FINAL REPORT

OF

HYDRAULIC MODEL STUDY

LITTLE'S CREEK CHANNEL

LITTLETON, COLORADO

PREPARED FOR:

THE WRITER CORPORATION
27 Inverness Drive East
Englewood, Colorado 80112

By:

J. F. RUFF and S. R. ABT

COLORADO STATE UNIVERSITY

ENGINEERING RESEARCH CENTER

FORT COLLINS, COLORADO 80523

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PREFACE

The Engineering Research Center at Colorado State University is located between two lakes, Horsetooth Reservoir of the Colorado Big Thompson Project and College Lake. The laboratories of the Center were strategically placed to utilize the high head, 250 feet, available from the reservoir and the storage capacity of the lake. The Center is the focal point for research and graduate education.

There are four principal parts to the Center; the offices for staff and graduate students, the hydraulics laboratory, the fluid dynamics laboratory, and the outdoor hydraulics - hydrology laboratory. The research activities of the Center are fluid mechanics, hydraulics, hydrology, ground-water, soil mechanics, hydro-biology, geomorphology and environmental engineering.

The hydraulics laboratory includes 50,000 square feet of floor space in which basic and applied research activities are undertaken. The floor of the laboratory in constructed over a large sump system, having one-acre foot capacity, which permits recirculation of water through the various research facilities. Generally, pumps are used for recirculation but the high head and large flow capacity from the reservoir can also be utilized.

The Center includes well equipped machine and woodwork shops. All research facilities of the Center are constructed on site and in the case of this model study, necessary metal work, carpentry, and nearly all the plastic work was done by personnel in the shops. The shop personnel are particularly well experienced in the art and skill of model construction.

Grateful acknowledgement is hereby expressed by the authors to Mr. Larry E. Reichert of the Writer Corporation and Mr. John Steven Lichliter of TriConsultants, Inc., for their cooperation during the conduct of this study, to personnel of the machine shops for their ingeneous contributions in solving model construction problems, particularly in the plastic works and to other contributing to the model study and the preparation of this report.

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SUMMARY

This report describes the hydraulic model study of the Little's Creek flood channel between South Santa Fe and the confluence with the South Platte River. The channel was subjected to flows of 1209 cfs, 1916 cfs and 2702 cfs and observations of the scour and measurements of the veolocites were made.

Some modifications were made to the walls and to the elevation of the drop structures to improve the flow conditions and to dissipate more of the energy in the flow. The crest of the drop structure at Station 17+15 was set at elevation 5320.0 and the bed upstream and downstream from the drop structure were set at 5318.5 and 5217.4, respectively.

Riprap and other channel protection should be placed at the base of the bridge piers near Station 17+15. Riprap should also be placed near the wall between Station 15+00 and 16+00 and extend out from the wall about 20 ft.

Velocities measured in the channel ranged from near zero to about 14 fps. The higher veolocites occurred near the drop structures and at the upstream end of the model in the vicinity of the bridge.

INTRODUCTION

General Description of the Project

The Little's Creek Project is a proposed flood control project to be constructed on Little's Creek between South Santa Fe Drive and the confluence with the South Platte River. The project will change the alignment of the creek and have a series of drop structures, vertical concrete channel walls, and a riprap and grass-lined channel bed. A bridge will provide access across the channel and a pedestrian sidewalk and bicycle path will parallel and traverse the channel. An earthen weir will be constructed across the channel near the confluence of the Platte River.

All features are designed to carry the once in 100-year flood. The peak flow of the hydrograph is 2702 cubic feet per second (cfs).

While the object of the project is flood protection, it is anticipated that the beautification of the area will improve the aesthetics and general assessed valuation of the area. The bike path will tie into the bike path trail system extending along the South Platte River.

Description of the Little's Creek Channel

Little's Creek runs generally westward through Littleton. The reach of Channel modeled is located west of Santa Fe Drive and is between West Bowles Avenue and Church Avenue. The model limits are shown in Figure 1 and extend from South Santa Fe Drive to the the confluence of the South Platte River.

The channel upstream from the model is steep and lined with riprap. The channel expands after passing under the Santa Fe Avenue bridge. Bridge piers are located in the vicinity of existing concrete encased sanitary sewer which crosses the channel bed. This sewer is encased by a drop structure. Immediately downstream from the drop structure, the channel is directed to the left at an angle of approximately 30 degrees and is contained between the exterior vertical walls 80 ft apart. Two additional drop structures are located in the channel before the channel is directed to the right at 35 degrees. The channel width is 80 ft between the left wall and a low interior wall. The overall channel width varies between exterior channel walls from 110 to 100 to 103 ft in the downstream direction. Cross sections of the channel are shown in Figure 2. Near the downstream end of the channel, an earthen berm forms a weir across the channel and impounds a small pond. This berm restricts the backwater from the Platte River from encroaching into the channel under low flow conditions. The water from the pond will be pumped into the river. The slope of the entire reach is generally less than 0.5% with the exception of short section in the vicinity of the drop structures. This section has a slope of 0.71%.

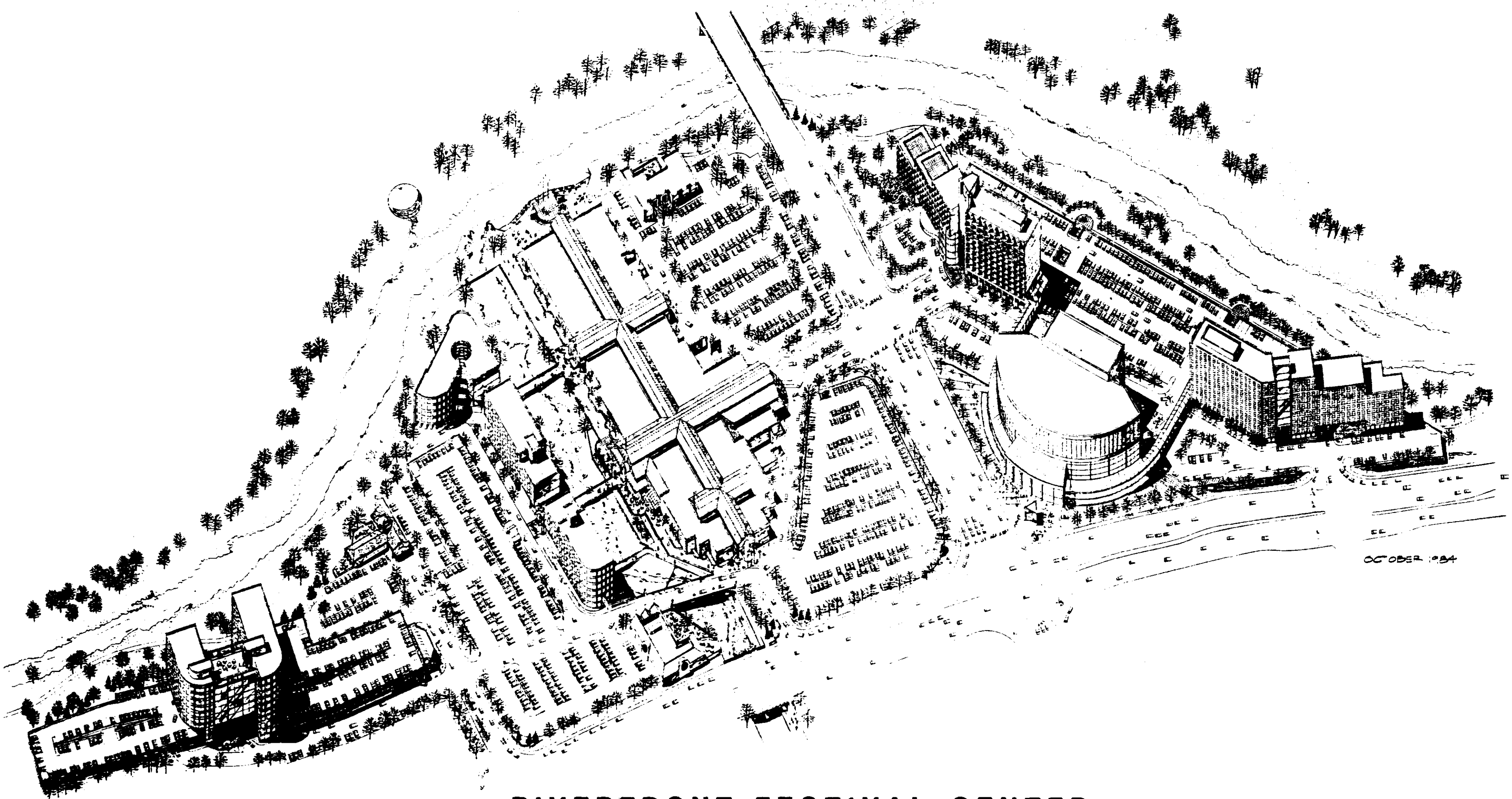

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Figure 1 - General Location Of Little's Creek

