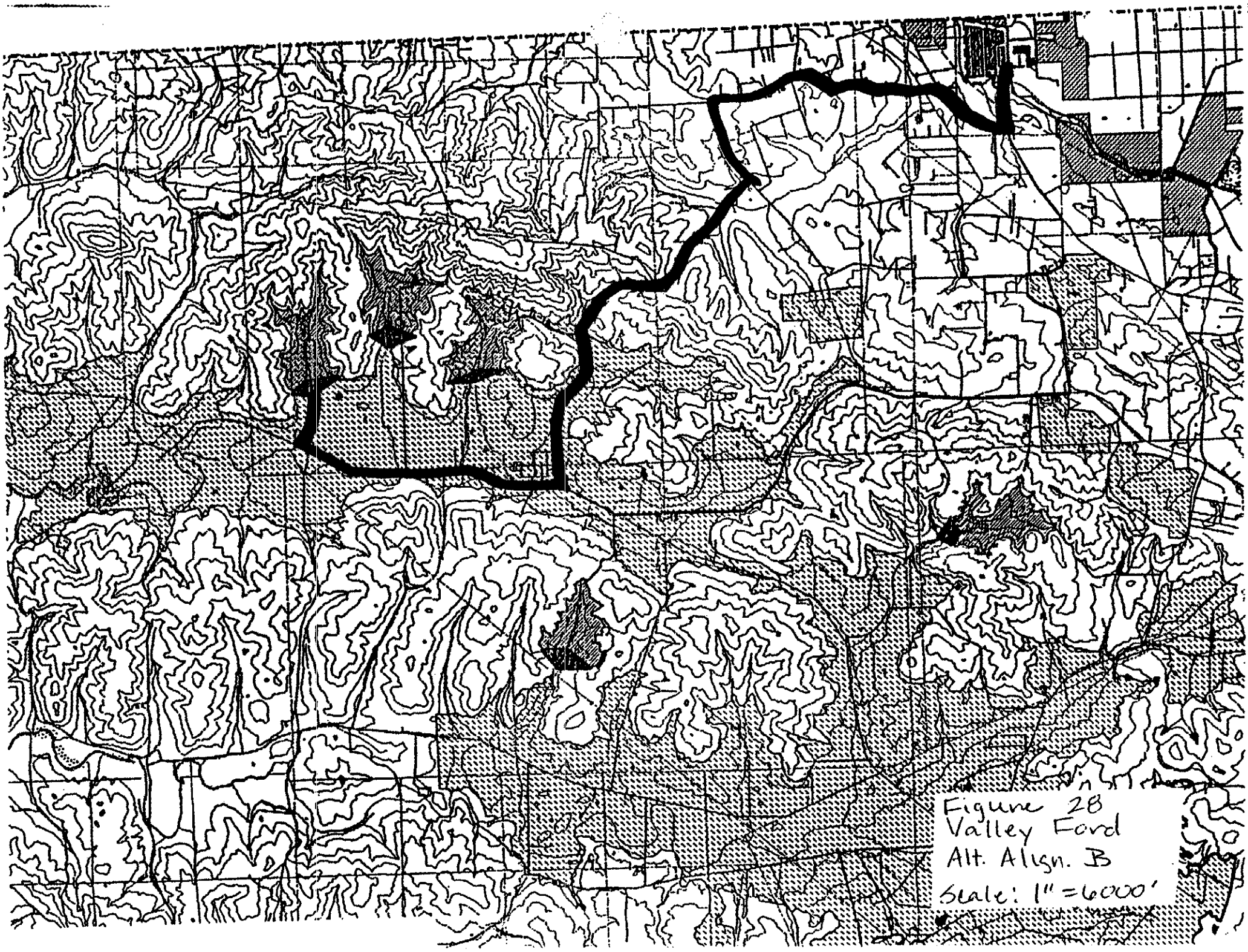


Figure 28
Valley Ford
Alt. Align. B
Scale: 1" = 6000'

