51st Avenue Bridge

Hydraulic Study

1/29/80

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51st Avenue Bridge

Hydraulic Analysis

I. Introduction

1.1 General

The Salt River channel, as it passes through Phoenix, is normally a dry alluvial channel, but during wet periods the Salt River Project is forced to release flows through their reservoir systems. These flows are a barrier to the movement of traffic between the north and south area of the valley. The closest all weather crossing to the 51st Avenue Bridge site is the Central Avenue Bridge. There are no all weather crossings west of the Central Avenue Bridge.

Presented in this report is an analysis of hydraulic conditions of proposed improvements at the 51st Avenue Bridge over the Salt River. The design for this bridge site was for 130,000 cfs. A mathematical hydraulic model was developed, utilizing the Corps of Engineer's HEC-2 computer program. The HEC-2 computer program is a rigid boundary model that does not simulate sediment transport.

The purpose of this study was to analyze various alternative bridge lengths and channel improvements. This study will present a hydraulic comparison of each alternate. An alternate was then selected for final hydraulic and structural design.

1.2 Available Information

The analysis presented in this report is based on the following information:

1. Aerial photographs by Kenney Aerial Mapping dated 12/19/78.
2. Digitized x-sections based on August 1979 survey and photography by Kenney Aerial Mapping.
3. Material size distribution from Nicholas-Cowie & Associates, Inc.
4. Proposed horizontal and vertical alignment for the selected alternate by Nicholas-Cowie & Associates, Inc.
5. Design discharge of 130,000 cfs as per contract specifications.
6. Calibration discharge for 12/19/78 of 105,000 cfs as per Salt River Project (letter 10-3-79 from R.L. Juetten, Manager of Water Resources & Services).
7. Groundline information for thalweg in 1952 from USGS topographic maps.
8. Groundline information for thalweg in 1963 from Maddox & Associates, Aerial Surveys, Inc.
9. "Scour at Bridge Waterways" Highway Research Board.
10. "Open Channel Hydraulics", McGraw Hill Book Company, by V.T. Chow 1959.
11. "Handbook of Hydraulics" McGraw Hill Book Company, by King & Brater.
12. "HEC-2 Water Surface Profiles", U.S. Army Corps of Engineers, 1976.

II. Existing Conditions

The Salt River is an alluvial river composed mainly of sand, and gravel with a small percentage of silt. The channel is continually shifting and is extremely unstable. The shifting of the channel has been effected by land mining and filling operations.

Since 1952 the channel bottom has degraded as shown in Plate 1. This is probably caused by a combination of factors. The first is the fact that the Salt River Reservoir System has blocked the sediment movement upstream of the dams. Sand and gravel is being removed and transported downstream during periods of flow in the Salt River and is not being replaced as rapidly by upstream sediment. The second factor is the mining operations in the vicinity of 51st Avenue. There is an existing sand and gravel operation downstream of the bridge and there has been mining operations upstream.

The existing bridge at 51st Avenue is a 175 foot bridge that has been used in periods of low flow. The 51st Avenue roadway is washed out during medium and high flows.

Field surveys at the bridge show scour holes to elevation 981, which is near the bottom of the existing piles. These scour holes are approximately 15 feet below the existing channel.

III. Calibration

The mathematical model was calibrated using the December 19, 1978 aerial photographs of the flooded river. The flow in the river on this date was 105,000 cfs as determined by the Salt River Project. The x-sections that are used in the mathematical model are located on Plate II.

3.1 Flow Resistance Coefficient

The estimating of channel resistance is a difficult task for a natural river, especially when it is made up of boulders, gravel and sand in a dynamic environment. The size of the bed material can change during the degradation and agradation process.

The resistance coefficient or Mannings n-value was determined by computing the flood limits for a range of n-values, and then comparing the computed flood limits to the known flood limits as shown on Plate 2. A Mannings n of .030 (Computer run CAL-1) gave the flood limits that best calibrated with the flood limits that are shown on Plate 2. The n-value of .030 also corresponds to selected values found in Chow's "Open Channel Hydraulics" Figure 5-5(12) Page 119.

3.2 Field Observation

The Maricopa County Highway Department and Flood Control District staffs were interviewed as to their knowledge of flood limits during the December 1978 floods. They reported that at 51st Avenue the water came to top of the roadway at the south end of the bridge (elevation 1010.5), but did not top it. This

51ST AVENUE BRIDGE

105,000 CFS CALIBRATION

SCALE: 1"–420'

PLATE 2

LEGEND

1 — LOCATION OF SECTION 1

FLOOD LIMITS FROM PHOTO* DEC. 19, 1978

FLOOD LIMITS FROM COMPUTER (SURVEY DATE: AUG.1979)

* NOTE: SOME DISTORTION IN PHOTO

agrees closely with the computed elevation of 1010.4 feet found in computer run CAL-1.

IV. Alternates

4.1 Existing Bridge Alternates

In determining the bridge length and channel improvements for 51st Avenue Bridge, the feasibility of using the existing bridge was first analyzed. The existing bridge lies on a vertical curve with the south end of the bridge at elevation 1010.5± and the north end at elevation 1012.0± (top of road). Alternates 1A thru 3A analyze the effects of adding a 900 foot bridge to the existing 175 foot bridge. The results of these runs are shown in Table 1. A description of each alternate is found in Appendix A and the channel bottom and water surface elevation are plotted in Appendix B.

The bridge deck and girder system was assumed out of the water for the purpose of analysis. The water surface elevation at the bridge varied between elevation 1010± and 1011±, for the various alternatives analyzed.

The results of these alternates were reviewed by E.M. Plummer Consulting Engineers, Nicholas Cowie & Associates and the Maricopa County Highway Department. The review concluded that the existing bridge was too low, and the cost of raising the bridge deck was greater than the cost of a new bridge.

4.2 New Bridge Alternates

Alternates 7A - 7F, 4A, and 1A analyze the effects of various bridge length alternatives for a new bridge at 51st Avenue.

Table 1
51st AVENUE BRIDGE

ALTERNATE COMPARISONS

RUN NO.	EL 9	VEL 9	EL 10	VEL 10	EL 11	VEL 11	EL 13	VEL 13	EL 14	VEL 14	EL BR	VEL BR	EL 16	VEL 16	EL 17	VEL 17	EL 18	VEL 18	EL 19	VEL 19	
CAL-1	7.76	8.0	8.83	8.1	9.46	6.8	10.05	7.2	10.40	7.1	0.0	0.0	9.88	10.5	11.58	8.4	12.44	8.8	13.89	7.4	Exist 130,000 cfs
ALT-1A	7.61	8.7	8.92	8.4	9.32	8.2	10.08	9.0	10.68	8.1	10.64	8.3	10.72	8.1	10.76	10.3	12.26	9.5	13.95	7.7	900' addition 995.8
ALT-1B	7.61	8.7	8.92	8.4	9.32	8.2	10.08	9.0	10.30	10.5	10.21	10.8	10.40	10.4	11.40	9.5	12.55	9.1	14.06	7.6	900' addition 998.8
ALT-1C	7.61	8.7	8.92	8.4	9.32	8.2	10.08	9.0	10.94	6.7	10.91	6.8	10.95	6.7	10.50	10.6	12.18	9.5	13.93	7.7	900' addition 992.8
ALT-2A	7.61	8.7	8.92	8.4	9.77	5.4	9.79	6.9	9.84	7.7	9.80	7.9	9.86	7.8	10.50	5.6	10.30	13.1	13.95	7.7	Channel 9(992.3) thru 17(995.0)
ALT-2B	7.61	8.7	8.92	8.4	9.77	5.4	9.73	7.5	9.75	8.7	9.70	8.8	9.80	8.8	10.65	6.6	10.29	13.1	13.95	7.7	Channel 9(992.3) thru 17(997.4)
ALT-3A	7.61	8.7	8.92	8.4	9.32	8.2	10.30	12.4	11.30	12.3	11.14	12.7	11.51	12.1	13.60	7.4	14.04	7.5	14.89	6.8	Fill to top of pipe from 12-17
ALT-4A	7.61	8.7	8.92	8.4	9.25	8.6	10.03	9.8	10.75	8.7	10.70	8.9	10.79	8.7	10.92	10.6	12.51	9.3	14.09	7.6	1000' new 995.8
ALT-4B	7.61	8.7	8.92	8.4	9.25	8.6	10.03	9.8	10.29	11.3	10.18	11.6	10.42	11.2	11.73	9.6	12.90	8.8	14.26	7.4	1000' new 998.8
ALT-4C	7.61	8.7	8.92	8.4	9.25	8.6	10.03	9.8	11.04	7.1	11.01	7.3	11.06	7.1	10.67	10.9	12.42	9.4	14.06	7.6	1000' new 992.8
ALT-5A	7.61	8.7	8.92	8.4	9.76	5.5	9.67	7.9	9.80	8.3	9.76	8.5	9.84	8.4	10.62	5.9	10.24	13.3	13.97	7.7	Channel 9(995.0) thru 17(995.0)
ALT-5B	7.61	8.7	8.92	8.4	9.76	5.5	9.58	8.5	9.71	9.4	9.65	9.6	9.76	9.5	10.78	7.0	10.24	13.3	13.97	7.7	Channel 9(992.3) thru 17(997.4)
ALT-6A	7.61	8.7	8.92	8.4	9.25	8.6	10.27	14.1	12.11	12.2	11.92	12.6	10.81	12.3	14.31	7.5	14.81	7.1	15.50	6.3	Fill to top of pipe from 12-17
ALT-7A	7.61	8.7	8.92	8.4	9.20	9.0	9.80	12.0	10.33	12.8	10.2	13.1	10.49	12.7	12.05	10.7	13.71	8.2	14.79	6.9	700' new(99.58
ALT-7B	7.61	8.7	8.92	8.4	9.22	8.8	9.92	11.1	10.51	11.1	10.43	11.3	10.61	11.0	11.36	10.9	13.08	8.8	14.39	7.3	800' new(995.8
ALT-7C	7.61	8.7	8.92	8.4	9.62	7.0	9.89	10.2	10.47	9.9	10.41	10.0	10.53	9.8	11.04	10.3	12.51	9.2	14.06	7.6	900' new 995.8
ALT-7D	7.61	8.7	8.92	8.4	9.32	8.2	10.12	8.7	10.80	7.2	10.76	7.4	10.82	7.2	10.64	10.4	12.18	9.5	13.92	7.7	1200' new 995.8
ALT-7E	7.61	8.7	8.92	8.4	9.34	8.1	10.15	8.4	10.83	6.8	10.80	6.8	10.84	6.7	10.63	9.9	11.94	9.9	13.87	7.8	1300' new 995.8
ALT-7F	7.61	8.7	8.92	8.4	9.40	7.9	10.16	8.2	10.87	6.2	10.85	6.3	10.88	6.2	10.56	9.9	11.93	9.9	13.87	7.8	1400' new 995.8

Lengths of 700 feet thru 1400 feet were simulated in the mathematical model and the results are shown in Table 1. The description of each alternate is shown in Appendix A and the channel bottoms and water surface profiles are shown in Appendix B. The water surface elevation at the bridge varied between elevation 1010.2 and 1010.8, while the velocity varied between 6.3 ft/sec to 13.1 feet per second.

4.3 Selected Bridge

The results of the new bridge alternatives were reviewed by E.M. Plummer Consulting Engineers, Nicholas-Cowie & Associates and the Maricopa County Highway Department. A 1000 foot new bridge was selected with dyking as is shown in Plate 3.

Various channel improvements were simulated in runs 4A-6A for a 1000 foot new bridge. The results of this analysis shows that the water surface elevation will vary between elevation 1009.7 to 1011.9. The velocity varies between 7.3 ft/sec and 12.6 ft/second.

Since the Salt River channel is unstable during peak flow periods, the channel bottom could vary to anyone of these suggested alternates. Channel stabilization with rip rap or grout was determined uneconomical, so the bridge was designed with all these alternate channel improvements being considered.

51ST AVENUE BRIDGE

DYKING FOR 1000' BRIDGE

SCALE: 1" - 420'

PLATE 3

LEGEND

1 — LOCATION OF SECTION 1

FLOOD LIMITS FROM PHOTO *
DEC. 19,1978

FLOOD LIMITS FROM COMPUTER
(SURVEY DATE: AUG. 1979)

DYKING

* NOTE: SOME DISTORTION IN PHOTO

V. Standard Project Storm

The Standard Project Storm for the Salt River near 51st Avenue is 290,000 cfs as determined by the Corps of Engineers. This flow was simulated on the mathematical model, with the dyking upstream and downstream of the bridge washed out, and the road still in place (Alt. 8). The water surface elevation at the bridge was 1013.55 feet and the velocity at the bridge was 16 feet per second.

