US Army Corps of Engineers
St. Louis District

Technical Report M33

GENERIC DIKE FLUME STUDY

By
Jasen L. Brown
Michael T. Rodgers
Edward H. Riiff
Robert D. Davinroy
David C. Gordon

U.S. Army Corps of Engineers
St. Louis District
Hydrologic and Hydraulics Branch
Applied River Engineering Center
Foot of Arsenal Street
St. Louis, MO 63118

Prepared for
U.S. Army Corps of Engineers, St. Louis District
Avoid and Minimize Program

In cooperation with:
ILLINOIS DEPARTMENT OF NATURAL RESOURCES
MISSOURI DEPARTMENT OF CONSERVATION
U.S. FISH AND WILDLIFE SERVICE

Final Report - MAY 2006

Approved for Public Release; Distribution in Unlimited

APPLIED RIVER ENGINEERING CENTER

Technical Report M33

GENERIC DIKE FLUME STUDY

By
Jasen L. Brown
Michael T. Rodgers
Edward H. Riiff
Robert D. Davinroy
David C. Gordon

U.S. ARMY CORPS OF ENGINEERS
ST. LOUIS DISTRICT
HYDROLOGIC AND HYDRAULICS BRANCH
APPLIED RIVER ENGINEERING CENTER
FOOT OF ARSENAL STREET
ST. LOUIS, MISSOURI 63118

Sponsored by and Prepared for:
U.S. ARMY CORPS OF ENGINEERS – ST. LOUIS DISTRICT
AVOID AND MINIMIZE PROGRAM

In Cooperation With:
ILLINOIS DEPARTMENT OF NATURAL RESOURCES
MISSOURI DEPARTMENT OF CONSERVATION
U.S. FISH AND WILDLIFE SERVICE

Final Report – MAY 2006

INTRODUCTION

The Mississippi River, although somewhat controlled through the use of river training structures, remains a dynamic river. While bathymetry and depths are constantly changing, existing structures, both natural and manmade, work to preserve the existing river planform to a relatively static alignment. The U.S. Army Corps of Engineers, St. Louis District, is responsible for a 300-mile reach of the Mississippi River from Lock and Dam 22 to Cairo, Illinois.

Several types of river training structures have already been implemented in the river to maintain the alignment and navigable depths. Some structures, such as straight dikes and trail dikes, have long been used by the Corps to solve navigation problems. Other structures, such as bendway weirs and chevrons, have only recently (within the last 15 years) been developed and put to work. Within the river channel, many opportunities exist to implement new structures and modify existing structures to serve the needs of both the navigation industry while improving environmental conditions. There are endless possibilities of river structure combinations available to solve river problems. Currently river engineers rely heavily upon good river engineering sense and intuition in determining what types and combinations of structures should be used or model tested. While good river engineering sense is a tool that can never be fully replaced by any advance in technology, additional insight into a structure's impact on channel bathymetry is needed for the river engineer to make better, more informed judgments regarding the selection of river training structures.

The U.S. Army Corps of Engineers, St. Louis District initiated the Generic Dike Flume study. The study was funded by the Avoid and Minimize Environmental Program. The purpose of the study was to evaluate new and existing river structures based on sediment transport conditions and the subsequent bathymetry of each test. Accordingly, this study is intended to be used as a tool to aid in the design and layout of river structures.

Mr. Jasen L. Brown, Hydraulic Engineer, and Mr. Edward H. Riff, Engineering Technician, under direct supervision of Mr. Michael T. Rodgers, Hydraulic Engineer, David C. Gordon, Hydraulic Engineer, and Mr. Robert D. Davinroy, District Potamologist, conducted the study between July 2003 and April 2004. Other personnel also involved with the study included Mr. Leonard Hopkins from the River Engineering Unit of the Hydrologic and Hydraulics Branch and Mr. Brian Johnson from the Environmental Branch of the Planning, Programs, and Project Management Division.

TABLE OF CONTENTS

INTRODUCTION 1

TABLE OF CONTENTS 3

STUDY OBJECTIVES 4

HYDRAULIC FLUME SETUP 4

1. SCALES AND BED MATERIALS 4
2. APPURTENANCES 5

HYDRAULIC FLUME TESTS 6

1. BASE TEST 6
2. STRUCTURE TESTING 7

CONCLUSIONS 38

1. ANALYSIS 38
    - Notched Dikes (Tests 2-7) 38
    - Notched L-Dikes (Tests 8-11) 38
    - Chevrons (Tests 12-17) 39
    - Sloped Dikes (Tests 18, 19) 40
    - Double Dike (Test 20) 41
    - Wedge Dikes (Tests 21, 22) 41
    - MRS Structures (Tests 23, 24, 25) 41
    - Angled Dikes (Tests 26, 27) 42
    - W-Dikes (Test 28, 29, 30) 43
2. SUMMARY 44
3. RECOMMENDATIONS 48
4. INTERPRETATION OF MODEL TEST RESULTS 48

FOR MORE INFORMATION 50

APPENDIX OF PLATES 51

STUDY OBJECTIVES

The primary objective of this study was to evaluate new and existing river structures and their influence on the bathymetry of the generic flume. Each test was evaluated on the structure's or structures' impact on the overall bed configuration as well as the bathymetry created in the immediate area of the tested structure or structures. It should be noted that these impacts are evaluated as general trends, not specific measurements. From these evaluations, further insights into the bathymetry forming characteristics of each structure or type of structure can be gained and utilized in future river engineering projects. This study is not intended to show preference to any particular river structure or structures, but rather to provide a tool to be used in selecting a river training structure to be used alone or in a configuration of structures to achieve project goals.

HYDRAULIC FLUME SETUP

1. Scales and Bed Materials

In order to investigate the sediment transport conditions and habitat development described previously, a hydraulic flume was designed and constructed. Plate 1 is a photograph of the hydraulic flume used in this study. The flume employed a horizontal scale of 1 inch = 250 units (generic "units" used to measure bathymetric changes in lieu of actual scaled units such as feet, meters, etc.) and a vertical scale of 1 inch = 50 units for a 5 to 1 distortion ratio of linear scales. The horizontal scale was chosen so that the flume would be 2500 units in width, which is similar to the average width of the prototype in the St. Louis District. The vertical scale was chosen through an iterative process that yielded a bed configuration similar to what is seen in a typical Mississippi River hydrographic survey. The bed material was granular plastic urea, Type II, with a specific gravity of 1.40.

Tests requiring notches in structures were denoted with either “Deep” or “Shallow” notched structures. The terms “Deep” or “Shallow” refer to the depth of the notch relative to the height of the structure. Shallow notches were cut to a depth of +5 vertical units, while deep notches were cut to a depth of -15 vertical units.

2. Appurtenances

The flume was constructed of clear acrylic. The flume was then mounted in a standard micro model hydraulic table. Rotational jacks located within the hydraulic table controlled the slope of the tabletop. The measured slope of the insert and flume was approximately 0.0035 inch/inch. River training structures in the model were made of galvanized steel mesh.

Flow of both water and sediment into the flume was regulated by customized computer hardware and software interfaced with an electronic control valve and submersible pump. Discharge was monitored by a magnetic flow meter interfaced with the customized computer software. Water stages were manually checked with a mechanical three-dimensional point digitizer. Resultant bed bathymetries were measured and recorded with a three-dimensional laser scanner. Micro modeling methodology was used to evaluate the resultant bathymetry of various structural measures within a generic hydraulic flume.

In all flume tests, a steady state flow was simulated in the generic channel. This served as the average design energy response of the river. Because of the constant variation experienced in the prototype, this steady state flow was used to theoretically analyze the ultimate expected sediment response. The flow was held steady at a constant flow rate of 5.4 GPM (Gallons per Minute) during flume calibration and for all design alternative tests. The most important factor during the modeling process is the establishment of an equilibrium condition of sediment transport. The steady flow in the flume simulated an energy condition representative of the river's ultimate channel forming flow and sediment transport potential.

HYDRAULIC FLUME TESTS

1. Base Test

A base test was achieved once an adequate flow condition, including sufficient depth and sediment transport, was obtained. Deeper water was present in the upstream portion of the flume as flume entrance structures focused flow toward the center of the channel. As the flow progressed toward the downstream end of the flume, no control structures were in place to prevent the main flow from spreading out and shallowing. Because of this, the base test consisted of a bathymetry that was narrow, deep, and centered in the upstream portion, while wide and shallow in the downstream portion. The resultant bathymetry of this bed response served as Base Test 1. Additional base tests are shown after every five alternatives. These base tests were run to maintain the validity of test results. Each structure test was to be compared to the most recent base test. While there were differences in the base test bathymetries, all base tests showed the same pattern of deep water in the center of the upstream reach with a wider, shallower channel in the downstream reach. The minor differences in the base tests can be attributed to the fact that micromodeling methodology was used in a hydraulic flume that is 2 to 3 times the width of an average micromodel. This increased width makes channel meandering (within the hard banks) possible. Given that no two surveys of any particular reach of the Mississippi River will ever yield identical bathymetries, this variance was considered well within tolerable limits.

Plates 2, 8, 14, 20, 26, and 32 show the resultant bathymetries of each base test.

2. Structure Testing

An important factor in testing was to alter only the aspects of the model pertinent to the individual structure being tested. Flume discharge and entrance conditions were not altered in any way. Structures in the flume were added with care taken to ensure proper scale, as well as proper alignment and elevation.

The aforementioned laser scanner was used to survey and capture any changes in bathymetry caused by the implementation of structures.

Multiple structures and groups of structures were tested to qualitatively examine the bathymetric response of the channel. Structures were placed along the LDB (Left Descending Bank) at the 7250 mark along the X-axis. The effectiveness of each test was evaluated through a qualitative comparison of the resultant bed configuration to that of the base condition.

Base Test 1 (Plate 2)

Plate 2 shows the resultant bathymetry of Base Test 1. In this test, the main flow was concentrated toward the LDB side of the channel. Some deposition did occur along the LDB between the 0 and 5000 marks on the X-axis. A large area of deposition was located along the RDB (Right Descending Bank) in the upstream half of the channel. In the downstream half of the channel, the main flow spreads out over the majority of the channel width. This resulted in shallower depths in the middle of the channel, and some slightly deeper depths near the LDB and the RDB near the channel exit.

Test 1: Single Dike, No Notch (Plate 3)

Type of Structure	Number of Structures	Notch Info	Dimensions	Height
Dike	1	None	750	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 1 shows deposition similar to the base test along the RDB and LDB upstream of the dike. • Increased deposition along the LDB occurred downstream of the dike. • Downstream of the dike, channel deepening occurred near the middle of the channel resulting in a continuous path of deep water extending to the model exit.	• An area of deep scour occurred on the downstream side of the dike. This scour was equal in width to the length of the dike, and extended approximately 200 units downstream. • A line of scour also occurred coming off the end of the dike extending downstream for 2 to 3 dike lengths.

Test 2: Single Dike, Deep Notch LDB (Plate 4)

Type of Structure	Number of Structures	Notch Info	Dimensions	Height
Dike	1	190 units long Notched to -15 LDB Side	750	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 2 shows similar deposition similar to the base test along the RDB and LDB upstream of the dike. • Downstream of the dike, channel deepening occurred near the middle of the channel resulting in a continuous path of deep water extending to the model exit. This channel deepening was significantly deeper than the base test, but somewhat shallower than in Test 1. • Downstream of the dike notch, significant side channel development along the LDB.	• Significant scour was seen on the downstream of the dike as in Test 1. • A line of scour formed off the end of the dike extending downstream. This line of scour was shallower than the same line of scour present in Test 1. • A deep line of scour extended downstream of the dike notch along the LDB to the model exit. This formed a significant side channel with a well isolated island. The island (area above 0 LWRP) was approximately 1500 units in length and 500 units in width.

Test 3: Single Dike, Deep Notch Middle (Plate 5)

Type of Structure	Number of Structures	Notch Info	Dimensions	Height
Dike	1	190 units long Notched to -15 Middle of Dike	750	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 3 shows similar deposition similar to the base test along the LDB upstream of the dike. • The depositional area along the RDB upstream of the dike was significantly less than the base test. • The thalweg in the upstream portion of the model was deeper than in the base test. • Downstream of the dike, channel deepening occurred near the middle of the channel resulting in a continuous path of deep water extending to the model exit. This channel deepening was similar to Test 2.	• Significant scour was seen on the downstream of the dike as in Test 1 and Test 2. • A line of scour formed off the end of the dike extending downstream. This line of scour was similar to the same line of scour from Test 2. • A deep line of scour extended downstream of the dike notch extending to the model exit. • A thin line of deposition formed along the LDB downstream of the dike. • A small secondary channel formed below the notch and a narrow isolated island was created.

Test 4: Single Dike, Deep Notch RDB (Plate 6)

Type of Structure	Number of Structures	Notch Info	Dimensions	Height
Dike	1	190 units long Notched to -15 RDB Side	750	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 4 upstream of the dike was similar to that of Test 3.	• Significant scour was seen on the downstream of the dike as in previous tests. • A deep line of scour formed downstream of the dike notch and extended downstream approximately one dike length. • Much of the downstream section of the channel was deeper in this test as opposed to the base test. • Some deposition was present along the LDB. The shoaling near the channel exit was significantly less than in the base test.

Test 5: Single Dike, Shallow Notch LDB (Plate 7)

Type of Structure	Number of Structures	Notch Info	Dimensions	Height
Dike	1	190 units long Notched to +5 LDB Side	750	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 5 was similar to Test 4 upstream of the dike. • Downstream of the dike, channel deepening occurred near the middle of the channel resulting in a continuous path of deep water extending to the RDB side of the model exit. This channel deepening was significantly deeper than the base test. • Downstream of the dike, the channel was much shallower than in the base test.	• Significant scour was seen on the downstream side of the dike as in previous tests. • A line of scour formed off the end of the dike extending downstream. This line of scour was much shorter than in previous tests. • A shallow line of scour extended downstream of the dike notch along the LDB. This line of scour extended about halfway to the model exit. This scour pattern was not nearly as distinct as the scour in Test 2 (Deep Notch LDB). • An island (area above 0 LWRP) was formed downstream of the un-notched section of dike and measured approximately 1500 units in length and 400 units in width. The island was not strongly isolated from the LDB.

Base Test 2 (Plate 8)

The bathymetry of Base Test 2 was somewhat similar to Base Test 1, but did have some differences. In the upstream portion of the channel, the area of deep water was deeper than in Base Test 1. Also, the area of deposition along the RDB in the upstream portion of the channel was smaller than in Base Test 1.

Test 6: Single Dike, Shallow Notch Middle (Plate 9)

Type of Structure	Number of Structures	Notch Info	Dimensions	Height
Dike	1	190 units long -15 LWRP LDB Side	750	+15

Overall Bed Configuration	Near Dike Configuration
• The upstream bathymetry of Test 6 was similar to Base Test 2. • Downstream of the dike, channel deepening occurred near the middle of the channel.	• An area of deep scour occurred on the downstream side of the dike. • A deep line of scour was present off the end of the dike extending downstream. • Just downstream of the dike notch, a deep line of scour formed and extended approximately 2 dike lengths downstream. After 2 dike lengths downstream, the line of scour shallowed but did extend to the model exit. • A thin band of deposition above 0 LWRP did appear along the RDB side of the line of scour associated with the dike notch.

Test 7: Single Dike, Shallow Notch RDB (Plate 10)

Type of Structure	Number of Structures	Notch Info	Dimensions	Height
Dike	1	190 units long Notched to +5 RDB Side	750	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 7 upstream of the dike was similar to that of Base Test 2. • Downstream of the dike, the channel was much deeper than that of Base Test 2, with the exception of the area along the LDB. This depositional area was present from just downstream of the dike all the way to the model exit.	• An area of scour was present on the downstream side of the dike. • The small section of dike on the RDB side of the notch created a deep line of scour extending downstream approximately 2 dike lengths.

Test 8: L-Dike, No Notch (Plate 11)

Type of Structure	Number of Structures	Notch Info	Dimensions	Height
L-Dike	1	None	500 units from LDB 750 unit Trail	+15

Overall Bed Configuration	Near Dike Configuration
• The upstream bathymetry of Test 8 was similar to that of Base Test 2. • The bathymetry downstream of the L-dike showed increased deposition along the LDB, along with increased scour in the middle of the channel and extending to the RDB at the model exit.	• There was a line of scour off the end of the section of the L-dike that was perpendicular to the direction of flow. • Some slight scour was observed on the downstream side of the same section. • Deposition was evident directly behind and below the L-dike.

Test 9: L-Dike, Deep Notch LDB (Plate 12)

Type of Structure	Number of Structures	Notch Info	Dimensions	Height
L-Dike	1	190 units long Notched to -15 LDB Side of Front Leg	500 units from LDB 750 unit Trail	+15

Overall Bed Configuration	Near Dike Configuration
• The upstream bathymetry of Test 9 was similar to that of Base Test 2. • The bathymetry downstream of the L-dike also showed trends similar to Base Test 2. • The scour located along the LDB in Test 9 was a direct result of the L-dike notch.	• A line of scour extending downstream off the end of the L-dike was observed. This line of scour was less prevalent than the same line of scour that developed in Test 8. • A narrow island of deposition formed downstream of the trail section of the L-Dike. This depositional area extended to the flume exit. • Scour below the notch extended to the flume exit and created a long secondary channel with good depth that isolated the island from the LDB.

Test 10: L-Dike, Deep Notch Middle (Plate 13)

Type of Structure	Number of Structures	Notch Info	Dimensions	Height
L-Dike	1	190 units long Notched to -15 Middle of Front Leg	500 units from LDB 750 unit Trail	+15

Overall Bed Configuration	Near Dike Configuration
• The upstream bathymetry of Test 10 was similar to that of Base Test 2. • The bathymetry downstream of the L-dike also showed trends similar to Base Test 2. • A line of deep water extended downstream from the notch in the structure.	• A deep line of scour extended downstream from the notch in the structure. • An island formed but was less distinct than Test 9 with a lower top elevation.

Base Test 3 (Plate 14)

The bathymetry of Base Test 3 was similar to Base Test 2. Plate 14 is a plan view map of the resultant bed configuration of Base Test 3.

Test 11: L-Dike, Deep Notch RDB (Plate 15)

Type of Structure	Number of Structures	Notch Info	Dimensions	Height
Dike	1	190 units long Notched to -15 RDB Side of Front Leg	500 units from LDB 750 unit Trail	+15

Overall Bed Configuration	Near Dike Configuration
• Upstream of the L-dike, the bathymetry was similar to that of Base Test 3. • Downstream of the L-dike, less deposition was observed in the middle of the channel toward the model exit when compared to Base Test 3.	• A scour hole was observed on the downstream side of the front leg of the L-dike. • A line of scour was present just downstream of the notch. This line of scour extended approximately 4000 units downstream.

Test 12: Chevron (Plate 16)

Type of Structure	Number of Structures	Location	Dimensions	Height
Chevron	1	750 units from LDB	250W x 300L	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry upstream of the chevron was similar to that of Base Test 3. • The bathymetry downstream of the chevron was also similar to Base Test 3, with the exception of a major area of shoaling that occurred immediately downstream of the chevron, extending through the end of the model. • The width of the area of deposition increased nearly linearly at a rate of approximately 1 unit of width for every 10 units of length.	• A slight scour hole did develop immediately behind the chevron. • Deposition also occurred upstream between the chevron and the LDB. • Scour was also evident around the outside of the chevron.

Test 13: Chevron, Apex Notch (Plate 17)

Type of Structure	Number of Structures	Location	Notch Location and Depth	Dimensions	Height
Chevron	1	750 units from LDB	Apex Notch Notched to -10	250W x 300L	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry upstream of the chevron was similar to that of Base Test 3. • A major area of shoaling occurred downstream of the chevron. The channel bathymetry on either side of this area of shoaling was significantly deepened when compared to Base Test 3.	• A line of deep scour was observed immediately behind the chevron apex and extended approximately 500 units downstream. • A small area of deposition was evident upstream of the chevron. • A wide side channel was formed along the LDB. • The deposition noted in Test 12, between the LDB and the chevron, was not noted in this test.

Test 14: Chevron, LDB Leg Notch, Stub Dikes On Each Leg (Plate 18)

Type of Structure	Number of Structures	Location	Stub Dike Lengths	Notch Location and Depth	Dimensions	Height
Chevron	1	750 units from LDB	50	Notched on LDB leg Notched to -10	350W x 300L	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry upstream of the chevron was similar to that of Base Test 3. • A major area of shoaling occurred downstream of the chevron. • The channel bathymetry on either side of this area of shoaling was significantly deepened when compared to Base Test 3.	• A line of deep scour was observed immediately behind the notch in the chevron LDB leg and extended approximately 500 units downstream. • Small lines of scour were observed off the ends of the stub dikes protruding from the chevron legs. • Deposition was noted upstream from the apex of the chevron. • The bathymetry downstream of the chevron dike on the LDB deepened, forming a significant second channel with a well isolated island.

Test 15: 2 Chevrons, Staggered Apex to Leg (Plate 19)

Type of Structure	Number of Structures	Upstream Chevron Location	Downstream Chevron Location	Dimensions	Height
Chevron	2	750 units from LDB	875 units from LDB, 7850 on the X-Axis	375W x 900L	+15

Overall Bed Configuration	Near Dike Configuration
• The upstream bathymetry was similar to Base Test 3. • The downstream condition showed channel deepening near the LDB and the RDB. • A large area of consistent deposition occurred from just downstream of the chevrons extending all the way to the model exit.	• A small line of scour was observed off the RDB leg of each chevron. • A scour hole was observed immediately behind the most upstream chevron. • A scour hole was present just inside the RDB leg of the downstream chevron. • Deposition was noted upstream from the apex of the chevron. • The bathymetry downstream of the chevron dike on the LDB deepened, forming a significant second channel with a well isolated island.

Base Test 4 (Plate 20)

In Base Test 4, the upstream bathymetry showed increased deposition along the LDB and RDB and a shallower thalweg when compared to Base Test 3. In the downstream half of the channel, less deposition was observed in the center of the channel with some increased scour along the LDB. Plate 20 is a plan view map of the resultant bed configuration of Base Test 4.

Test 16: 3 Chevrons, Staggered Apex to Leg (Plate 21)

Type of Structures	Number of Structures	Upstream Chevron Location	Middle Chevron Location	Downstream Chevron Location	Dimensions	Height
Chevrons	3	750 units from LDB	875 units from LDB, 7850 on the X-Axis	900 units from LDB, 8450 on the X-Axis	500W x 1500L	+15

Overall Bed Configuration	Near Dike Configuration
• Deep side channel development downstream of the chevrons along the LDB. • A large depositional area was observed directly downstream of the chevrons. This area was above 0 LWRP, was approximately 750 units wide, and extended all the way to the model exit. • The channel thalweg on the RDB side of the island created by the chevrons was significantly shallower than the LDB side, but was approximately 3 times wider. • No scour hole was observed immediately behind each chevron apex.	• More deposition behind each successive chevron. • Island formation similar to test 15, but with a higher island height and deeper side channel depth along the LDB. • Small line of scour off the end of the downstream chevron. • Deposition upstream of chevrons was evident.

