

TECHNICAL MEMORANDUM - INITIAL CONDITIONS HYDRAULIC ANALYSIS

WESTERN SEGMENT OF THE LAS VEGAS BELTWAY
CRAIG ROAD TO HUALAPAI WAY

CH2M HILL Client #185313
G. C. WALLACE Project #451.002
Submitted to:



APRIL 2004



G. C. WALLACE, INC.
Engineers • Planners • Surveyors

1555 S. Rainbow Boulevard
Las Vegas, NV 89146
T: (702) 804-2000 F: (702) 804-2299



CH2MHILL

2285 Corporate Circle - Suite 200
Henderson, NV 89074
T: (702) 369-6175 F: (702) 369-1107

**DESIGN MEMORANDUM
FOR
WESTERN SEGMENT OF THE
LAS VEGAS BELTWAY
CRAIG ROAD TO HUALAPAI WAY**

50% SUBMITTAL

451.002

April 2004

Prepared For:

**Clark County Department of Public Works
Design Engineering
500 South Grand Central Parkway, Ste. 2001
Las Vegas, NV 89155-4000
Phone: (702) 455-6050
Fax: (702) 455-6113**

Prepared By:

**G. C. Wallace, Inc.
1555 South Rainbow Boulevard
Las Vegas, NV 89146
Phone: (702) 804-2000
Fax: (702) 804-2297**



G. C. WALLACE, INC.
Engineers/Planners/Surveyors

**DESIGN MEMORANDUM
FOR
WESTERN SEGMENT OF THE
LAS VEGAS BELTWAY
CRAIG ROAD TO HUALAPAI WAY**

50% SUBMITTAL

451.002

April 2004

Prepared For:

**Clark County Department of Public Works
Design Engineering
500 South Grand Central Parkway, Ste. 2001
Las Vegas, NV 89155-4000
Phone: (702) 455-6050
Fax: (702) 455-6113**

Prepared By:

**G. C. Wallace, Inc.
1555 South Rainbow Boulevard
Las Vegas, NV 89146
Phone: (702) 804-2000
Fax: (702) 804-2297**

TABLE OF CONTENTS

	<u>Description</u>	<u>Page</u>
EXECUTIVE SUMMARY		iii
Introduction		iii
Purpose		iii
Conclusions and Recommendations		vi
I. INTRODUCTION		1
II. FEMA FLOODPLAIN INFORMATION		1
III. CLARK COUNTY REGIONAL FLOOD CONTROL DISTRICT (CCRFCD) FACILITIES		1
IV. PROJECT OBJECTIVES		6
V. HYDROLOGY		6
VI. REGIONAL FLOOD CONTROL FACILITY DESIGN		7
Beltway Channel		7
Detention Basins		9
Spillways		11
Cost Estimates		13
VII. CONCLUSIONS & RECOMMENDATIONS		14
VIII. REFERENCES		16
Appendix A – Beltway Channel Hydraulics		
Appendix B – Beltway Channel Storm Drain Lateral Hydraulics		
Appendix C – North Detention Basin Facilities		
Appendix D – Spillway Facilities		
Appendix E – Reference Material		
Appendix F – Plan and Profile Sheets		

LIST OF FIGURES

<u>No.</u>	<u>Description</u>	<u>Page</u>
FIGURE E-1	VICINITY MAP	iv
FIGURE E-2	LOCATION MAP	v
FIGURE 1	VICINITY MAP	2
FIGURE 2	LOCATION MAP	3
FIGURE 3	FLOOD INSURANCE RATE MAP	4
FIGURE 4	CCRFGD FACILITIES	5