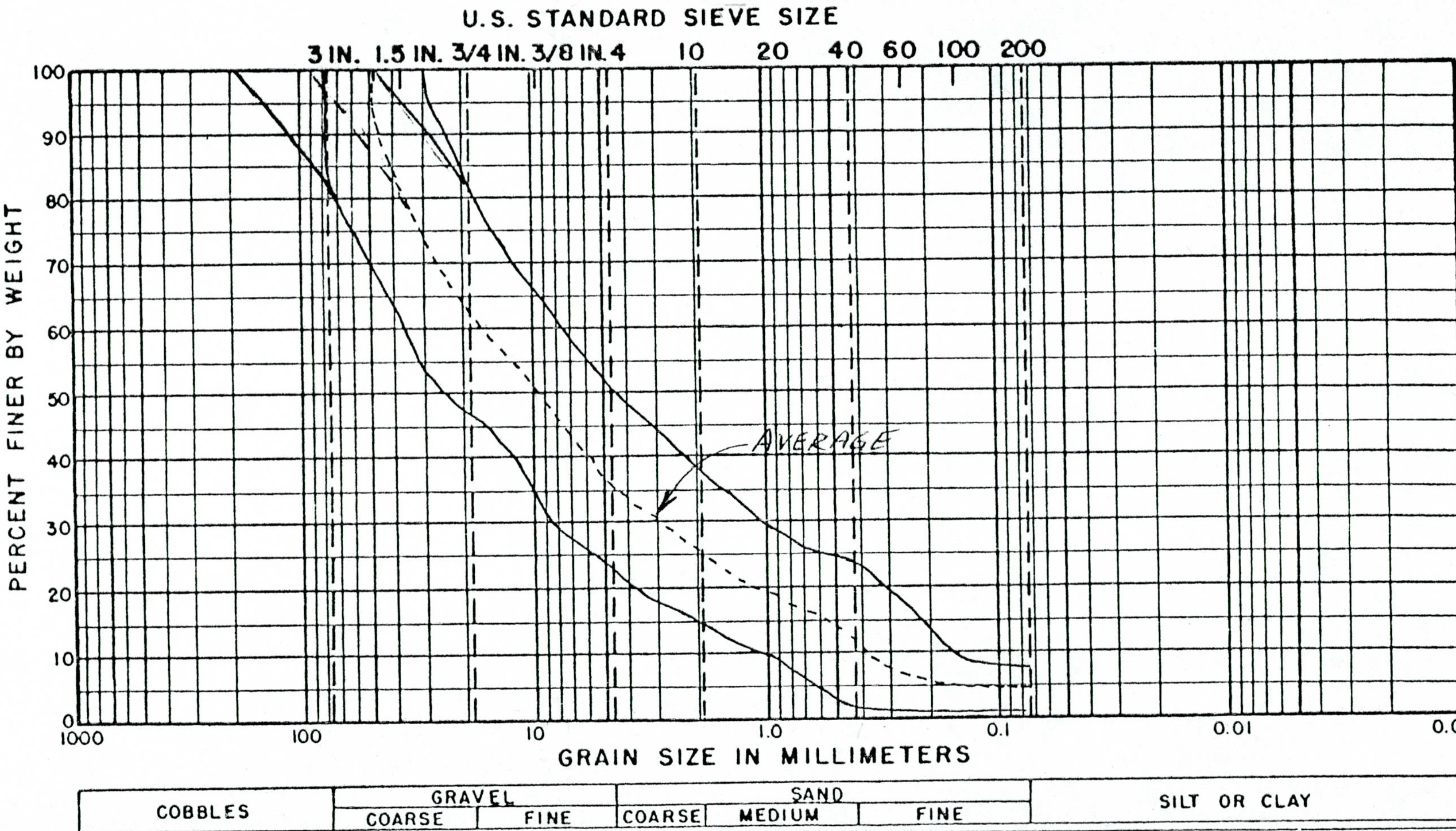
The same conditions were then simulated, but the road was assumed washed out (Alt. 9). The water surface elevation was 1014.2 and the average velocity at the bridge was 10 feet per second.

VI. Scour Analysis

6.1 Bed Material

The bed material sieve analysis was furnished by Nicholas-Cowie & Associates, Inc.. The gradation curve for this bridge site is shown in figure 1. The dashed line represents the average gradation curve for the samples tested and the solid lines represent the range. Testing was performed with a percussion drill which breaks up large boulders. Therefore, there was a modification at the upper end of the gradation curve.

The Hazen uniformity coefficient was $Cu = \frac{D_{60}}{D_{10}} = \frac{18}{.4} = 45$, which indicates a well graded gravel and sand mixture. The sandy gravel contains cobbles up to 100 mm (4 in size). The average diameter at D_{50} on Figure 1 was D_{50} = 10 mm. The mean diameter is $D_m = \sqrt{(max)(min)} = \sqrt{(100)(.1)} = 3.16$ mm.



	DEPTH	CLASSIFICATION		NAT. WC	LL	PL	PI	

— MODIFICATION DUE TO BROKEN COBBLES. THIS IS AN ESTIMATE BASED ON VISUAL JUDGEMENT — [initials]

GW - Sandy Gravel Comp. (B)

GRADATION CURVE

Figure 1

NICHOLAS COWIE & ASSOCIATES

6.2 Scour Depth

Presented in this report is the estimate of the probable scour depth at 51st Avenue for a 1000 foot bridge. The study is based on a velocity of 8.7 ft/sec and water depth at the bridge of 15 feet (Alt. 4A).

A number of researchers have proposed different formulas for estimating scour. The worksheets for these calculations are contained in Appendix C and the results are compiled in Table 2. The reference for these calculations is the manual called Scour at Bridge Waterways by the Highway Research Board.

The formula's give a wide variation in results and the factors used in each vary as shown in Table 2. These estimates were evaluated and correlated with field observations. Field measurements have shown a 15 foot scour hole after the December 1978 flooding, and the peak flow was at 120,000 cfs (Salt River Project letter dated October 3, 1979).

Scour Depth Estimates

Table 2

Method Sensitive to:

Methods	Scour Depth ft	Channel Contraction	Depth of Flow	Slope	Pier Width	Discharge	Bridge Width	Material Size	Velocity
Laursen's Long Contraction	6.8	X	X	X		X	X		
Laursen's Pier & Abutement	6.9		X						
Blench	4.0		X		X	X	X	X	
Breuser	3.5				X				
Chitale	19.4		X						X
Inglis-Poona	10.5		X		X	X	X		
Inglis-Lacey	16.7		X		X	X		X	
Larras	2.8				X				

VII. Summary and Conclusions

This report represents an analysis of hydraulic conditions and an estimate of probable scour related to the proposed bridge and channel improvements at the 51st Avenue Bridge over the Salt River. A mathematic model was utilized to estimate the hydraulic responses of the river subject to different design alternatives.

A 1000 foot bridge has been selected for final design. The channel should be cleaned out to elevation 995.8 within the right of way of the bridge. Dyking should be provided as shown in Plate 3. The dyke profiles are shown in Figure 2 and Figure 3.

The water surface elevation for 130,000 cfs at the bridge is 1011± . The dykes, roadway, and bridge are designed for this flow. Above 130,000 cfs, the south dykes and south roadway will wash out.

The Standard Project Flood of 290,000 cfs was also analyzed with the assumption the south dykes and roadway are washed out. The water surface elevation of 1014± feet was computed in Alternate 9.

The maximum probable scour at the bridge is estimated to be to elevation 980, which agrees with field observations. The

51ST AVENUE BRIDGE
SOUTHEAST DYKE PROFILE

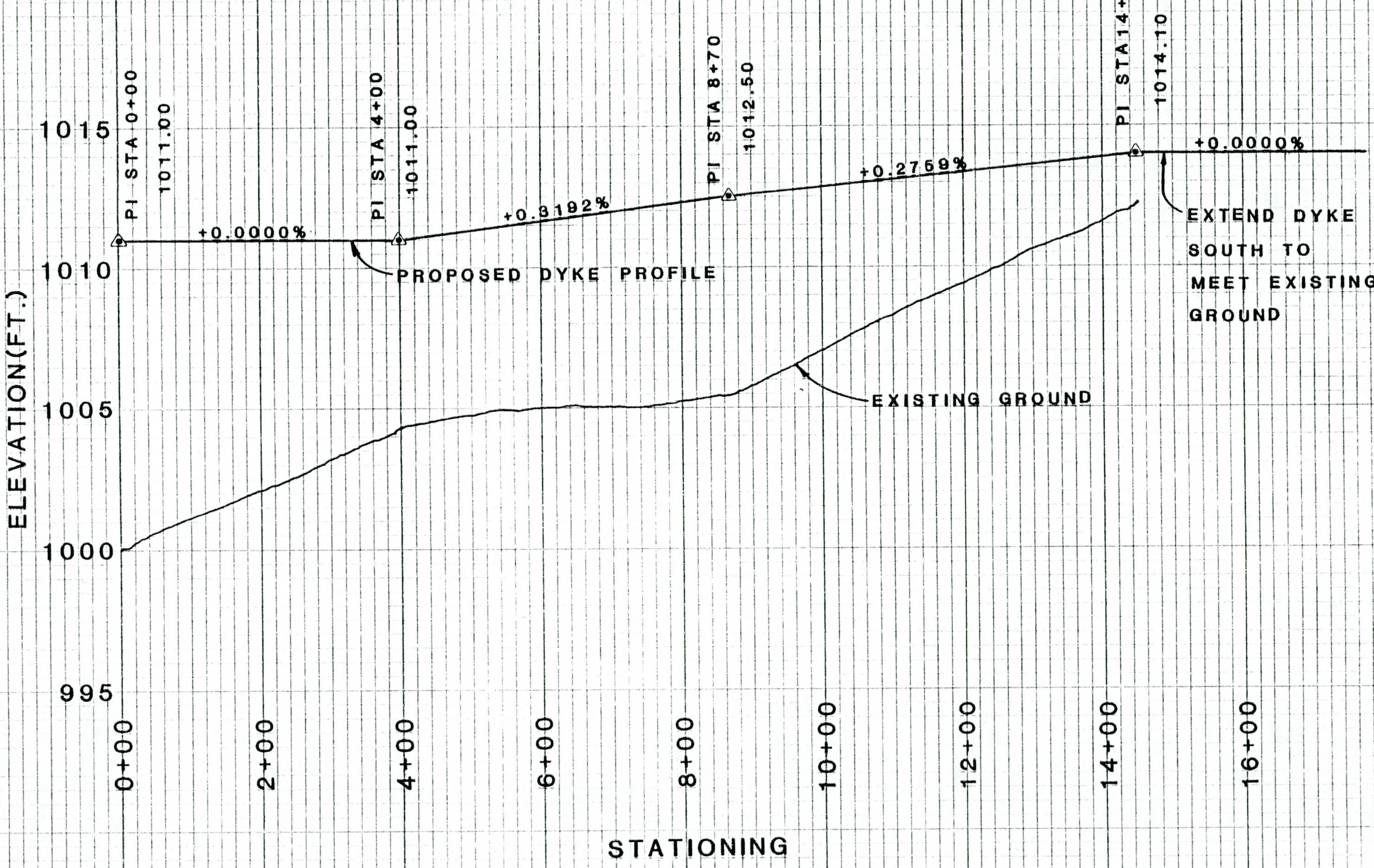


FIGURE 2

51ST AVENUE BRIDGE
SOUTHWEST DYKE PROFILE

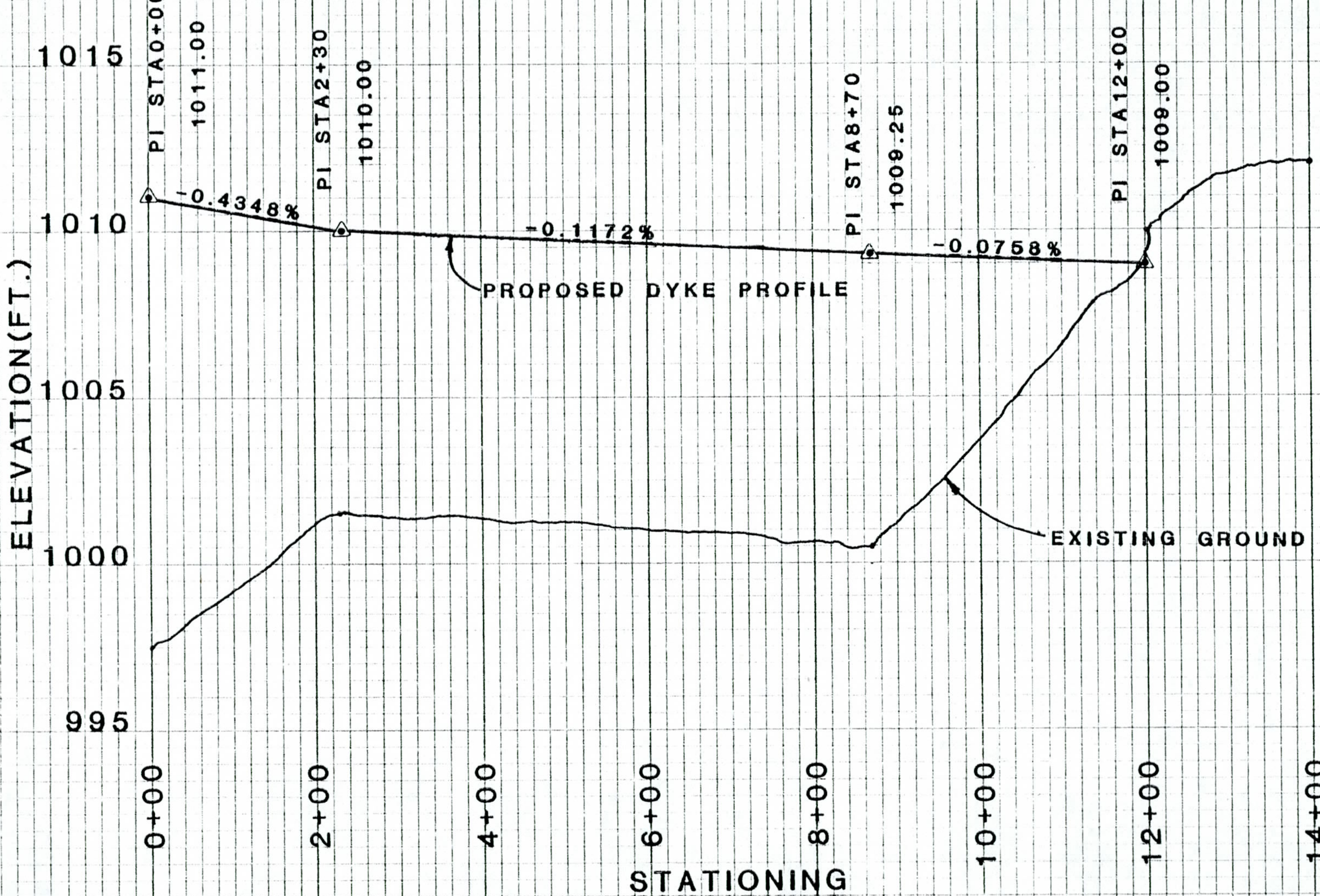


FIGURE 3

scour depth and degradation of the Salt River will be greatly influenced by mining operations upstream and downstream. These effects are impossible to predict because there are no current regulations limiting depth of mining.