Test 17: Chevron, LDB Leg Notch, Stub Dike On LDB Leg (Plate 22)

Type of Structure	Number of Structures	Location	Stub Dike Length	Notch Location and Depth	Dimensions	Height
Chevron	1	750 units from LDB	50	Notched on LDB leg Notched to -10	300W x 300L	+15

<table>
<tr><th>Overall Bed Configuration</th><th>Near Dike Configuration</th></tr>
<tr><td>

The flow past the LDB leg of the chevron was focused along the LDB and caused significant deepening along the LDB through the model exit.
The flow past the RDB side of the chevron scoured a path that continued downstream and angled toward the RDB.
When this flow encountered the RDB, significant scour was observed. An area of shoaling above 0 LWRP occurred downstream of the chevron. This depositional area was approximately 500 units in width and extended to the model exit.

</td><td>

Significant scour was observed just downstream of the chevron apex and also off the RDB and LDB legs of the chevron extending downstream.
An island formed downstream of the chevron.
Second channel on LDB deepened.

</td></tr>
</table>

Test 18: Sloped Dike, LDB to RDB (Plate 23)

Type of Structure	Number of Structures	Slope Info	Dimensions	Height
Sloped Dike	1	+15 at LDB bank, sloped to +10 at Dike's end	750 units	+15 sloped to +10

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 18 upstream of the dike was similar to that of Base Test 4. • Downstream of the dike, the channel thalweg was much deeper than that of Base Test 4, with the exception of an area along the LDB. This depositional area was present from just downstream of the dike, was 600 units in width, and extended all the way to the model exit.	• Some scour was observed just downstream of the RDB side of the dike. • A long and wide area of scour occurred from just downstream of the end of the dike and extended approximately 3000 units downstream. • Unlike Test 1, scour directly below the dike was not uniform. • Very little scour was observed on LDB side of dike.

Test 19: Sloped Dike, RDB to LDB (Plate 24)

Type of Structure	Number of Structures	Slope Info	Dimensions	Height
Sloped Dike	1	+10 at LDB bank, sloped to +15 at Dike's end	750 units	+10 sloped to +15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 19 upstream of the dike was similar to that of Base Test 4. • Downstream of the dike, the channel thalweg was much deeper than that of Base Test 4, with the exception of an area along the LDB. This depositional area was present from just downstream of the dike, was 750 units in width, and extended all the way to the model exit. • A small line of slight scour extending downstream along the LDB was present from just downstream of the dike.	• Some scour was observed just downstream of the RDB side of the dike. This line of scour was approximately 1500 units in length. • Scour was not evident below the dike.

Test 20: Double Dike (Plate 25)

Type of Structure	Number of Structures	Structure Locations	Dimensions	Height
Double Dike	2	Dikes spaced 100 units apart, at 7250 on the X-Axis	750 units	Upstream Dike at +15, Downstream Dike at +10

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 20 upstream of the dike was similar to that of Base Test 4. • Downstream of the dike, the channel thalweg was much deeper than that of Base Test 4, with the exception of an area along the LDB. This depositional area was present from just downstream of the dike, was 650 units in width, and extended all the way to the model exit. This depositional area was significantly higher in elevation than the depostional area behind the single dike in Test 1.	• Deep scour was observed just downstream of the RDB side of the dike. This line of scour was approximately 2000 units long. • Another long scour hole was located along the RDB between the 8500 mark on the X-axis and the model exit. • No scour developed just downstream of the dike except for at the RDB end of the dike.

Base Test 5 (Plate 26)

In Base Test 5, the upstream bathymetry showed decreased deposition along the LDB and RDB and a deeper thalweg when compared to Base Test 4. In the downstream half of the channel, more deposition was observed in the center of the channel with some increased scour along the LDB.

Test 21: Wedge Dike, 8 to 1 Slope (Plate 27)

Type of Structure	Number of Structures	Slope Info	Dimensions	Height
Wedge Dike	1	+15 at Upstream face, sloped to river bed at 1V to 8H slope.	750 units	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 21 upstream of the dike was shallower than that of Base Test 5. • The path of deep water was also narrower than in Base Test 5, with increased deposition along the RDB. • A narrow strip of deposition was observed just upstream of the dike along the LDB. • Downstream of the dike, a deep, wide flow path was observed from the LDB deposition to the RDB.	• Significant scour was seen extending downstream off the end of the dike. • A depositional area was observed downstream of the dike along the LDB.

Test 22: Wedge Dike, 4 to 1 Slope (Plate 28)

Type of Structure	Number of Structures	Slope Info	Dimensions	Height
Wedge Dike	1	+15 at Upstream face, sloped to river bed at 1V to 4H slope.	750 units	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 22 was similar to the bathymetry of Test 21	• The bathymetry of Test 22 was similar to the bathymetry of Test 21

Test 23: MRS Dike (Plate 29)

Type of Structure	Number of Structures	Structure Layout	Dimensions	Height
MRS Dike	1	6 Structure Points, 125 units apart	750	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 23 upstream of the dike was similar to Base Test 5. • A narrow strip of deposition was observed just upstream of the dike along the LDB. • Downstream of the dike, a deep, wide flow path was observed between the 1750 mark on the Y-axis and the RDB.	• Downstream of the dike, significant scour was observed between and just downstream of the MRS structure. • This downstream scour was approximately 500 units in length and was equal in width to the total dike length. • A small line of scour along the LDB extended from the dike to the model exit. • A depositional area also extending to the model exit was observed just downstream of the scour hole behind the dike.

Test 24: Staggered MRS Dike (Plate 30)

Type of Structure	Number of Structures	Structure Layout	Dimensions	Height
Staggered MRS Dike	1	6 Structure Points, 125 units apart in the X and Y Directions	750L x 125W	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 24 upstream of the dike showed a narrower strip of deep water extending down the middle of the channel. • Some deposition was observed along the LDB just upstream of the dike. • A depositional area extending to the model exit was observed just downstream of the scour hole behind the dike. • Downstream of the dike, a deep, some deepening occurred along the RDB and toward the middle of the channel when compared to Base Test 5.	• Some scour was observed between the structure points and just downstream of the MRS structure. This downstream scour was approximately 400 units in length and was equal in width to the total dike length. • A depositional area also extending to the model exit was observed just downstream of the scour hole behind the dike. • Downstream of the dike, some deepening occurred along the RDB and toward the middle of the channel when compared to Base Test 5.

Test 25: MRS Chevron (Plate 31)

Type of Structure	Number of Structures	Structure Layout	Dimensions	Height
MRS Chevron	1	6 Structure Points, 125 units apart in the shape of a chevron	250L x 300W	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 25 upstream of the dike was similar to Base Test 5. • A narrow strip of deposition was observed just upstream of the dike along the LDB. • Significant scour was observed between and just downstream of the chevron's MRS structures.	• A line of scour along the LDB extended from the LDB chevron leg to the model exit. • A deep flow path was observed flowing past the RDB leg of the chevron and toward the RDB. • A depositional area also extending to the model exit was observed just downstream of the scour behind the chevron. • A significant island formed with a secondary channel.

Base Test 6 (Plate 2

In Base Test 6, the upstream bathymetry showed increased deposition along the LDB and RDB and a shallower thalweg when compared to Base Test 5. In the downstream half of the channel, the bathymetry was similar to Base Test 5. Plate 32 is a plan view map of the resultant bed configuration of Base Test 6.

Test 26: Dike Angled Upstream (Plate 33)

Type of Structure	Number of Structures	Angle Info	Dimensions	Height
Angled Dike	1	Angled 30 degrees upstream	750 units total, 650 units effective width	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 26 upstream of the dike showed increased deep water at the channel thalweg when compared to Base Test 6. • The deposition along the RDB and LDB was similar to Base Test 6. • Increased depth downstream of the dike and near the middle of the channel was observed when compared to Base Test 6.	• A line of scour could be seen extending off the end of the dike and extending downstream. • Downstream of the dike, significant deposition was observed along the LDB.

Test 27: Dike Angled Downstream (Plate 34)

Type of Structure	Number of Structures	Angle Info	Dimensions	Height
Angled Dike	1	Angled 30 degrees downstream	750 units total, 650 units effective width	+15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 27 upstream of the dike showed a narrower deep-water path with increased deep water at the channel thalweg when compared to Base Test 6. • Increased deposition along the RDB in the downstream end of the flume was observed as well.	• A wide line of scour could be seen extending off the end of the dike and extending downstream. • Downstream of the dike, significant deposition was observed along the LDB. • A small area of scour was observed above and below the root of the dike. • A potential for localized shoreline erosion was observed.

Test 28: W-Dike 1 (Plate 35)

Type of Structure	Number of Structures	Orientation	Peak Heights
W-Dike	1	3 Points Upstream	Upstream points at +10, Downstream points at +15

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 28 upstream of the dike showed a narrower deep-water path when compared to Base Test 6. • Downstream of the dike, significant deposition was observed along the LDB. A deep water path was observed from near the center of the channel all the way toward the RDB. This area was significantly deeper than in Base Test 6.	• A wide line of scour could be seen extending off the end of the dike and extending downstream. • Two exceptionally deep scour holes were observed immediately downstream of the dike, one just behind the center of the dike, and one along the LDB. These scour holes were egg-shaped and were approximately 500 units in length. •

Test 29: W-Dike 2 (Plate 36)

Type of Structure	Number of Structures	Orientation	Peak Heights
W-Dike	1	3 Points Downstream	Upstream points at +15, Downstream points at +10

<table>
<tr><th>Overall Bed Configuration</th><th>Near Dike Configuration</th></tr>
<tr><td>

The bathymetry of Test 29 upstream of the dike showed a narrower deep-water path when compared to Base Test 6.
The deposition along the RDB was similar to Base Test 6. The deposition along the LDB had increased from Base Test 6.
Downstream of the dike, significant deposition, approximately 1000 units in width, was observed along the LDB.
Downstream of the dike, a deep water path was observed from near the center of the channel all the way toward the RDB. This area was significantly deeper than in Base Test 6.

</td><td>

A wide line of scour could be seen extending off the end of the dike and extending downstream.
A scour hole was observed immediately downstream of the RDB side of the dike.
A line of scour was also present from just off the end of the dike and extending downstream angled slightly toward the RDB.

</td></tr>
</table>

Test 30: W-Dike 3 (Plate 37)

Type of Structure	Number of Structures	Orientation	Peak Heights
W-Dike	1	3 Points Upstream	Upstream points at +15, Downstream points at +10

Overall Bed Configuration	Near Dike Configuration
• The bathymetry of Test 30 upstream of the dike showed a narrower deep-water path when compared to Base Test 6. • The deposition along the RDB was similar to that of Base Test 6. • There was increased deposition along the LDB when compared to Base Test 6. • Heavy deposition was present downstream of the dike along the LDB. • The middle and RDB side of the channel downstream of the dike was primarily deep water.	• At the dike, some scour occurred just downstream of the RDB half of the dike. • A line of deeper scour was observed off the end of the dike extending downstream and slightly toward the RDB.

CONCLUSIONS

1. Analysis

In summarizing the testing results, each category of structure will be discussed individually along with the trends developed from manipulation of each type of structure. The summary of this report should be used as an aid in the design of river structures that have the opportunity to provide environmental benefit.

Notched Dikes (Tests 2-7)

- Notches in the middle of the dike and near the bankline produced significant scour downstream of the notch.
- Both deep and shallow notches near the center or bank side of the dike typically led to the development of an island and side channel.
- Deep notches tended to produce longer and deeper scour paths than did shallow notches.
- Notches along the end of the dike did not form bathymetric patterns much different from those of a dike without a notch (Test 1).

Notched L-Dikes (Tests 8-11)

- The bathymetry observed for an unnotched L-Dike (Test 8) was similar to the bathymetry observed with a standard unnotched dike (Test 1).
- Placing a deep notch in an L-Dike in the center of the dike and near the bankline produced similar results to standard dikes with notches in those same locations (Tests 2 and 3).
- Deep notches in the middle or near the LDB side of the face of the L-Dike tended to produce deep scour just downstream of the notch, along with a thin line of deposition immediately downstream of the trail of the L-Dike.
- A deep notch in the L-Dike near the trail produced much different results than a riverside notch in a standard dike. The notch created scour

patterns along the inside of the trail and a shallow thin bar developed just downstream of the structure's trail.

Chevrons (Tests 12-17)

- All chevrons tested reacted similarly in that the bathymetry showed that the chevrons divided the flow smoothly, redirecting some flow without any abrupt changes causing heavy scour. In all cases:
    - A small bar formed just upstream of the chevron's apex.
    - A plunge pool developed within the apex.
    - Small scour patterns formed along the outside of the legs.
    - Significant deposition occurred downstream of the plunge pool.
    - Secondary channel development was evident.
- In the case of a field of two or more chevrons (Tests 15 & 16), deposition behind the chevrons and side channel depth both increased with the number of chevrons in the field.
- Notches in the chevron significantly increased the scour within the apex and changed the depositional patterns downstream of the structure.
    - Effects of the apex notch (Test 13):
        - A long, deep, narrow scour pattern formed beginning in the apex and extending downstream outside of the structure.
        - The scour pattern split the depositional area downstream of the structure which created a "forked" pattern. The split area merged downstream into a narrow bar formation.
    - Effects of the leg notch:
        - The scour pattern on the inside of the structure was larger and deeper than that of a chevron without a notch but less than that of a chevron with an apex notch.
        - The stub dikes along each leg had two effects:

- Stub dikes along both legs created a more pronounced depositional area or forked pattern that merged into a wider bar downstream (Test 14).
- A stub dike along the leg with the notch formed a single narrow bar inline with the same leg (Test 17).

Sloped Dikes (Tests 18, 19)

- In both sloped dike tests, the path of deep water, at or below –10 LWRP, was significantly widened downstream of the structure when compared to Base Test 4 (Plate 20).
- Both dikes formed a smaller, shallower plunge pool on the downstream side of the dike than a standard level-crested dike (Test 1).
- The dike sloped from the bankline toward the river channel is a common design used on the Middle Mississippi River (Test 18).
    - This dike created a much larger scour hole from the end of the structure in the downstream direction.
    - Bar development downstream of the structure was similar to that of the level-crested dike (Test 1).
- The dike sloped down from the river to the bankline showed the following (Test 19):
    - The scour hole off the end of the structure was similar to that of the level-crested dike (Test 1).
    - A shallow, narrow, long side channel formed along the bankline.
    - The depositional area downstream of the dike was more pronounced than the bar formed by the level-crested dike.

Double Dike (Test 20)

The double dike configuration produced similar bathymetric patterns to those of the single dike in Test 1. Differences between the tests are as follows:

- The bathymetry of this test showed no significant scour or plunge pool downstream of the dikes.
- Deep scour was observed off the end of the double dike configuration extending in the downstream direction.
- A slightly larger depositional area was created downstream of the structures.

Wedge Dikes (Tests 21, 22)

The wedge dikes tested in these two tests differed only in the slope of the downstream edge of the dike.

- Both tests resulted in similar bathymetries to that observed in Test 20, the Double Dike.
- The steeper of the two wedge slopes, 4 horizontal to 1 vertical, produced more scour off the end of the dike than the less steep 8 to 1 slope.
- The dike with an 8 to 1 slope produced a slightly larger bar downstream of the structure. The bar downstream of the 4 to 1 sloped dike was more similar to the standard dike (Test 1).

MRS Structures (Tests 23, 24, 25)

- Scour was observed between the MRS points as well as just downstream of the points.
- Scour was not observed off the ends to the structures.

- The plunge pool area just downstream of the single row MRS was shallower than the scour created by a standard dike. However, the area of scour extended further downstream of the structure.
- This scour was somewhat reduced by using 2 rows and staggering the MRS points upstream to downstream as in Test 24 (Plate 30).
- A narrow side channel was formed along the bankline by the single row MRS.
- A shallower side channel was formed by the double row MRS.
- In the MRS Chevron, deep scour was observed both between and just downstream of the points of the MRS structure. As what would be expected in a typical continuous chevron, flow was redirected both left and right of the chevron while an area of deposition formed directly downstream. The habitat around the chevron was strikingly different than a traditional chevron, with what appears to be less upstream deposition and more depth associated with the structure itself.

Angled Dikes (Tests 26, 27)

- In both tests, deposition was observed downstream of the structures along the LDB that was nearly equal in width to the overall length of the dike.
- The depositional area upstream of the dike was more pronounced with the upstream angled dike.
- Some scour was observed off the end of the dike angled upstream while even more scour was observed off the end of the dike angled downstream.
    - The scour off the end of the downstream angled dike was directed toward the RDB.
    - The scour off the end of the upstream angled dike was directed downstream parallel with both banks.
- The upstream angled dike did not form a plunge pool on the downstream side of the structure.

- The downstream angled dike created a deep isolated area of scour on the downstream side of the structure, where the dike meets the bankline. Structures similar to this one on the Middle Mississippi River have also created deep scour in the same area which subsequently eroded the bankline into a “roundout”.
- The difference between the effects of these two structures on the river channel was pronounced. The upstream angled structure formed a much deeper, wider channel downstream while the downstream angled dike had bathymetric patterns similar to the base test.

W-Dikes (Test 28, 29, 30)

A W-Dike can be laid out in 4 distinct methods. There are two separate lay-outs and 2 separate gradients along the crest of the structure:

1. 3 points upstream or 2 points upstream.
2. Starting from the bank either sloping up or down and alternating slopes at the points.

Three of these were tested in the model while results of the 4^{th} can be inferred from the other tests. The results on the bathymetric patterns are uniquely different depending upon the layout and slope of the structure.

- 3-Points Upstream:
    - Upstream Points High (Test 30) – Two small areas of scour occurred within the middle “V” and near the bankline.
    - Upstream Points Low (Test 28) – Significant deep scour occurred within the middle “V” of the structure. Because the legs of the “V” slope upward in the downstream direction, a significant amount of flow is concentrated into the apex from both sides of the leg. A large deep scour area was formed at the bankline due to the bank-side leg that concentrates flow here. These two scour holes are separated by a high, narrow bar. The middle scour hole is separated from the main channel by another narrow bar.

- 2-Points Upstream
    - Upstream Points High (Test 29) – A small area of scour occurred within the “V” closest to the bankline. A larger area of scour occurred within the “V” closest to the river channel.
    - Upstream points Low – (Results inferred) Significant scour occurred within both the “V’s” separated by a high, narrow bar. If another leg is added at the end of the structure in the upstream direction, another narrow bar would separate both scour holes from the river channel.

All 3 tests produced similar scour holes off the ends of the structures and bathymetric patterns in the river channel downstream of the dike.

2. Summary

A tabular summary showing certain observed bathymetric characteristics associated with each test follows the conclusions for each type of structure.

Notched Dikes

The tests showed that deep notches near the bankline or middle of the dike would create the greatest opportunity to create a deep, secondary channel.

Notched L-Dikes

Results were similar to notched dikes except an isolated scour hole could be formed along the inside leg of the dike with a notch near river channel.

Chevrons

Test results showed that deeper and / or longer scour patterns were created by notching the apex or legs of the chevrons.   Unique depositional patterns were formed with the notches and / or stub dikes along the legs of the chevron.

Sloped Dikes

A dike sloping upward from the bankline toward the river channel created a small side channel that was less pronounced than those formed with deep notches.

Double-Dike

The double-dike formation appeared to allow less scour downstream of the structure.

Wedge Dikes

The wedge dike structure also appeared to allow less scour downstream of the structure.

MRS Structures

The plunge pool area that formed downstream of the single row MRS was shallower than the plunge pool from a standard dike. However, the area of scour extended further downstream of the structure. The scour was somewhat reduced by using 2 rows and staggering the MRS points upstream to downstream. The MRS chevron produced significant differences from the standard chevron including less upstream deposition and additional scouring in the immediate vicinity of the structure.

Angled Dikes

The most significant difference between the upstream and downstream angled dikes was their effect on the river channel. The upstream angled structure formed a much deeper, wider channel downstream while the downstream angled dike had bathymetric patterns similar to the base test. This was due to the downstream angled dike forcing flow into the bankline while the upstream dike forced it towards the river channel. Consistent with actual river structures, the downstream angled structure created a large scour hole along the bankline.

W-Dikes

The resultant bathymetry of each test suggested that when laying out a W-dike, the most environmentally beneficial layout would be to have the upstream points somewhat lower in elevation than the downstream points. However, to protect the bankline, the first leg should be angled in the upstream direction and sloped down from towards the first upstream point. In Test 28, with the upstream points at +10 and the downstream points at +15, a very diverse scour and deposition pattern developed. In Test 29 and Test 30, where the upstream points were higher in elevation than the downstream points, a less diverse scour and deposition pattern was observed. A modification to the suggested W-Dike design could create additional diversity with the addition another leg at the end of the structure oriented in the upstream direction. This addition would create another narrow bar that would separate both scour holes from the river channel.

Table 1:

Test No.	Test Description	Side Channel Creation	Scour Through Structure	Long Scour Channel	Shallow Wide Scour	Main Channel Navigability Improvement	No. of Depositional Areas Created	No. of Scour Holes Created
1	Single Dike				x	x	2	1
2	Dike - Deep LDB Notch	x	x	x	x	x	2	2
3	Dike - Deep Mid Notch	x	x	x	x	x	3	2
4	Dike - Deep RDB Notch		x		x	x	2	1
5	Dike - Shallow LDB Notch	x			x	x	2	2
6	Dike - Shallow Mid Notch	x			x	x	3	2
7	Dike - Shallow RDB Notch				x	x	2	1
8	L-Dike				x	x	2	1
9	L-Dike, Deep LDB Notch	x	x	x		x	2	2
10	L-Dike, Deep Mid Notch	x	x	x			2	2
11	L-Dike, Deep RDB Notch		x		x		2	1
12	Chevron	x		x		x	1	2
13	Chevron, Deep Apex Notch	x	x	x		x	1	3
14	Chevron, LDB Leg Notch, Leg Stub Dikes	x	x	x		x	1	3
15	Chevrons (2), Staggered Apex to Leg	x		x		x	1	3
16	Chevrons (3), Staggered Apex to Leg	x		x		x	1	3
17	Chevron, LDB Leg Notch, Leg Stub Dike	x	x	x		x	1	3
18	Sloped Dike, LDB to RDB				x	x	2	1
19	Sloped Dike, RDB to LDB	x			x	x	2	1
20	Double Dike				x	x	2	1
21	Wedge Dike, 8 to 1 Slope				x	x	2	1
22	Wedge Dike, 4 to 1 Slope				x	x	2	1
23	MRS Dike	x	x		x	x	2	1
24	Staggered MRS Dike	x	x		x	x	2	1
25	MRS Chevron	x	x		x	x	1	1
26	Dike Angled Upstream					x	2	1
27	Dike Angled Downstream			x	x		2	2
28	W-Dike 1			x		x	2	3
29	W-Dike 2			x		x	2	2
30	W-Dike 3			x	x	x	2	2

3. Recommendations

Due to the endless combination of alternatives, this study was only able to test a few representative samples of structures. A more comprehensive study may seek to evaluate structure differences in greater detail. Due to the size of the flume, bathymetric patterns created by smaller changes in the structures were not able to be evaluated. The following are recommendations for further study:

1. A wider longer flume should be used to evaluate localized effects in greater detail.
2. Evaluate differences in notch sizes, such as the difference between a shallow wide notch and a narrow deep notch and / or a combination of notches.
3. Evaluate the effect of these notches within a system of structures.
4. Determine the bathymetric patterns lacking in the river system and seek to reproduce these patterns through a structure developmental program.