EXECUTIVE SUMMARY

INTRODUCTION

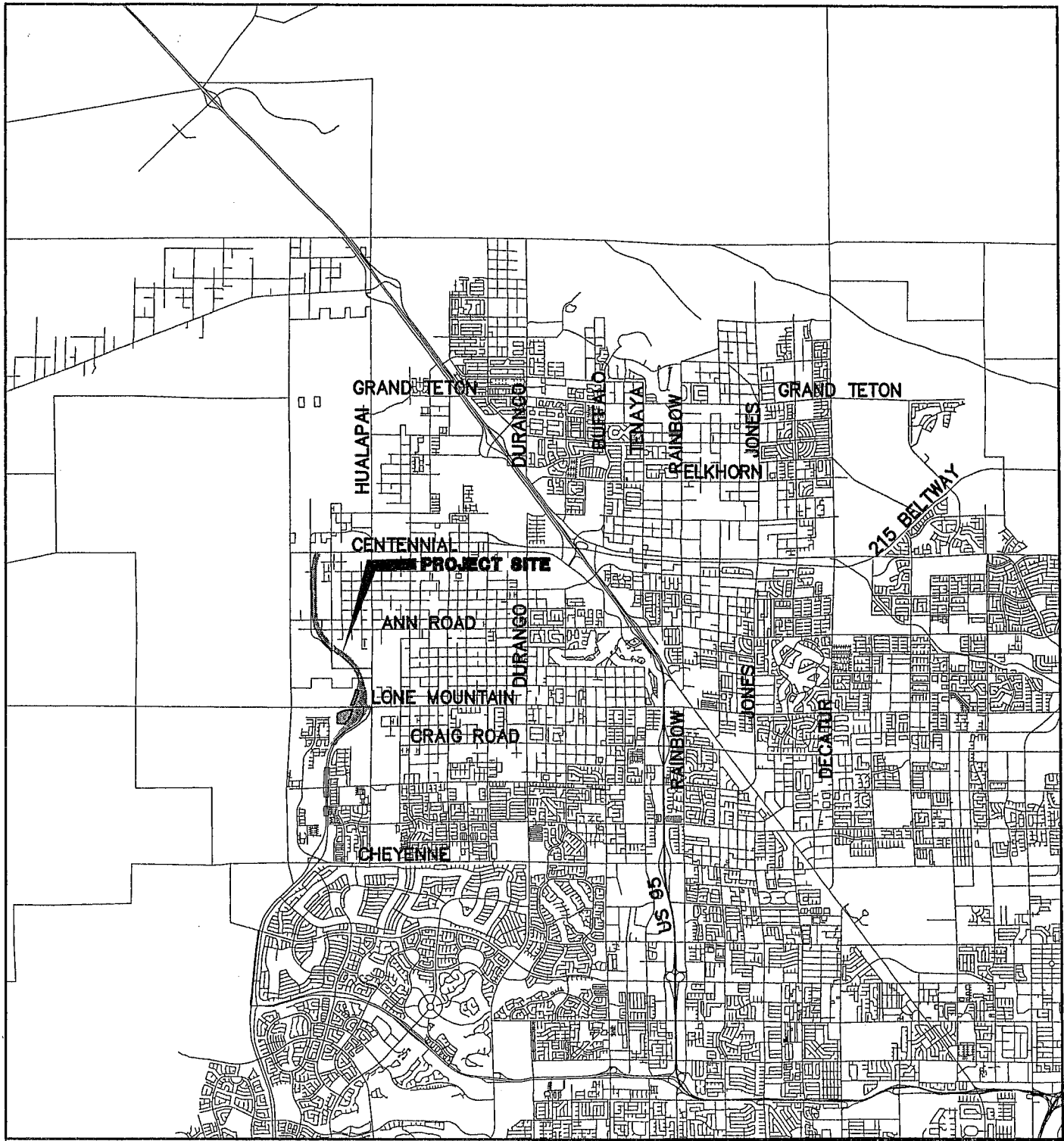
CH2M HILL, as the prime consultant for the design of the segment of the Las Vegas Beltway from Craig Road to Hualapai Way, has contracted with G. C. Wallace, Inc. (GCW) to provide engineering and design services for the Gowan Beltway West Channel facilities from Centennial Parkway to the Lone Mountain – Beltway Detention Basins, and for the Lone Mountain - Beltway Detention Basin facilities. A vicinity map and location map showing the location of the project are included as Figures E-1 and E-2.

PURPOSE

The purpose of this memorandum is to present the results of the initial hydraulic modeling to conduct normal depth analysis and to prepare preliminary cost estimates for the Gowan Beltway West Channel and the Lone Mountain – Beltway Detention Basins and pertinent facilities.