APPENDIX A

51st AVENUE BRIDGE

COMPUTER RUNS

Run No.	Parameters Used
CAL-1	Existing cross section (N=.030); Q=100,000 cfs; 110,000 cfs; 120,000 cfs; 130,000 cfs; starting elevation = 997.5.
CAL-2	Existing cross section (N=.035); Q=100,000 cfs; 110,000 cfs; 120,000 cfs; 130,000 cfs; starting elevation = 997.5.
CAL-3	Existing cross section (N=.025); Q=100,000 cfs; 110,000 cfs; 120,000 cfs; 130,000 cfs; starting elevation = 997.5.
CAL-4	Existing cross section (N=.030); Q=100,000 cfs; 110,000 cfs; 120,000 cfs; 130,000 cfs; starting elevation = 996.0.
ALT-1A	900 foot bridge addition to existing 175 foot bridge; channel under bridge cleaned to elevation 995.8; no other channelization; dyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.
ALT-1B	900 foot bridge addition to existing 175 foot bridge; channel under bridge cleaned to elevation 998.8; no other channelization; dyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.
ALT-1C	900 foot bridge addition to existing 175 foot bridge; channel under bridge cleaned to elevation 992.8; no other channelization; dyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.
ALT-2A	900 foot bridge addition to existing 175 foot bridge; channelization from x-section 9 (EL. 992.3) thru x-section 17 (EL. 995.0); dyking from x-section 9 thru X-section 19 on south bank, sanitary sewer not there.

ALT-2B 900 foot bridge addition to existing 175 foot bridge; channelization from x-section 9 (EL. 992.3) thru x-section 17 (EL. 997.4); dyking from x-section 9 thru x-section 19 on south bank; sanitary sewer not there.

ALT-3A 900 foot bridge addition to existing 175 foot bridge; channelization from x-section 12 (EL. 1000.7) thru x-section 17 (EL. 1001.86); dyking from x-section 9 thru x-section 19 on south bank; sanitary sewer in.

ALT-4A 1000 foot new bridge; channel under bridge cleaned to elevation 995.8; no other channelization; dyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.

ALT-4B 1000 foot new bridge; channel under bridge cleaned to elevation 998.8; no other channelization; dyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.

ALT-4C 1000 foot new bridge; channel under bridge cleaned to elevation 992.8; no other channelization; dyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.

ALT-5A 1000 foot new bridge; channelization from x-section 9 (EL. 992.3) thru x-section 17 (EL.995.0); dyking from x-section 9 thru x-section 19 on south bank; sanitary sewer not there.

ALT-5B 1000 foot new bridge; channelization from x-section 9 (EL. 992.3) thru x-section 17 (997.4); dyking from x-section 9 thru x-section 19 on south bank; sanitary sewer not there.

ALT-6A 1000 foot new bridge; channelization from x-section 12 (EL. 1000.7) thru x-section 17 (EL.1001.86); dyking from x-section 9 thru x-section 19 on south bank; sanitary sewer in.

ALT-7A 700 foot new bridge; channel under bridge cleaned to elevation 995.8; no other channelization; dyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.

ALT-7B 800 foot new bridge; channel under bridge cleaned to elevation 995.8; no other channelization; dyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.

ALT-7C 900 foot new bridge; channel under bridge cleaned to elevation 995.8; no other channelization; dyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.

ALT-7D 1200 foot new bridge; channel under bridge cleaned to elevation 995.8; no other channelization; dyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.

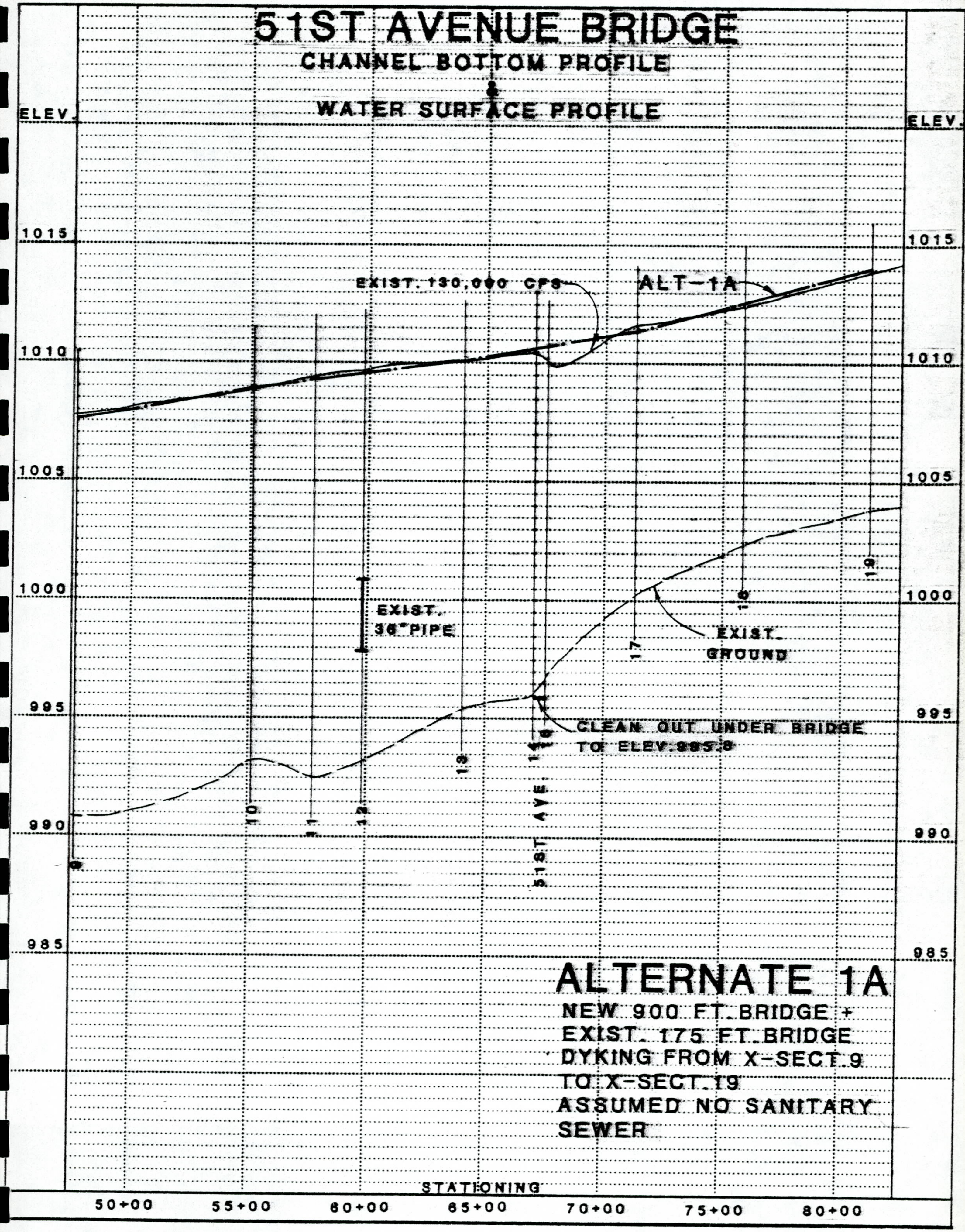
ALT-7E 1300 foot new bridge; channel under bridge cleaned to elevation 995.8; no other channelization; kyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.

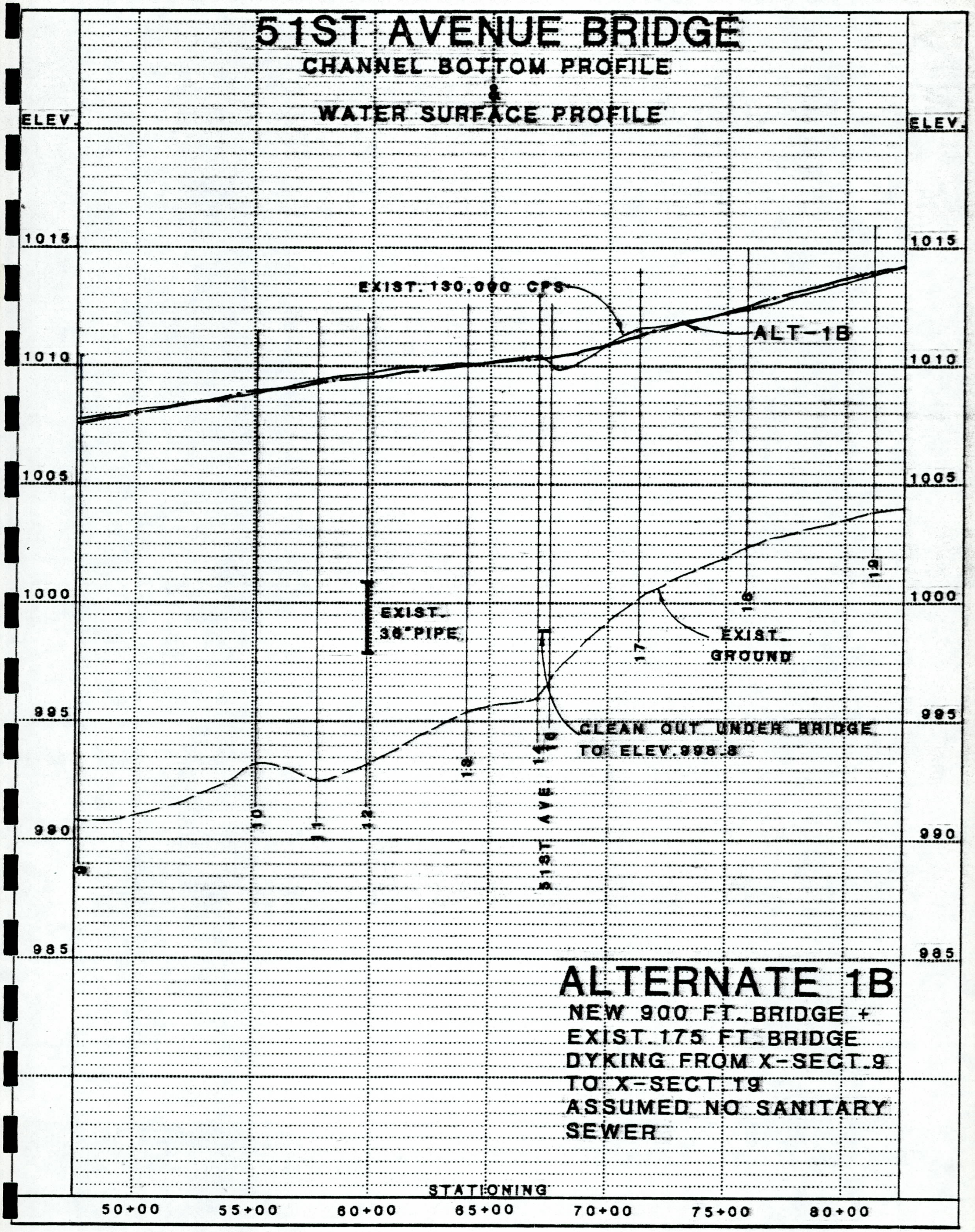
ALT-7F 1400 foot new bridge; channel under bridge cleaned to elevation 995.8; no other channelization; dyking from cross section 9 thru cross section 19 on south bank; sanitary sewer not there.

ALT-8 1000 foot new bridge; dykes washed out but road still in place; channel cleaned out to elevation 995.8; 290,000 cfs for standard project flood.

ALT-9 1000 foot new bridge; dykes and road washed out; channel cleaned out to elevation 995.8; standard project flood of 290,000 cfs.

APPENDIX B


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT-1A
EXIST.
36" PIPE
EXIST.
GROUND
CLEAN OUT UNDER BRIDGE
TO ELEV. 995.8
51ST AVE.
10
11
12
13
14
16
17
19
ALTERNATE 1A
NEW 900 FT. BRIDGE +
EXIST. 175 FT. BRIDGE
DYKING FROM X-SECT. 9
TO X-SECT. 19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CPS
ALT-1B
EXIST. 36" PIPE
EXIST. GROUND
CLEAN OUT UNDER BRIDGE TO ELEV. 998.8
51ST AVE.
9
10
11
12
13
14
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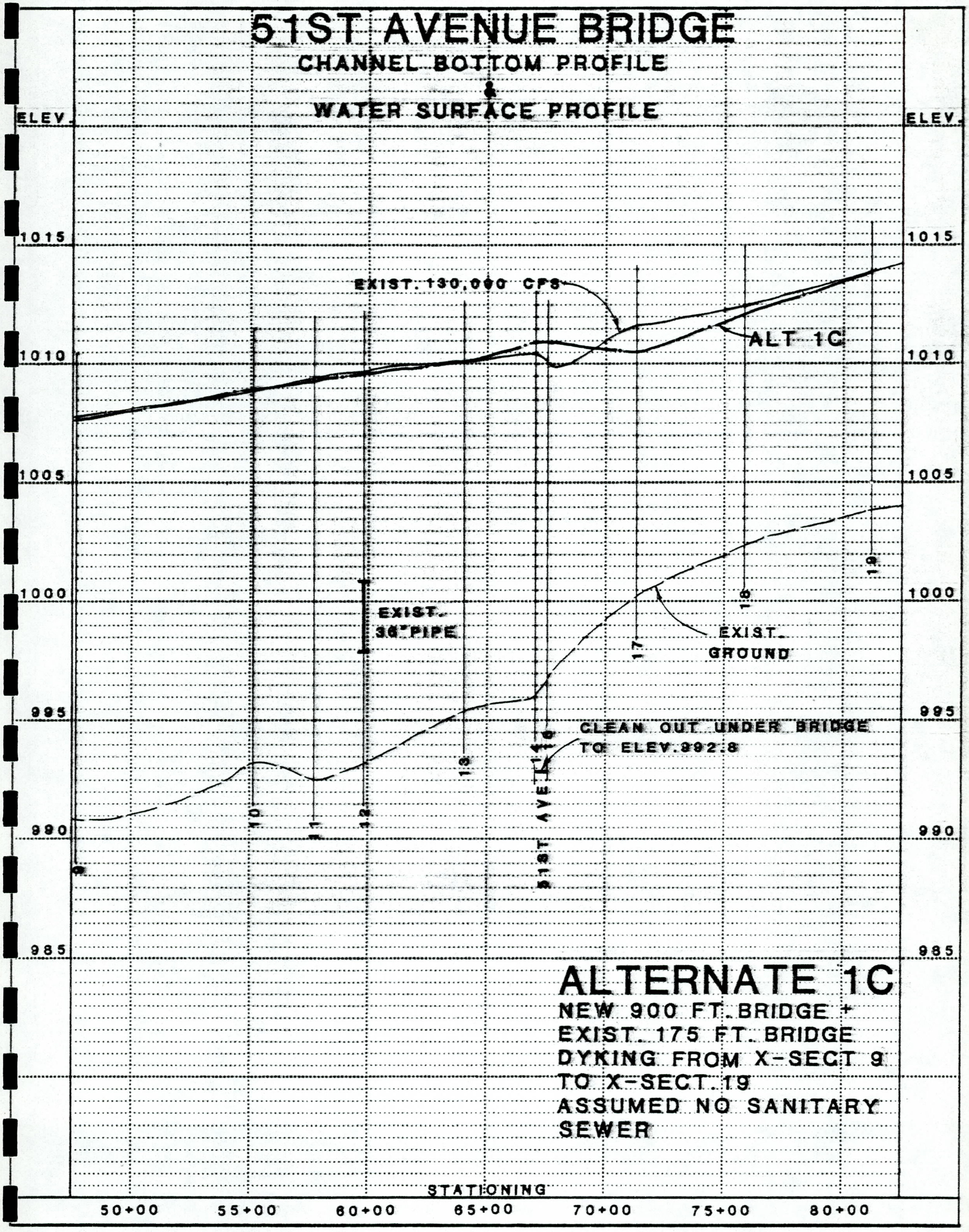
17
18
19
ALTERNATE 1B
NEW 900 FT. BRIDGE +
EXIST. 175 FT. BRIDGE
DYKING FROM X-SECT. 9
TO X-SECT. 19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00