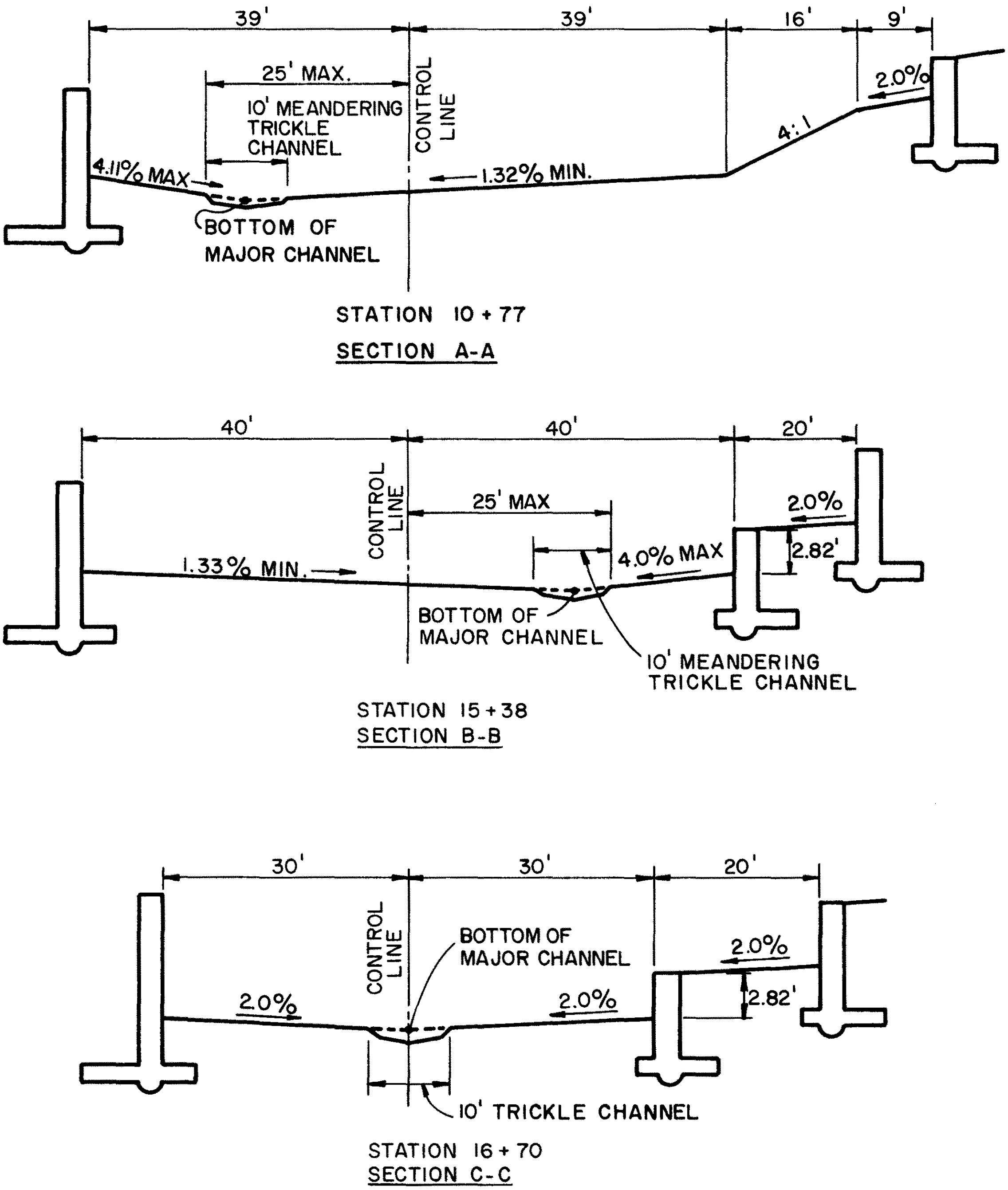

Figure 2 - Channel Cross Sections

Selection of Model Criteria and Scale

The objective of the model is to develop flows dynamically and kinematically similar to the prototype. Geometrical similarity must be maintained also. Dimensional analysis will show that the Froude number is important for the objectives of this study. Open channel flow is dependent upon gravity, hence, the Froude criterion prevails and was chosen to determine the geometric scale.

A model-prototype scale of 1:10 was selected as the most feasible based on our analysis of the model size required for accurate representation of the flow conditions, available laboratory space and facilities, ease of construction, and economy of construction costs. Table 1 contains some characteristics ratios between model and prototype at the selected scale.

TABLE I

MODEL PROTOTYPE SCALE RATIOS

Parameter	Scale Ratio		Absolute Magnitude	
	Function of the Length	Numerical Ratio	Prototype	Model
Length	L_r	1:10	1 ft	0.10 ft
Area	$(L_r)^2$	1:100	100 ft^2	1.00 ft^2
Velocity	$(L_r)^{1/2}$	1:3.16	1 fps	0.32 fps
Discharge	$(L_r)^{5/2}$	1:316.2	1000 cfs	3.16 cfs
Time	$(L_r)^{1/2}$	1:3.16	1 hr	18.97 min

Scope of the Model Study

The purpose of the model study is to investigate the flow conditions in the proposed realigned channel of Little's Creek from the vicinity of the Santa Fe Avenue bridge to the confluence of the South Platte River. The specific objectives sought in the model are:

1. Determine through visual observations, photographs, and velocity traverses the flow characteristic in the channel for the 5 year, 10 year, and 100 year flood.
2. Identify areas of potential local scour.
3. Study the performance of the drop structures located at Stations 16+80 and 17+15.

THE MODEL

Model Construction

The general location of Little's Creek and the limits of the model are shown in Figure 3. The dimensions of the model facilities and the arrangement are given in Figure 3 with a photograph of the completed model shown in Figure 4.

The model was constructed within the limits of an existing flume used primarily for model studies. A head box was constructed to provide some stilling action to the flow entering the model and to direct the flow to the entrance of the model.

Water to the head box was supplied from one of two pumps; an 18-inch turbine pump, or a 12-inch turbine pump. The discharge was regulated by valves in the supply pipeline. Discharge measurements were made with a calibrated orifice in the supply line from the 18-inch pump and with a Venturi meter in the 12-inch pump pipeline.

The walls of the model were fabricated from plywood. The channel bed was formed from sand and gravel. The bed was molded to the correct shape using pegs in the bed set to the elevation for each peg location. A straight-edge also was pulled through sections of the bed to mold the topography to the correct cross section and slope.

The first series of tests were performed to identify areas of scour and a movable bed model was used. The bed was reshaped at the conclusion of each scour test run.

The second series of tests were performed to determine the local velocities throughout the channel. Prior to the velocity tests, the bed was reshaped and pea gravel placed on the bed to the correct elevation. Cement powder then was sprinkled over the bed to form a thin veneer. Moisture from the bed reacted with the cement dust to create a thin coat of cured cement which stabilized the bed and provided some protection from erosion of the bed. At the higher flow rates, the bed would still erode after this treatment.

The Manning's "n" for cement mortar is about 0.016 to 0.018. Little's Creek channel will be grassed, level and relatively smooth and should have a Mannings roughness on the order of 0.022 to 0.0026. The model prototype ratio of Manning's "n" at the scale of 1:10 is $n_r = L_r^{1/6} = 1/1.47$. Therefore, the cement motar lining of the model will represent a prototype n of 0.023 to 0.026 which is similar to that of a grass lined channel.

Below the drop structures, angular rocks approximately 1 to 3 inches (model dimensions) in size were placed on the bed. The rocks were used to simulate the form roughness of the riprap to be placed downstream from the drop structures. For the movable bed tests, no additional treatment to the bed was performed on these areas. For the stable bed velocity tests, a thin mortar mixture was poured over these rocks to insure a more stable and less erodible bed. The mortar mixture was not designed to simulate a grouted riprap condition, although, it would be similar to a grouted riprap bed.

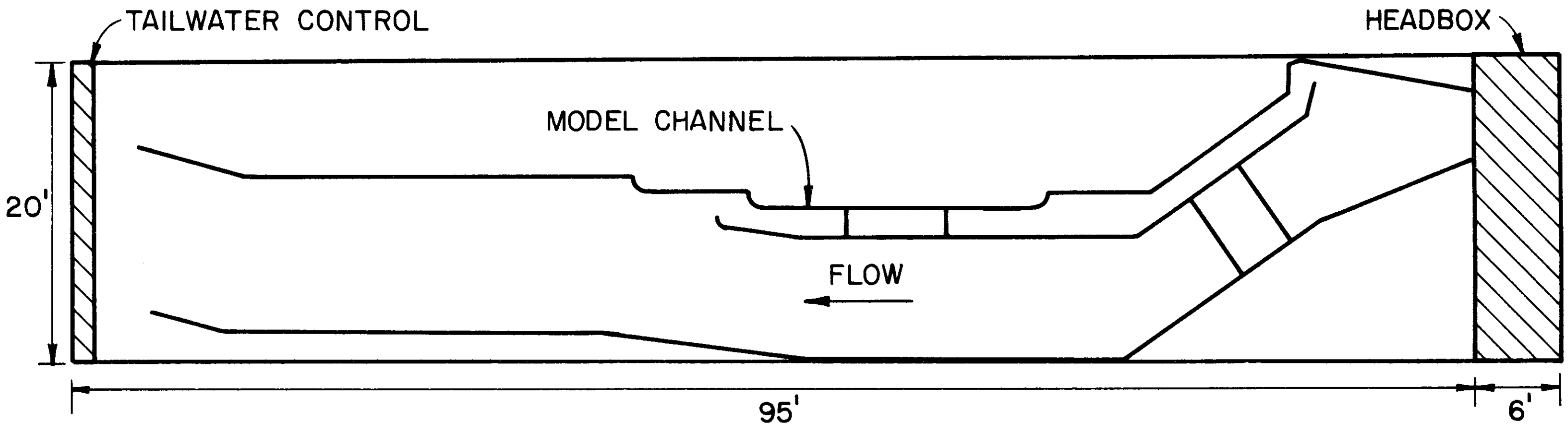

Figure 3 - Model Facilities

Figure 4 - Photograph Of The Model

MODEL TESTS AND RESULTS

Scour Tests

The model was constructed to conform to the initial drawings provided by TriConsultants, Inc. The wall forming the drop structure at Station 17+15 intersected the interior wall and was set at the same elevation (elevation 5320.3) as the interior wall. Tests were performed initially with a movable bed model.

Three discharges were tested in the model. These discharges were selected from the report entitled, "Major Drainageway Planning - Lee Gulch Little Creek Phase B - Preliminary Design," prepared for the Urban Drainage and Flood Control District, City of Littleton, Arapahoe County by KKBNA Consulting Engineers in 1978. The three discharges are described as the 5 year flood without detention, Q_p = 1209 cfs; the 10 year flood, Q_p = 1916 cfs; and the 100 year flood (future conditions), Q_p - 2702 cfs. The discharges were selected from Table II at the railroad tracks of the above referenced report.

Observations of the flow conditions indicated that the water flowing over the drop structure at Station 17+15 encroached into the area between the interior wall and the right [1] wall at a discharge on the order of 200 cfs. As the discharge increased to 2702 cfs, a significant portion of the flow was deflected into the channel between the interior wall and the right wall and scour and erosion were noted in this area. The tailwater for this run was set at 5318.5. Some local scour was observed in the main channel near the interior wall at about Station 15+90. An eddy had been observed at this location during the run and appeared to be the result of the flow separation at the change in alignment of the interior wall. Scour was observed also near the left wall from about Station 15+00 to Station 16+00.

The flow conditions in the vicinity of the drop structures during the scour tests at a discharge of 2702 cfs are shown in Figure 5. A small standing wave occurred upstream from Station 17+15. A hydraulic jump formed downstream from the drop at 17+15. Initially, little energy dissipation was evident downstream from the drop at Station 16+80. As the run proceeded, the bed below both drop structures eroded. The eroded holes provided pools in which hydraulic jumps formed.

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[1] Right and left refer to the observer's right and left as they look downstream.