The project has been divided into two phases. Phase 1, which was addressed in the hydrology report, consisted of providing estimated flows and their corresponding discharge locations to the future storm drain facilities. Phase 2, which is addressed in this report, consists of providing hydraulic design of the future regional flood control facilities. The following is a list of the regional facilities shown in the 2002 Master Plan Update, Clark County Regional Flood Control District, that are to be addressed in Phases 1 and 2 of this project:

GOBW 0277 is a 1,400-linear foot (LF) 10-foot wide by 4.5-foot deep concrete channel;
GOBW 0250 is a 1,400 LF 10-foot wide by 7.5-foot deep concrete channel;
GOBW 0248 is a 100 LF 10-foot wide by 8-foot high RCB;
GOBW 0220 is a 1,500 LF 15-foot wide by 7.5-foot deep concrete channel;
GOBW 0194 is a 1,400 LF 15-foot wide by 10-foot deep concrete channel;
GOBW 0124 is a 3,700 LF 14-foot wide by 7-foot deep concrete channel;
GOBW 0096 is a 1,500 LF 15-foot wide by 7.5-foot deep concrete channel;
GOBW 0054 is a 200 LF 8-foot wide by 8-foot high RCB connector pipe;
GOBW 0053 is a 300 LF 8-foot wide by 8-foot high RCB connector pipe;
GOBW 0052 is a 555 acre-foot Detention Basin System;
GOBW 0051 is a 100 LF 18-inch RCP outlet; and
GOBW 0050 is a 32,890 cfs PMF spillway.



GRAPHIC SCALE



(IN FEET)

1 inch = 10000 ft.



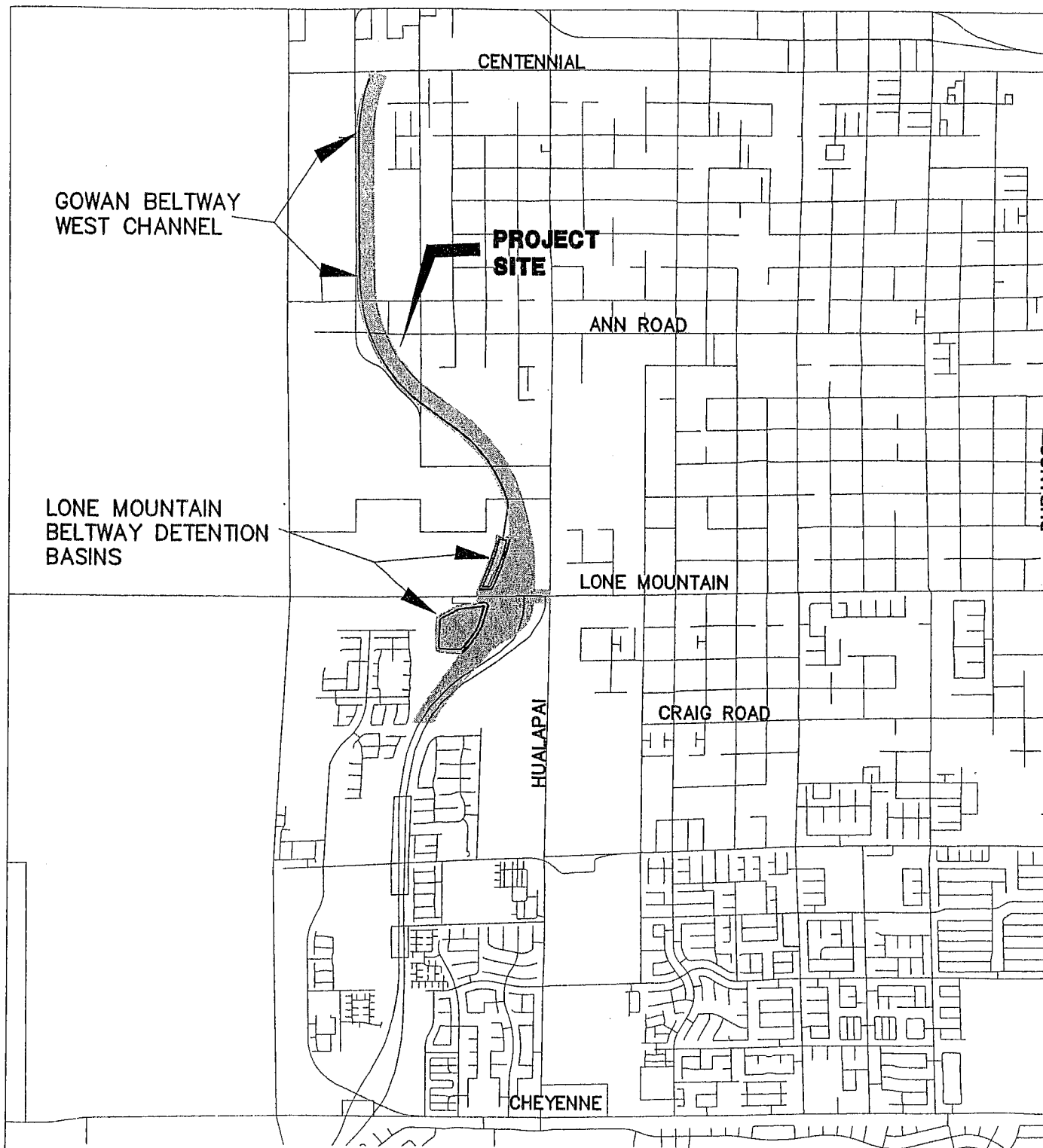
SCALE 1" = 10,000'