4. Interpretation of Model Test Results

In the interpretation and evaluation of the results of the tests conducted, it should be remembered that the results of these model tests were qualitative in nature. Any hydraulic model, whether physical or numerical, is subject to biases introduced as a result of the inherent complexities that exist in the prototype. Anomalies in actual hydrographic events, such as prolonged periods of high or low flows are not reflected in these results, nor are complex physical phenomena, such as the existence of underlying rock formations or other unknown non-erodible variables. Flood flows were not simulated in this study.

This model study was intended to serve as a tool for the river engineer to guide in assessing the general trends that could be expected to occur in the actual river from a variety of imposed design alternatives. Measures for the final design may be modified based upon engineering knowledge and experience, real estate and construction considerations, economic and environmental impacts, or any other special requirements.

FOR MORE INFORMATION

For more information about micro modeling or the Applied River Engineering Center, please contact Robert Davinroy, Jasen Brown or David Gordon at:

Applied River Engineering Center
U.S. Army Corps of Engineers - St. Louis District
Hydrologic and Hydraulics Branch
Foot of Arsenal Street
St. Louis, Missouri 63118

Phone: (314) 263-4714, (314) 263-8093, or (314) 263-4230
Fax: (314) 263-4166

E-mail: Robert.D.Davinroy@mvs02.usace.army.mil
Jasen.L.Brown@mvs02.usace.army.mil
David.Gordon@mvs02.usace.army.mil

Or you can visit us on the World Wide Web at:
http://www.mvs.usace.army.mil/engr/river/river.htm

APPENDIX OF PLATES

Plate number 1 through 27 follow:

1. Test Flume
2. Base Test 1
3. Test 1
4. Test 2
5. Test 3
6. Test 4
7. Test 5
8. Base Test 2
9. Test 6
10. Test 7
11. Test 8
12. Test 9
13. Test 10
14. Base Test 3
15. Test 11
16. Test 12
17. Test 13
18. Test 14
19. Test 15
20. Base Test 4
21. Test 16
22. Test 17
23. Test 18
24. Test 19
25. Test 20
26. Base Test 5
27. Test 21
28. Test 22
29. Test 23
30. Test 24
31. Test 25
32. Base Test 6
33. Test 26
34. Test 27
35. Test 28
36. Test 29
37. Test 30
38. Base Test 1 and Tests 1 – 5

39. Base Test 2 and Tests 6 – 10
40. Base Test 3 and Tests 11 – 15
41. Base Test 4 and Tests 16 – 20
42. Base Test 5 and Tests 21 – 25
43. Base Test 6 and Tests 26 – 30

ENTRANCE CONTROL DIKES

FLOW

U.S ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: J. BROWN

APPLIED RIVER ENGINEERING CENTER

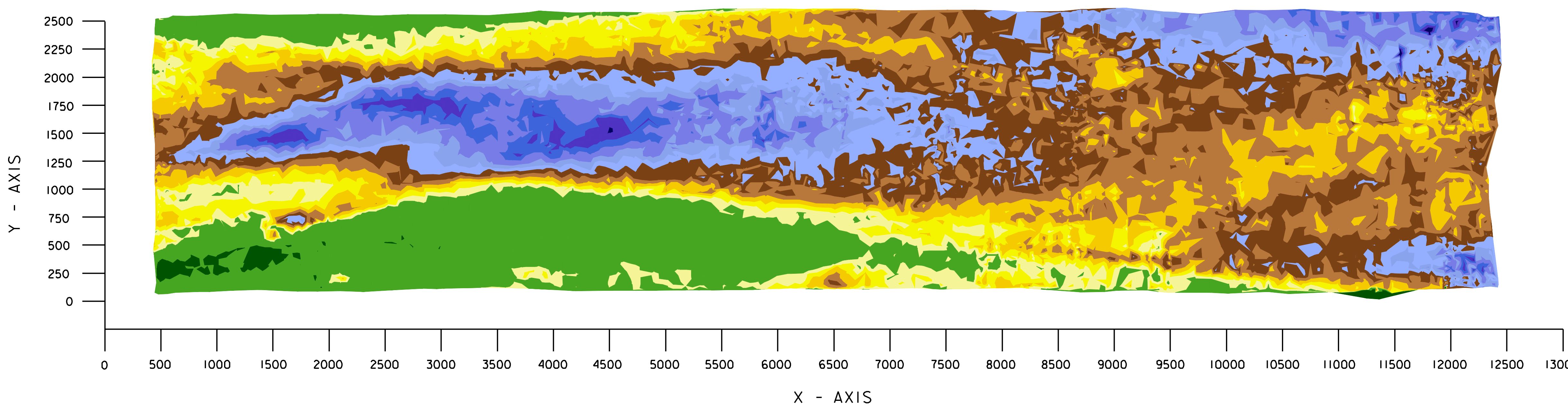
GENERIC DIKE FUME STUDY

TEST FLUME

3000 2400 1800 1200 600 0 1500 3000

FILE NAME: FLUME.PUB

PLATE NO. 1



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

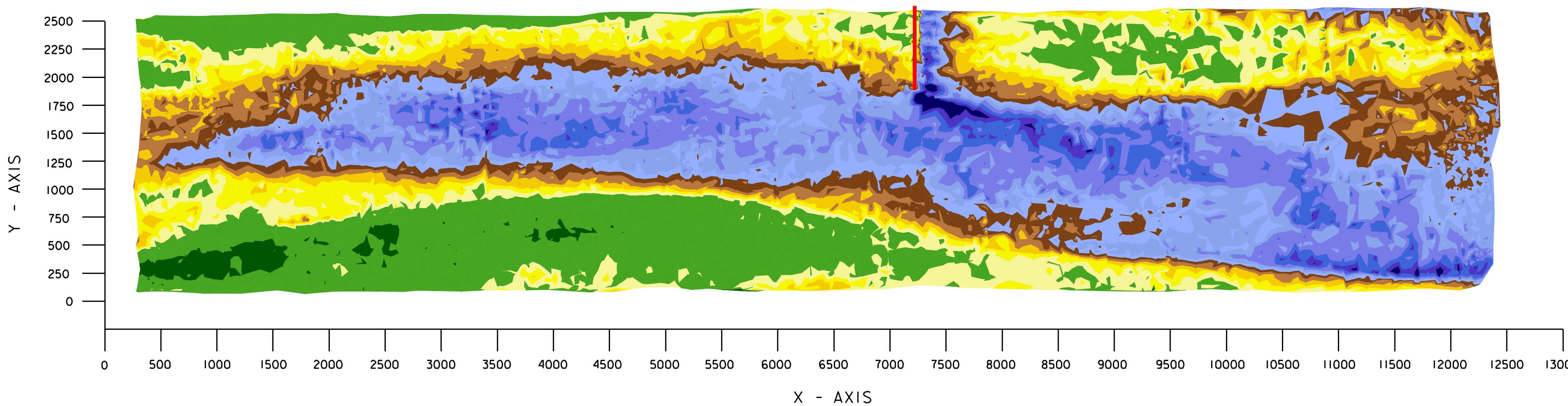
GENERIC DIKE FLUME STUDY
BASE TEST 1

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

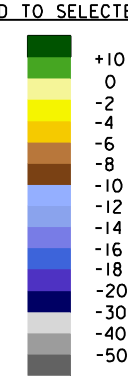
DESIGN FILE: BASE1.DGN
PLOT DATE:

PLATE NO. 2



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

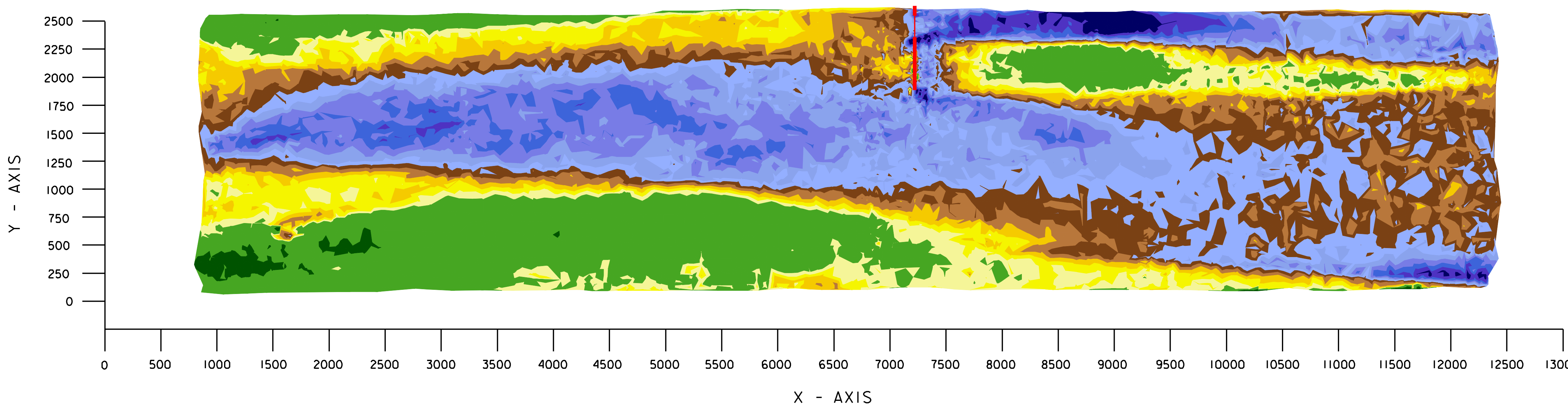
PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 1: SINGLE DIKE, NO NOTCH

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST1.DGN
PLOT DATE:
PLATE NO. 3



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

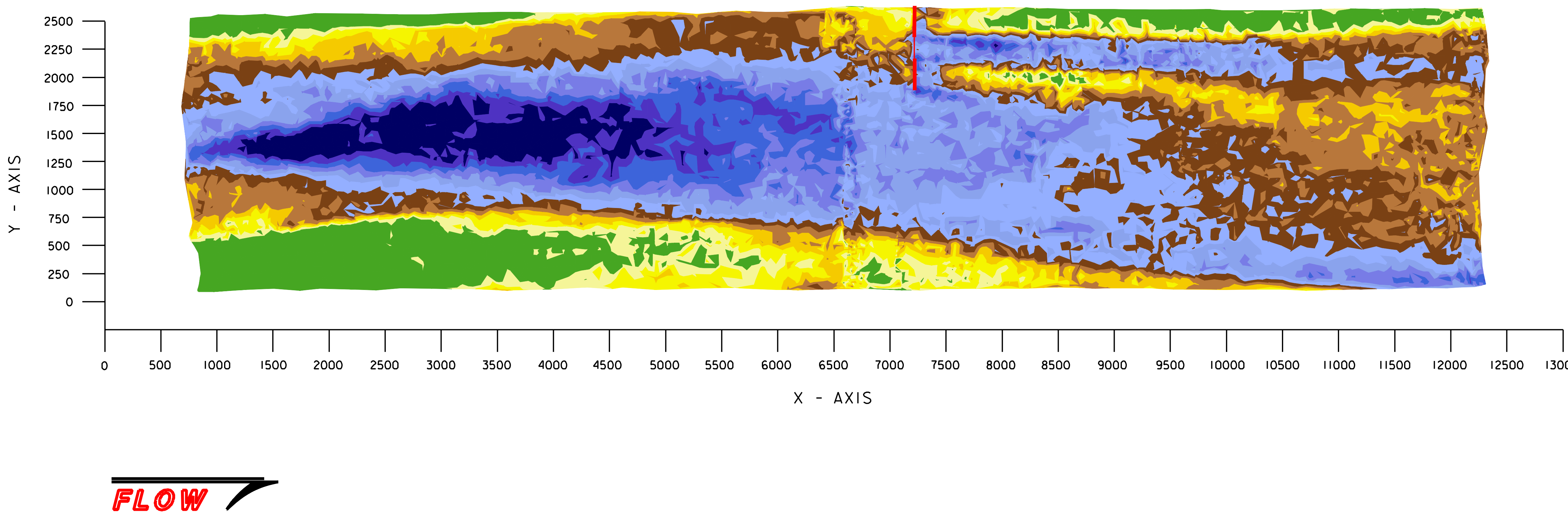
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 2: SINGLE DIKE, DEEP NOTCH LDB

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST2.DGN
PLOT DATE:
PLATE NO. 4



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

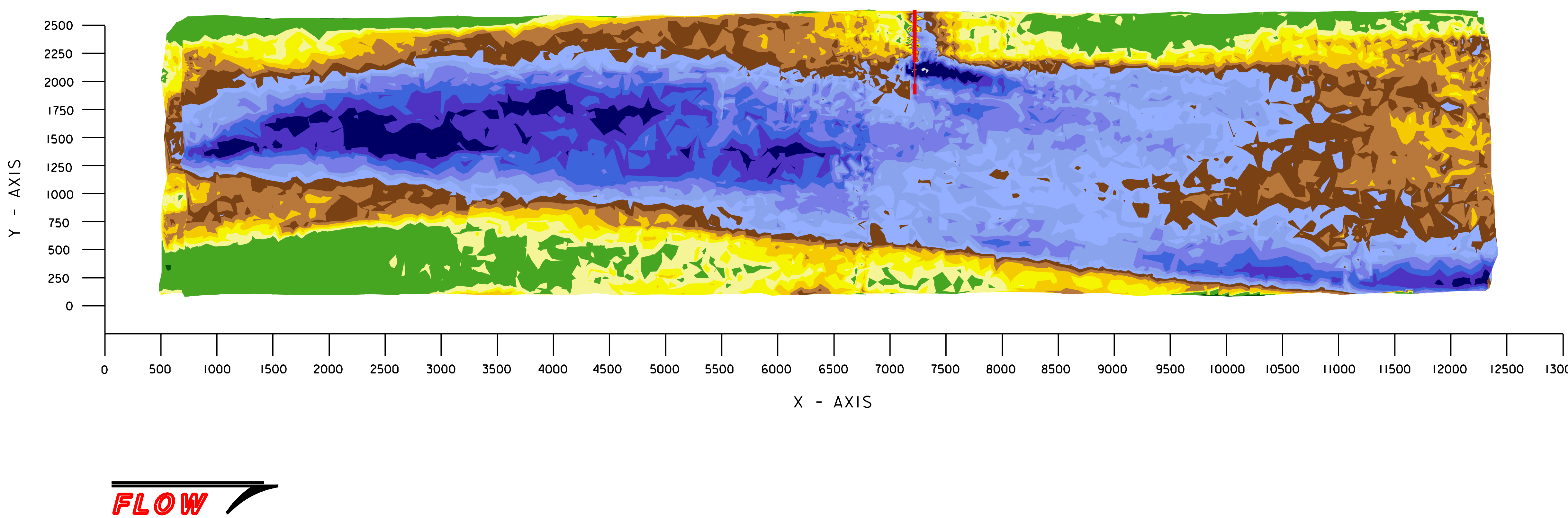
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 3: SINGLE DIKE, DEEP NOTCH MIDDLE

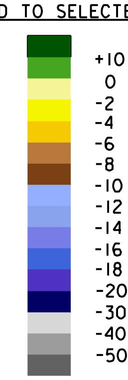
APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST3.DGN
PLOT DATE:
PLATE NO. 5



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

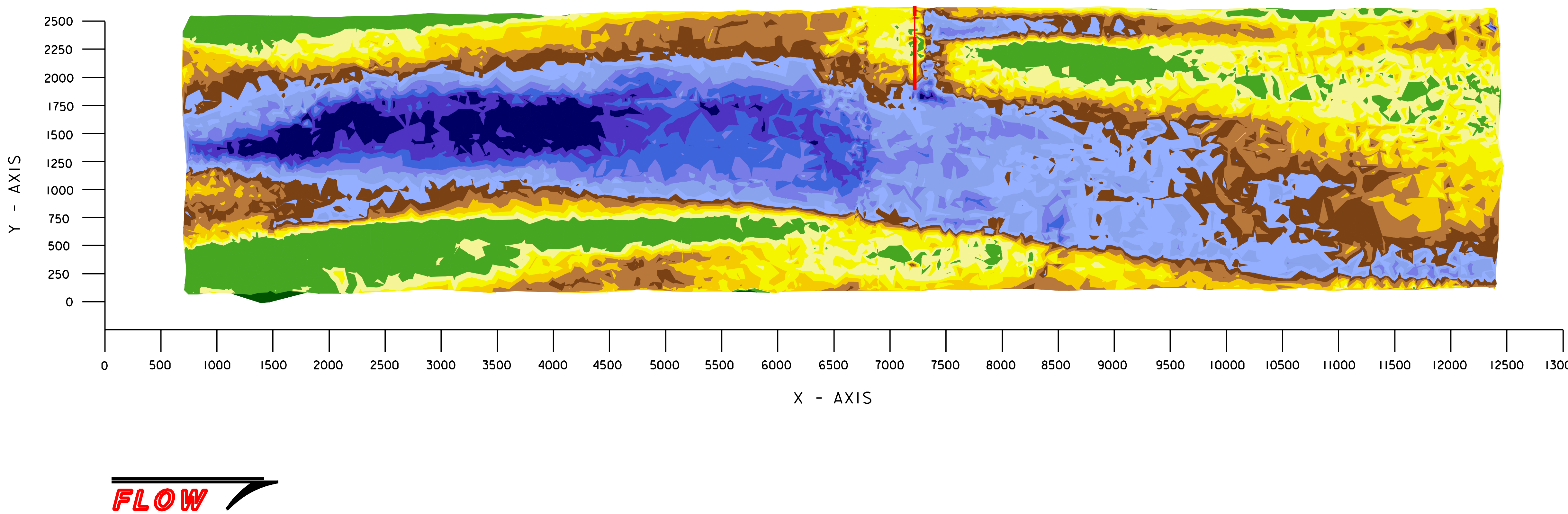
GENERIC DIKE FLUME STUDY
TEST 4: SINGLE DIKE, DEEP NOTCH RDB

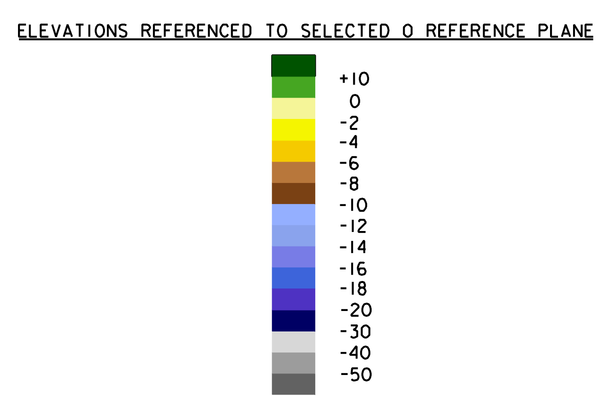
1100 825 550 275 0 550 1100

APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: TEST4.DGN
PLOT DATE:

PLATE NO. 6





U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

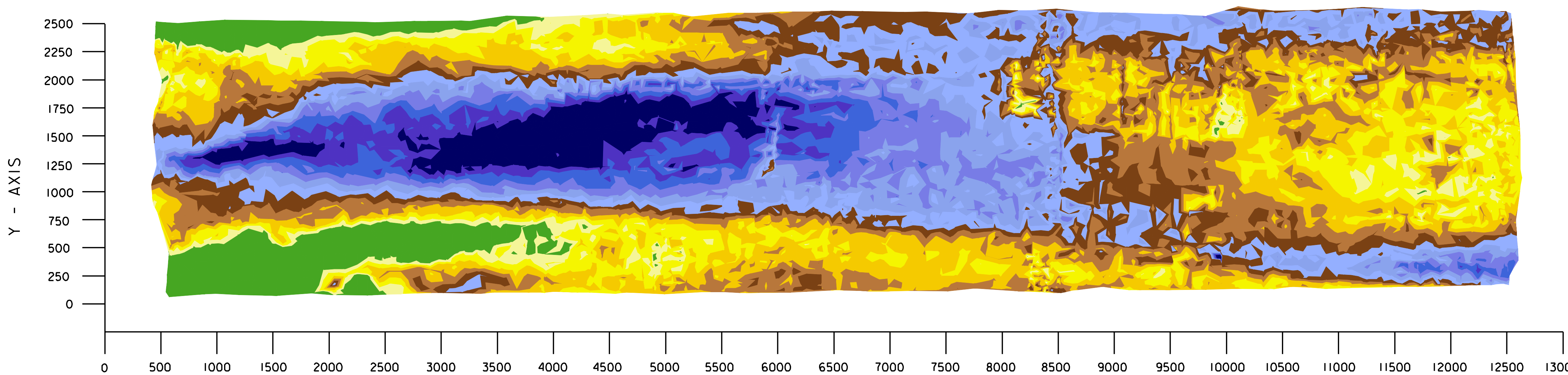
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 5: SINGLE DIKE, SHALLOW NOTCH LDB

1100 825 550 275 0 550 1100

APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: TEST5.DGN
PLOT DATE:
PLATE NO. 7



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

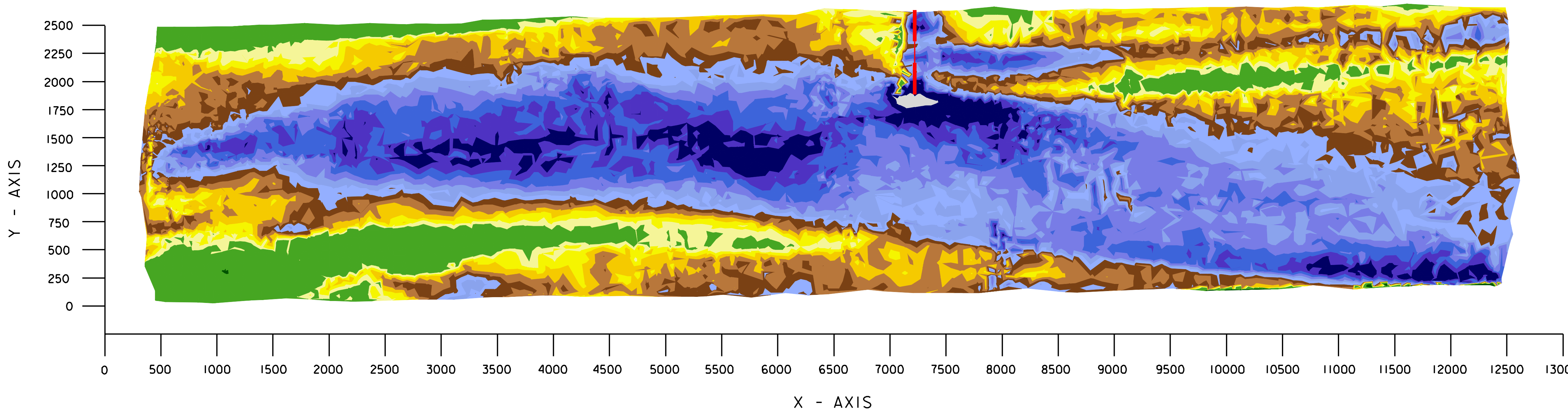
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
BASE TEST 2