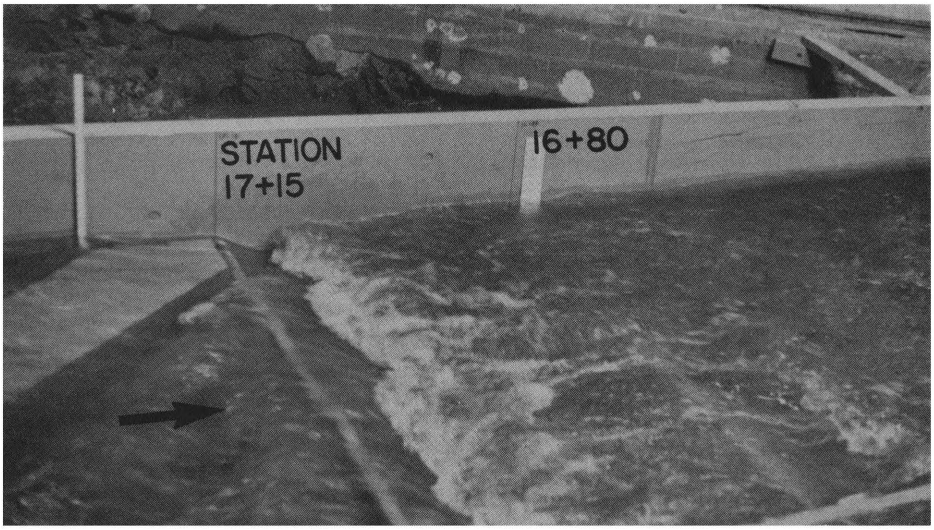


Figure 5 - Flow Conditions In Vicinity Of Drop Structure At A Discharge Of 2702 cfs.

It appeared that flow conditions would improve and the energy could be better dissipated if the elevation of the drop structure at Station 17+15 was lowered. The crest of the drop structure was lowered 1.25 ft. Lowering the crest and maintaining the height of the interior wall at the drop structure allowed the flow to remain in the main channel without encroaching into the area between the interior and right walls at a higher discharge than the original configuration. The existing concrete encased sewer was used also as a drop structure with this arrangement.

The elevation of a section of the interior wall was lowered also. Lowering the wall provides a path for the water that flows into the area between the interior wall and the right wall at about Station 17+75 to return to the main channel. The wall was lowered 1.46 ft between the raised deck at about Station 14+75 and a point downstream from the drop structures at Station 16+70.

Tests were performed with this model configuration and the movable bed at a discharge of 2702 cfs and with the tailwater set at 5318.5. It appeared that little energy was dissipated by the drop structures when the bed of the channel upstream from the drop was flush with the crest. As the channel eroded, pools formed below the drops, a more stable hydraulic, jump formed, and better flow conditions prevailed. Therefore, the performance of the drop structures with the upstream bed of the channel flush with the crest still was not considered satisfactory. However, further modifications to the drop structures are described later.

The emphasis of these tests was to determine areas of potential local scour downstream from the structures. Scour occurred near the left wall of the channel from about Station 15+20 to STation 16+10. Contours of the scour zone are shown in Figure 6 for this test. The contours should be used only in a relative sense to identify potential areas of scour and not as the absolute depth of scour that may occur.

A plan showing the location of 4 bridge piers was received at the conclusion of the scour tests. The piers were installed in the model and tests were performed to observe the flow characteristics in the vicinity of the piers. The flow impacted the piers and rose up on the upstream face of the pier approximately 3 to 4 ft with occasional splashes to higher elevations. The piers act somewhat like baffle blocks and appear to assist the redirection of the flow at this location in the channel. No deterimental conditions were observed in the vicinity of the bridge piers. However, the foundation of the piers must be protected from local scour.

Additional tests were performed also at discharges of 1209 cfs and 1916 cfs with tailwater set at 5318.5 and with no tailwater controlling the flow downstream. The condition of no tailwater was assumed to simulate the condition of low flow in the Platte

River. Generally the scour patterns observed at discharges of 1209 cfs and 1916 cfs with the tailwater set at 5318.5 were similar to those observed at a discharge of 2702 cfs. When no tailwater was provided, scour patterns were generally similar to those previously observed for the higher tailwater conditions. However, because of the higher velocities for this tailwater condition and the fine sediment used for the bed of the model, sediment transport resulting from the erosion and scour process occurred throughout the entire channel and was evident by the aggradation and degradation observed throughout the model channel. The model was operated only for short periods of time during the tests conducted at the no tailwater condition because of the loss of material. Scour tests were conducted at a discharge of 2702 cfs and no tailwater control, but data were not collected. The channel degraded too rapidly in the model to allow satisfactory observations.

Velocity Tests

The bed of the model was reformed to the correct topography after completion of the scour tests. The bed was then stabilized to prevent it from moving during the tests performed to collect velocity data. Stabilization was accomplished by spreading a thin coating of cement dust on the channel bed and allowing the moisture in the sand to cure the cement and form a crust on the sand.

Velocity data initially were taken at 5 stations along the channel. At each station, 4 velocities were measured in the cross section. Because of the size of the flow meter and the shallow depths in the model, velocities were measured at only one point in the vertical section. This point was at about mid-depth and would be approximately the average velocity at that section.

The velocities measured for a flow of 2702 cfs with the tailwater at 5318.5 are shown in Figure 7. The model configuration was as per the original plans with the exception that the interior wall was lowered 1.46 ft and the drop structure at Station 17+15 was lowered 1.25 ft. The elevation of the top of the interior wall at Station 16+70 was set at about 5319.7 and near Station 14+95 was set at about 5318.0. The crest elevation of the drop structure at Station 17+15 was set at 5320.05. The velocities indicated that there was a quiesent zone in the vicinity of the left wall between Stations 16+00 and 16+80 and near the interior wall at Station 14+50. The highest velocities were located in the right hand portion of the channel at the drop structures and then shifted across the channel to a location near the left wall. The drop structures were not effectively dissipating the energy in the flow for these conditions. A hydraulic jump did not completely form below the structures.

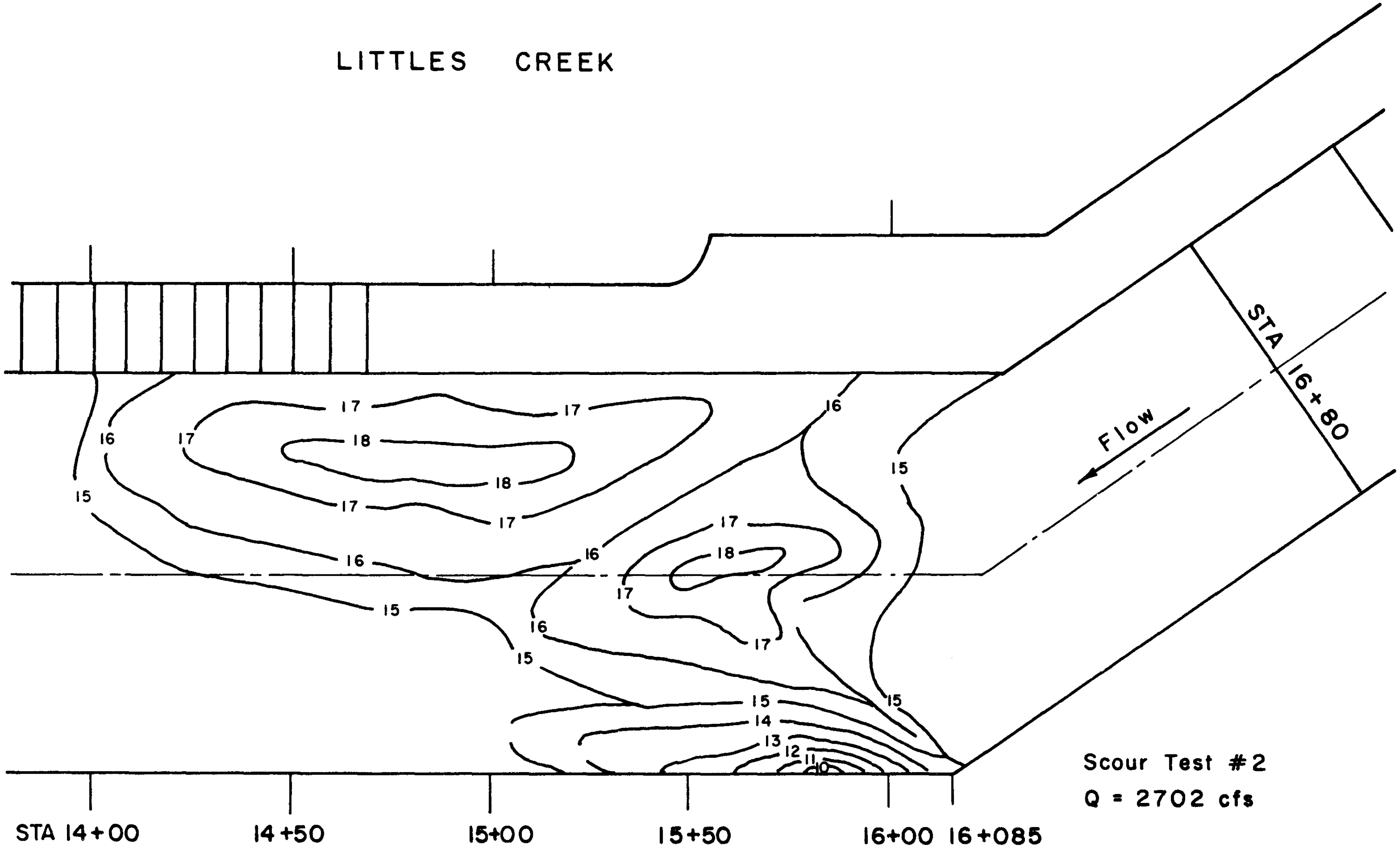


Figure 6 - Scour Contours Following A Flow of 2702 cfs With Tailwater Set At 5318.5.

The performance of the channel at a flow of 1916 cfs was checked and the velocities are shown in Figure 8. Generally, the velocity distribution in the channel is similar to the pattern for the higher flow rate.