WESTERN SEGMENT OF THE
LAS VEGAS BELTWAY
CRAIG ROAD TO HUALAPAI WAY

FIGURE E-1
VICINITY MAP

**G.C. WALLACE, INC.**

Engineers/Planners/Surveyors 1505 SOUTH RAINBOW BLVD., LAS VEGAS, NV 89146



GRAPHIC SCALE



(IN FEET)

1 inch = 3000 ft.



SCALE 1" = 3,000'

WESTERN SEGMENT OF THE
LAS VEGAS BELTWAY
CRAIG ROAD TO HUALAPAI WAY

FIGURE E-2
LOCATION MAP



G.C. WALLACE, INC.

Engineers/Planners/Surveyors 1555 SOUTH RAINBOW BLVD./LAS VEGAS, NV 89146

CONCLUSIONS AND RECOMMENDATIONS

1. The project facilities are not located in a FEMA-designated Special Flood Hazard Area.
2. The Gowan Beltway West Channel system will have design flows ranging from approximately 520 cfs at the north end to 2,180 cfs at the south end.
3. The detention basin facilities will include two basins located on the northwest and southwest quadrants of the Lone Mountain Road interchange. The peak storage volume for the detention basin on the northwest quadrant will be approximately 150 acre-feet. The peak storage volume for the detention basin on the southwest quadrant will be approximately 500 acre-feet.
4. A dual level outfall is planned for the Lone Mountain - Beltway Detention Basins to minimize adverse impacts to downstream facilities. The lower level outfall will restrict peak discharge for the combined detention basins to approximately 47 cfs for the level of storage that will collect to the basins for the design storm that encompasses the watershed for the Gowan Detention Basins. The second level outfall will increase the discharge to approximately 180 cfs maximum as the storage volume increases from a volume of 320 acre-feet to 650 acre-feet. This will provide for a storm centered over tributary watershed for the Lone Mountain - Beltway Detention Basins to discharge from the basins in approximately seven days while minimizing adverse impacts on the Gowan North system.
5. Two Beltway Channel alignment and profile options were presented based on the existing topography and the proposed Western Beltway alignment. The first option is an open channel system from the Centennial Parkway alignment to the inlet system at the north detention basin. The second option is a box culvert system from Centennial Parkway to immediately south of Ann Road and an open channel system from that point to the inlet system to the north detention basin. Option #2 is the recommended alternative that is shown on the drawings. Option #2 was selected to avert the need to acquire additional right-of-way to accommodate the depressed beltway and the required access roadway and manway for an open channel system.