51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT 1C
EXIST.
36" PIPE
EXIST.
GROUND
CLEAN OUT UNDER BRIDGE
TO ELEV. 992.8
51ST AVE
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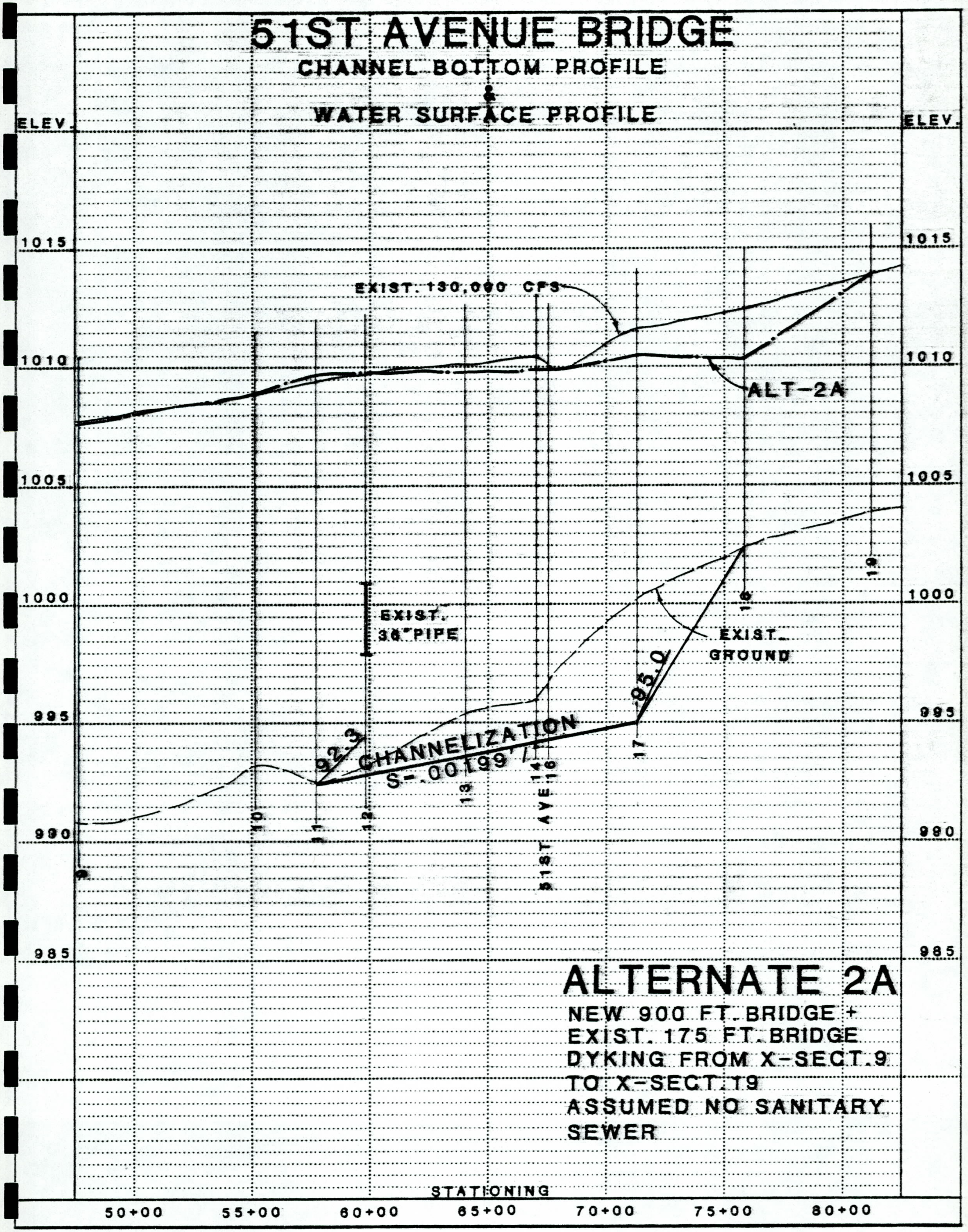
ALTERNATE 1C
NEW 900 FT. BRIDGE +
EXIST. 175 FT. BRIDGE
DYKING FROM X-SECT 9
TO X-SECT 19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT-2A
EXIST.
36" PIPE
EXIST.
GROUND
95.0
92.3
CHANNELIZATION
S=.00199'/'
9
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12
13
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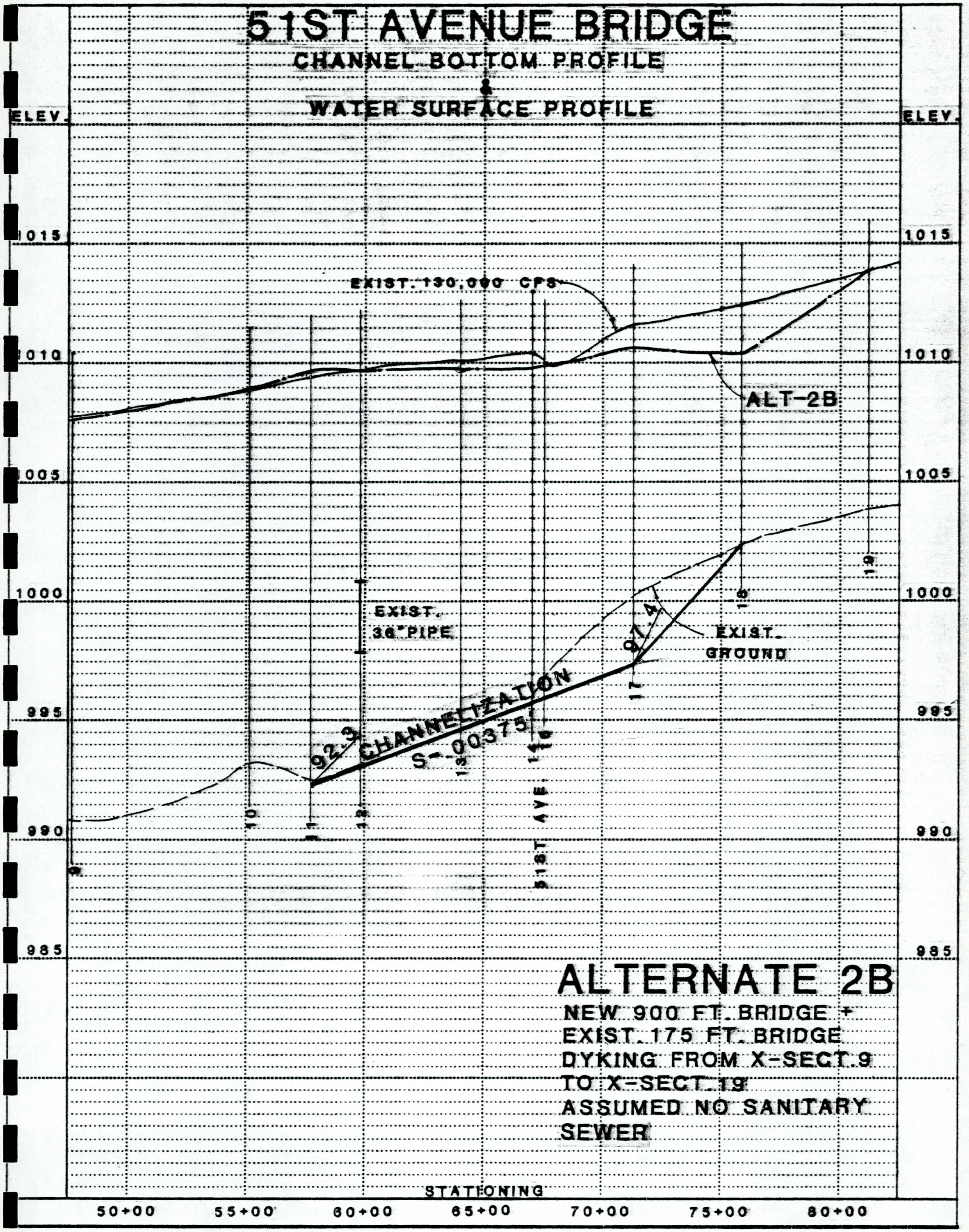
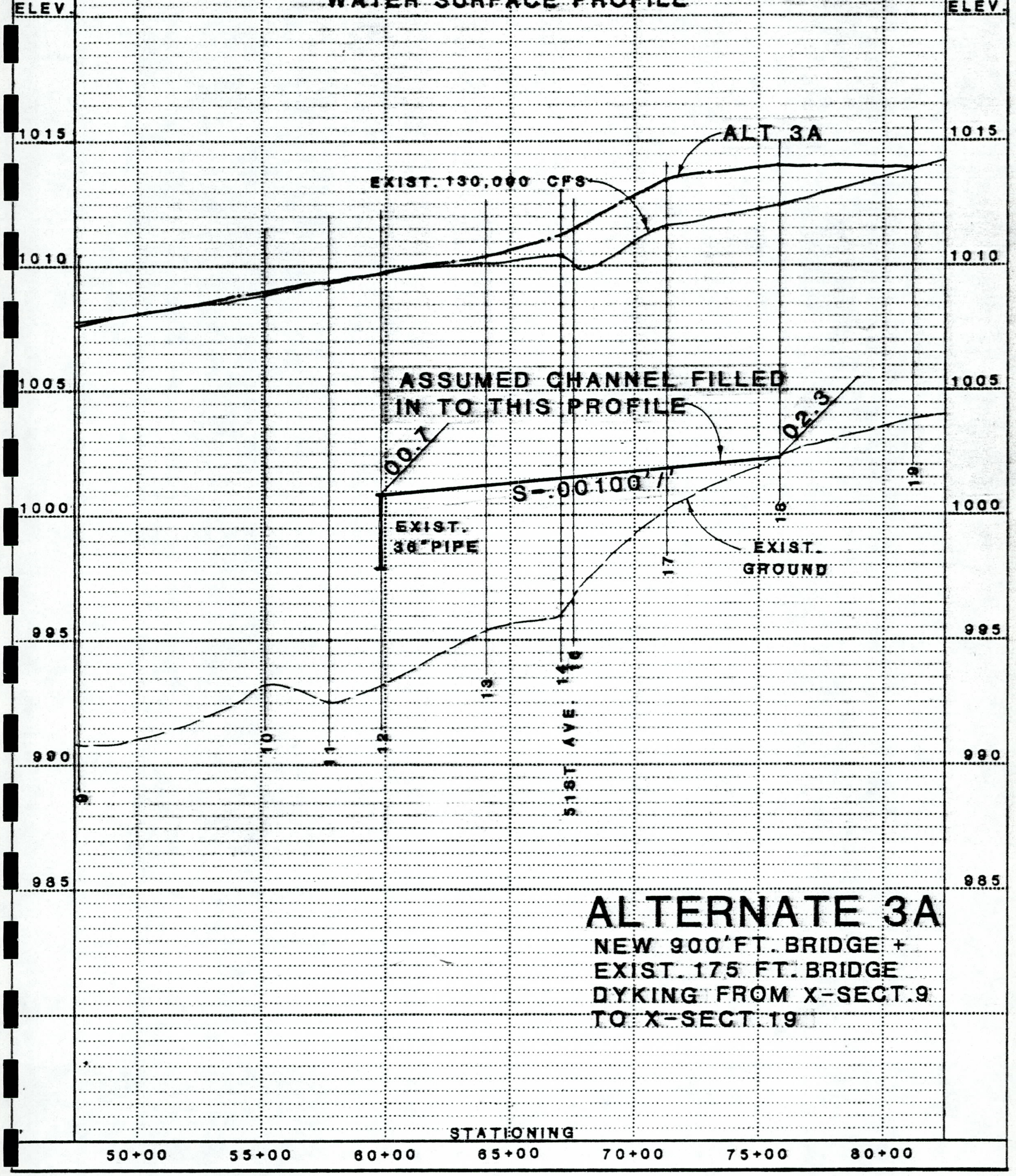
16
17
18
19
51ST AVE
ALTERNATE 2A
NEW 900 FT. BRIDGE +
EXIST. 175 FT. BRIDGE
DYKING FROM X-SECT. 9
TO X-SECT. 19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT-2B
EXIST.
36" PIPE
EXIST.
GROUND
CHANNELIZATION
S=.00375
92.3
97.4
51ST AVE.
9
10
11
12
13
14
16
17
18
19
ALTERNATE 2B
NEW 900 FT. BRIDGE +
EXIST. 175 FT. BRIDGE
DYKING FROM X-SECT. 9
TO X-SECT. 19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00