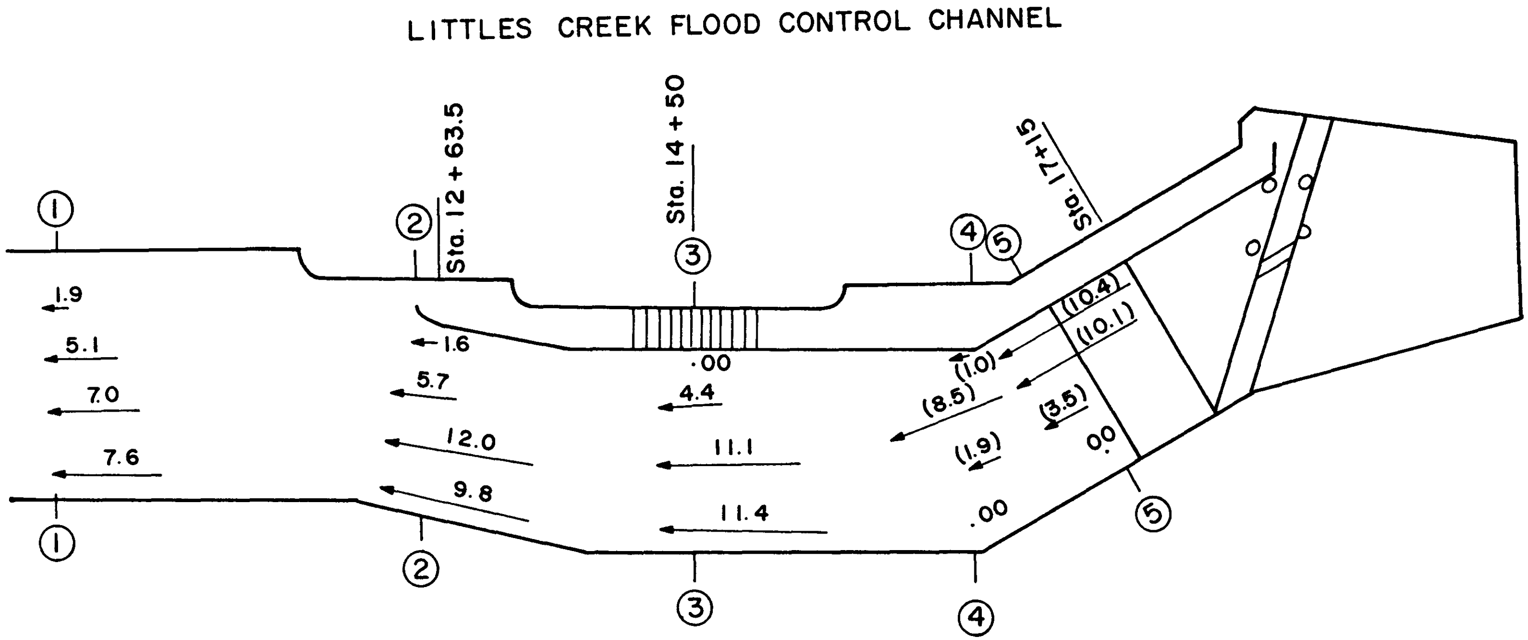
The channel bed between the drop structures at Stations 16+80 and 17+15 and the concrete encased sewer was lowered 1.5 ft to see if the effectiveness of the drops could be improved by providing plunge pools. Flow conditions through the drop structures are shown in the photograph of Figure 9. The view in Figure 9 is looking upstream. Velocities in the channel for this modification are shown in Figure 10 for a flow of 2702 cfs. Additional velocity data were taken in the vicinity of the piers and the sewer and just downstream from the drop structure at Station 17+15. Velocities were lowered and the distribution was improved even though the distributions were not completely uniform.

Water surface elevations were also measured during this series of tests. Water surface profiles are presented in Figure 11 for flows of 1209 cfs, 1916 cfs, and 2702 cfs with the tailwater at 5318.5 and for flows of 1209 cfs and 1916 cfs without tailwater control. Tabulated data for these record runs are presented in the Appendix.

Average velocities which would be used in flood routing models were calculated based on the measured water surface elevations at three cross sections for a flow of 2702 cfs and the tailwater set at 5318.5. The velocities were:

Station 16+00	V = 5.7 fps;
Station 14+00	V = 5.9 fps;
Station 12+00	V = 6.0 fps.

A change in the alignment of the right wall between approximately Stations 17+75 and 18+00 was proposed near the end of the test program. Instead of turning northward near Station 17+75, the wall would continue in a straight line to the intersection with the existing retaining wall. A cursory examination was made of this change by holding a piece of plywood in the proposed location. No changes in the overall flow patterns or conditions could be observed.



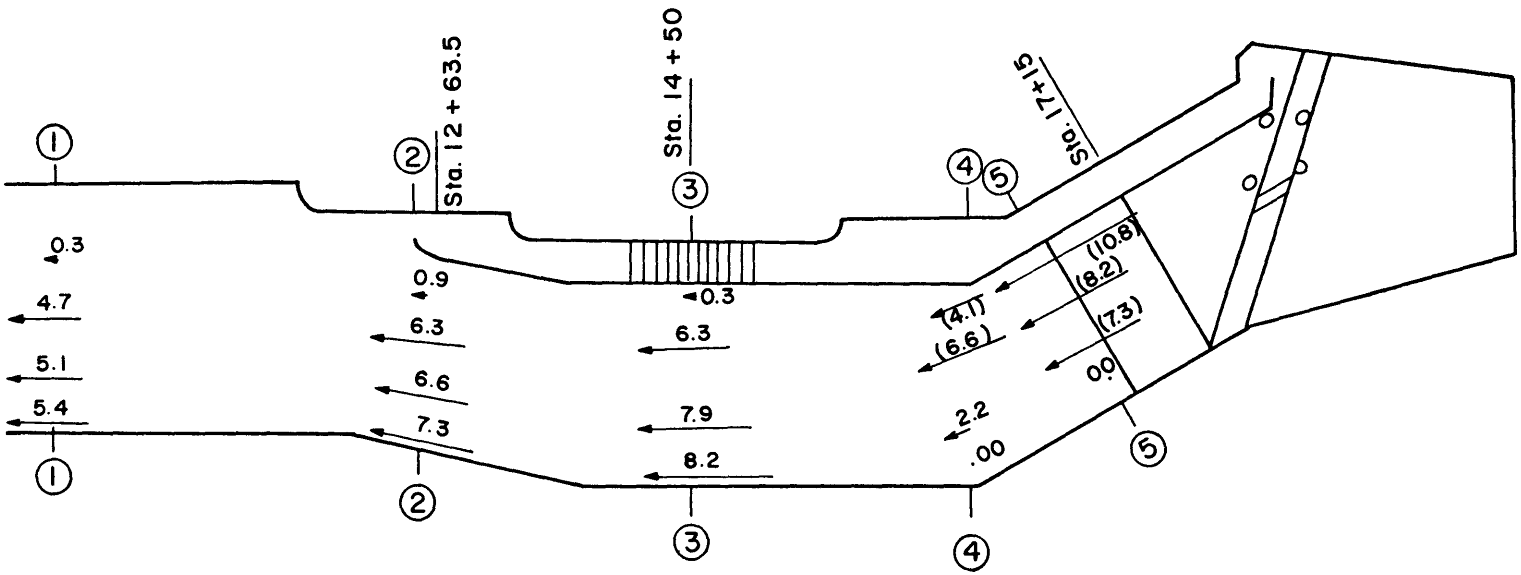
Notes:

Velocity Traverse Location

Velocity in Prototype Dimensions (fps)

Figure 7 - Velocity Distribution In The Channel With Original Drop Structure At A Flow of 2702 cfs.

LITTLES CREEK FLOOD CONTROL CHANNEL



Notes:

Velocity Traverse Location

Velocity in Prototype Dimensions (fps)

Figure 8 - Velocity Distribution In The Channel With Original Drop Structure At A Flow Of 1916 cfs.