6. Minor amounts of additional right-of-way will be required to provide for the proposed channel alignment at Ann Road that curves around the proposed bridge abutment at the west side of the Ann Road alignment and to accommodate the channel access roads/ramps at the proposed locations.
7. Three storm drain lateral inflow options to the Beltway Channel were presented in this report. Option A consists of four inflow locations at the Centennial, Tropical, Ann, and Washburn alignments. Option B consists of seven inflow locations at the Centennial, Azure, Tropical, El Campo, Ann, Hammer, and Washburn alignments. Option C consists of ten inflow locations at the Centennial, Regina, Azure, Tropical, El Campo, La Mancha, Ann, Stephen, Hammer, and Washburn alignments. Option B is the recommended alternative shown in the drawings.
8. The LMBW detention basin outfall extends east from the 8-foot by 8-foot RCB balancing conduit. A 434 linear foot 36-inch RCP conveys 180 cfs under pressure to a 66-inch RCP. At the junction to the 66-inch RCP the flow in the pipe changes to a gravity flow condition. The flow is conveyed 324 linear feet to a 717 linear foot 72-inch RCP that connects to the proposed (Gowan North Channel) Phase IV. The onsite beltway storm drainage system connects to the outfall system at the junction with the 72-inch RCP.
9. For the South Detention Basin, a 590 linear feet, 10-feet wide concrete spillway weir is proposed (with 3-feet deep cutoff wall at each side of the weir apron). The spillway weir will be centered about the low point on the beltway ramp. A similar concrete spillway weir is proposed at the north side of the north detention basin where overflow will discharge from that basin.

I. INTRODUCTION

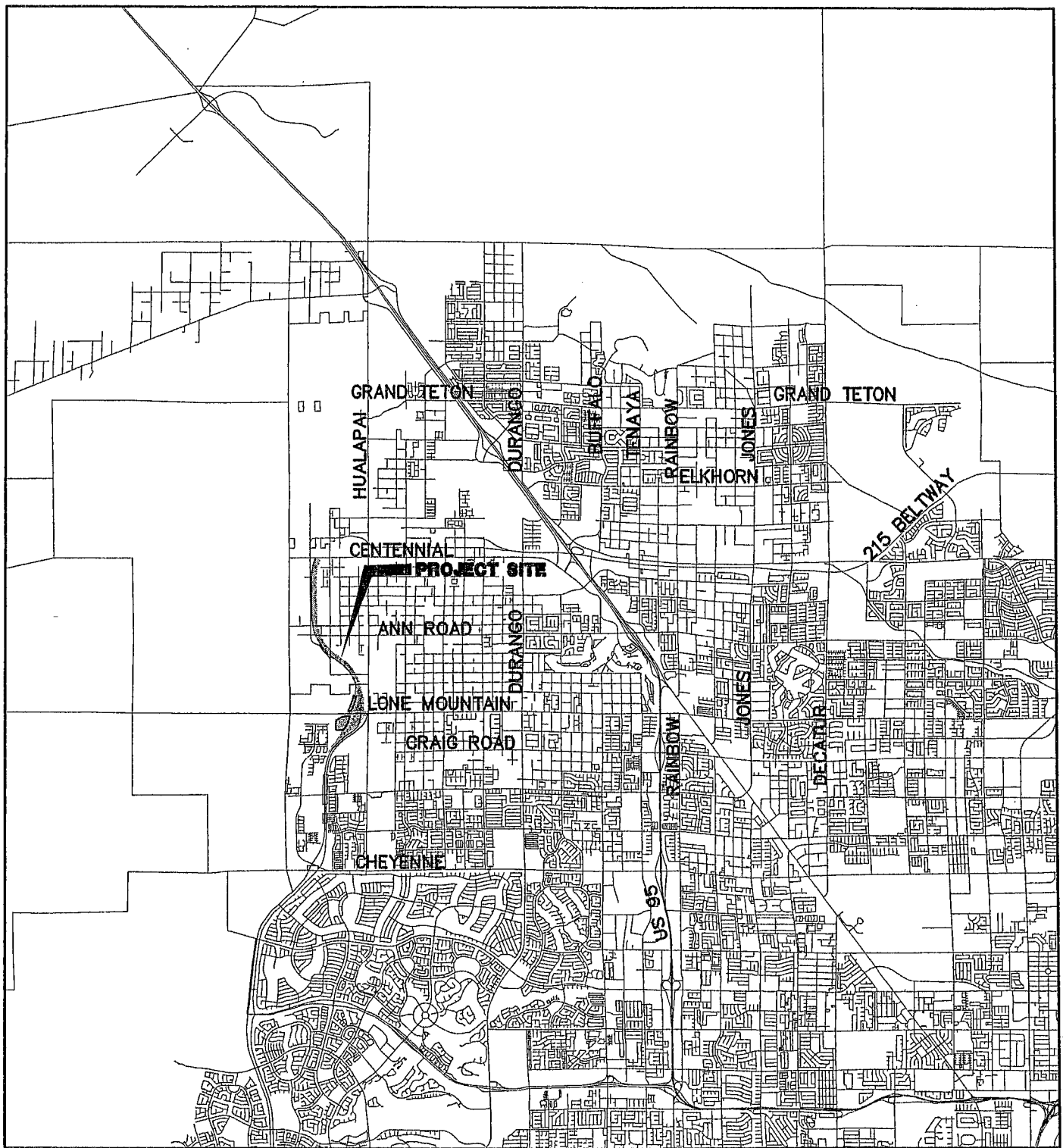
CH2M HILL, as the prime consultant for the design of the segment of the Las Vegas Beltway from Craig Road to Hualapai Way, has contracted with G. C. Wallace, Inc. (GCW) to provide engineering and design services for the Lone Mountain – Beltway Detention Basins (hereinafter referred to as the LMBW Detention Basins) and the Gowan Beltway West Channel from Centennial Parkway to the LMBW Detention Basins (hereinafter referred to as the Beltway Channel). A vicinity map and location map showing the exact location of the project are included as Figures 1 and 2.