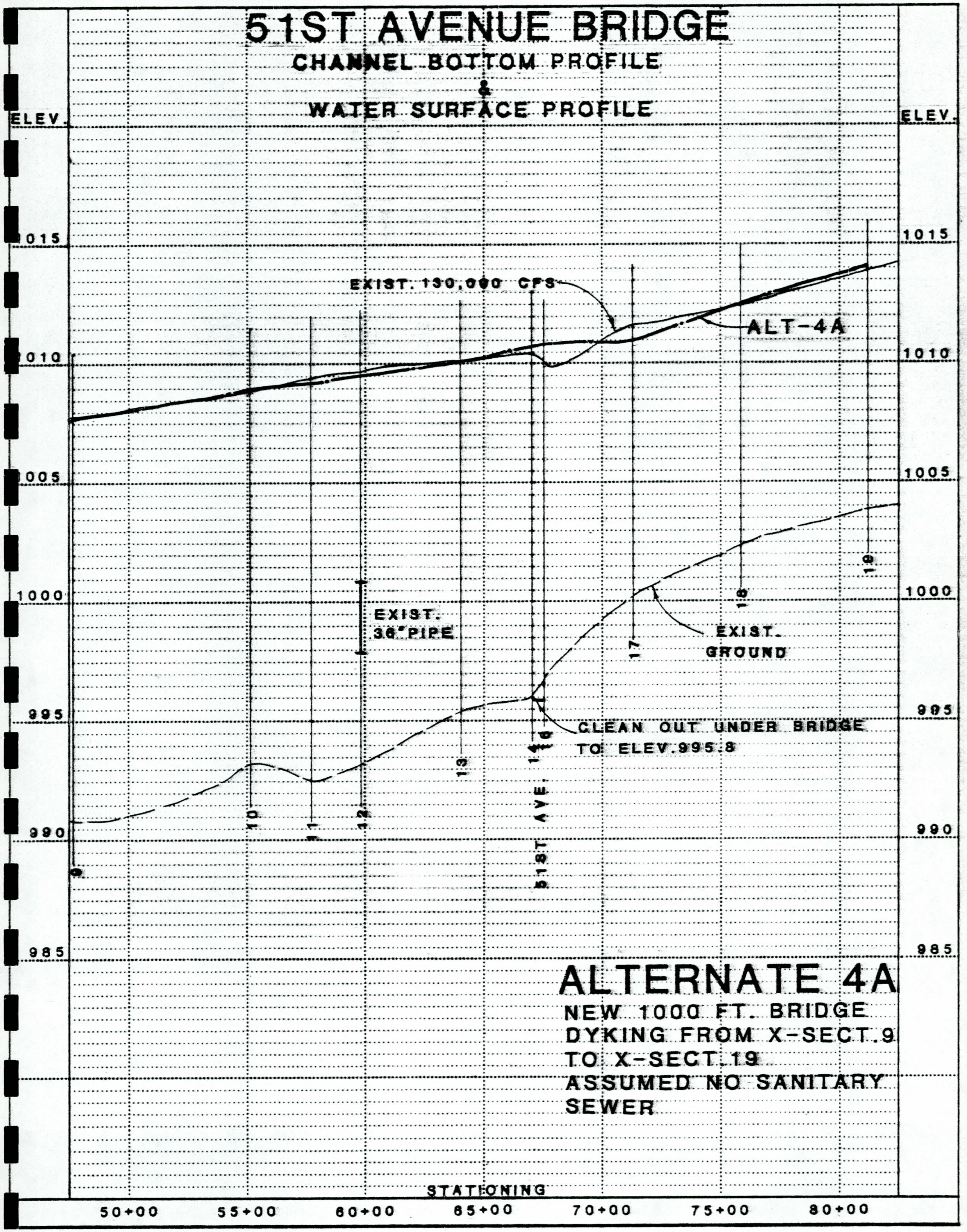
51ST AVENUE BRIDGE

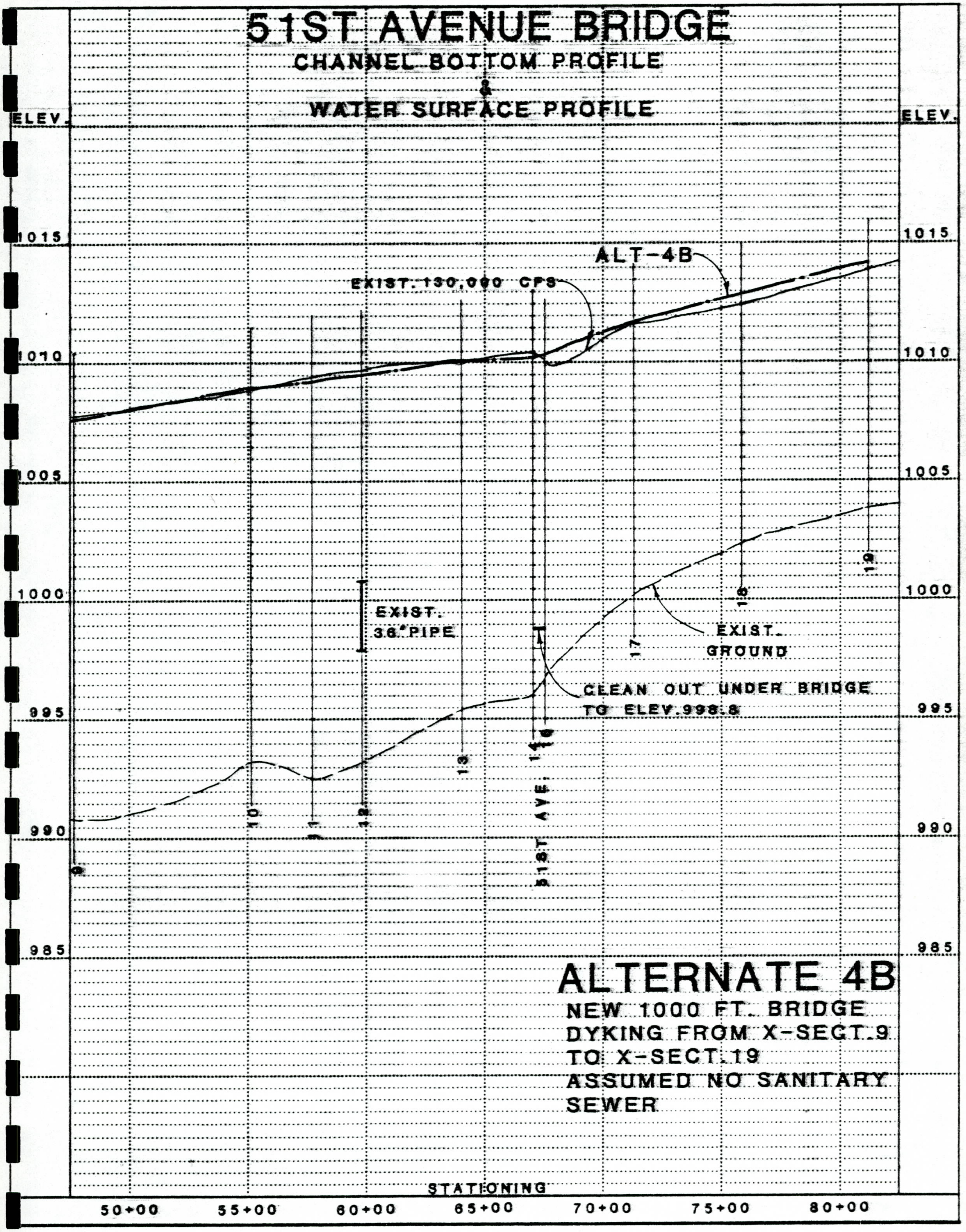
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE

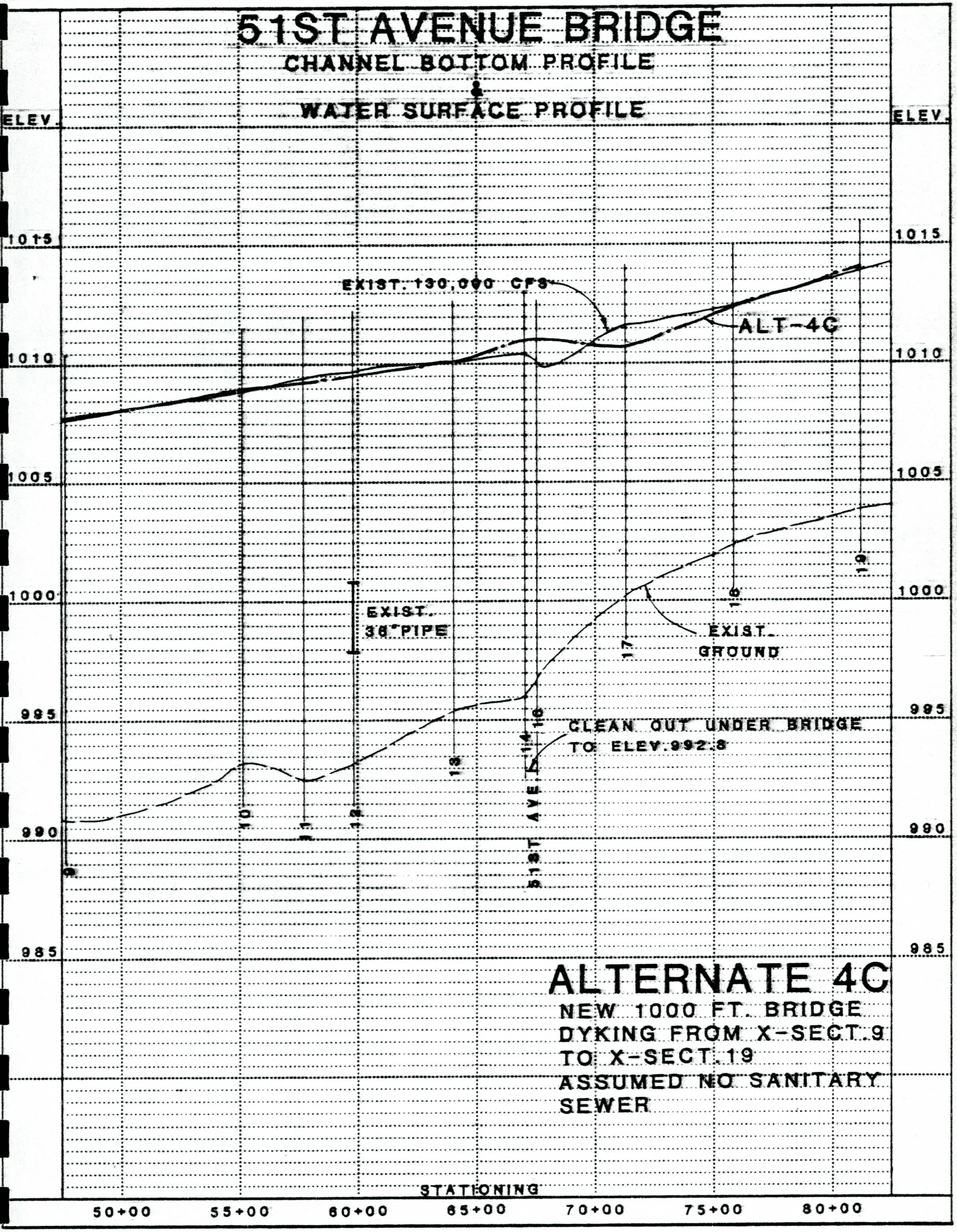


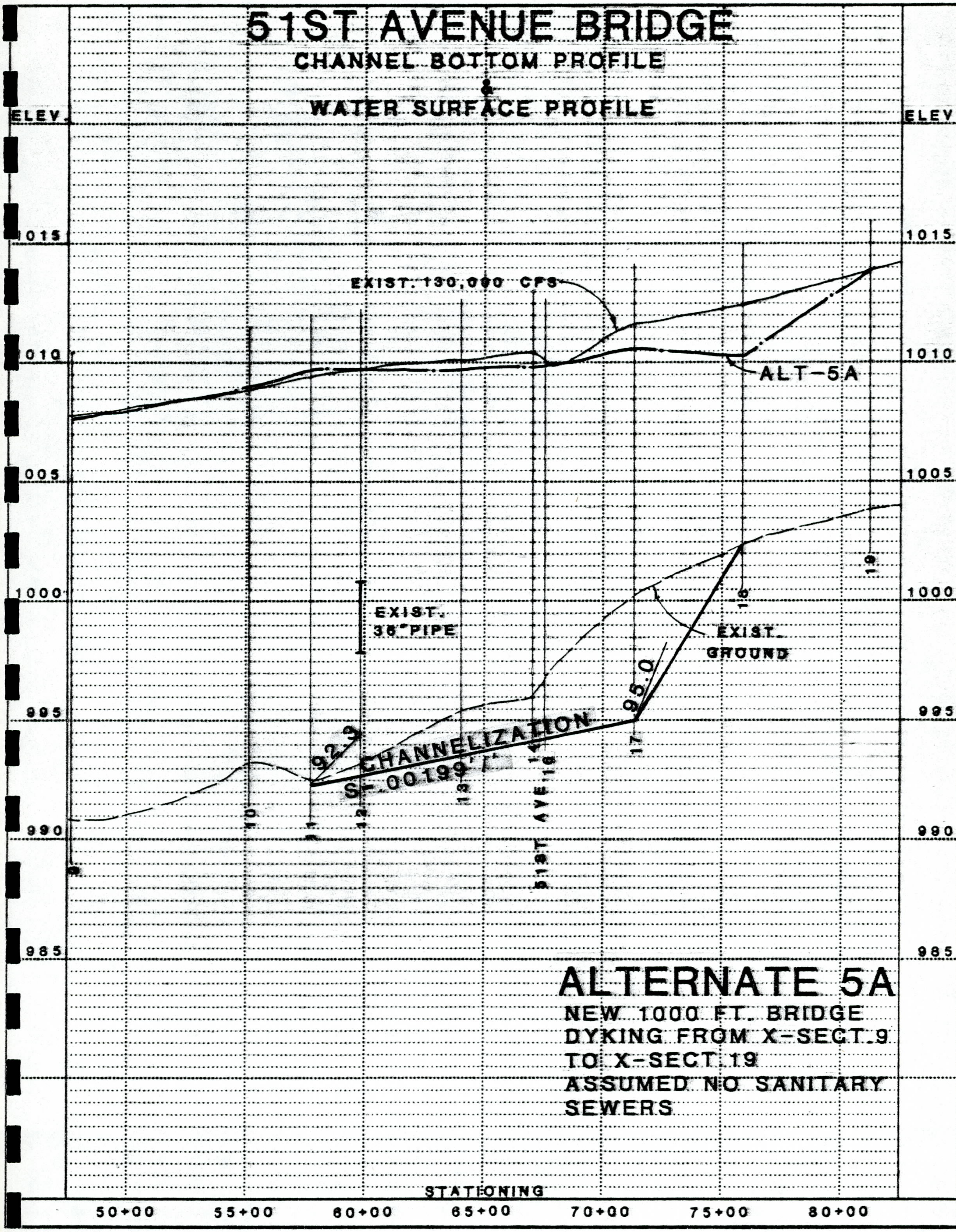
ALTERNATE 3A

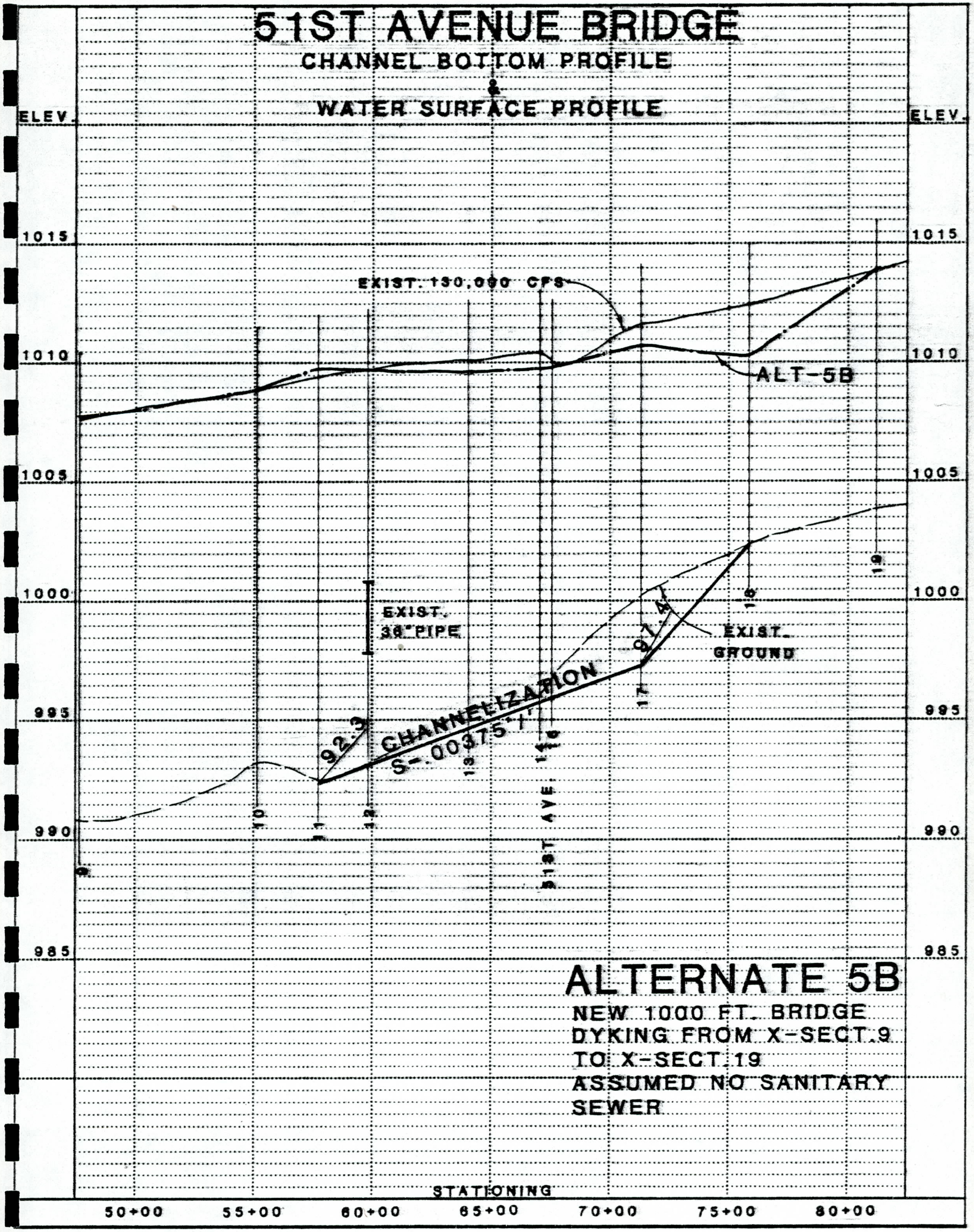
NEW 900' FT. BRIDGE +
EXIST. 175 FT. BRIDGE
DYKING FROM X-SECT. 9
TO X-SECT. 19


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT-4A
EXIST.
36" PIPE
EXIST.
GROUND
CLEAN OUT UNDER BRIDGE
TO ELEV. 995.8
51ST AVE.
9
10
11
12
13
14
17
18
19
ALTERNATE 4A
NEW 1000 FT. BRIDGE
DYKING FROM X-SECT. 9
TO X-SECT. 19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
ELEV.
1015
1010
1005
1000
995
990
985
ALT-4B
EXIST. 130,000 CFS
EXIST. 36" PIPE
EXIST. GROUND
CLEAN OUT UNDER BRIDGE TO ELEV. 998.8
51ST AVE.
9
10
11
12
13
14
17
18
19
ALTERNATE 4B
NEW 1000 FT. BRIDGE
DYKING FROM X-SECT. 9
TO X-SECT. 19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT-4C
EXIST. 36" PIPE
EXIST. GROUND
CLEAN OUT UNDER BRIDGE TO ELEV. 992.8
9
10
11
12
13
14
16
17
18
19
51ST AVE.
ALTERNATE 4C
NEW 1000 FT. BRIDGE
DYKING FROM X-SECT. 9
TO X-SECT. 19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT-5A
EXIST.
36" PIPE
EXIST.
GROUND
95.0
92.3
CHANNELIZATION
S=.00199'/'
9
10
11
12
13
14
51ST AVE.
16
17
18
19
ALTERNATE 5A
NEW 1000 FT. BRIDGE
DYKING FROM X-SECT. 9
TO X-SECT. 19
ASSUMED NO SANITARY
SEWERS
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00



51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT-5B
EXIST. 36" PIPE
EXIST. GROUND
CHANNELIZATION
S=.00375'/'
92.3
91.4
51ST AVE.
9
10
11
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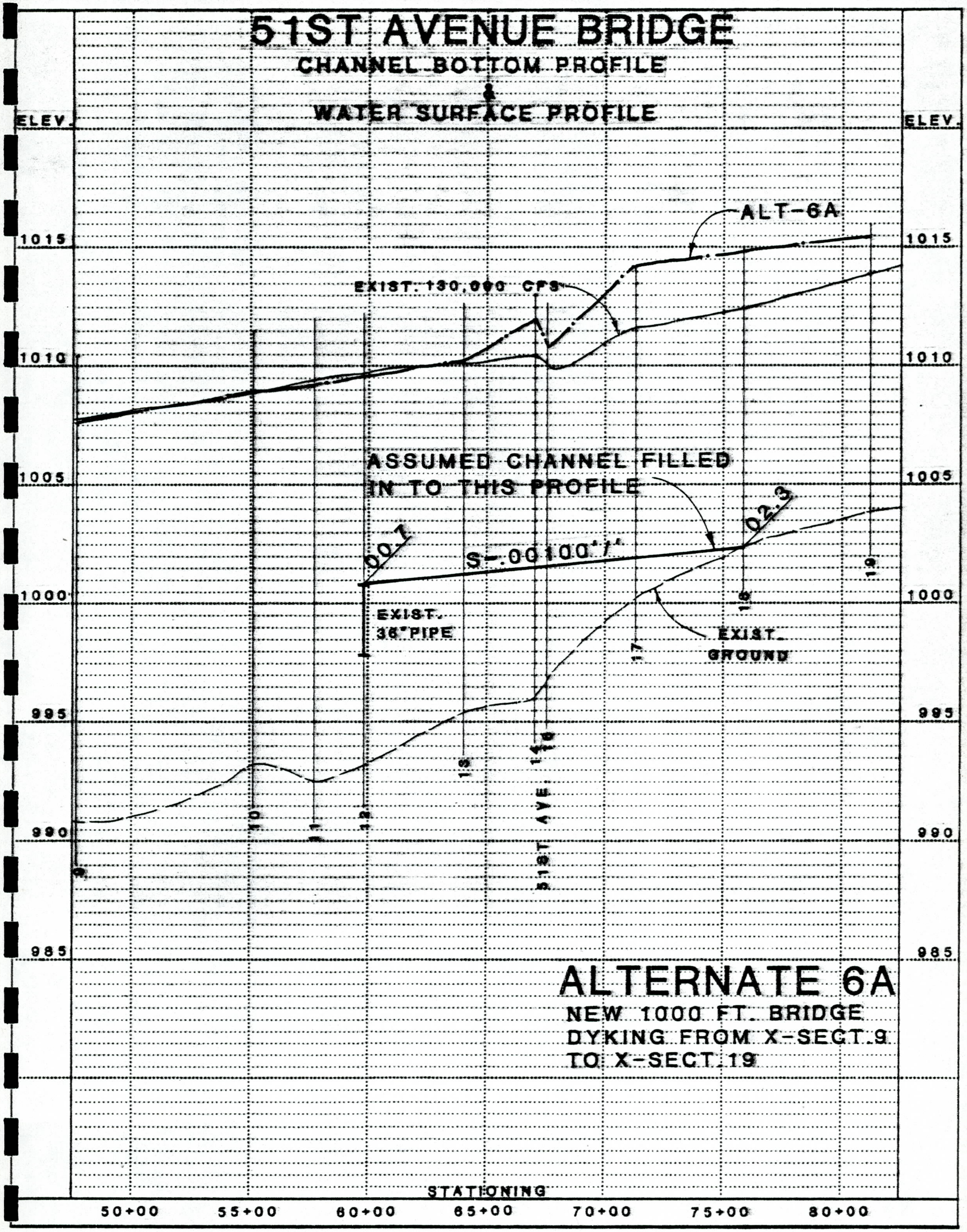
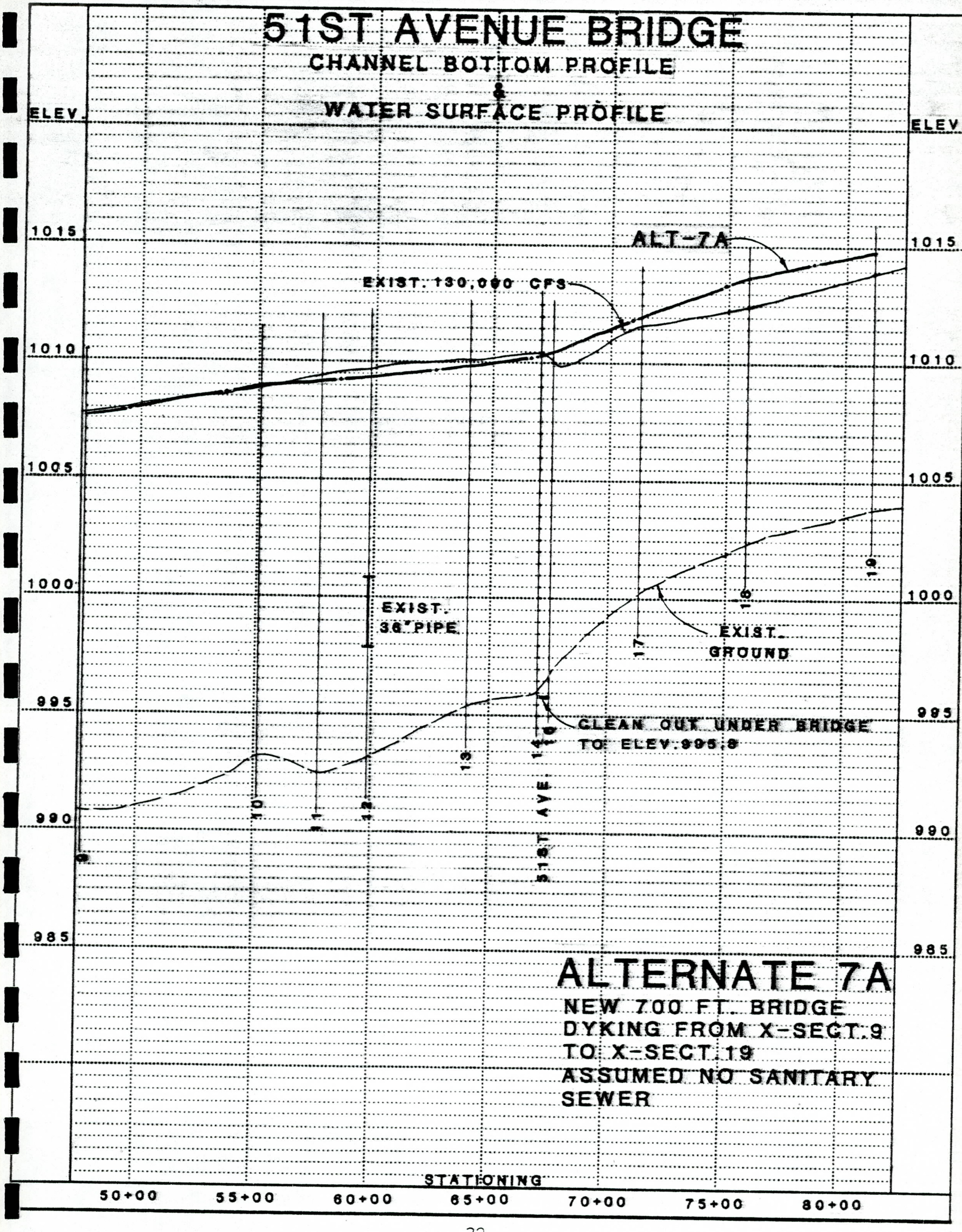
14
16
17
18
19
ALTERNATE 5B
NEW 1000 FT. BRIDGE
DYKING FROM X-SECT. 9
TO X-SECT. 19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
ELEV.
ALT-6A
EXIST. 130,000 CFS
ASSUMED CHANNEL FILLED IN TO THIS PROFILE
S=.00100'/'
00.7
02.3
EXIST. 36" PIPE
EXIST. GROUND
51ST AVE.
ALTERNATE 6A
NEW 1000 FT. BRIDGE
DYKING FROM X-SECT.9 TO X-SECT.19
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00
1015
1010
1005
1000
995
990
985