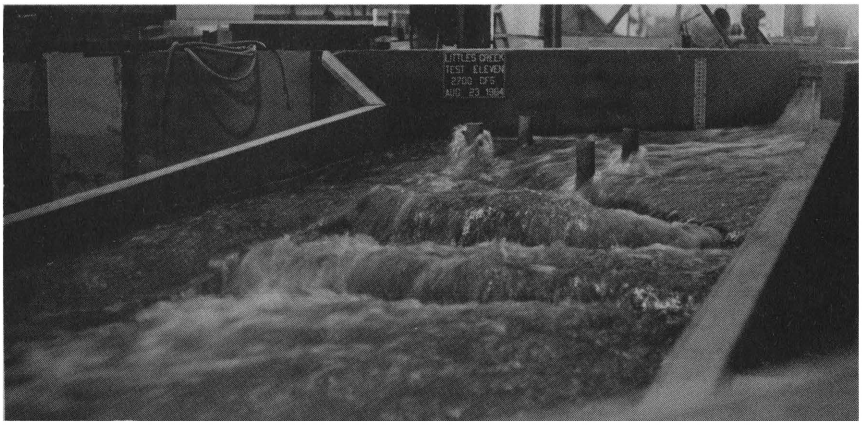


Figure 9 - Flow Conditions At The Drop Structures

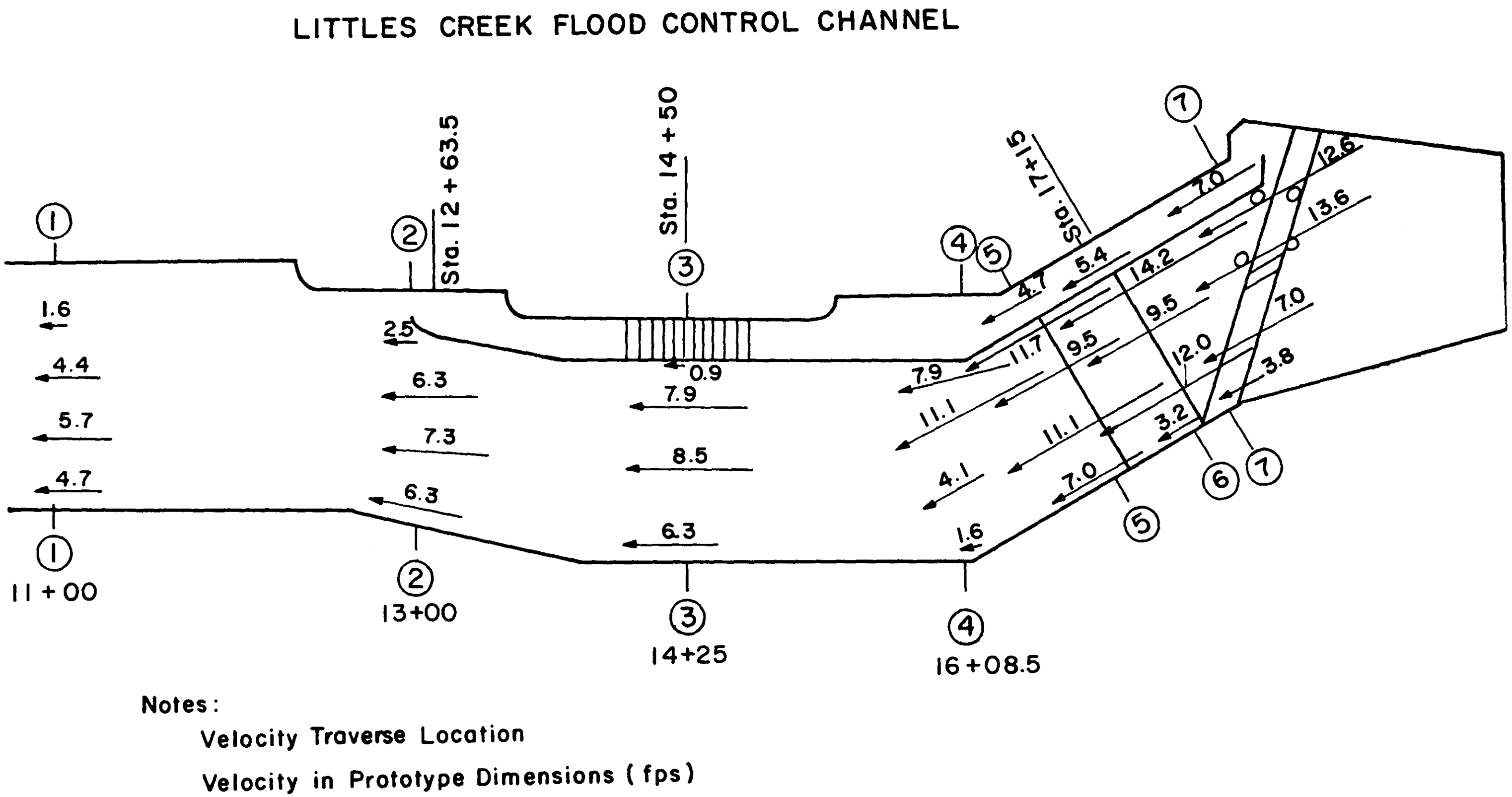
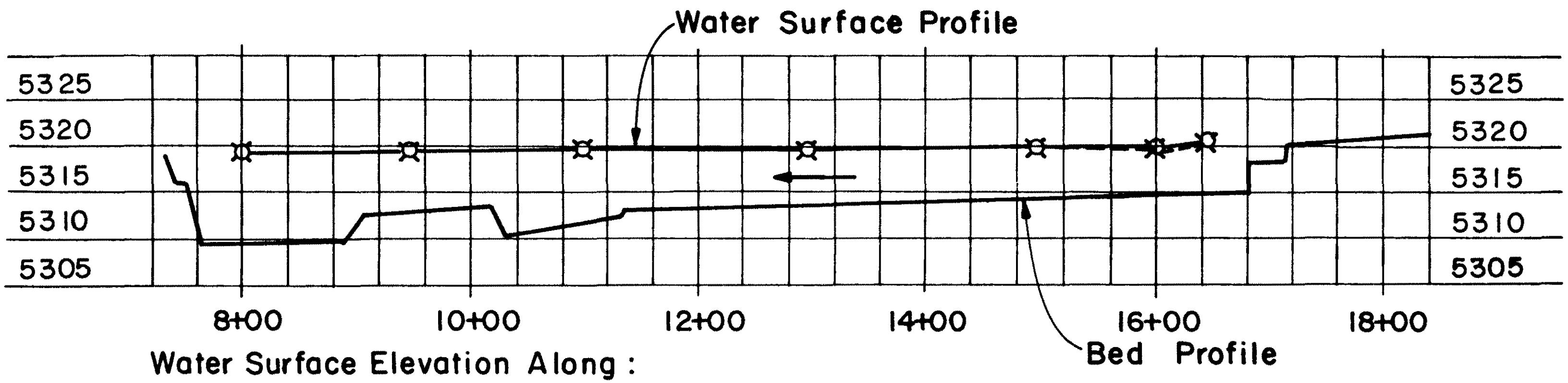


Figure 10 - Velocity Distribution In The Channel With Modified Drop Structure At A Flow of 2702 cfs

LITTLES CREEK

BED AND WATER SURFACE PROFILE

Test: 16   cfs: 1209   Date



Water Surface Elevation Along:

× Right and Interior Wall

o Left Wall

Tailwater set at 5318.5

Figure 11a - Water Surface Profiles For A Discharge Of 1209 cfs And Tailwater Set At 5318.5

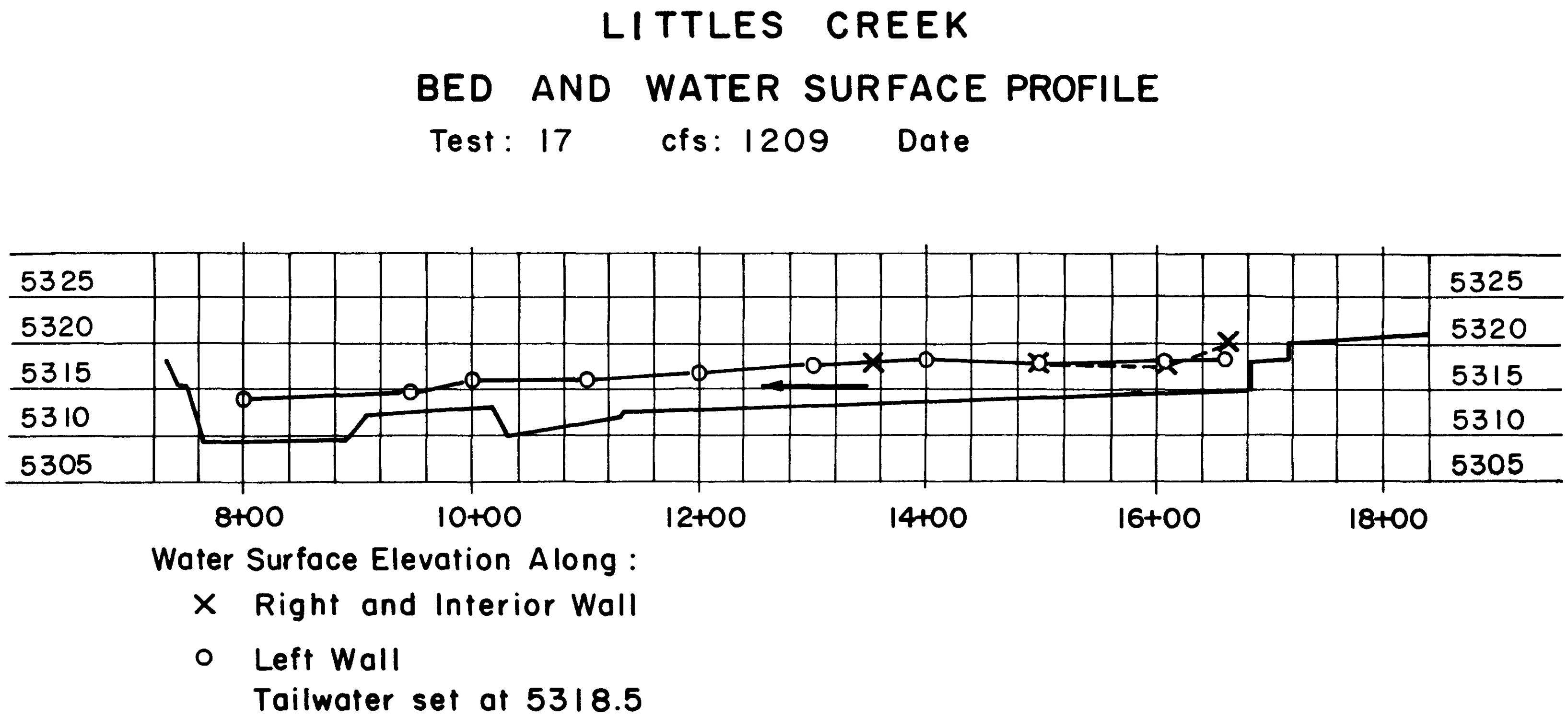


Figure 11b - Water Surface Profiles For A Discharge Of 1209 cfs And Tailwater Controlled By Channel Roughness

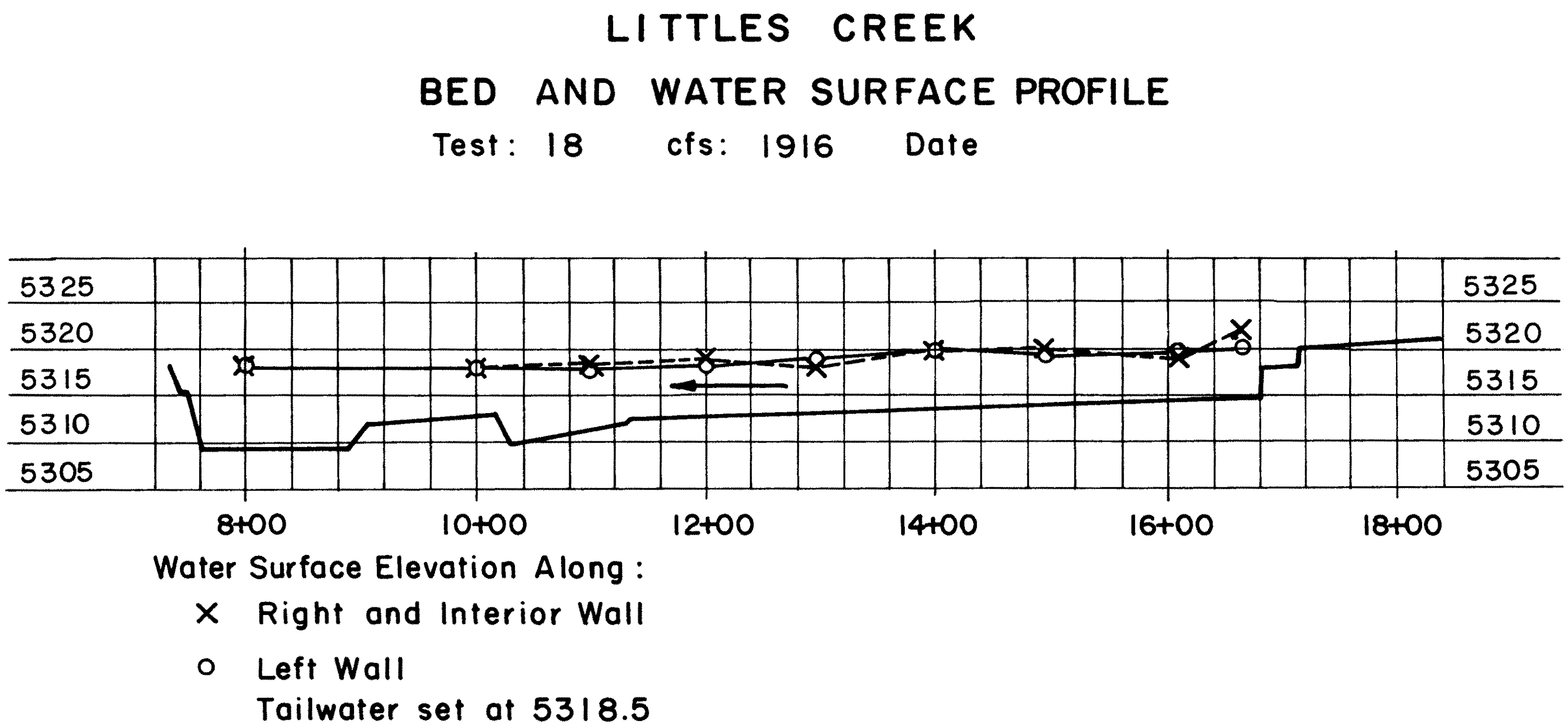


Figure 11c - Water Surface Profiles For A Discharge Of 1916 cfs And Tailwater Set At 5318.5