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: BASE2.DGN
PLOT DATE:
PLATE NO. 8



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

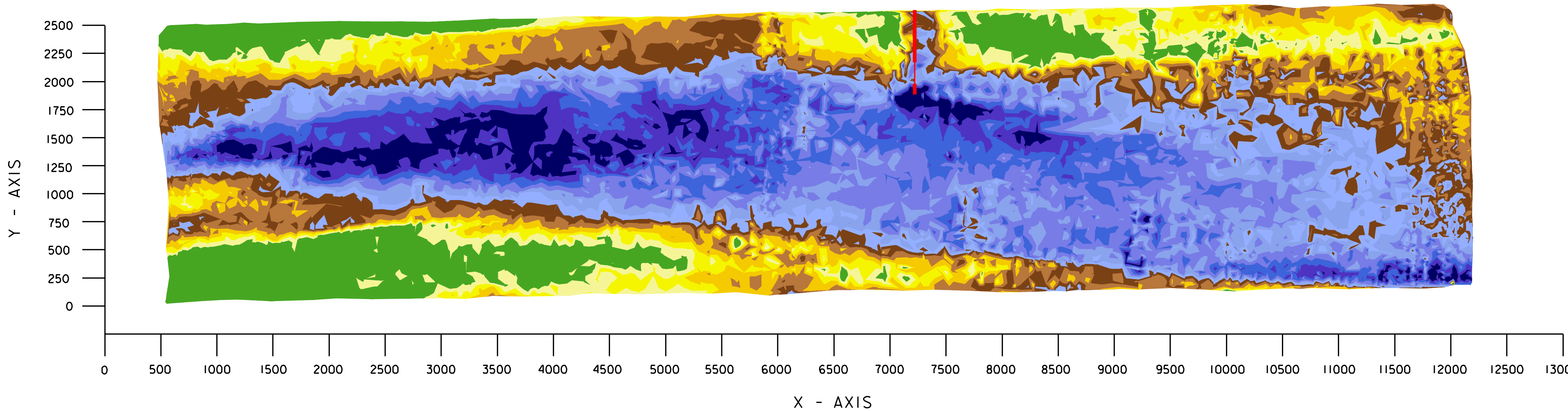
PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 6: SINGLE DIKE, SHALLOW NOTCH MIDDLE

1100 825 550 275 0 550 1100

APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: TEST6.DGN
PLOT DATE:
PLATE NO. 9



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

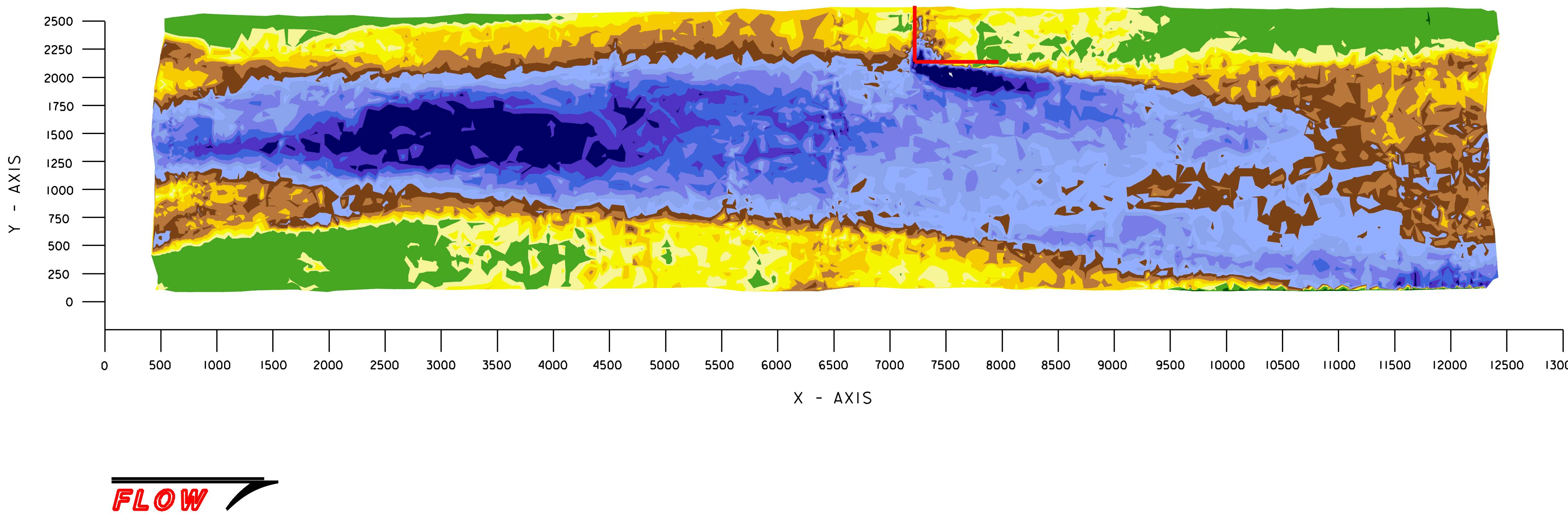
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 7: SINGLE DIKE, SHALLOW NOTCH RDB

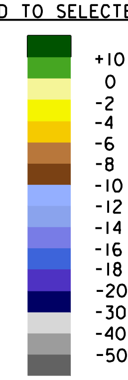
APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST7.DGN
PLOT DATE:
PLATE NO. 10



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

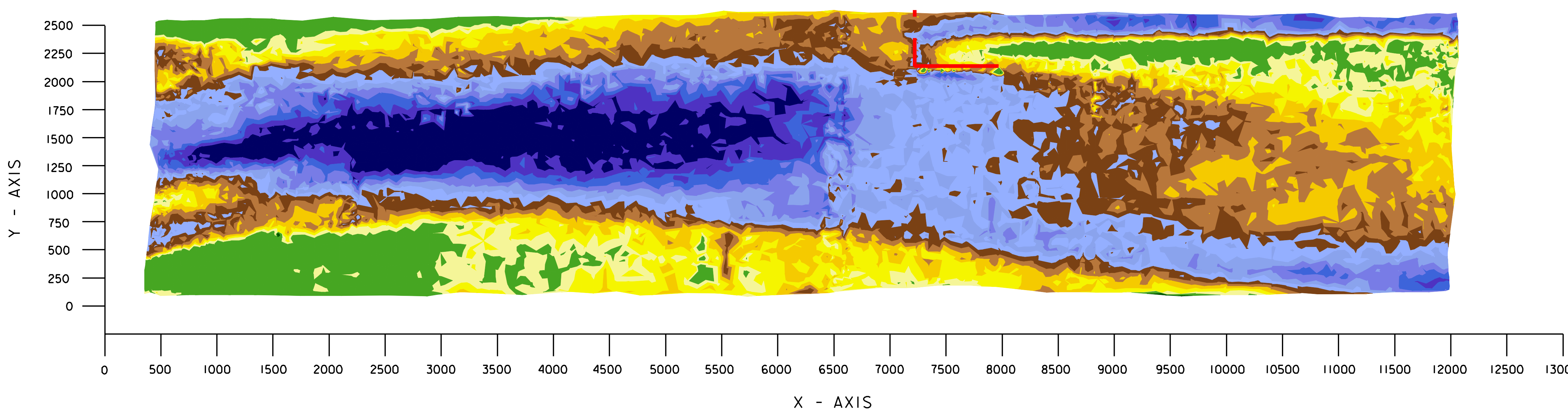
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 8: L-DIKE, NO NOTCH

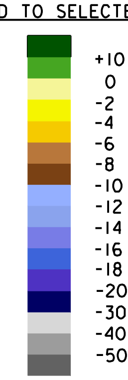
APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST8.DGN
PLOT DATE:
PLATE NO. 11



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

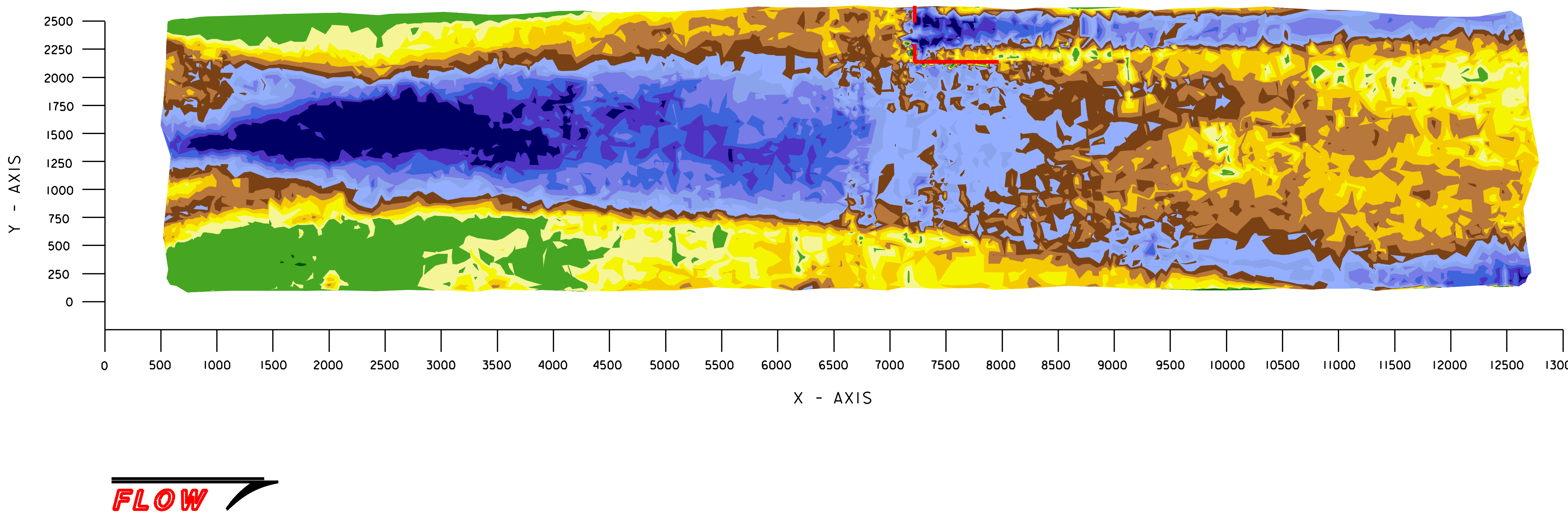
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 9: L-DIKE, DEEP NOTCH LDB

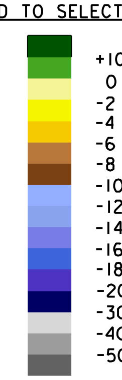
APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST9.DGN
PLOT DATE:
PLATE NO. 12



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

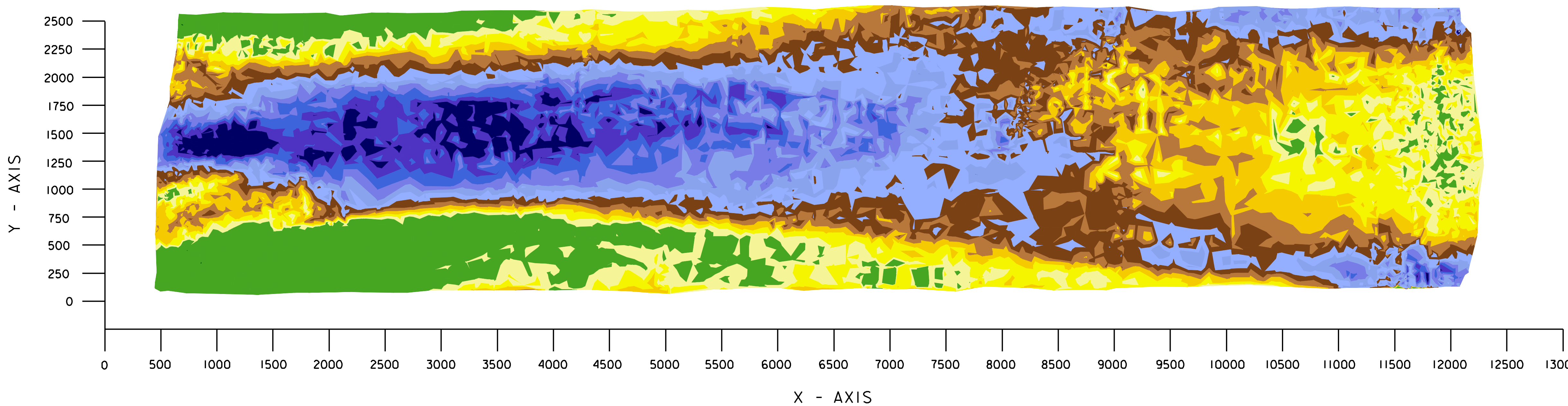
GENERIC DIKE FLUME STUDY
TEST 10: L-DIKE, DEEP NOTCH MIDDLE

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST10.DGN
PLOT DATE:

PLATE NO. 13



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

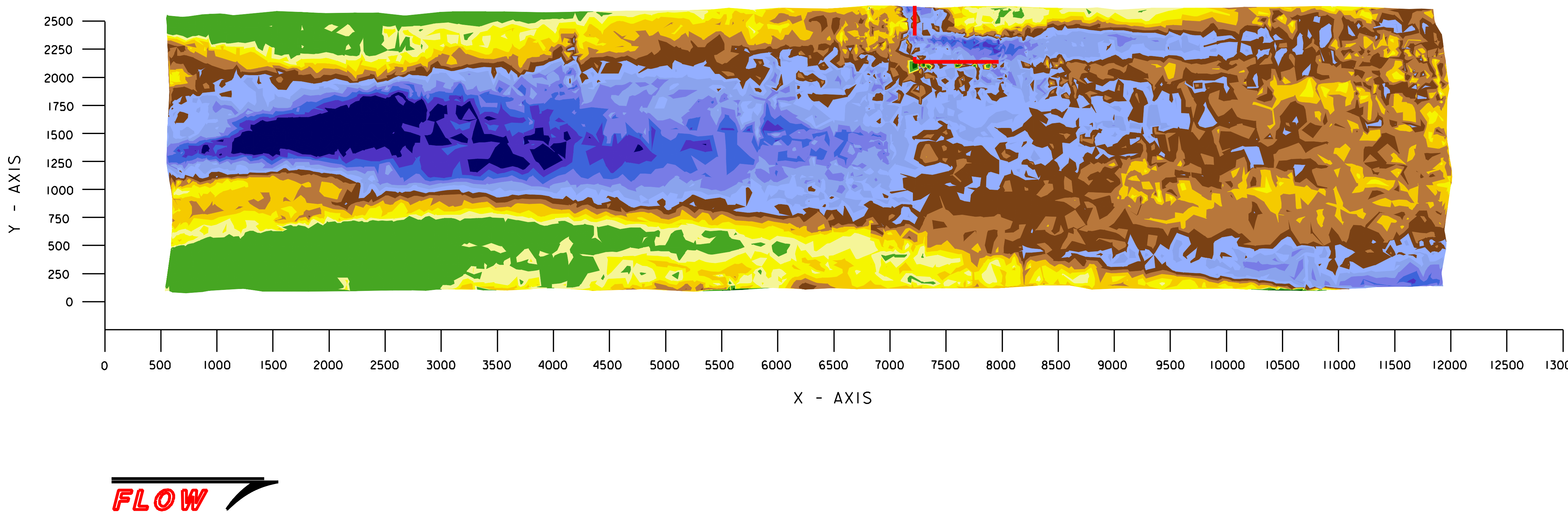
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

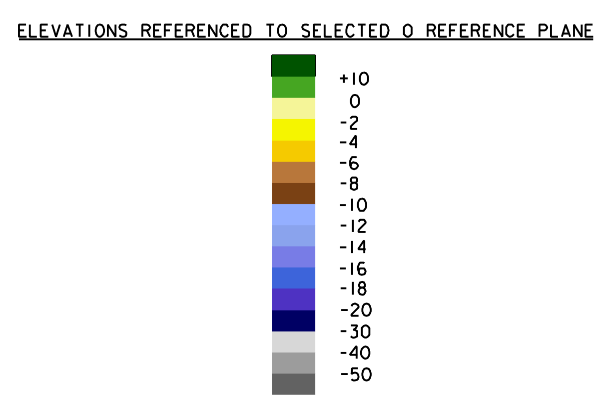
GENERIC MICRO MODEL
BASE TEST 3

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: BASE3.DGN
PLOT DATE:
PLATE NO. 14





U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

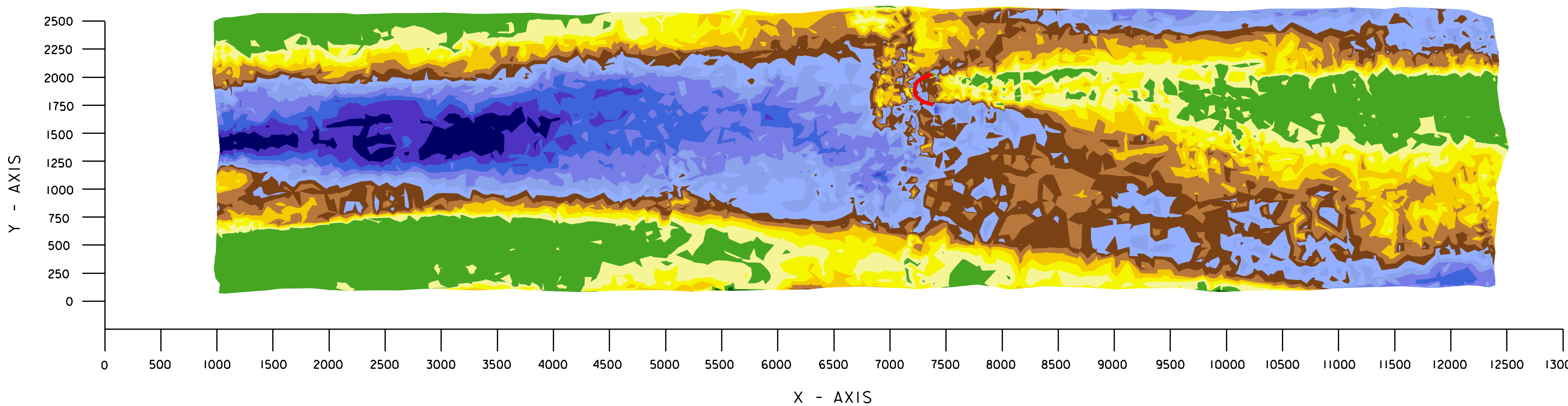
APPLIED RIVER ENGINEERING CENTER

GENERIC DIKE FLUME STUDY
TEST 11: L-DIKE, DEEP NOTCH RDB

1100 825 550 275 0 550 1100

DESIGN FILE: TEST11.DGN
PLOT DATE:

PLATE NO. 15



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

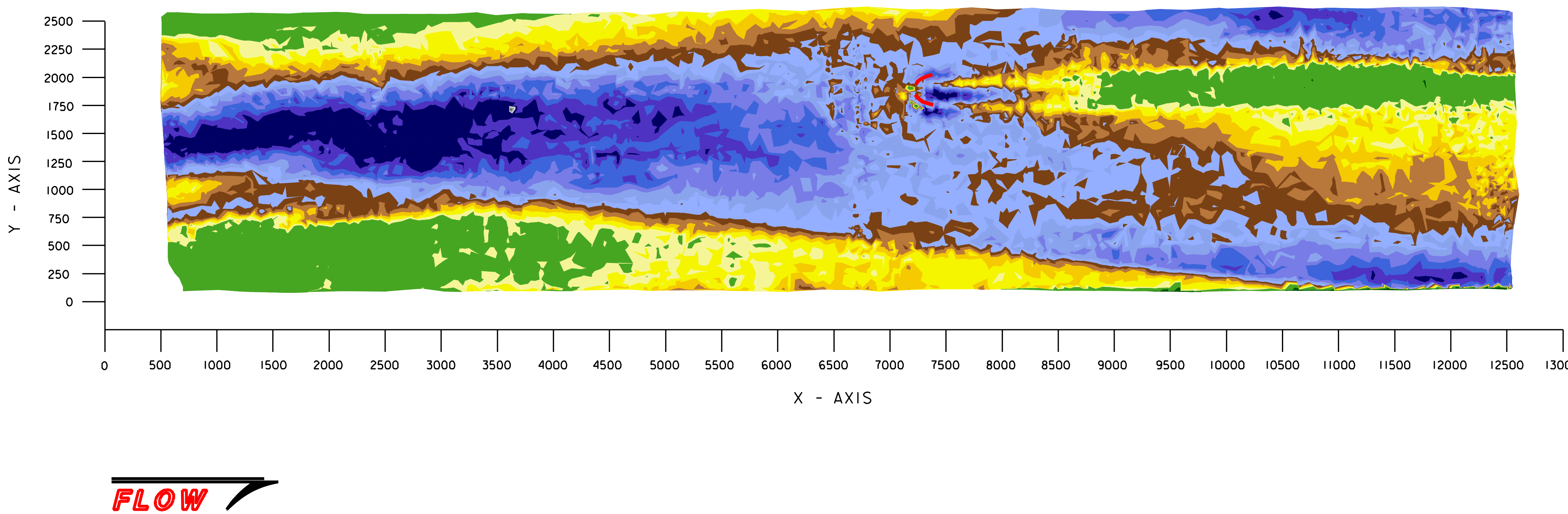
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 12: CHEVRON

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST12.DGN
PLOT DATE:
PLATE NO. 16



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

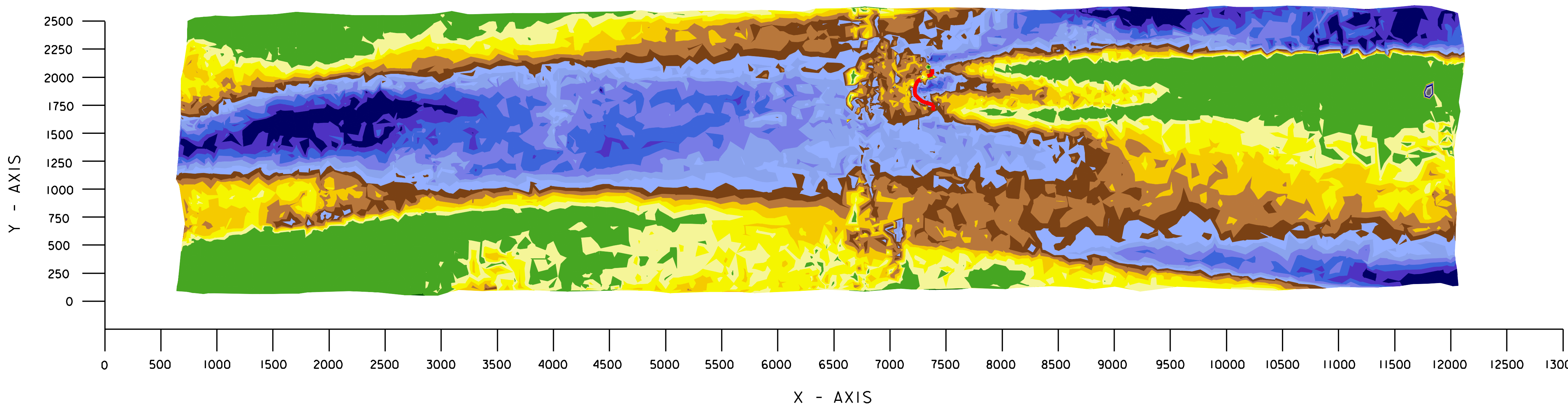
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 13: CHEVRON, APEX NOTCH