51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
1015
1010
1005
1000
995
990
985
ALT-7A
EXIST. 130,000 CFS
EXIST. 36" PIPE
EXIST. GROUND
CLEAN OUT UNDER BRIDGE TO ELEV.995.8
9
10
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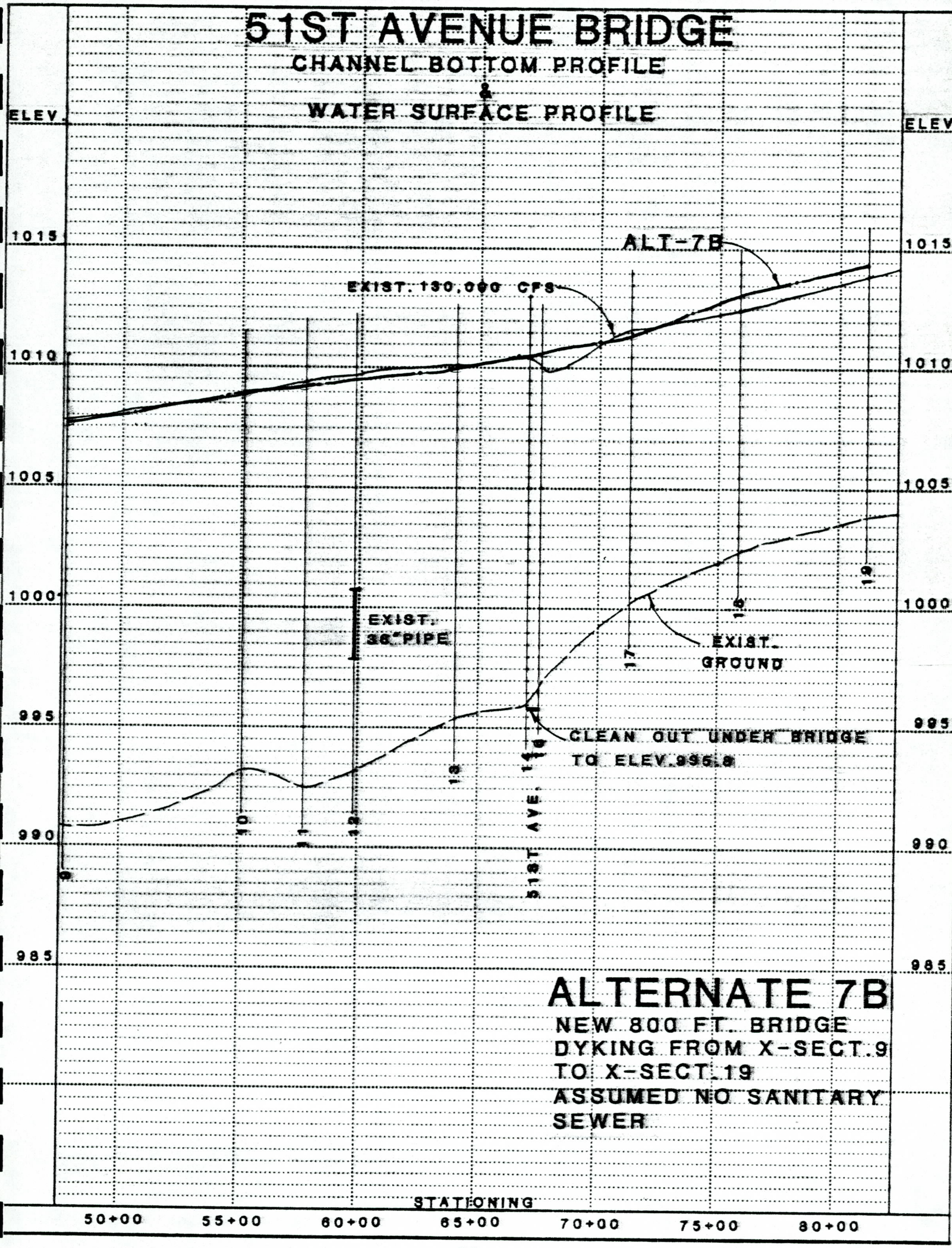
14
15
17
18
19
51ST AVE.
ALTERNATE 7A
NEW 700 FT. BRIDGE
DYKING FROM X-SECT.9
TO X-SECT.19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00



51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
ELEV.
1015
1010
1005
1000
995
990
985
ALT-7B
EXIST. 130,000 CFS
EXIST.
36" PIPE
EXIST.
GROUND
CLEAN OUT UNDER BRIDGE
TO ELEV.995.8
51ST. AVE.
9
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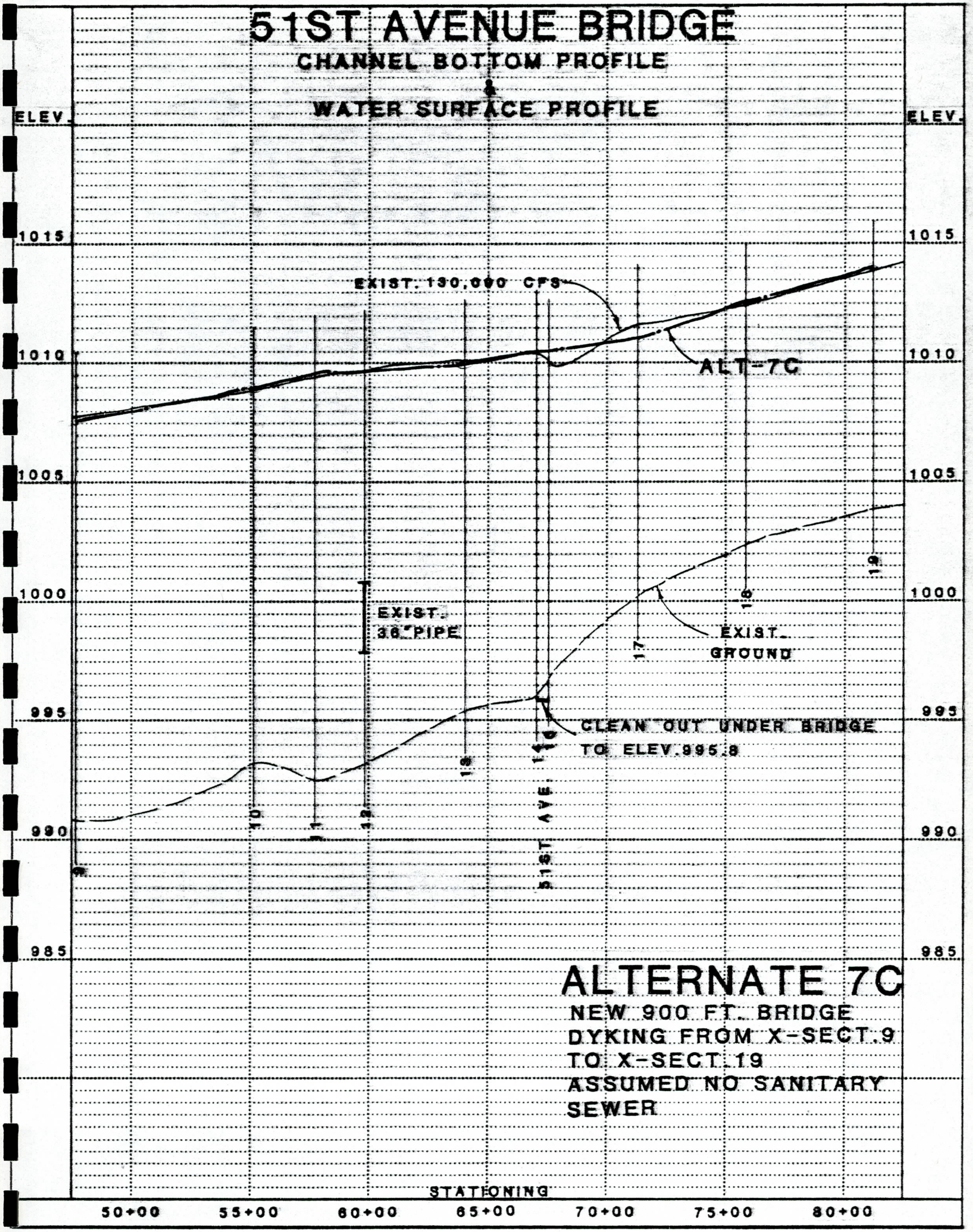
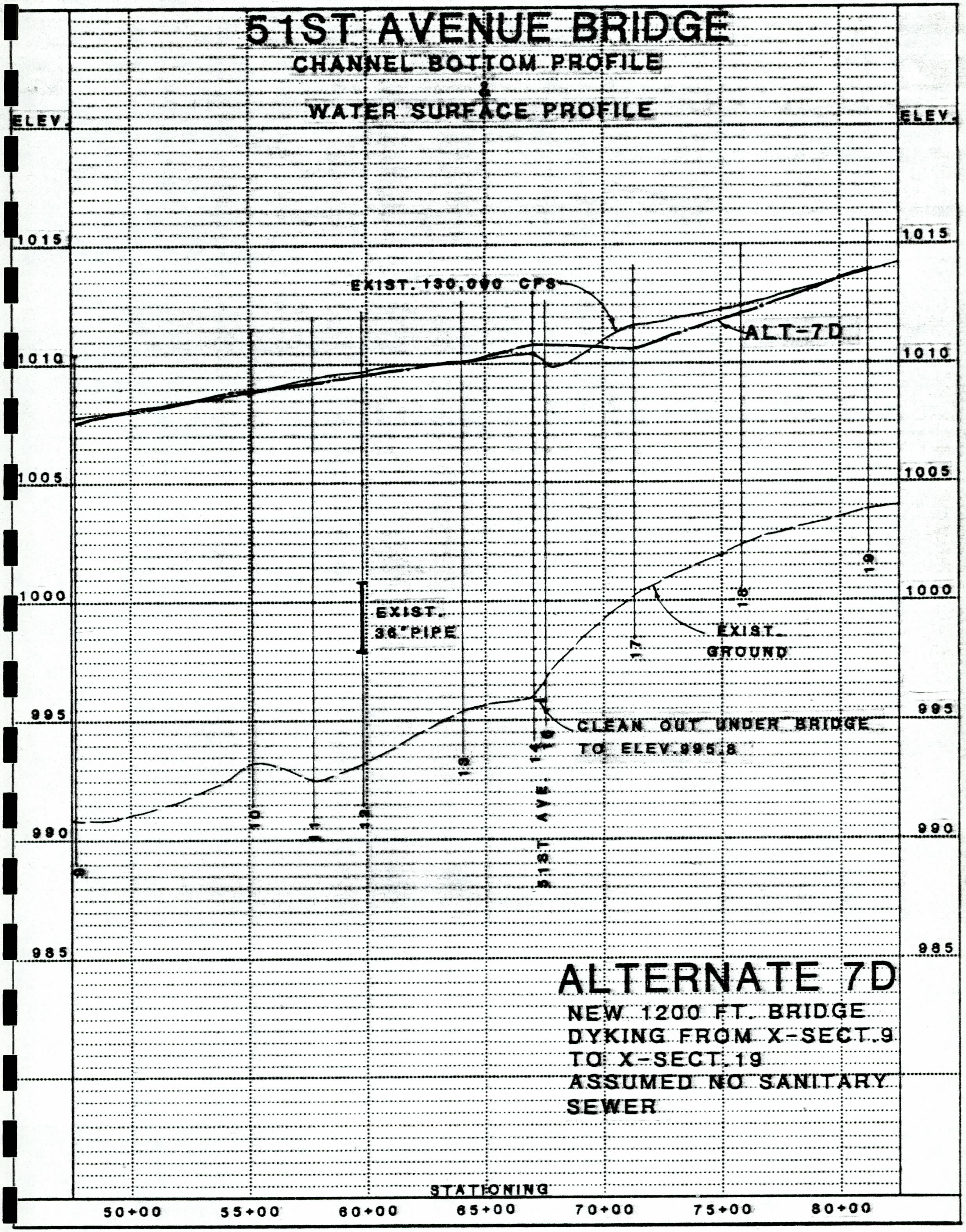
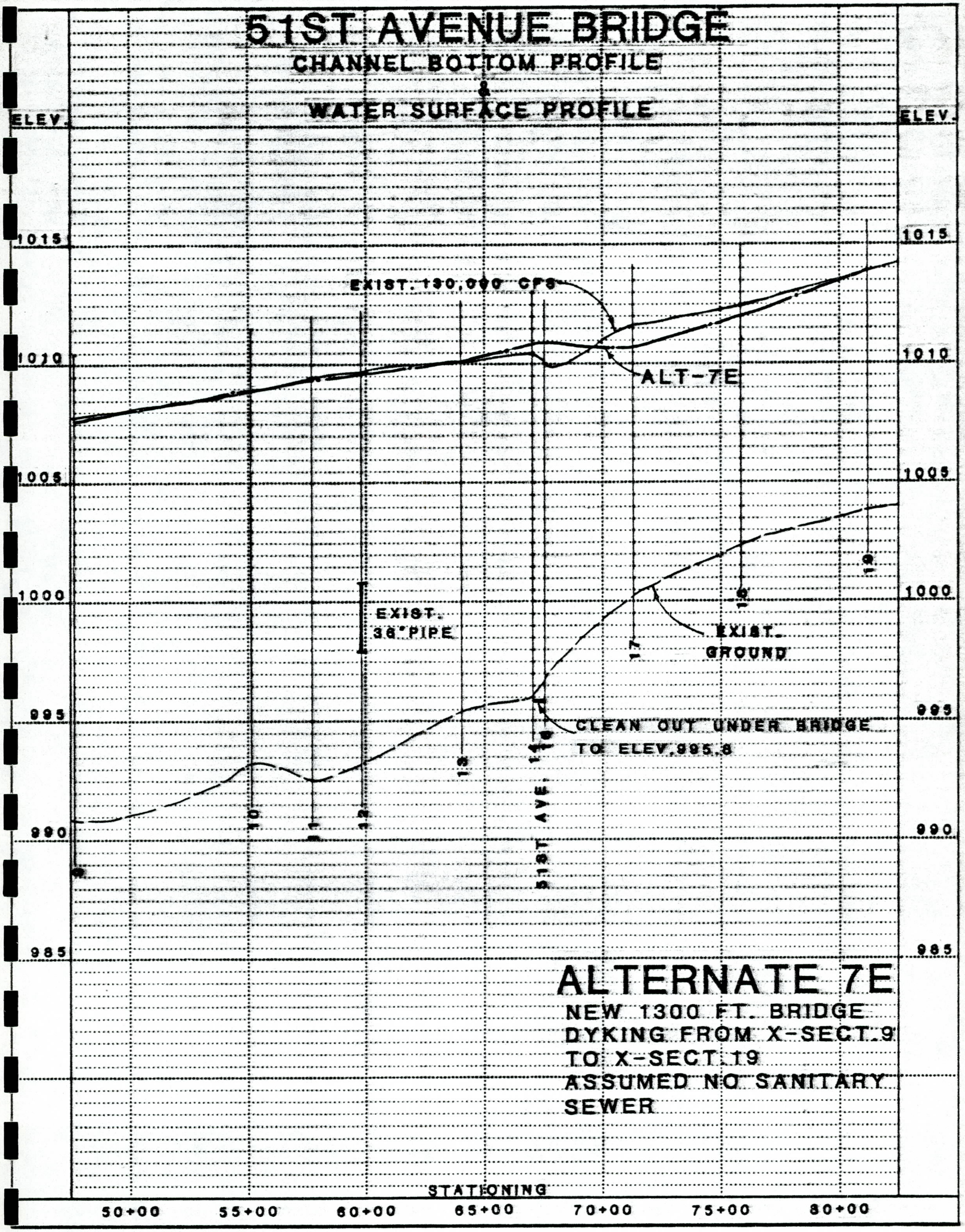
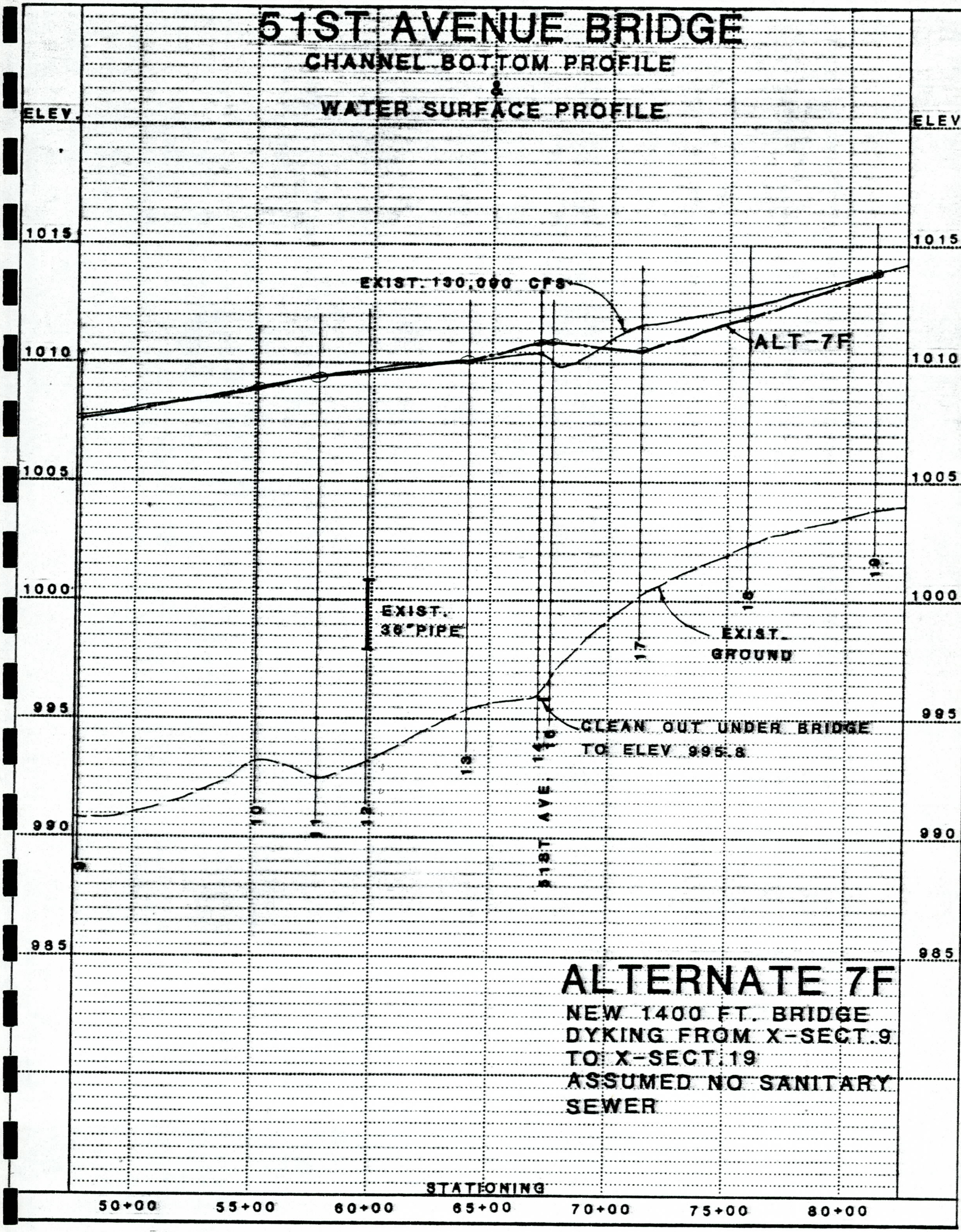
13
14
16
17
18
19
ALTERNATE 7B
NEW 800 FT. BRIDGE
DYKING FROM X-SECT.9
TO X-SECT.19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00