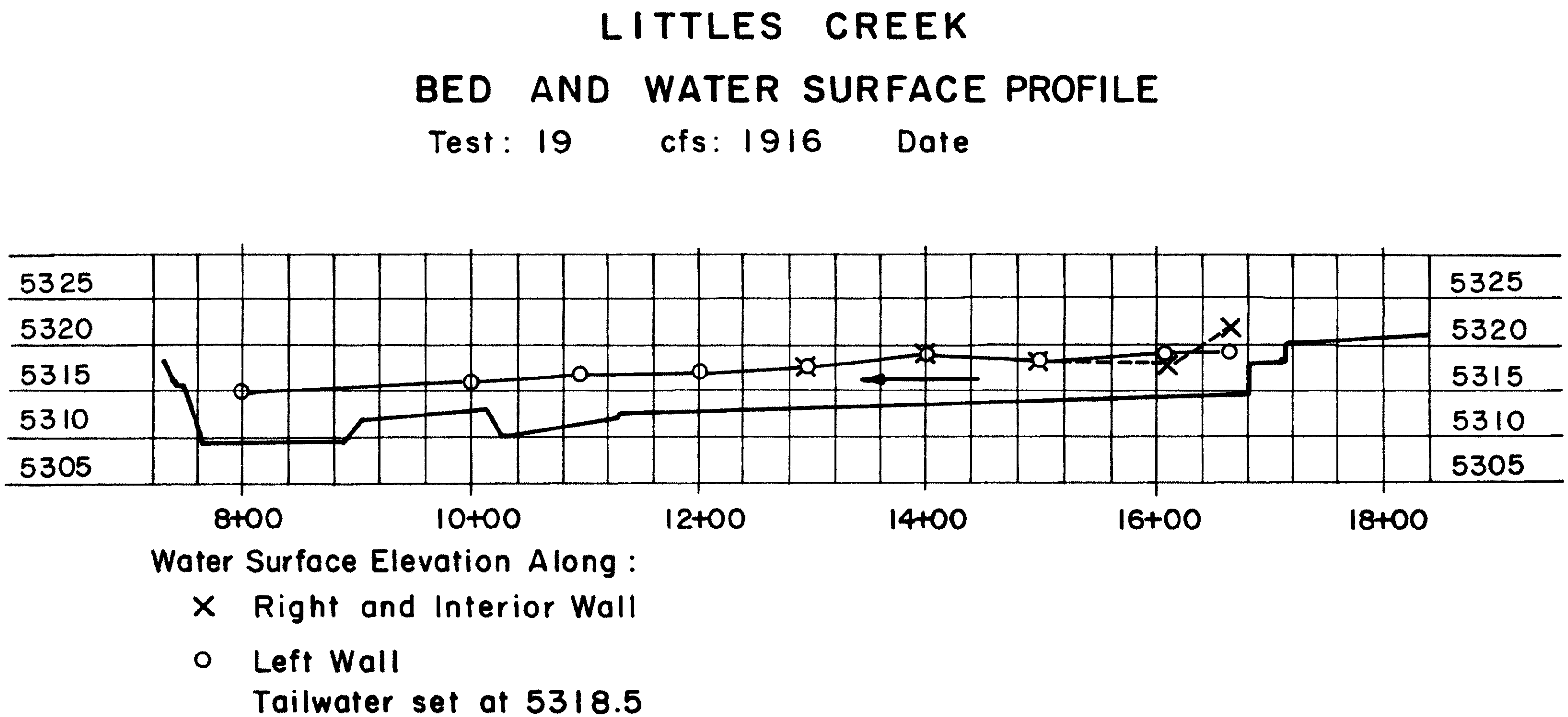
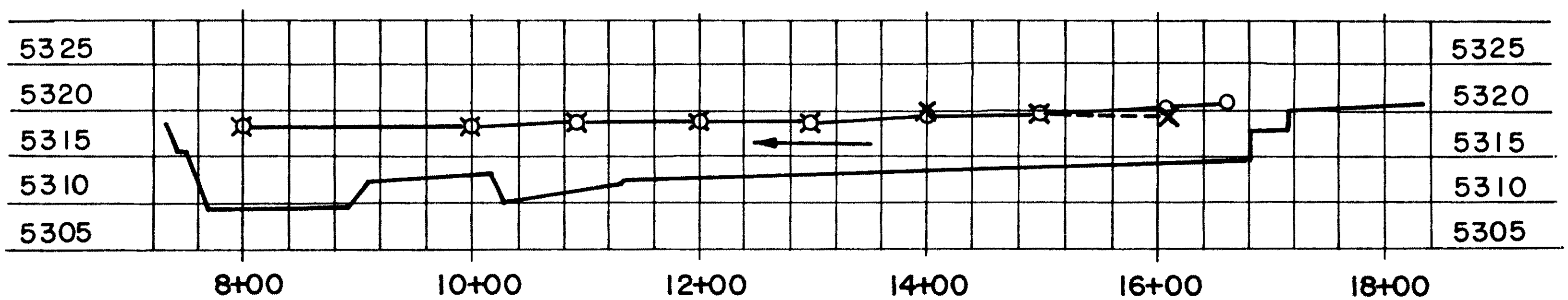


Figure 11d - Water Surface Profiles For A Discharge Of 1916 cfs And Tailwater Controlled By Channel Roughness

LITTLES CREEK

BED AND WATER SURFACE PROFILE

Test: 20 cfs: 2702 Date



Water Surface Elevation Along:

× Right and Interior Wall

○ Left Wall

Tailwater set at 5318.5

Figure 11e - Water Surface Profiles For A Discharge Of 2702 cfs And Tailwater Set At 5318.5

CONCLUSIONS AND RECOMMENDATIONS

Drop Structures

The crest elevation of the drop structure at Station 17+15 should be set at about elevation 5320.0. The bed elevation upstream from this drop structure and between the concrete encased sewer should be set at elevation 5318.5 to form a small plunge pool for the flow. The bed should be stablized to protect it against a movement from the velocities that are on the order of 14 fps.

The crest elevation of the drop structure at Station 16+80 should remain at elevation 5318.9. The bed elevation between the drop structures at Stations 16+80 and 17+15 should be set at approximately elevation 5317.4. The bed also should be protected against velocities on the order of 14 fps. Downstream from the drop at Station 16+80, erosion protection should be provided for 60 to 80 ft against velocities on the order of 12 fps observed in the toe of the hydraulic jump.

Channel

The scour tests indicated a zone of potential local scour located along the left wall from approximately Station 15+00 to Station 16+00. Scour protection should be provided in this reach and extend out from the wall into the channel about 15 to 20 ft.

Bridge Piers

Erosion protection should be provided around the bridge piers to protect them from local scour. Approach velocities are on the order of 14 fps in the vicinity of the piers.

Velocities

Velocities measured throughout the channel at a discharge of 2702 cfs are given in Figure 10. The velocities range from about 14 fps at points across the drop structures down to about 2 fps near the walls of the structure.

If floods of the magnitudes of any of the discharges tested in this model flow in Little's Creek, some scour and erosion will occur on the bed, in the vicinity of the drop structures, and near the ends of the erosion protection. This scour is not unusual, but it should be anticipated. Periodic inspection of the channel should be performed and preventive maintenance measures initiated if required. Immediately following any flood, inspection of the channel should be performed, and repair and maintenance measures undertaken.

APPENDIX

LITTLE'S CREEK MODEL STUDY
TEST SEQUENCE

Test Number	Date	Discharge (cfs)	Tailwater Elevation MSL	Comments
1	8/07/84	2702	5318.5	Channel downstream from 13+50 stabilized to erode at higher discharge rates. Wooden sidewalk installed. Interior wall set at elevation required for drop @ 21.3.
2	8/08/84	2702	5318.5	Drop structure crest elevation @ 17+15 set lower @ 19.8. Interior wall lowered 1.46 ft from about 17+05 to 14+50 at raised deck. Topography adjusted between sidewalk and interior wall. Initial scour tests complete.
3	8/09/84	2702	5318.5	Bridge piers installed. Additional scour tests initiated. Scour results similar to Test 2.
4	8/13/84	1209	5318.5	Sidewalk reconstructed per modified plans. Scour patterns similar to Test 2, but depths less.
5	8/13/84	1209	channel controls tailwater	General scour in channel. Scour patterns similar to Test 2, but depths less.
6	8/13/84	1916	5318.5	General scour in channel. Head cutting upstream from tail box commencing. Scour patterns similar to Test 2, but depths less.
7	8/13/84	1916	channel controls tailwater	General scour in channel. Head cutting upstream from tail box. Scour patterns similar to Test 2, but depths less. Scour tests completed.
8	8/20/84	2702	5318.5	Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded.
9	8/20/84	1916	5318.5	Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded.
10	8/20/84	1916	channel controls tailwater	Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded.
11	8/23/84	2702	5318.5	Model modified. Channel bed between Station 16+80 and 17+15 and between Station 17+15 and the concrete encased sewer lowered 1.5 ft. Velocity traverse stations added at drop structures. Bed fixed to prevent scour. Velocity data collected. Water surface elevations along walls recorded. Flow conditions at drop structures observed.
12	8/23/84	1916	5318.5	Channel bed between drop structures lowered. Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded.
13	8/23/84	1209	5318.5	Channel bed between drop structures lowered. Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded.

LITTLE'S CREEK MODEL STUDY
TEST SEQUENCE
(Continued)

14	8/24/84	1209	channel controls tailwater	Channel bed between drop structures lowered. Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded.
15	8/24/84	1916	channel controls tailwater	Channel bed between drop structures lowered. Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded. Model channel deteriorates because of high velocity and low water depth.
16	8/28/84	1209	5318.5	*** RECORD RUN *** Channel bed between drop structures lowered. Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded.
17	8/28/84	1209	channel controls tailwater	*** RECORD RUN *** Channel bed between drop structures lowered. Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded.
18	8/28/84	1916	5318.5	*** RECORD RUN *** Channel bed between drop structures lowered. Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded.
19	8/28/84	1916	channel controls tailwater	*** RECORD RUN *** Channel bed between drop structures lowered. Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded.
20	8/28/84	2702	5318.5	*** RECORD RUN *** Channel bed between drop structures lowered. Bed fixed to prevent scour in model. Velocity data collected. Water surface elevations along walls recorded.