1100 825 550 275 0 550 1100

APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: TEST13.DGN
PLOT DATE:
PLATE NO. 17



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

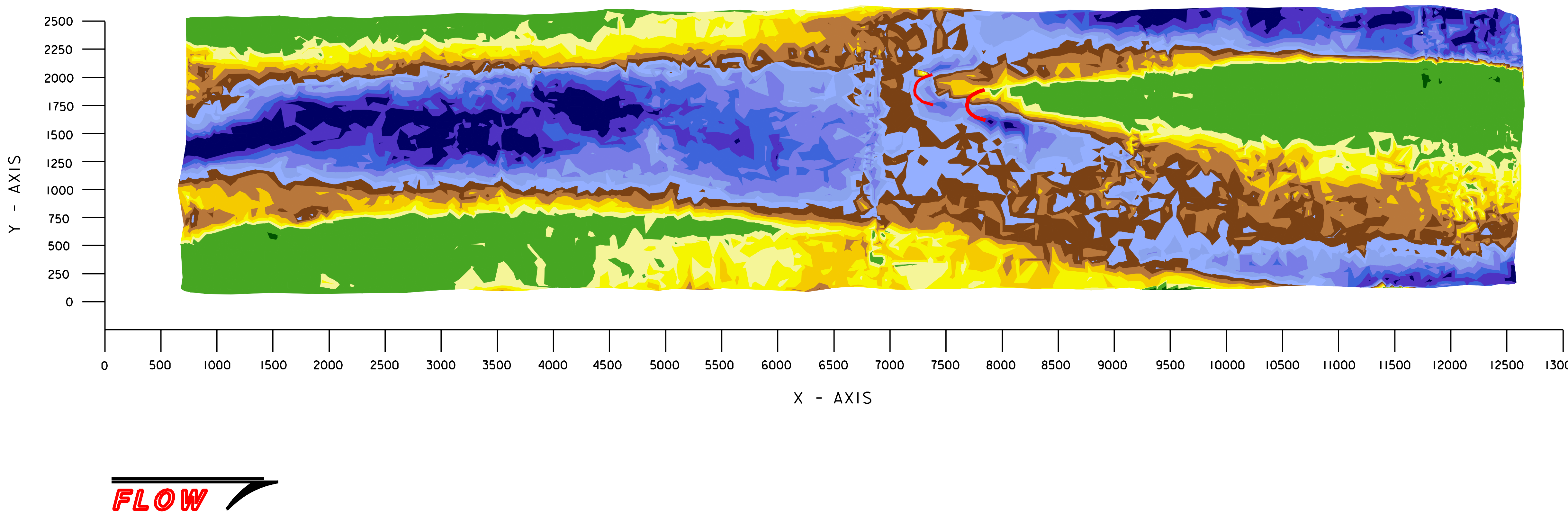
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 14: CHEVRON, LDB LEG NOTCH,
STUB DIKES ON EACH LEG

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST14.DGN
PLOT DATE:
PLATE NO. 18



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

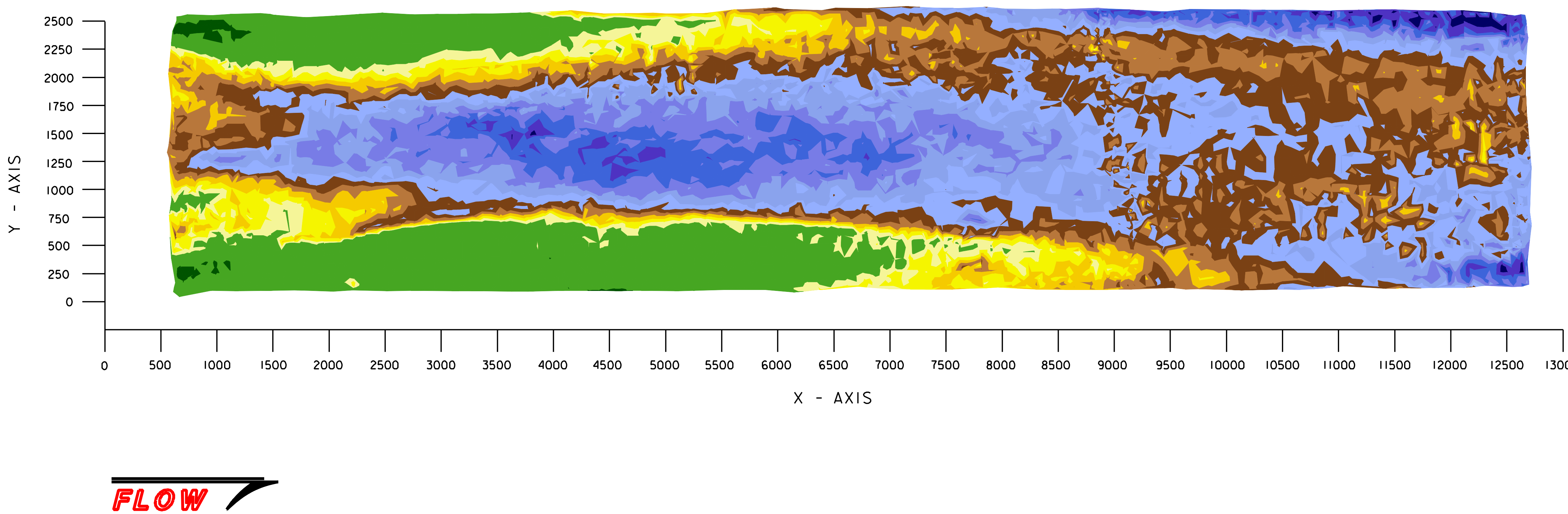
GENERIC DIKE FLUME STUDY
TEST 15: TWO CHEVRONS, STAGGERED APEX TO LEG

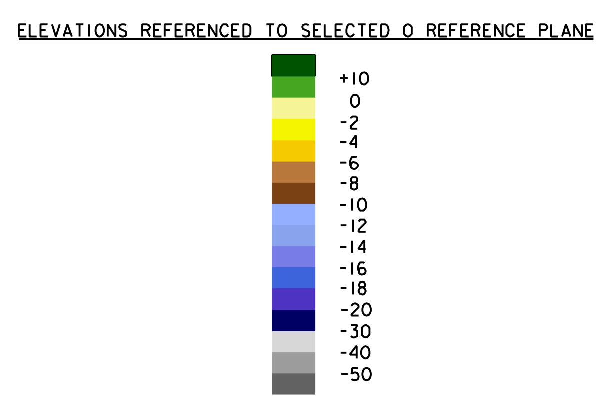
APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST15.DGN
PLOT DATE:

PLATE NO. 19





U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

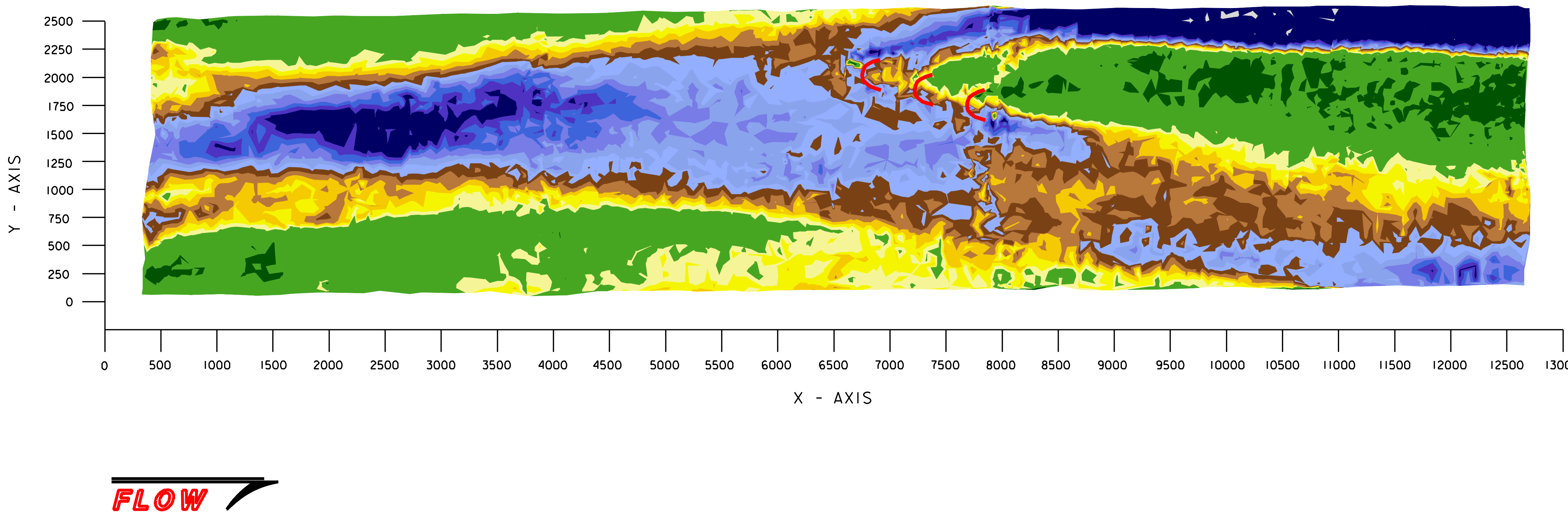
GENERIC MICRO MODEL
BASE TEST 4

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: BASE4.DGN
PLOT DATE:

PLATE NO. 20



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

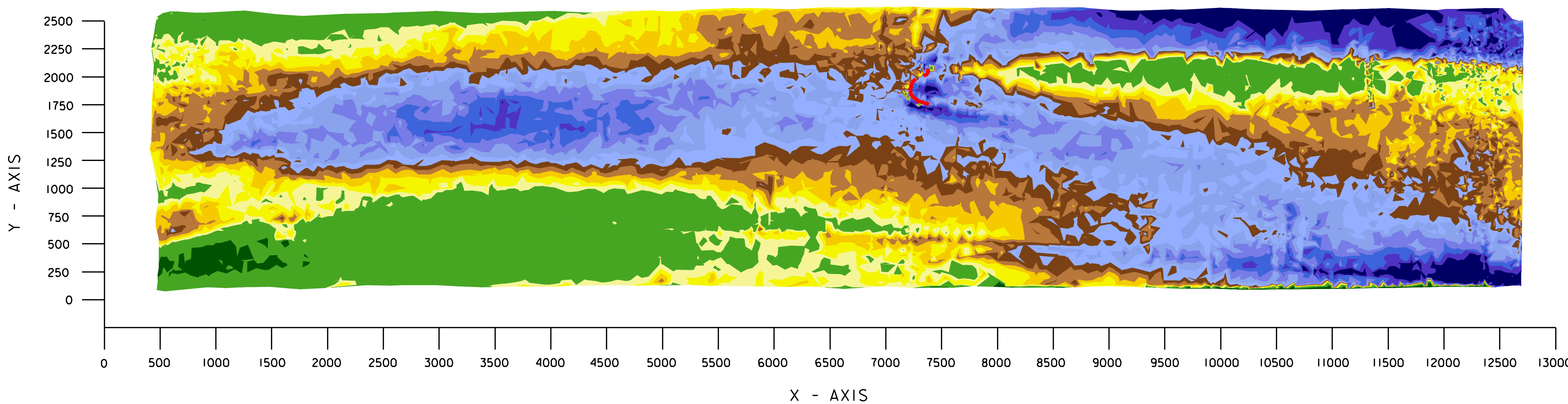
PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 16: 3 CHEVRONS, STAGGERED APEX TO LEG

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST16.DGN
PLOT DATE:
PLATE NO. 21



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY

TEST 17: CHEVRON, LDB LEG NOTCH,
STUB DIKE ON LDB LEG

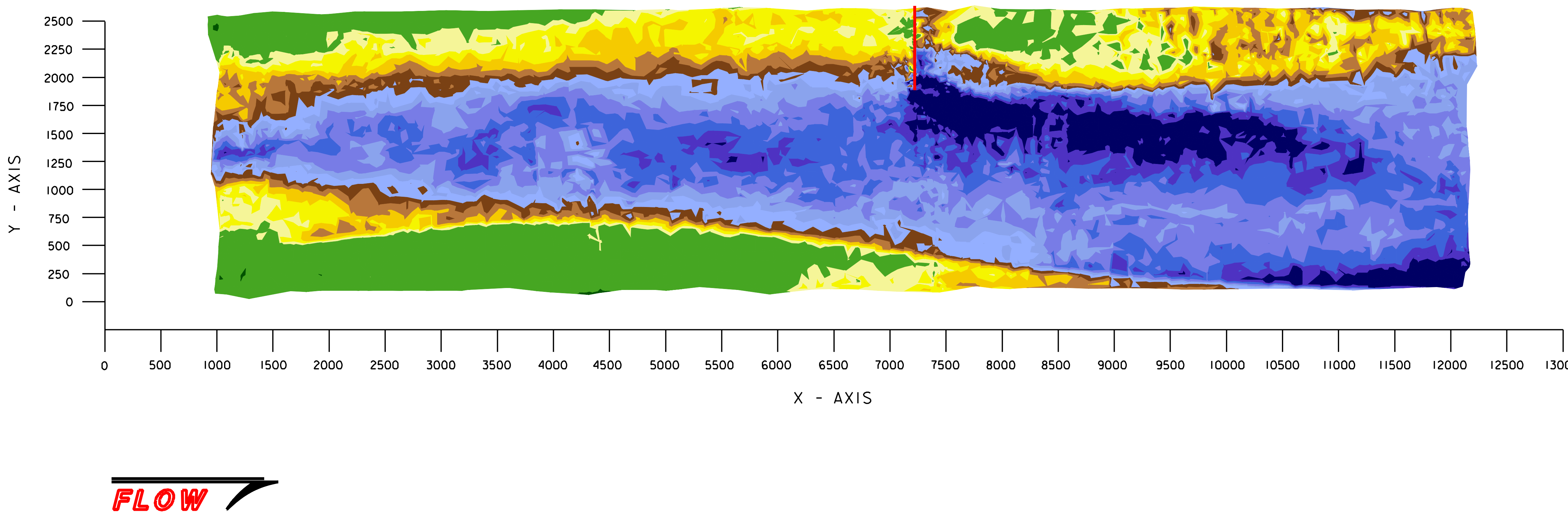
1100 825 550 275 0 550 1100

APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: TEST17.DGN

PLOT DATE:

PLATE NO. 22



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

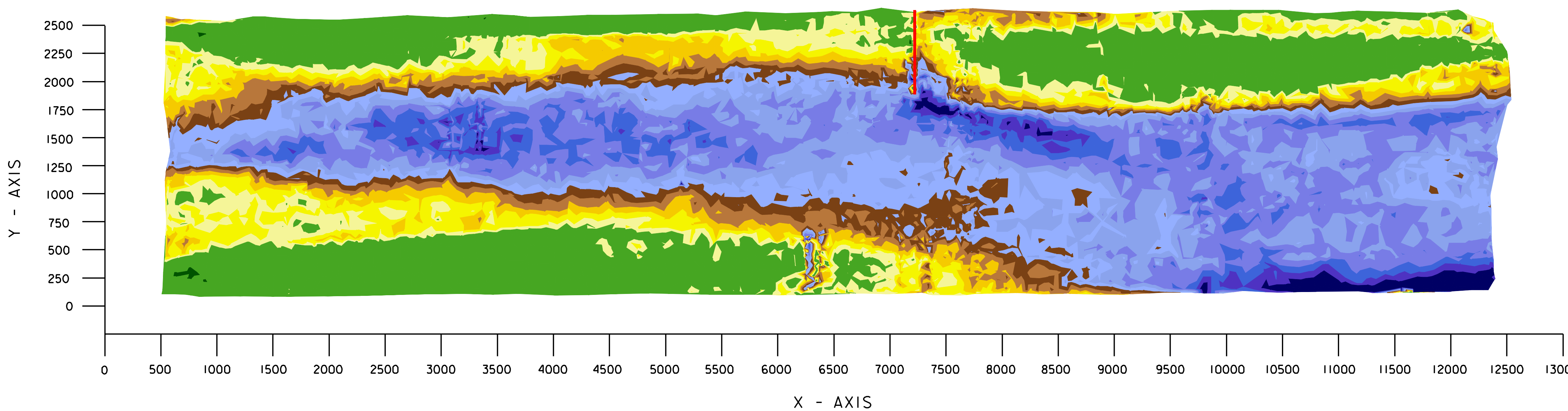
GENERIC DIKE FLUME STUDY
TEST 18: SINGLE DIKE, SLOPED LDB TO RDB

1100 825 550 275 0 550 1100

APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: TEST18.DGN
PLOT DATE:

PLATE NO. 23



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

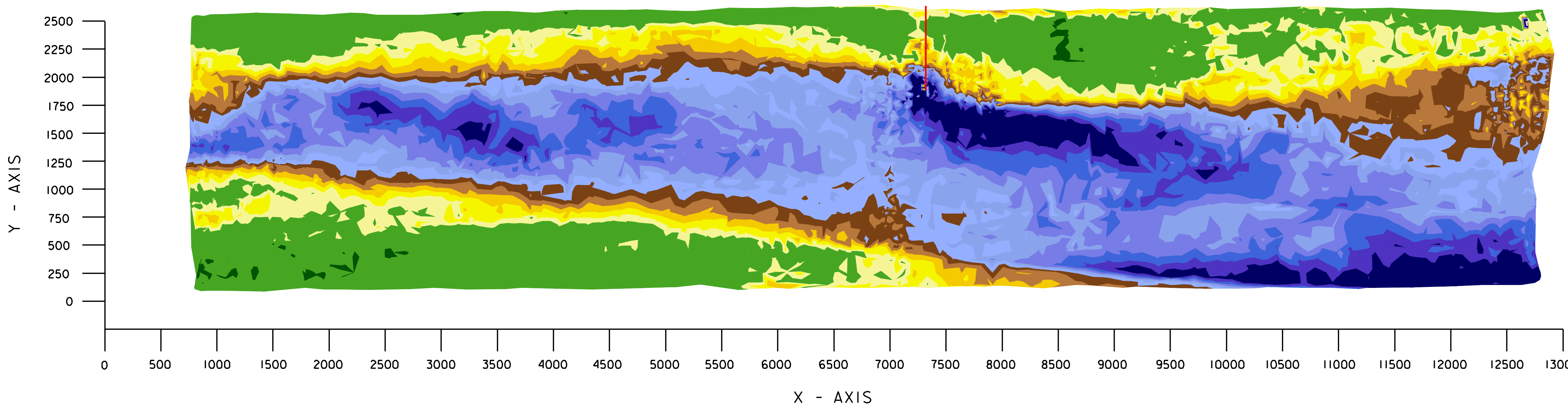
PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 19: SINGLE DIKE, SLOPED RDB TO LDB

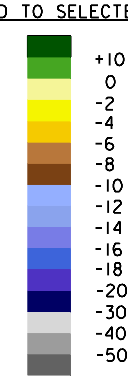
APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST19.DGN
PLOT DATE:
PLATE NO. 24



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

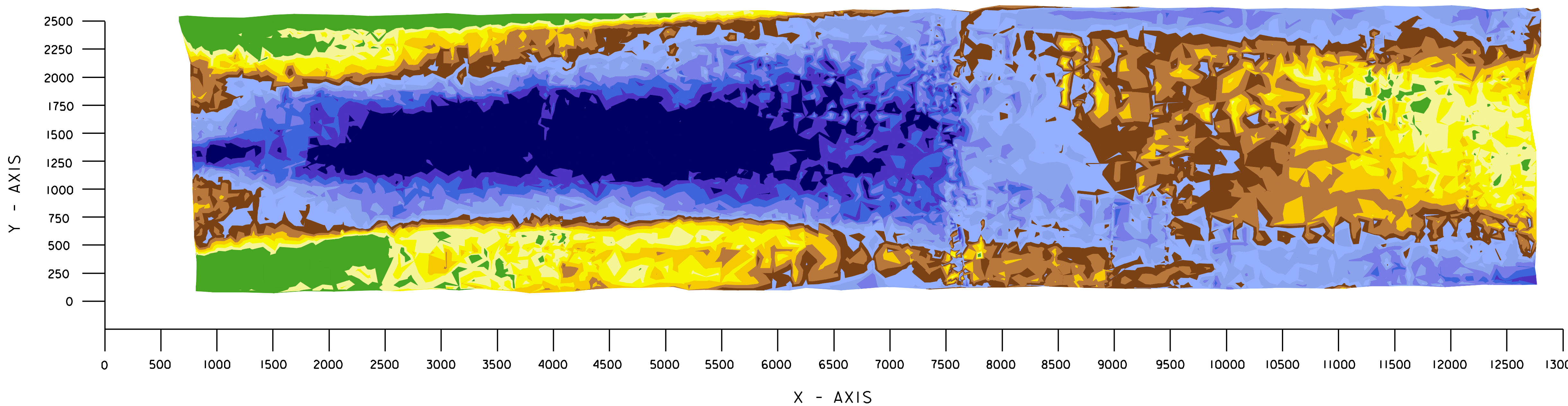
GENERIC DIKE FLUME STUDY
TEST 20: DOUBLE DIKE

1100 825 550 275 0 550 1100

APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: TEST20.DGN
PLOT DATE:

PLATE NO. 25



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

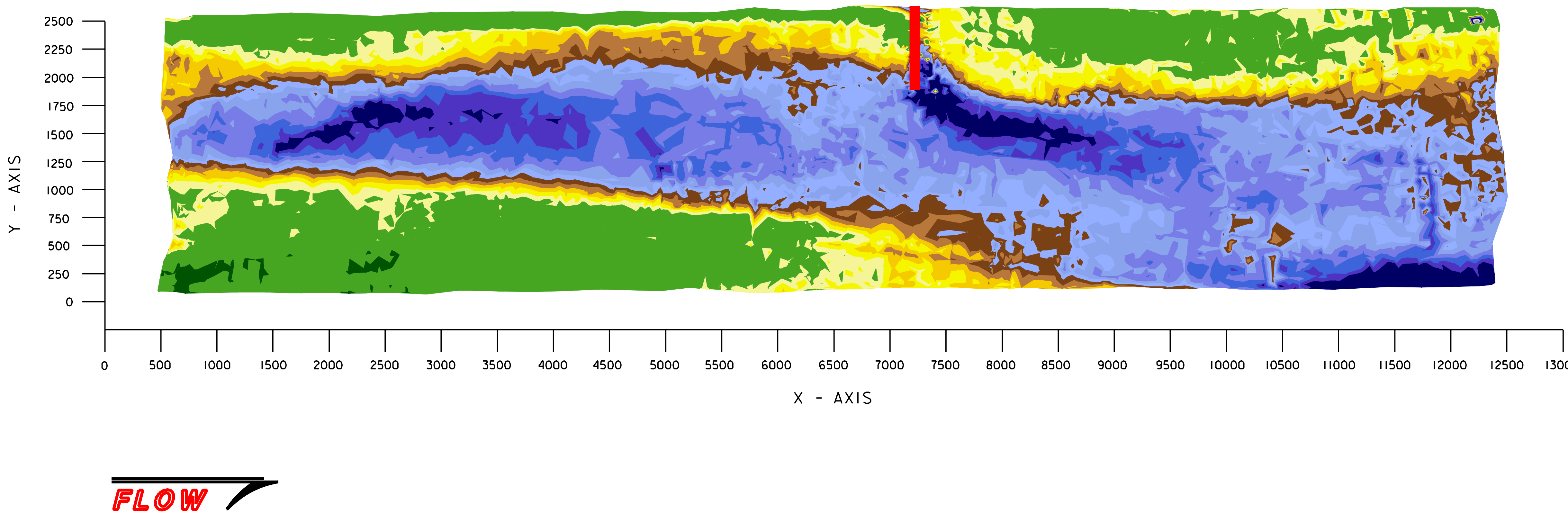
GENERIC MICRO MODEL
BASE TEST 5

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: BASE5.DGN
PLOT DATE:

PLATE NO. 26



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

GENERIC DIKE FLUME STUDY

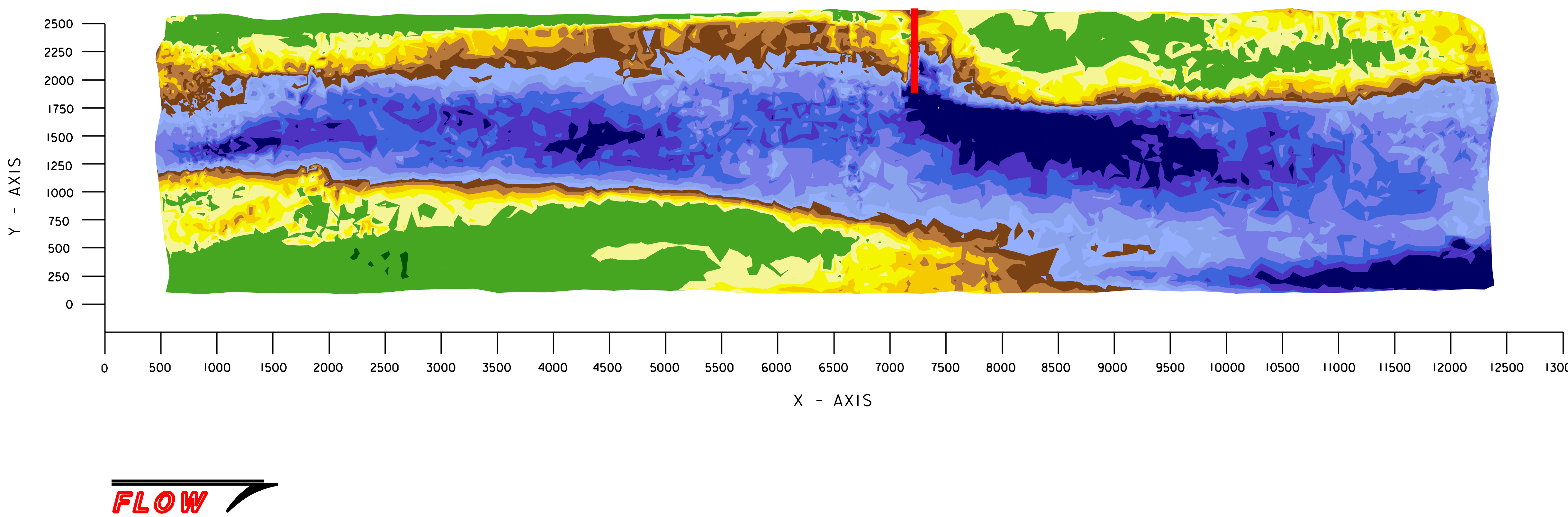
TEST 21: WEDGE DIKE, 8 TO 1 SLOPE

1100 825 550 275 0 550 1100

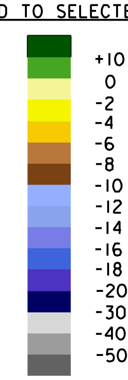
DESIGN FILE: TEST21.DGN

PLOT DATE:

PLATE NO. 27



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

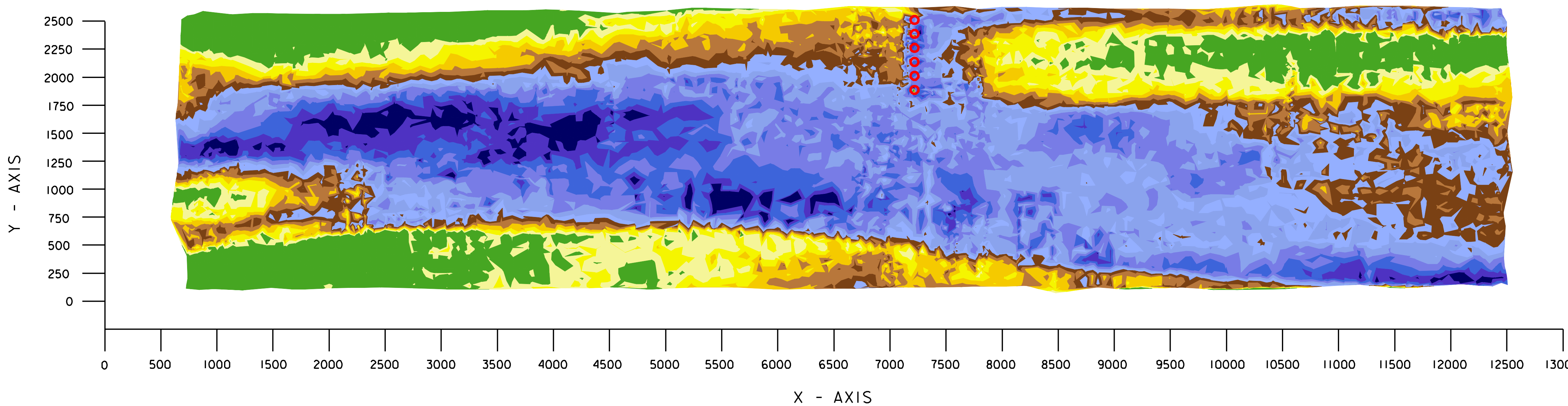
APPLIED RIVER ENGINEERING CENTER

GENERIC DIKE FLUME STUDY
TEST 22: WEDGE DIKE, 4 TO 1 SLOPE

1100 825 550 275 0 550 1100

DESIGN FILE: TEST22.DGN
PLOT DATE:

PLATE NO. 28



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

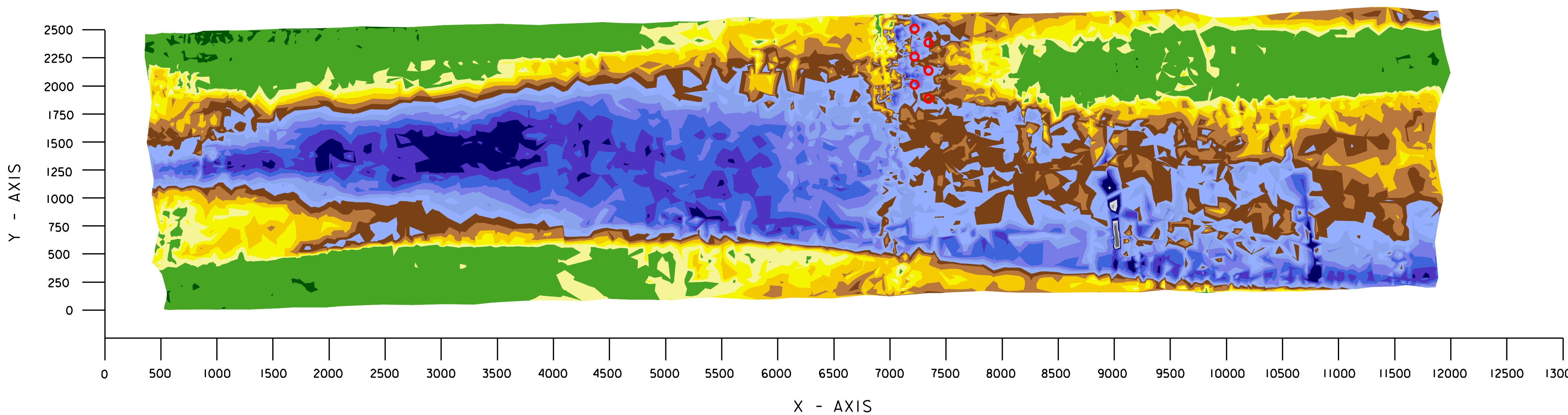
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 23: MRS DIKE

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST23.DGN
PLOT DATE:
PLATE NO. 29



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

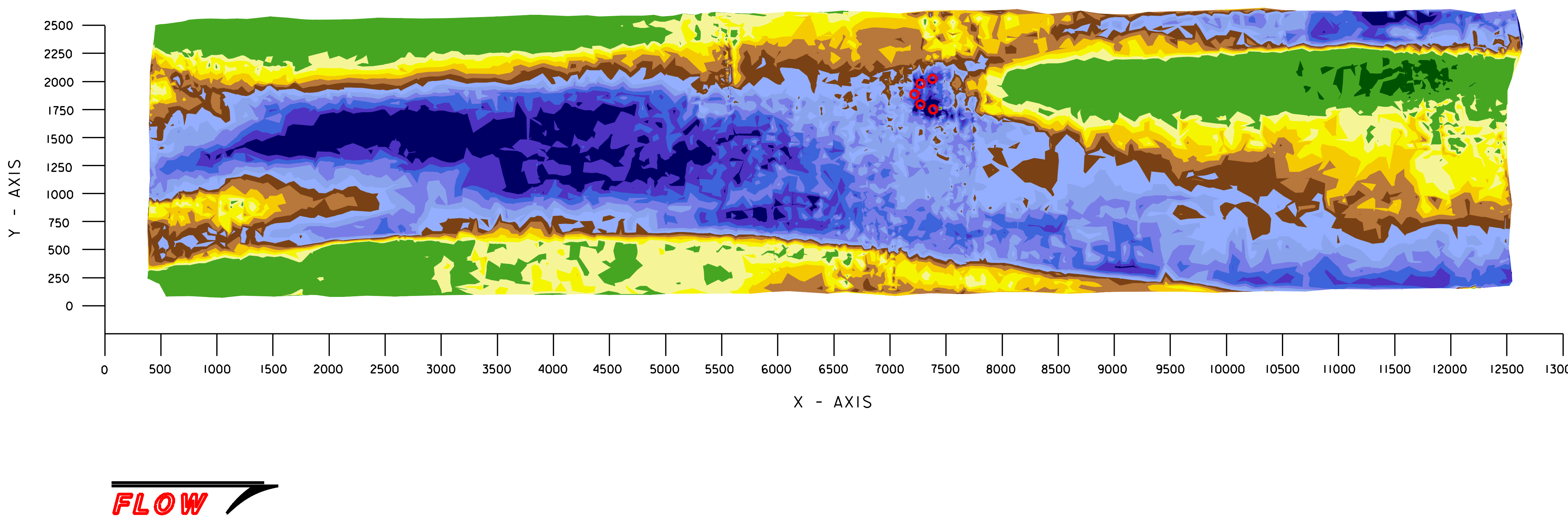
GENERIC DIKE FLUME STUDY
TEST 24: STAGGERED MRS DIKE

1100 825 550 275 0 550 1100

APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: TEST24.DGN
PLOT DATE:

PLATE NO. 30



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

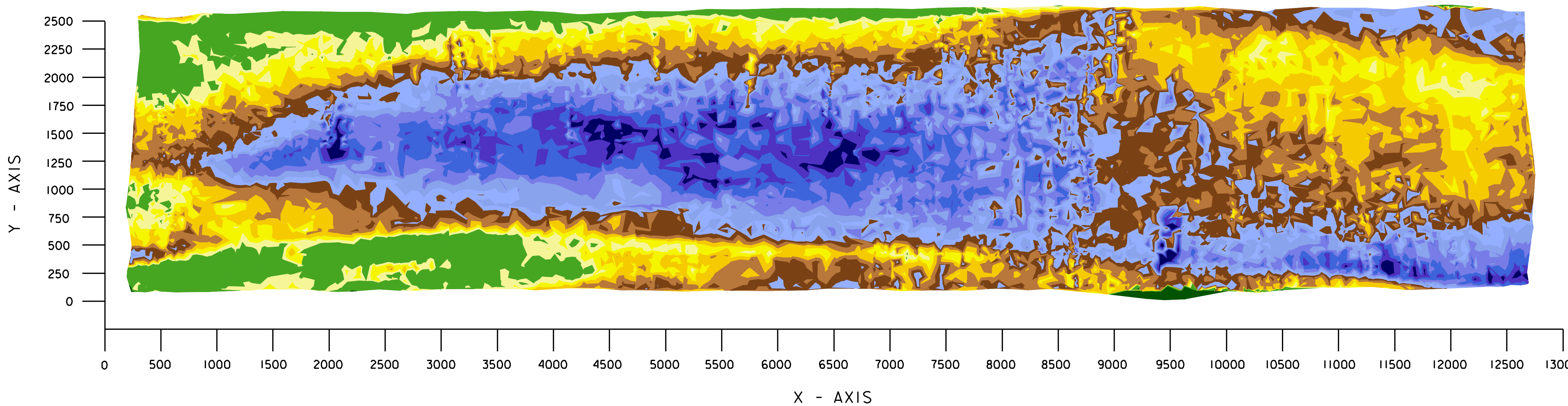
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 25: MRS CHEVRON

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST25.DGN
PLOT DATE:
PLATE NO. 31



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

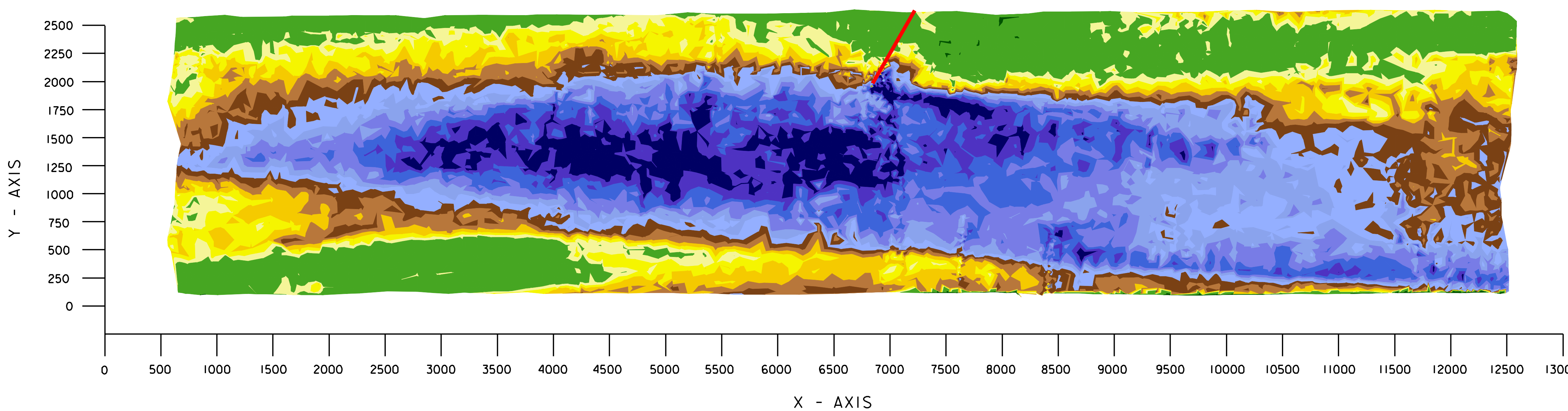
GENERIC MICRO MODEL
BASE TEST 6

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

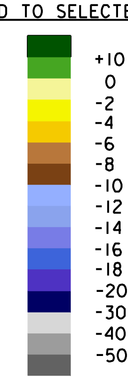
DESIGN FILE: BASE6.DGN
PLOT DATE:

PLATE NO. 32



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

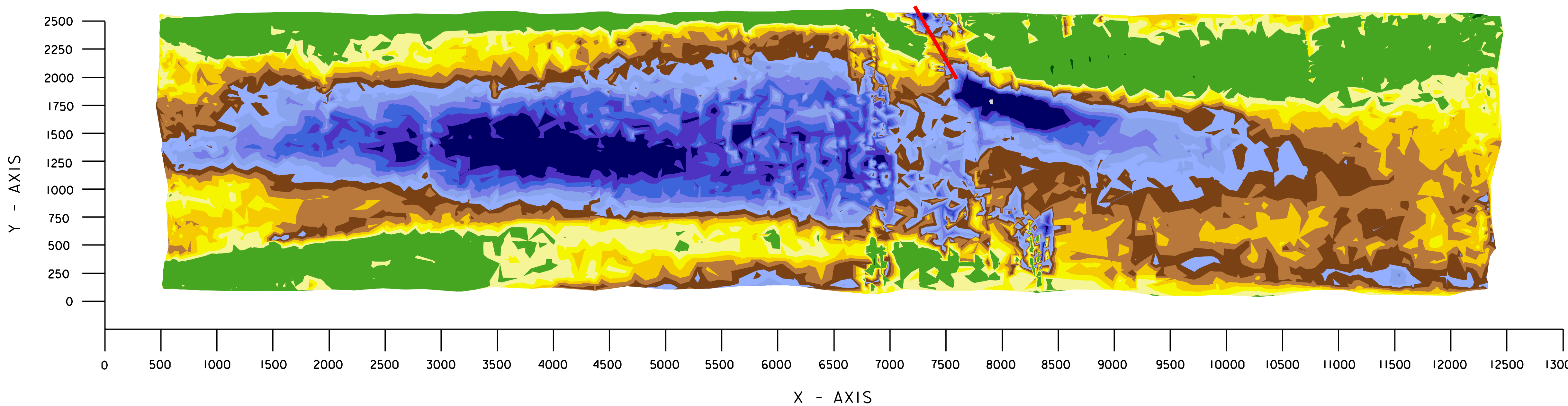
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 26: DIKE ANGLED UPSTREAM

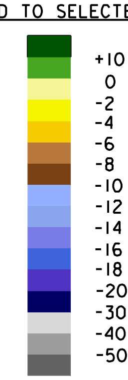
APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST26.DGN
PLOT DATE:
PLATE NO. 33



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

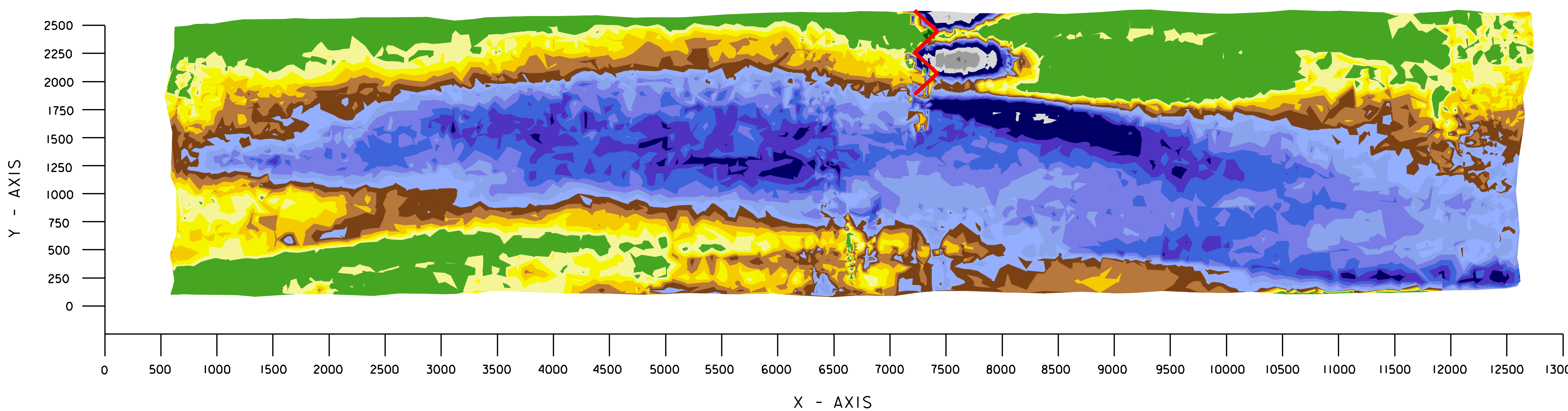
APPLIED RIVER ENGINEERING CENTER

GENERIC DIKE FLUME STUDY
TEST 27: DIKE ANGLED DOWNSTREAM

1100 825 550 275 0 550 1100

DESIGN FILE: TEST27.DGN
PLOT DATE:

PLATE NO. 34



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

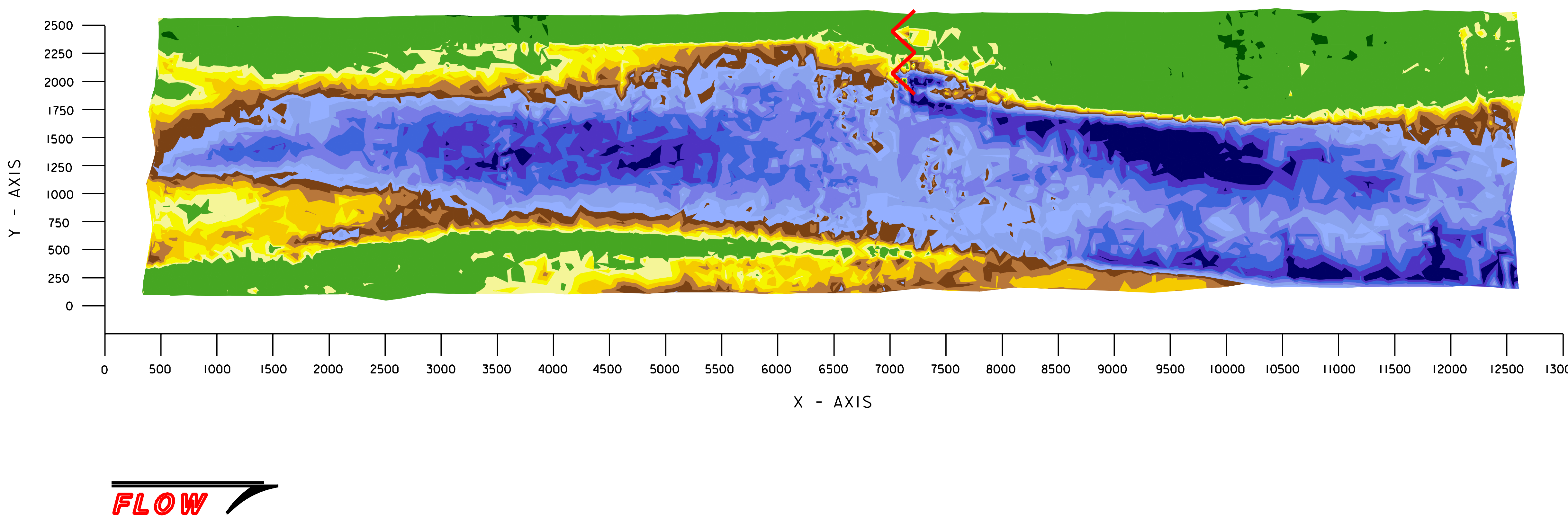
GENERIC DIKE FLUME STUDY
TEST 28: W - DIKE 1