51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT-7C
EXIST.
36"PIPE
EXIST.
GROUND
CLEAN OUT UNDER BRIDGE
TO ELEV.995.8
51ST AVE.
9
10
11
12
13
14
16
17
18
19
ALTERNATE 7C
NEW 900 FT. BRIDGE
DYKING FROM X-SECT.9
TO X-SECT.19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT-7D
EXIST.
36" PIPE
EXIST.
GROUND
CLEAN OUT UNDER BRIDGE
TO ELEV.995.8
51ST AVE.
9
10
11
12
13
14
16
17
18
19
ALTERNATE 7D
NEW 1200 FT. BRIDGE
DYKING FROM X-SECT.9
TO X-SECT.19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT-7E
EXIST.
36" PIPE
EXIST.
GROUND
CLEAN OUT UNDER BRIDGE
TO ELEV.995.8
9
10
11
12
13
14
51ST AVE.
17
18
19
ALTERNATE 7E
NEW 1300 FT. BRIDGE
DYKING FROM X-SECT.9
TO X-SECT.19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00


51ST AVENUE BRIDGE
CHANNEL BOTTOM PROFILE
&
WATER SURFACE PROFILE
ELEV.
ELEV.
1015
1010
1005
1000
995
990
985
EXIST. 130,000 CFS
ALT-7F
EXIST. 36" PIPE
EXIST. GROUND
CLEAN OUT UNDER BRIDGE TO ELEV 995.8
9
10
11
12
13
14
16
17
18
19
51ST AVE.
ALTERNATE 7F
NEW 1400 FT. BRIDGE
DYKING FROM X-SECT.9
TO X-SECT.19
ASSUMED NO SANITARY
SEWER
STATIONING
50+00
55+00
60+00
65+00
70+00
75+00
80+00

APPENDIX C

INGLIS - POONA

$$\frac{D_s}{b} = 1.7\left(\frac{q^{.66}}{b}\right)^{.78}$$

Where: D_s = depth of scour from water surface
q = average discharge intensity
b = width of pier

Solution

$$q = \frac{130{,}000}{1000} = 130 \frac{ft^3/sec}{ft}$$

$$D_s = 2.5(1.7)\left(\frac{130^{.66}}{2.5}\right)^{.78}$$

$$D_s = 25.5'$$

$$d_s = D_s - d = 25.5' - 15 = \underline{\underline{10.5'}}$$

INGLIS - LACEY

$$D_s = .946\,(Q/f)^{.33}$$

Where: D_s = depth of scour from water surface
Q = DISCHARGE cfs
$f = 1.76\sqrt{d_{mm}}$

Solution:

$$f = 1.76\sqrt{3.16} = 3.12$$

$$D_s = .946\left(\frac{130{,}000}{3.12}\right)^{.33} = 31.65$$

$$d_s = D_s - d = 31.65 - 15 = \underline{\underline{16.65'}}$$

Scour Analysis

LAURSEN'S LONG CONTRACTION

Equation C-2, pg 32

$$\frac{Y^2}{Y_1} = \frac{d_s}{Y_1} + 1 = \left(\frac{Q_T}{Q_c}\right)^{6/7} \left(\frac{B_1}{B_2}\right)^{\frac{6(2+a)}{7(3+a)}} \left(\frac{n_2}{n_1}\right)^{\frac{6(a)}{7(3+a)}} \rightarrow 1$$

Given: $Q_T = 130{,}000$ cfs $\quad B_1 = 2400$ Ft $\quad y_1 = 9$ Ft

$Q_c = 130{,}000$ cfs $\quad B_2 = 1000$ Ft

Solution: Find a:

$$\frac{\sqrt{gyS}}{w} = \frac{\sqrt{32.2(15)(.0027)}}{1.1} = .71$$

$\therefore a = 1$

Find ds:

$$d_s = 9\left[\left(\frac{130{,}000}{130{,}000}\right)^{6/7}\left(\frac{2400}{1000}\right)^{\frac{6(2+1)}{7(3+.1)}} - 1\right]$$

ds = 6.8 Ft

BY GRAPH:
Using FIG C-6. to Find

$\frac{B_1}{B_2} = 2.4 \qquad \frac{d_s}{y_1} = .75 \qquad$ ds = 6.75

LAURSEN'S — PIER AND ABUTEMENT

Use FIGURE C-11

Given:

$$\frac{y_o}{b} = \frac{15'}{2.5'} = 6$$

from FIGURE C-11

$$\frac{d_s}{b} = 2.75$$

$$\therefore d_s = 2.75(2.5) = \underline{\underline{6.88'}}$$

BLENCH

$$D_s = y_r (1.8) \left(\frac{b}{y_r}\right)^{1/4}$$

Where: D_s = depth of scour from Water Surface

$$y_r = \sqrt[3]{\frac{q^2}{F_b}}$$

$$F_b = 1.9\sqrt{d_{mm}}$$

q = avearge discharge intensity

Solution:

$$q = \frac{Q}{W} = \frac{130{,}000}{1000} = 130 \ \frac{ft^3/sec}{ft}$$

$$F_b = 1.9\sqrt{3.16} = 3.38$$

$$y_r = \sqrt[3]{\frac{130^2}{3.38}} = 17.09$$

$$D_s = 17.09 (1.8) \left(\frac{2.5}{17.09}\right)^{.25} = 19.0$$

$$d_s = 19.0 - 15.00 = \underline{\underline{4.0'}}$$

BREUSER

$$dse = 1.4b$$

Where: dse = MAX. equilibrium scour measured from mean bed elevation

b = pier width

Solution:

$$dse = 1.4(2.5) = \underline{\underline{3.5'}}$$

CHITALE

$$y = 6.65F - .51 - 5.49F^2$$

Where: $F = \frac{V}{\sqrt{gd}}$

Solution: $F = \frac{8.7\ ft/sec}{\sqrt{32.2(15)}} = .40$

$$y = 6.65(.4) - .51 - 5.49(.4)^2$$

$$= 2.68 - .51 - .88 = 1.29$$

$$y = \frac{ds - d}{d} = \frac{\text{depth of scour below river depth}}{\text{normal depth}}$$

$$ds - d = dy = 1.29(15) = \underline{\underline{19.4'}}$$

LARRAS

$$d_{se} = 1.42\,K b^{.75}$$

Where: K = coeff dependent of pier shape = 1.0

Solution:

$$d_{se} = 1.42(1)(2.5)^{.75} = \underline{\underline{2.8'}}$$