LITTLE'S CREEK FLOOD CONTROL CHANNEL

Test: 16			Date: 8/28/84		Run Time: 1:30	
Discharge: 1209 cfs Tailwater: 5318.5						
STATION	Water Surface Elevations Taken @ Walls:					
	LEFT		RIGHT		INTERIOR	
	Mean	Peak	Mean	Peak	Mean	Peak
16+50	21.0	21.5	21.0	21.5		
16+08.5	20.0	25.3			19.5	19.8
15+00	20.3	20.5	20.0	20.3	20.0	20.3
14+50	20.5	20.7			20.3	20.5
14+00	20.4	20.6			20.5	20.8
13+50	19.3	19.5	19.5	19.8	20.0	20.3
13+00	19.0	19.2	19.0	19.3		
12+50	19.0	19.3	19.0	19.3		
12+00	19.2	19.4	19.2	19.4		
11+50	19.2	19.4	19.0	19.2		
11+00	19.0	19.1	19.0	19.1		
10+50	18.8	19.0	18.8	19.0		
10+00	18.5	18.8	18.0	18.8		
09+50	18.5	18.7	18.8	19.0		
Tailwater	18.5	18.8	18.8	19.0		

LITTLE'S CREEK FLOOD CONTROL CHANNEL

Test: 17		Date: 8/28/84		Run Time: 2:30		
Discharge: 1209 cfs Tailwater: Channel Control						
STATION	Water Surface Elevations Taken @ Walls:					
	LEFT		RIGHT		INTERIOR	
	Mean	Peak	Mean	Peak	Mean	Peak
16+50	18.5	19.2	20.0	20.2		
16+08.5	18.0	18.4			17.5	18.0
15+00	17.8	18.2			18.0	18.2
14+50	18.3	18.3			18.3	18.5
14+00	18.4	18.6			18.3	18.5
13+50	17.9	18.3	16.9	16.9	17.6	17.8
13+00	17.6	17.9				
12+50	17.2	17.5				
12+00	16.8	17.0				
11+50	16.4	16.7				
11+00	16.1	16.5				
10+50	15.8	16.2				
10+00	15.4	15.6				
09+50	14.8	15.0				
Tailwater	14.0	14.2				

LITTLE'S CREEK FLOOD CONTROL CHANNEL

Test: 18 | Date: 8/29/84 | Run Time: 10:20

Discharge: 1916 cfs
Tailwater: 5318.5

STATION	Water Surface Elevations Taken @ Walls:					
	LEFT		RIGHT		INTERIOR	
	Mean	Peak	Mean	Peak	Mean	Peak
16+50	20.4	20.7	21.5			
16+08.5	19.7	20.2			19.2	19.7
15+00	19.5	20.0	19.5	19.7	19.8	20.0
14+50	20.0	20.0			20.0	20.2
14+00	20.1	20.2			20.2	20.4
13+50	19.7	19.9	19.7	20.0	19.2	19.5
13+00	19.2	19.7	18.8	19.0		
12+50	18.6	18.9	18.7	19.0		
12+00	18.8	19.1	19.0			
11+50	18.9	19.1	18.8	18.9		
11+00	18.7	19.0	18.8	19.0		
10+50	18.5	18.7	18.4	18.6		
10+00	18.5	18.6	18.4	18.5		
09+50	18.5		18.5			
Tailwater	18.5		18.5			

LITTLE'S CREEK FLOOD CONTROL CHANNEL

Test: 19 Date: 8/29/84 Run Time: 11:00

Discharge: 1916 cfs
Tailwater: Channel Control

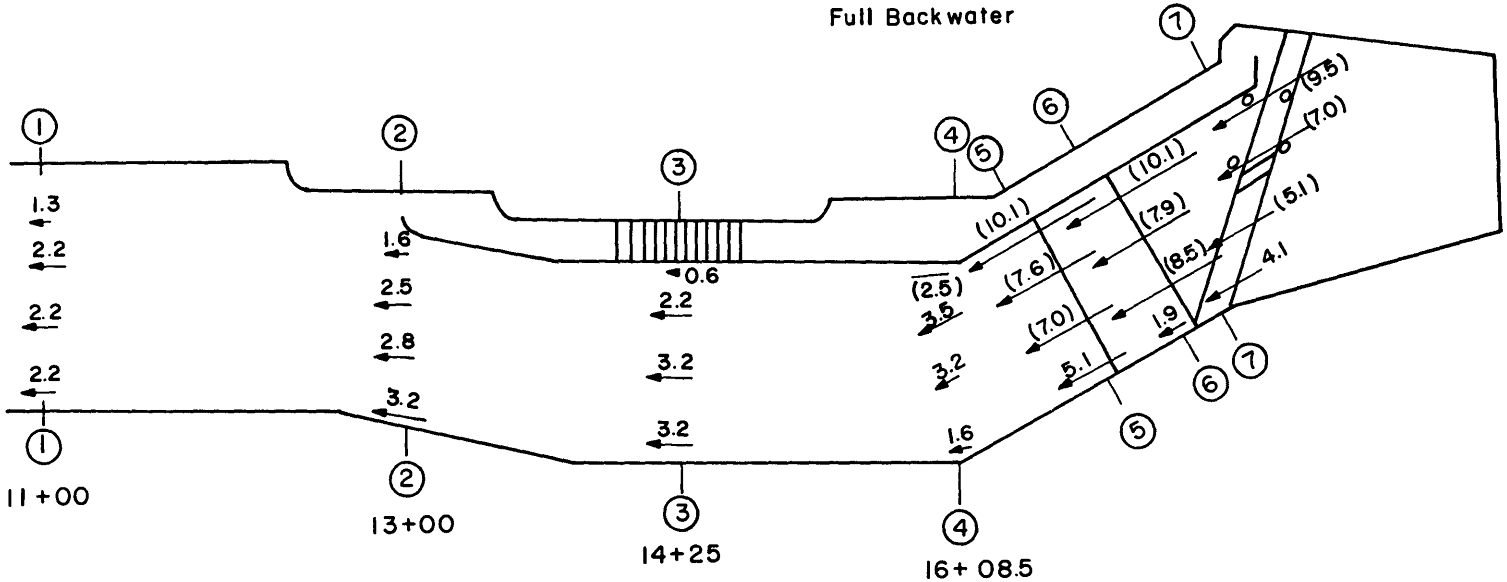
STATION	Water Surface Elevations Taken @ Walls:					
	LEFT		RIGHT		INTERIOR	
	Mean	Peak	Mean	Peak	Mean	Peak
16+50	19.4	20.0	21.5			
16+08.5	18.8	19.2			17.8	18.3
15+00	18.5	19.0	18.4		18.4	18.6
14+50	18.7	18.9			18.7	19.0
14+00	18.8	18.9			19.0	19.2
13+50	18.3	18.7	18.4	18.7	18.5	18.7
13+00	17.7	17.9				
12+50	16.9	17.1				
12+00	17.0	17.3				
11+50	17.0	17.2				
11+00	16.9	17.1				
10+50	16.8	17.2				
10+00	16.0	16.2				
09+50	15.5	15.8				
Tailwater	14.5	15.0				

LITTLE'S CREEK FLOOD CONTROL CHANNEL

Test: 20			Date: 8/29/84			Run Time: 2:00
Discharge: 2702 cfs Tailwater: 5318.5						
STATION	Water Surface Elevations Taken @ Walls:					
	LEFT		RIGHT		INTERIOR	
	Mean	Peak	Mean	Peak	Mean	Peak
16+50	21.0	21.4	Overtopping Wall			
16+08.5	20.2	20.7			19.5	20.5
15+00	20.0	20.6	19.8	20.1	19.9	20.2
14+50	20.0	20.5			20.0	20.3
14+00	19.8	19.8			20.4	20.6
13+50	19.4	19.7	19.5	19.7	20.0	20.1
13+00	18.8	19.1	19.0	19.3		
12+50	18.9	19.1	19.0	19.2		
12+00	19.0	19.3	19.2	19.5		
11+50	19.1	19.4	19.0	19.2		
11+00	19.0	19.3	19.0	19.2		
10+50	18.8	19.2	18.6	18.9		
10+00	18.6	18.9	18.5			
09+50	18.6	18.8	18.5			
Tailwater	18.5	18.7	18.5			

LITTLES CREEK FLOOD CONTROL CHANNEL

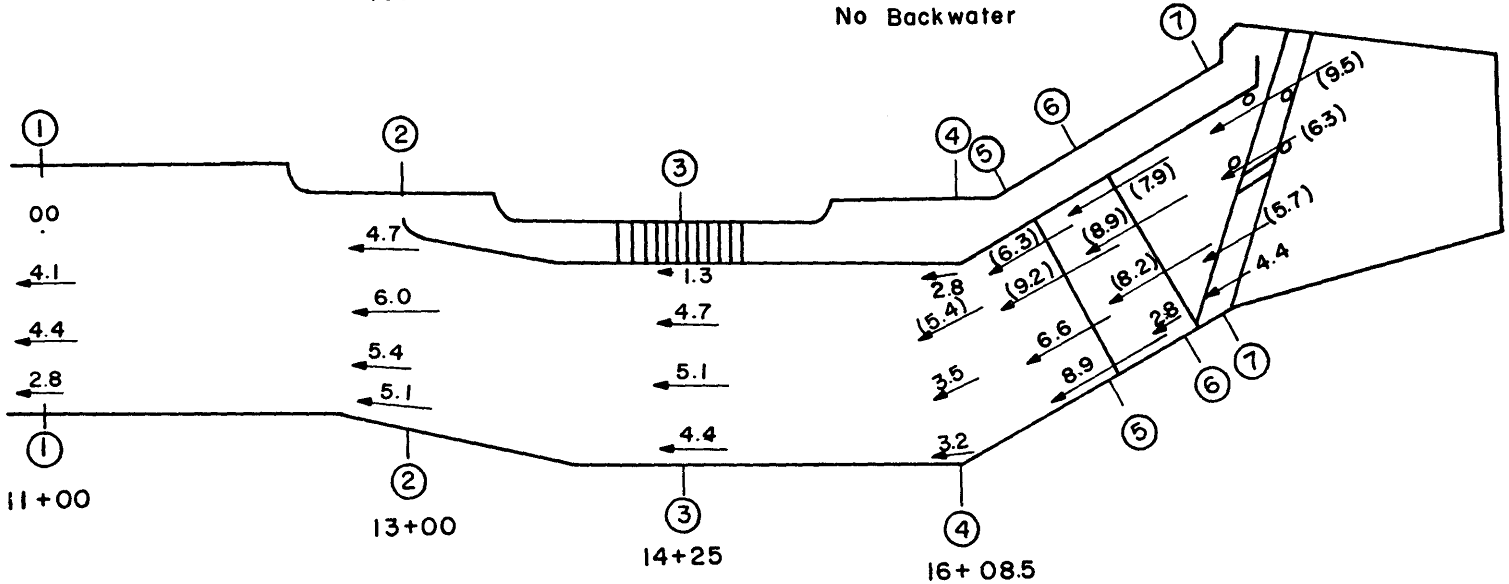
Test: 16 Date: 8/28/84 cfs: 1209 (5 yr)
Full Backwater