II. FEMA FLOOD PLAIN INFORMATION

Figure 3 shows the project site in relation to designated Federal Emergency Management Agency (FEMA) flood zones. According to Flood Insurance Rate Map (FIRM) Panels 32003C 1750 E and 2150 E, dated September 27, 2002, the project site lies within FEMA-designated Zone X. Areas designated as Zone X are described as being outside of the 500-year floodplain.

III. CLARK COUNTY REGIONAL FLOOD CONTROL DISTRICT (CCRFCD) FACILITIES

Figure 4 is reproduced from Figure F-7 of the *2002 Clark County Regional Flood Control District (CCRFCD) Las Vegas Valley Master Plan Update* (Reference 1, hereinafter referred to as the 2002 MPU). This figure depicts the project site in relation to existing and proposed CCRFCD facilities. As shown on the figure, Facility GOBW 0277 is a 1,400 linear foot (LF) 10-foot wide by 4.5-foot deep concrete channel. Facility GOBW 0250 is a 1,400 LF 10-foot wide by 7.5-foot deep concrete channel. Facility GOBW 0248 is a 100 LF 10-foot wide by 8-foot high RCB. Facility GOBW 0220 is a 1,500 LF 15-foot wide by 7.5-foot deep concrete channel. Facility GOBW 0194 is a 1,400 LF 15-foot wide by 10-foot deep concrete channel. Facility GOBW 0124 is a 3,700 LF 14-foot wide by 7-foot deep concrete channel. Facility GOBW 0096 is a 1,500 LF 15-foot wide by 7.5-foot deep concrete channel. Facility GOBW 0050 is a 32,890 cfs PMF spillway. Facility GOBW 0051 is a 100 LF 18-inch RCP outlet. Facility GOBW 0052 is the 555 acre-feet Lone Mountain-Beltway Detention Basin. Facility GOBW 0053 is a 300 LF 8-foot wide by 8-foot high

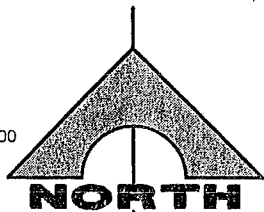


GRAPHIC SCALE



(IN FEET)

1 inch = 10000 ft.



SCALE 1" = 10,000'