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST28.DGN
PLOT DATE:

PLATE NO. 35



ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

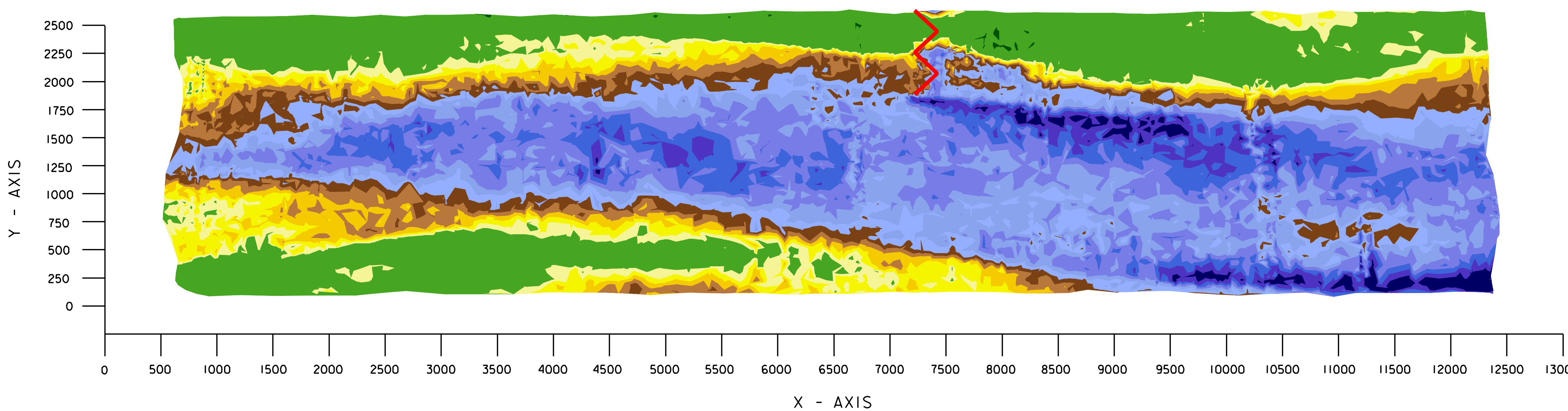
PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 29: W - DIKE 2

APPLIED RIVER ENGINEERING CENTER

1100 825 550 275 0 550 1100

DESIGN FILE: TEST29.DGN
PLOT DATE:
PLATE NO. 36



FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

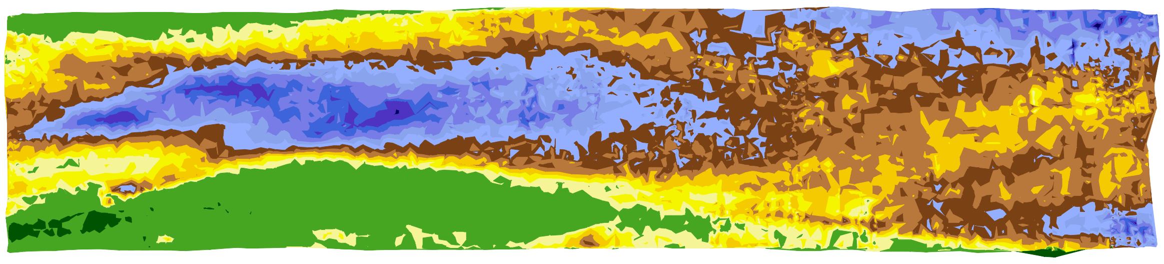
PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

GENERIC DIKE FLUME STUDY
TEST 30: W - DIKE 3

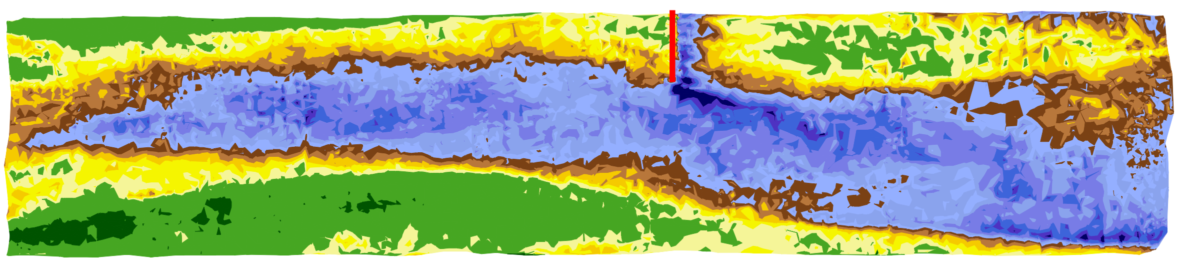
1100 825 550 275 0 550 1100

APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: TEST30.DGN
PLOT DATE:
PLATE NO. 37

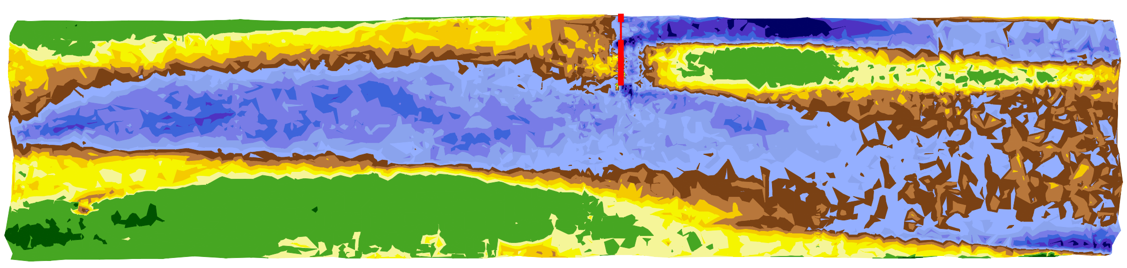


BASE TEST 1



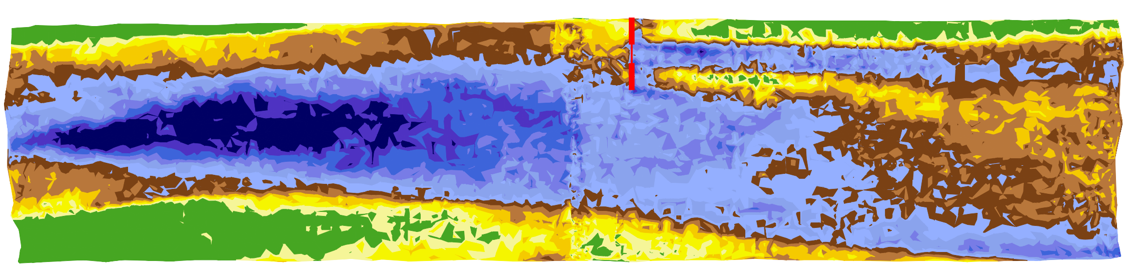
TEST 1

SINGLE DIKE, NO NOTCH



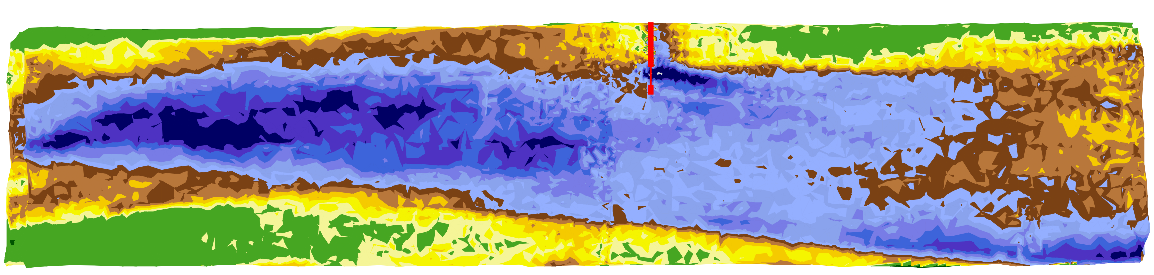
TEST 2

SINGLE DIKE, DEEP NOTCH LDB



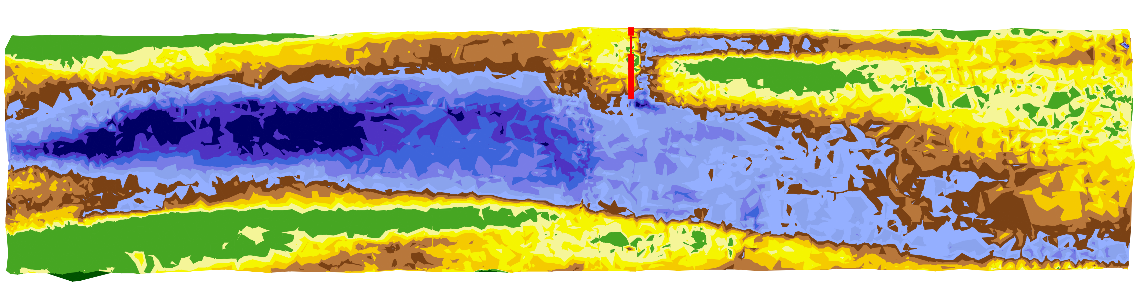
TEST 3

SINGLE DIKE, DEEP NOTCH MIDDLE



TEST 4

SINGLE DIKE, DEEP NOTCH RDB

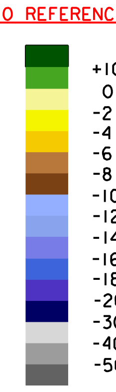


TEST 5

SINGLE DIKE, SHALLOW NOTCH LDB

FLOW

ELEVATIONS REFERENCED TO
SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

GENERIC DIKE FLUME STUDY
BASE TEST 1 &
TESTS 1 THROUGH 5

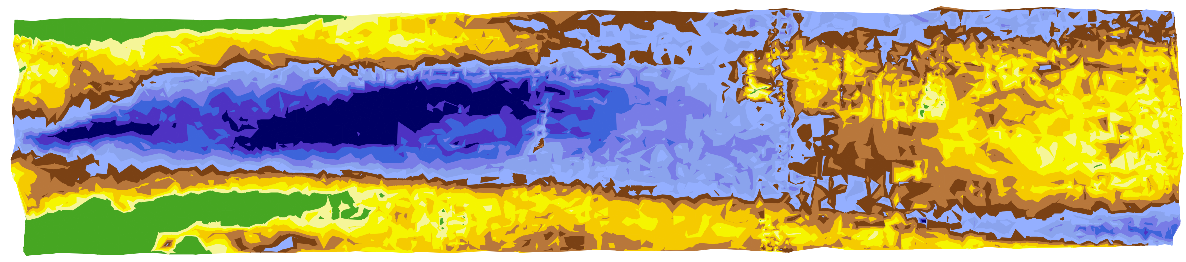
2000 1500 1000 500 0 1000 2000

PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

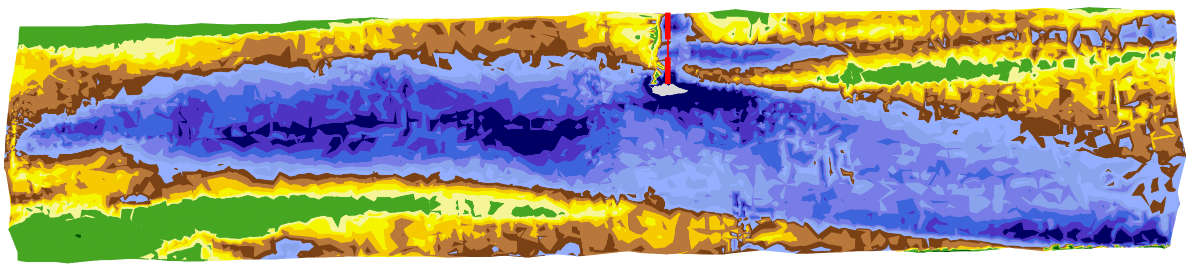
APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: OVERALL - B1.DGN
PLOT DATE:

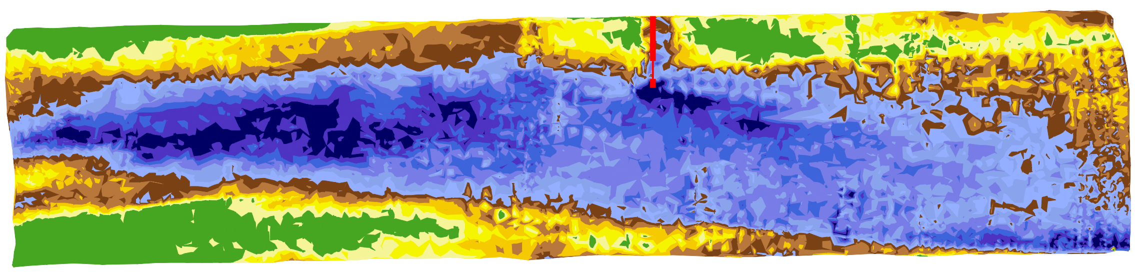
PLATE NO. 38



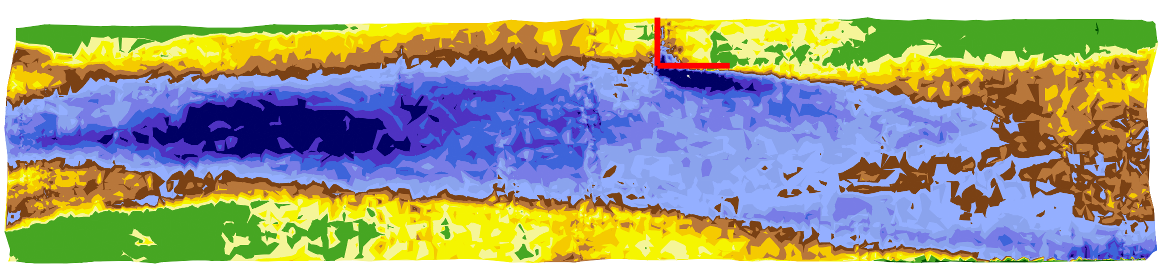
BASE TEST 2



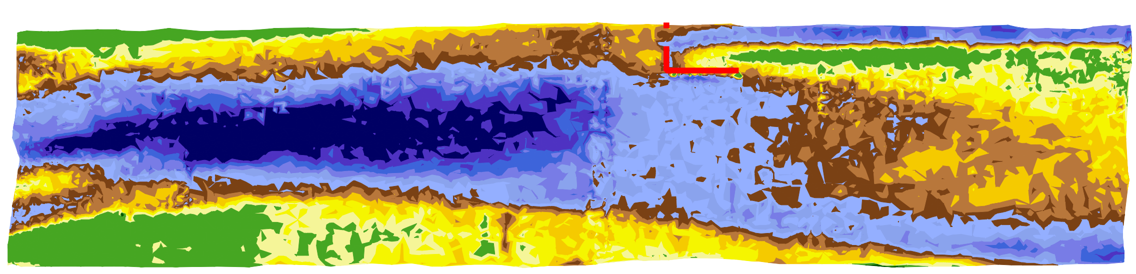
TEST 6
SINGLE DIKE, SHALLOW NOTCH MIDDLE



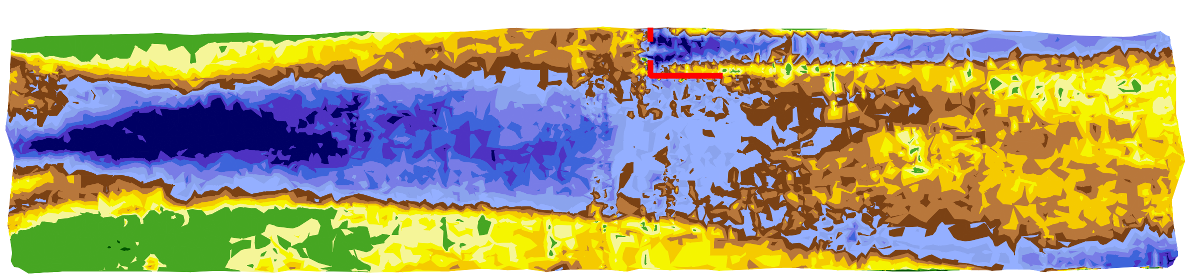
TEST 7
SINGLE DIKE, SHALLOW NOTCH RDB



TEST 8
L-DIKE, NO NOTCH



TEST 9
L-DIKE, DEEP NOTCH LDB



TEST 10
L-DIKE, DEEP NOTCH MIDDLE

FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE

+10
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-30
-40
-50

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

GENERIC DIKE FLUME STUDY
BASE TEST 2 &
TESTS 6 THROUGH 10

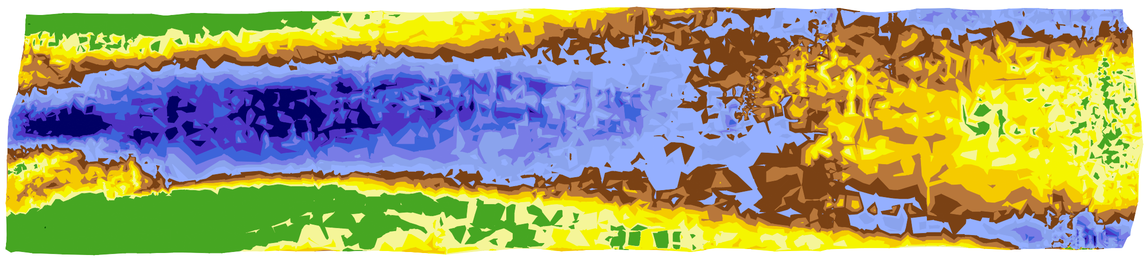
2000 1500 1000 500 0 1000 2000

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

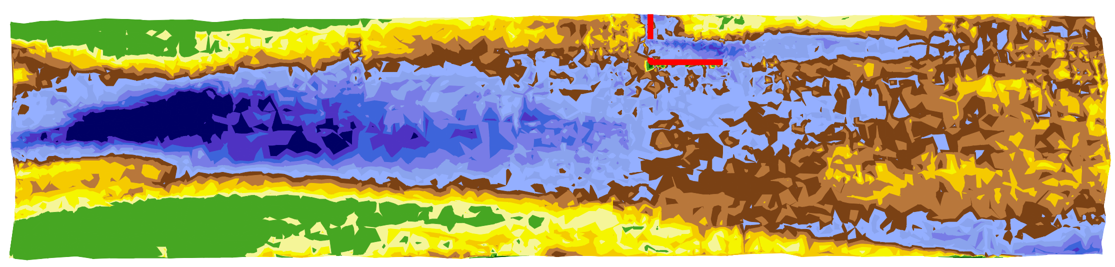
APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: OVERALL - B2.DGN
PLOT DATE:

PLATE NO. 39

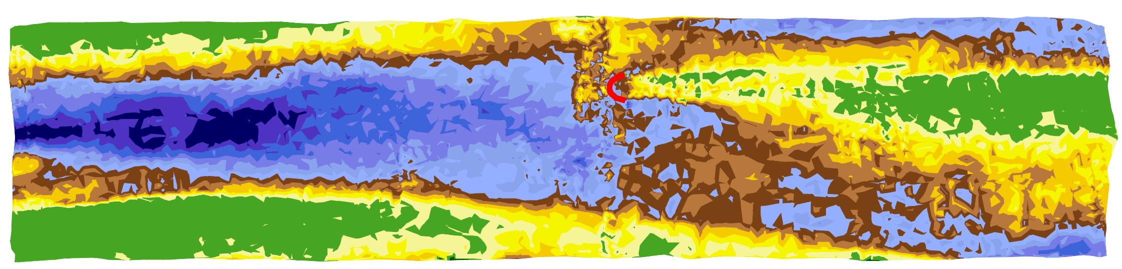


BASE TEST 3



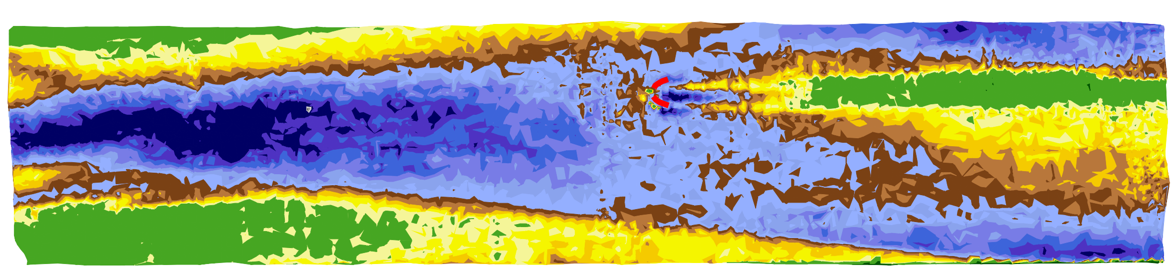
TEST 11

L-DIKE, DEEP NOTCH RDB



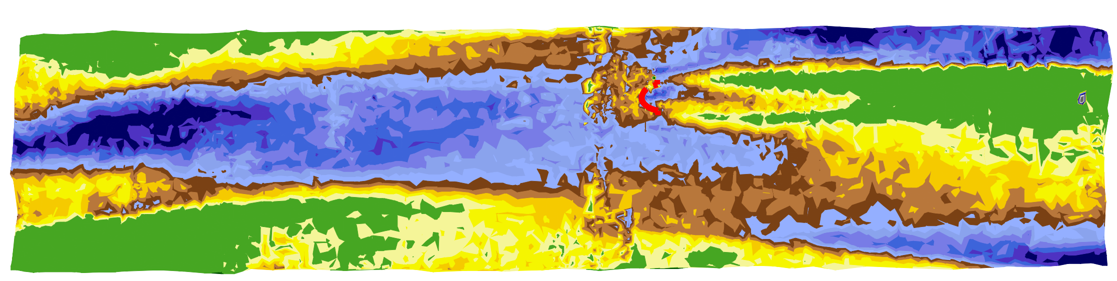
TEST 12

CHEVRON



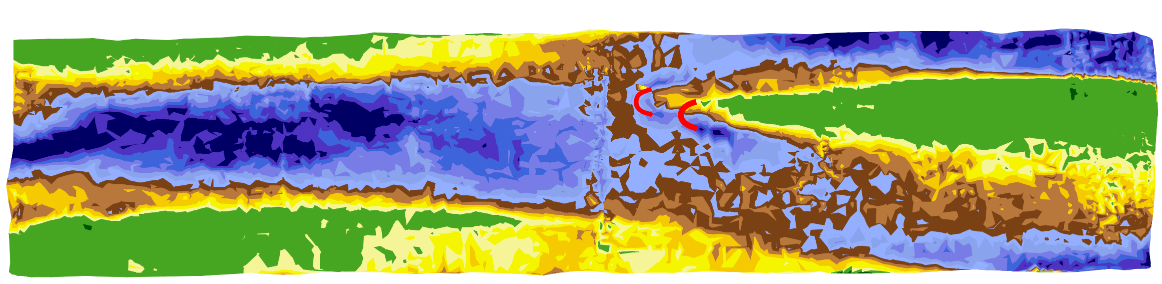
TEST 13

CHEVRON, APEX NOTCH



TEST 14

CHEVRON, LDB LEG NOTCH, STUB DIKES ON EACH LEG

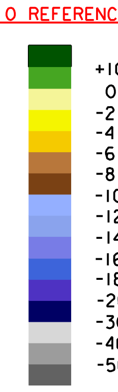


TEST 15

TWO CHEVRONS, STAGGERED APEX TO LEG

FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

GENERIC DIKE FLUME STUDY
BASE TEST 3 &
TESTS 11 THROUGH 15

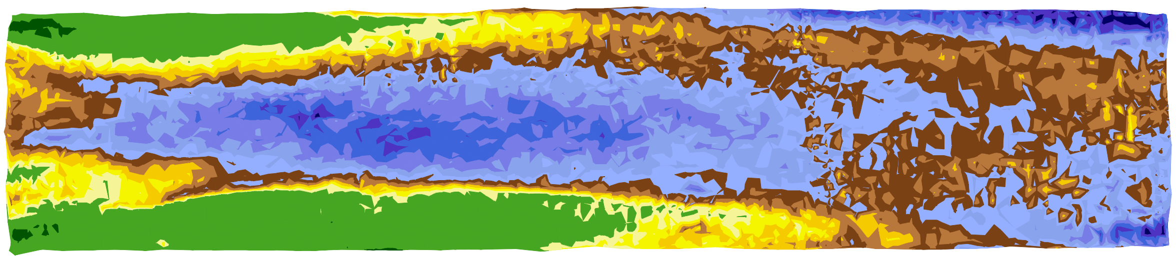
2000 1500 1000 500 0 1000 2000

PLATE NO. 40

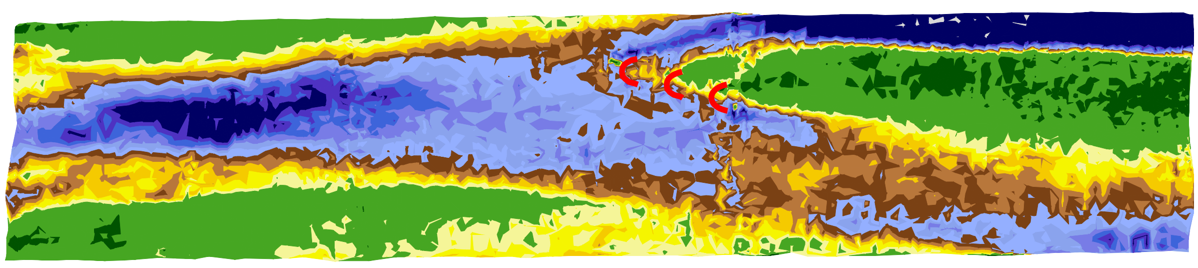
DESIGN FILE: OVERALL - B3.DGN
PLOT DATE:

PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

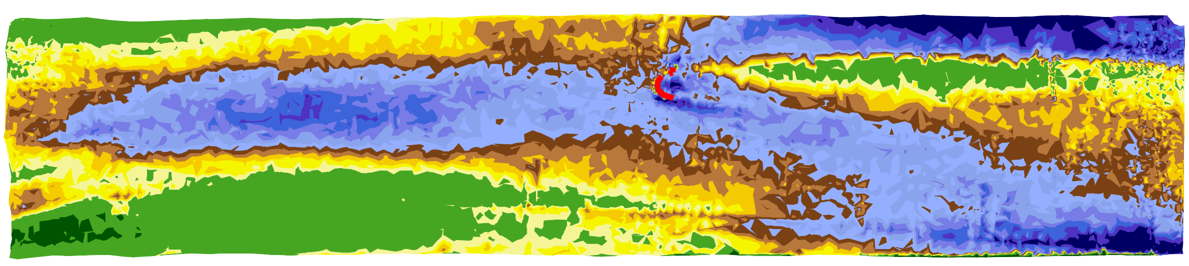


BASE TEST 4



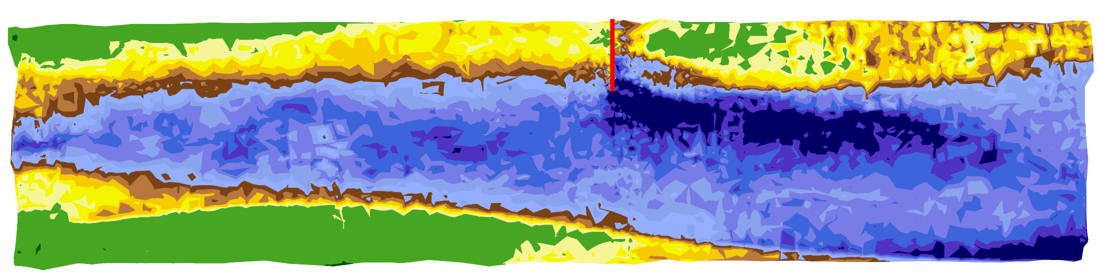
TEST 16

3 CHEVRONS, STAGGERED APEX TO LEG



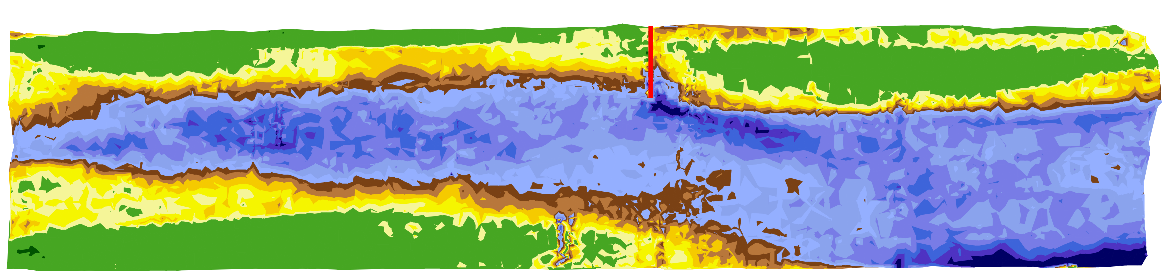
TEST 17

CHEVRON, LDB LED NOTCH, STUB DIKE ON LDB LEG



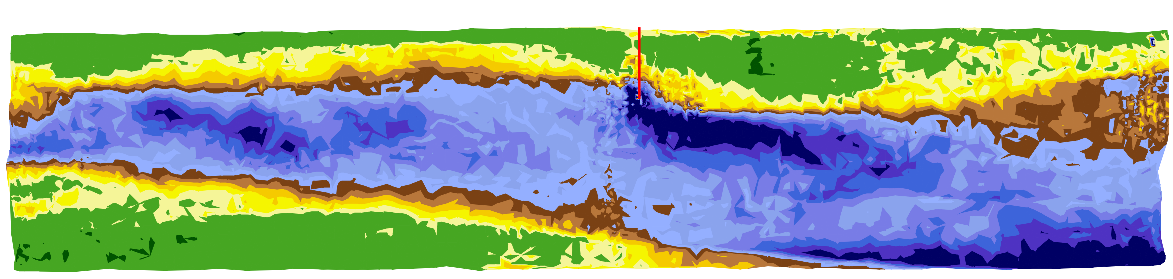
TEST 18

SINGLE DIKE, SLOPED LDB TO RDB



TEST 19

SINGLE DIKE, SLOPED RDB TO LDB

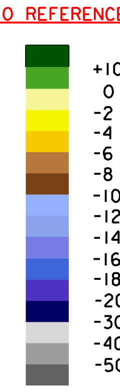


TEST 20

DOUBLE DIKE

FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

GENERIC DIKE FLUME STUDY
BASE TEST 4 &
TESTS 16 THROUGH 20

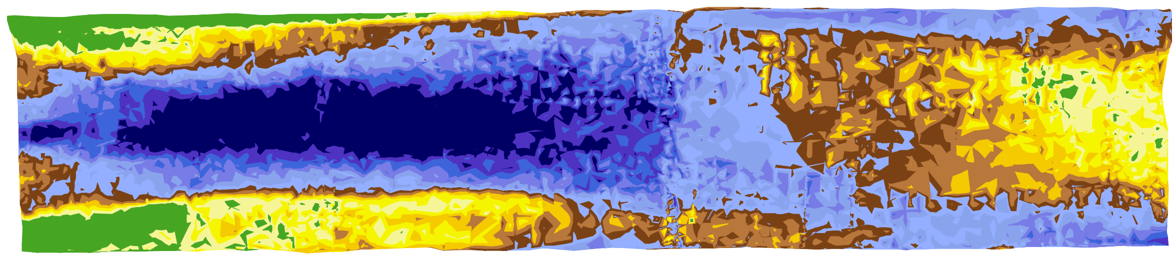
2000 1500 1000 500 0 1000 2000

PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

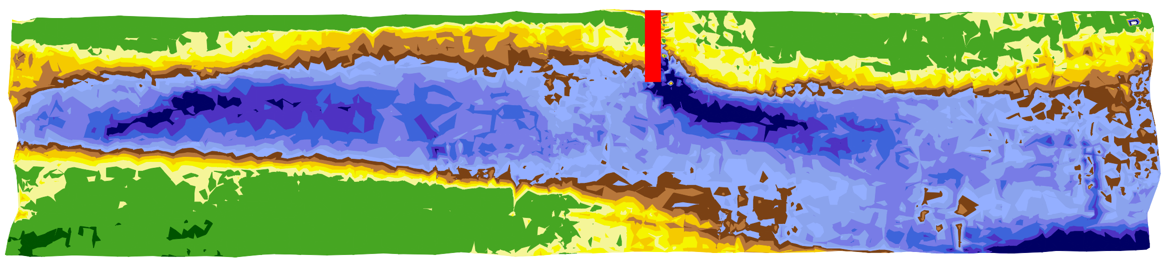
APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: OVERALL - B4.DGN
PLOT DATE:

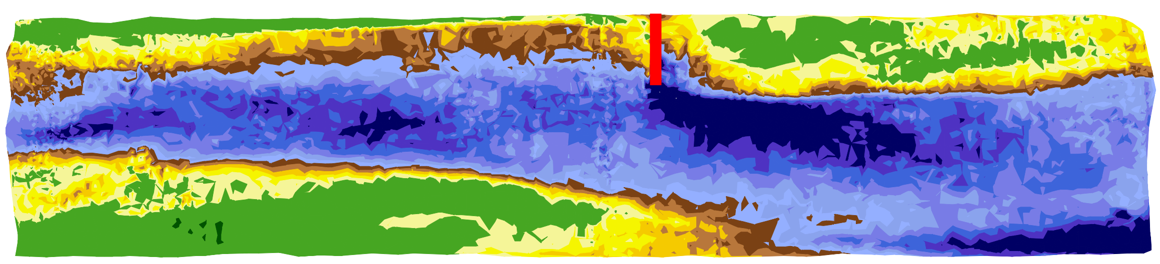
PLATE NO. 41



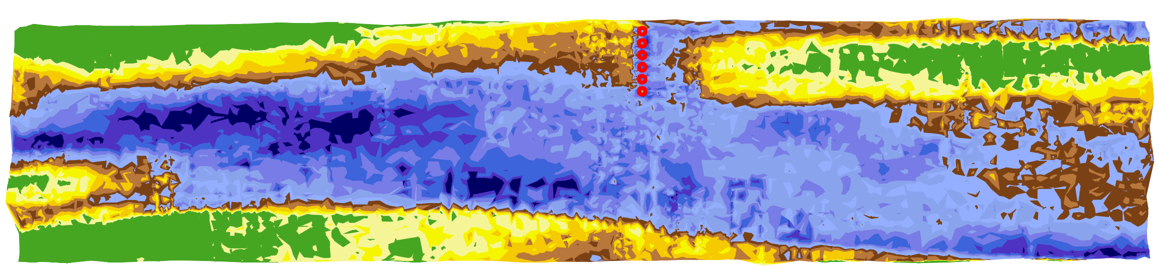
BASE TEST 2



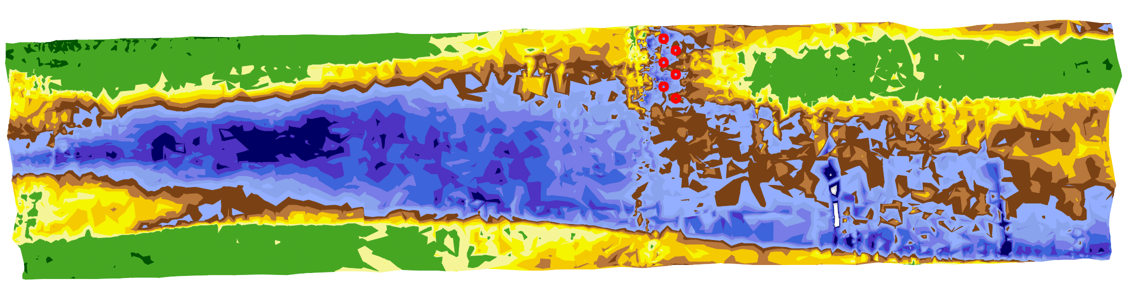
TEST 21
WEDGE DIKE, 8 TO 1 SLOPE



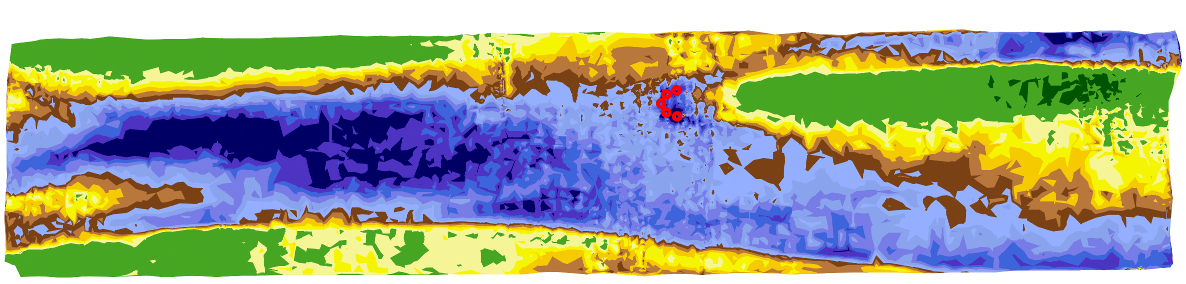
TEST 22
WEDGE DIKE, 4 TO 1 SLOPE



TEST 23
MRS DIKE



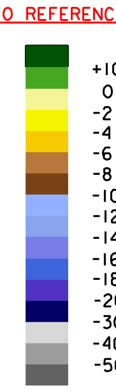
TEST 24
STAGGERED MRS DIKE



TEST 25
MRS CHEVRON

FLOW

ELEVATIONS REFERENCED TO
SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

GENERIC DIKE FLUME STUDY
BASE TEST 5 &
TESTS 21 THROUGH 25

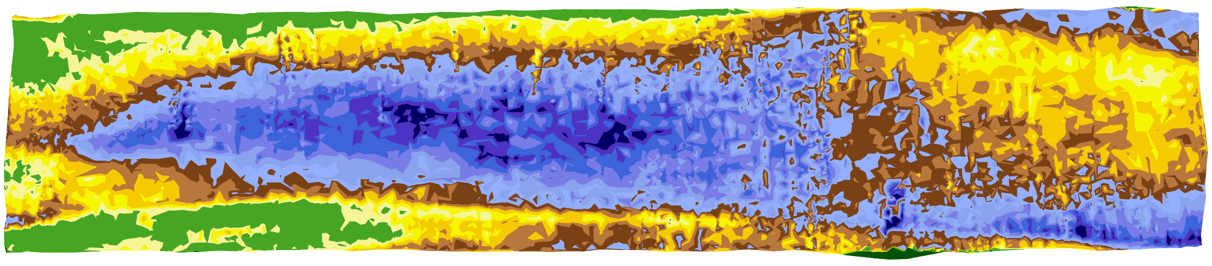
2000 1500 1000 500 0 1000 2000

PREPARED BY: J. BROWN
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

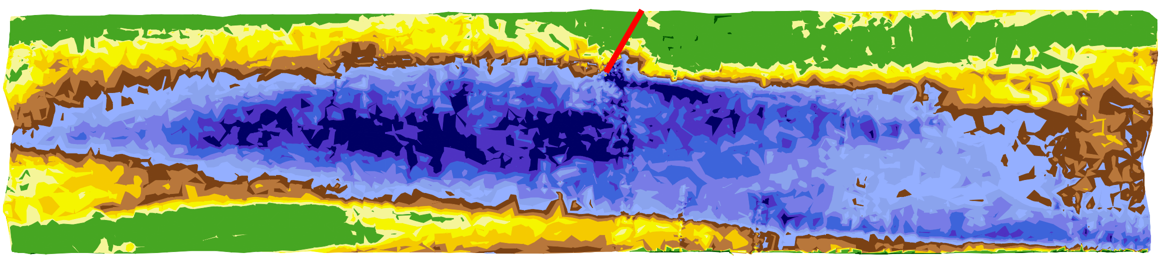
APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: OVERALL - B5.DGN
PLOT DATE:

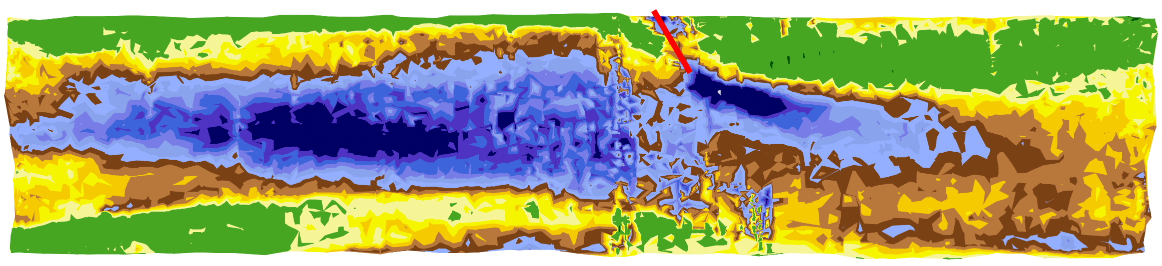
PLATE NO. 42



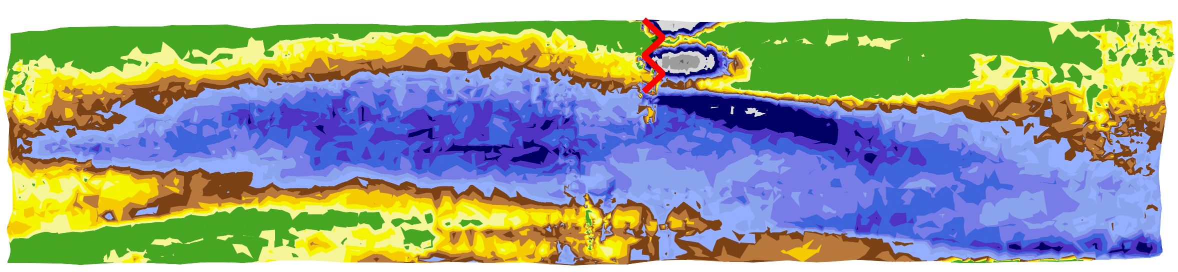
BASE TEST 6



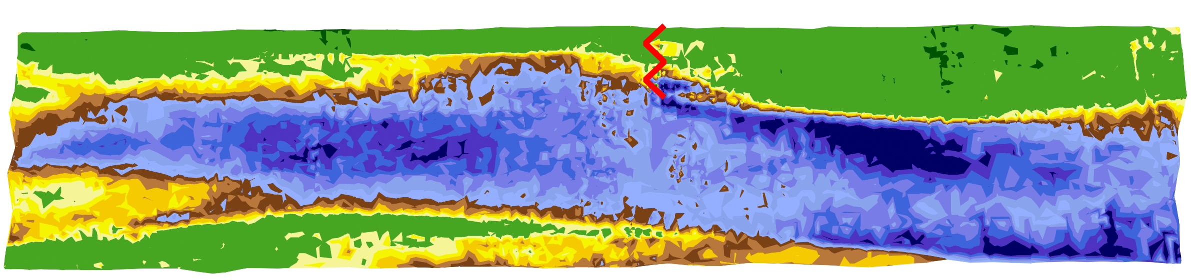
TEST 26
DIKE ANGLED UPSTREAM



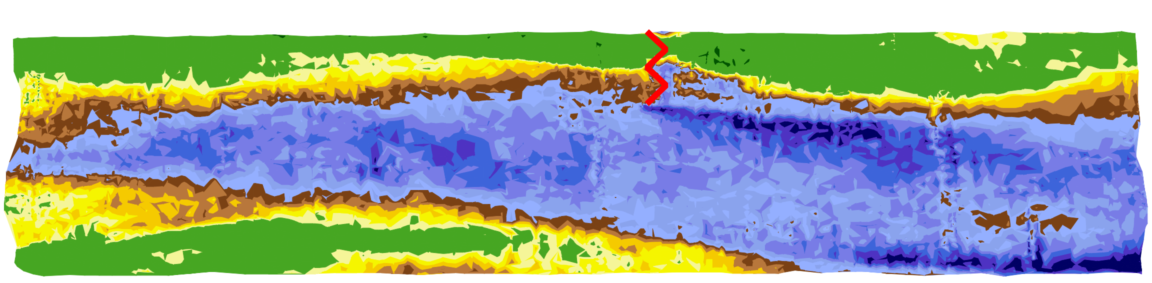
TEST 27
DIKE ANGLED DOWNSTREAM



TEST 28
W-DIKE 1



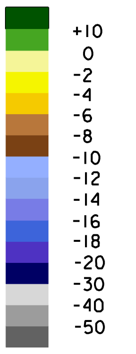
TEST 29
W-DIKE 2



TEST 30
W-DIKE 3

FLOW

ELEVATIONS REFERENCED TO SELECTED 0 REFERENCE PLANE



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

GENERIC DIKE FLUME STUDY
BASE TEST 6 &
TESTS 25 THROUGH 30

2000 1500 1000 500 0 1000 2000

PREPARED BY: J. BROWN
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

DESIGN FILE: OVERALL - B6.DGN
PLOT DATE:

PLATE NO. 43