(1) Station Numbers for Flow Meter Readings
Velocities in fps (Prototype)

LITTLES CREEK FLOOD CONTROL CHANNEL

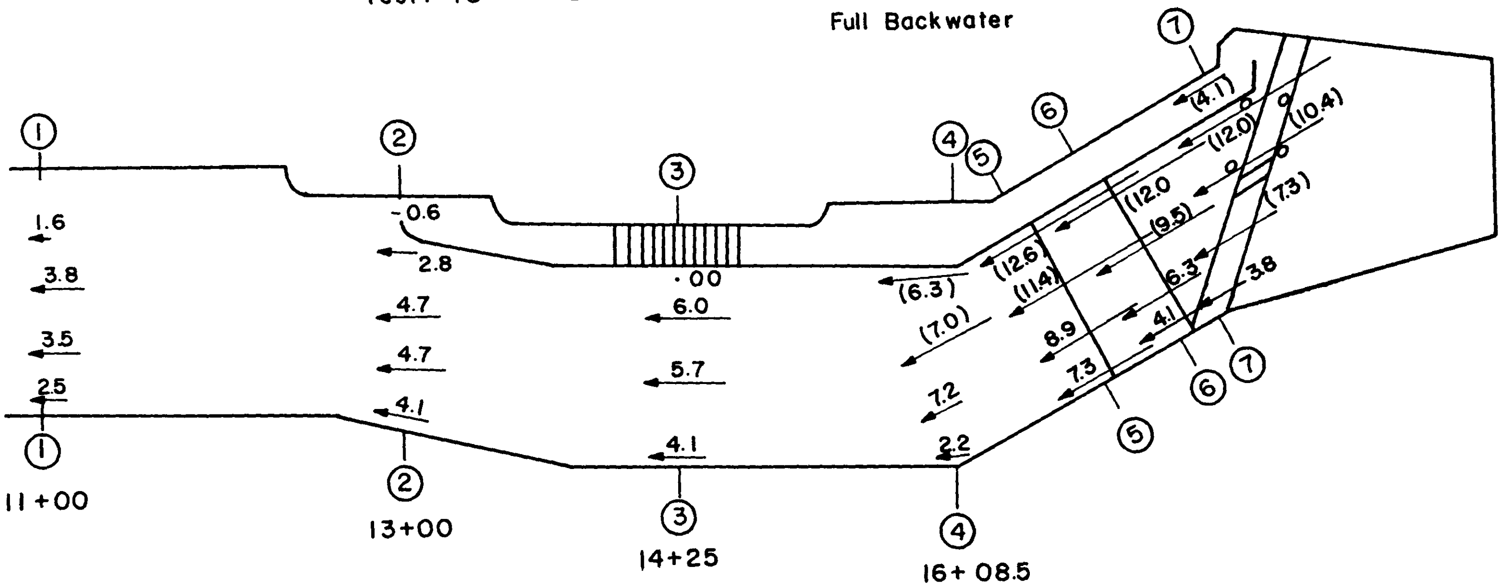
Test: 17 Date: 8/28/84 cfs: 1209 (5 yr)
No Backwater



① Station Numbers for Flow Meter Readings
Velocities in fps (Prototype)

LITTLES CREEK FLOOD CONTROL CHANNEL

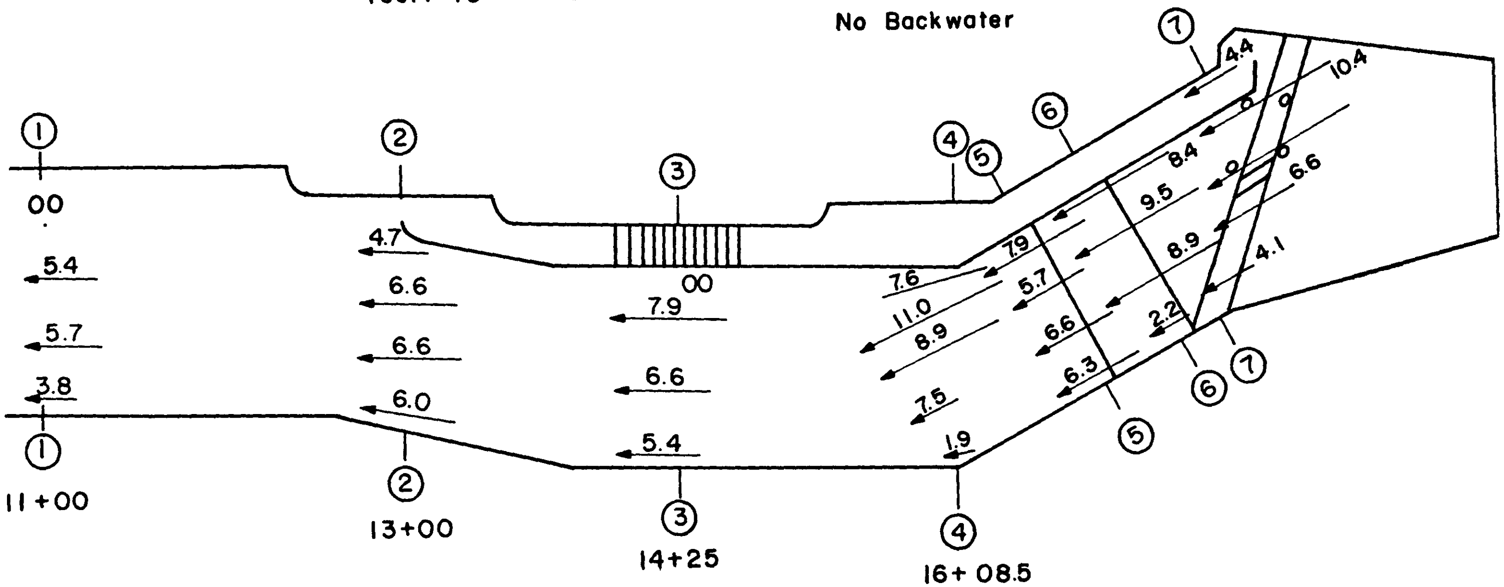
Test: 18 Date: 8/29/84 cfs: 1916 (10yr)
Full Backwater



(1) Station Numbers for Flow Meter Readings
Velocities in fps (Prototype)

LITTLES CREEK FLOOD CONTROL CHANNEL

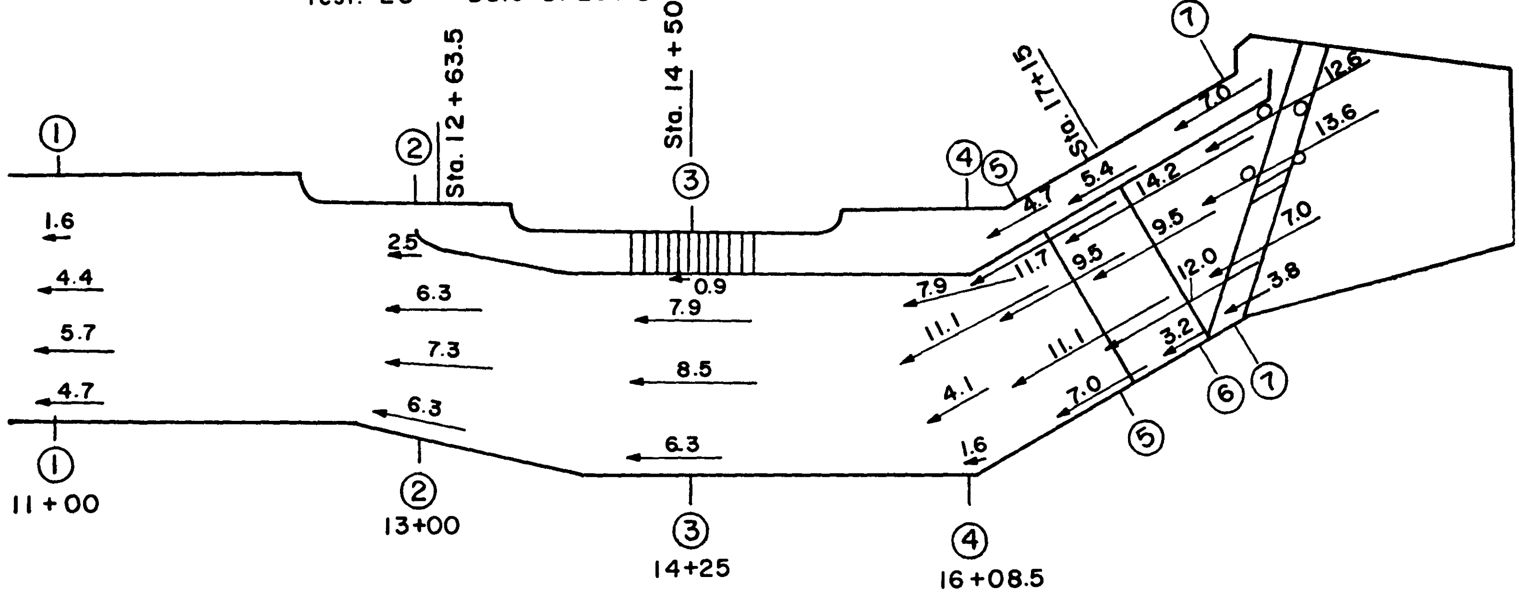
Test: 19 Date: 8/29/84 cfs: 1916 (10yr)
No Backwater



(1) Station Numbers for Flow Meter Readings
Velocities in fps (Prototype)

LITTLES CREEK FLOOD CONTROL CHANNEL

Test: 20 Date: 8/29/84 cfs: 2700 (100 yr)



Notes:

Velocity Traverse Location

Velocity in Prototype Dimensions (fps)