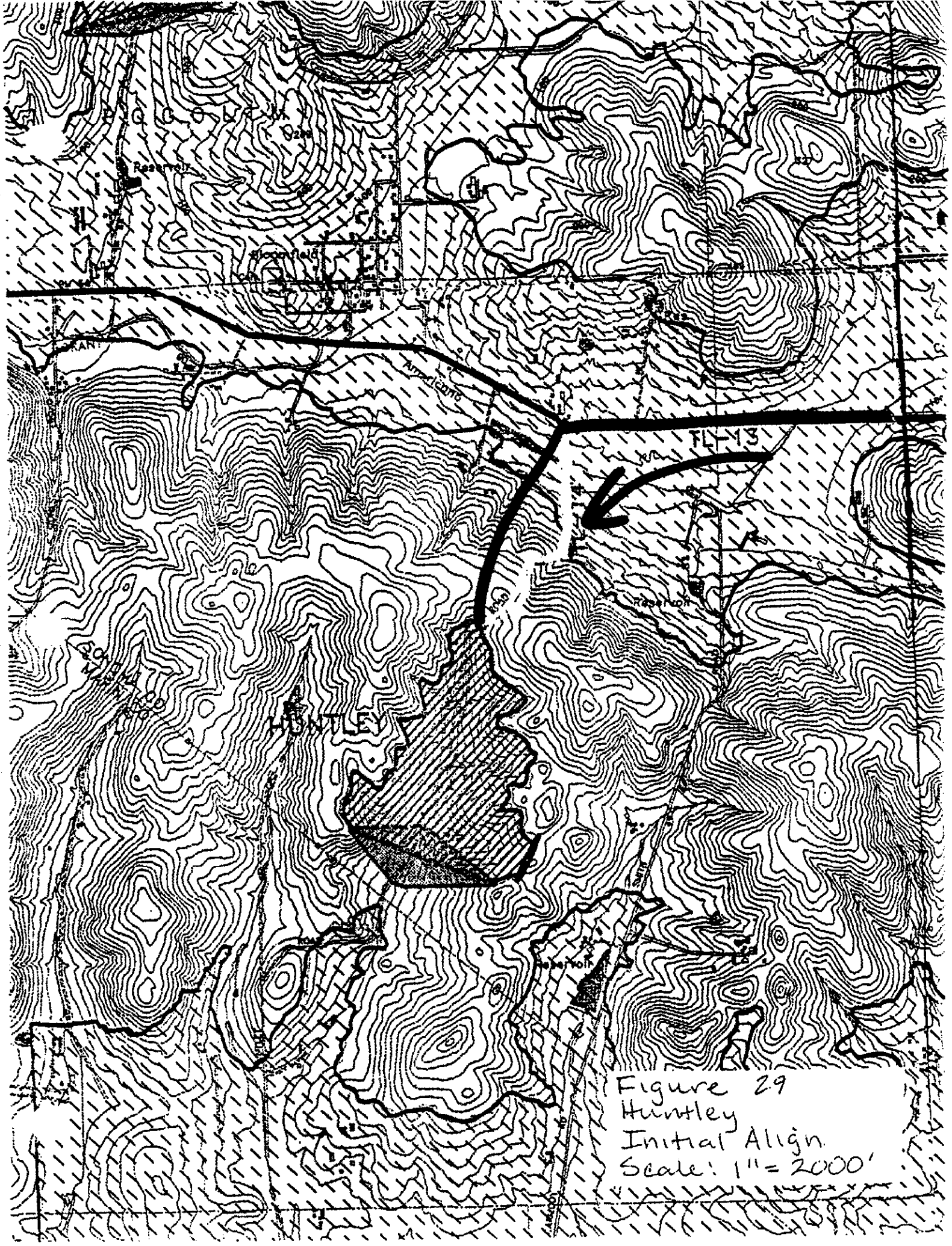


Figure 2.9
Huntley
Initial Align.
Scale: 1" = 2000'