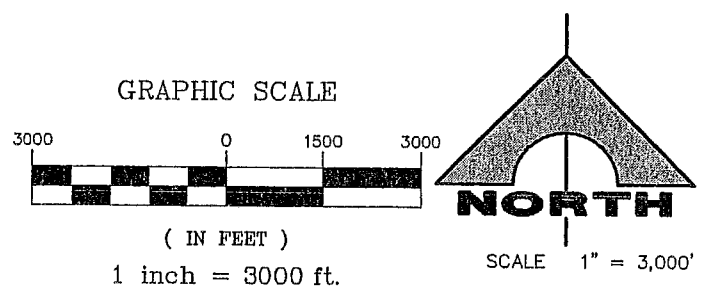
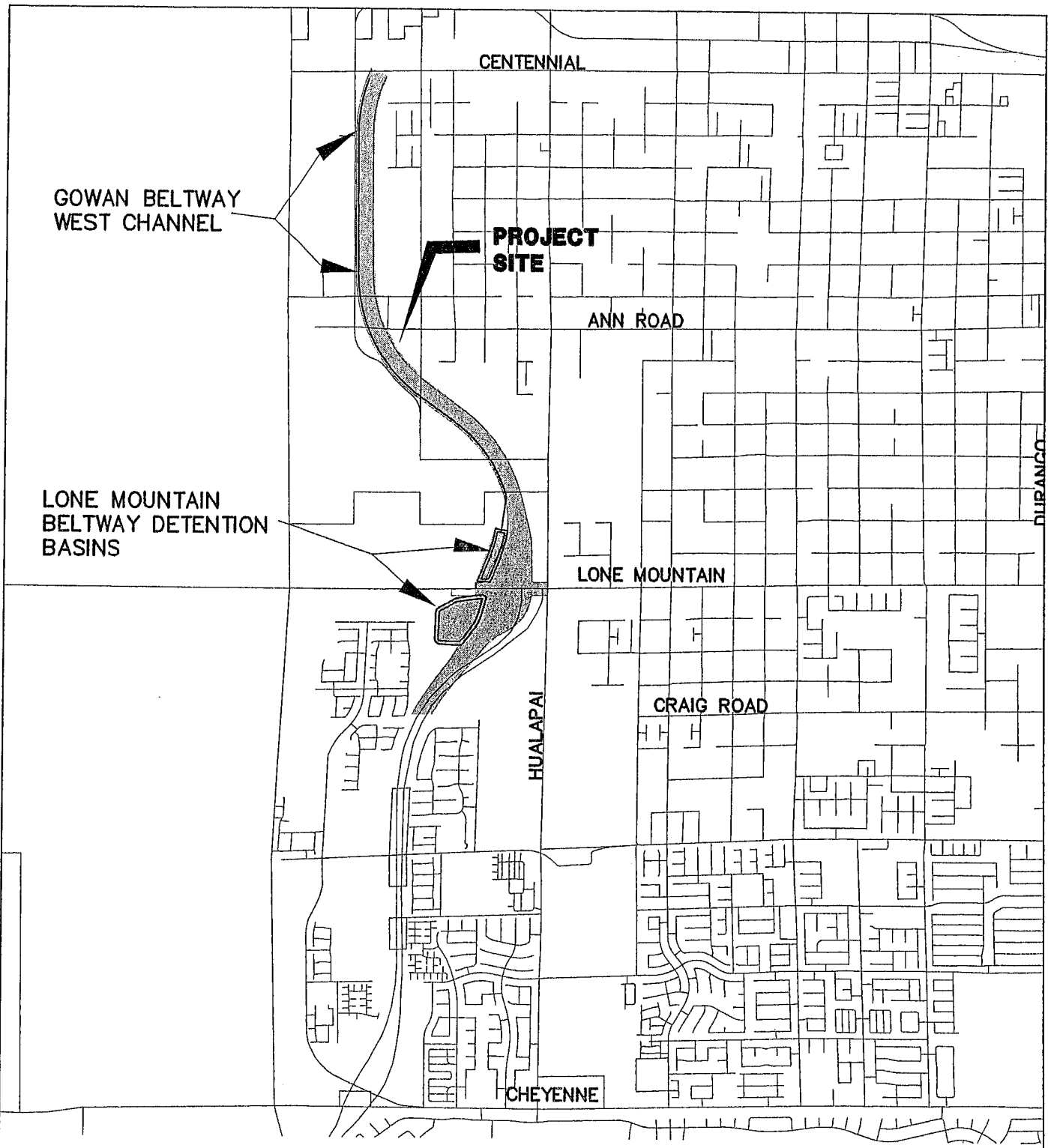
WESTERN SEGMENT OF THE
LAS VEGAS BELTWAY
CRAIG ROAD TO HUALAPAI WAY

FIGURE 1
VICINITY MAP

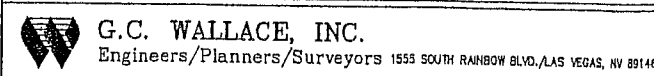
**G.C. WALLACE, INC.**

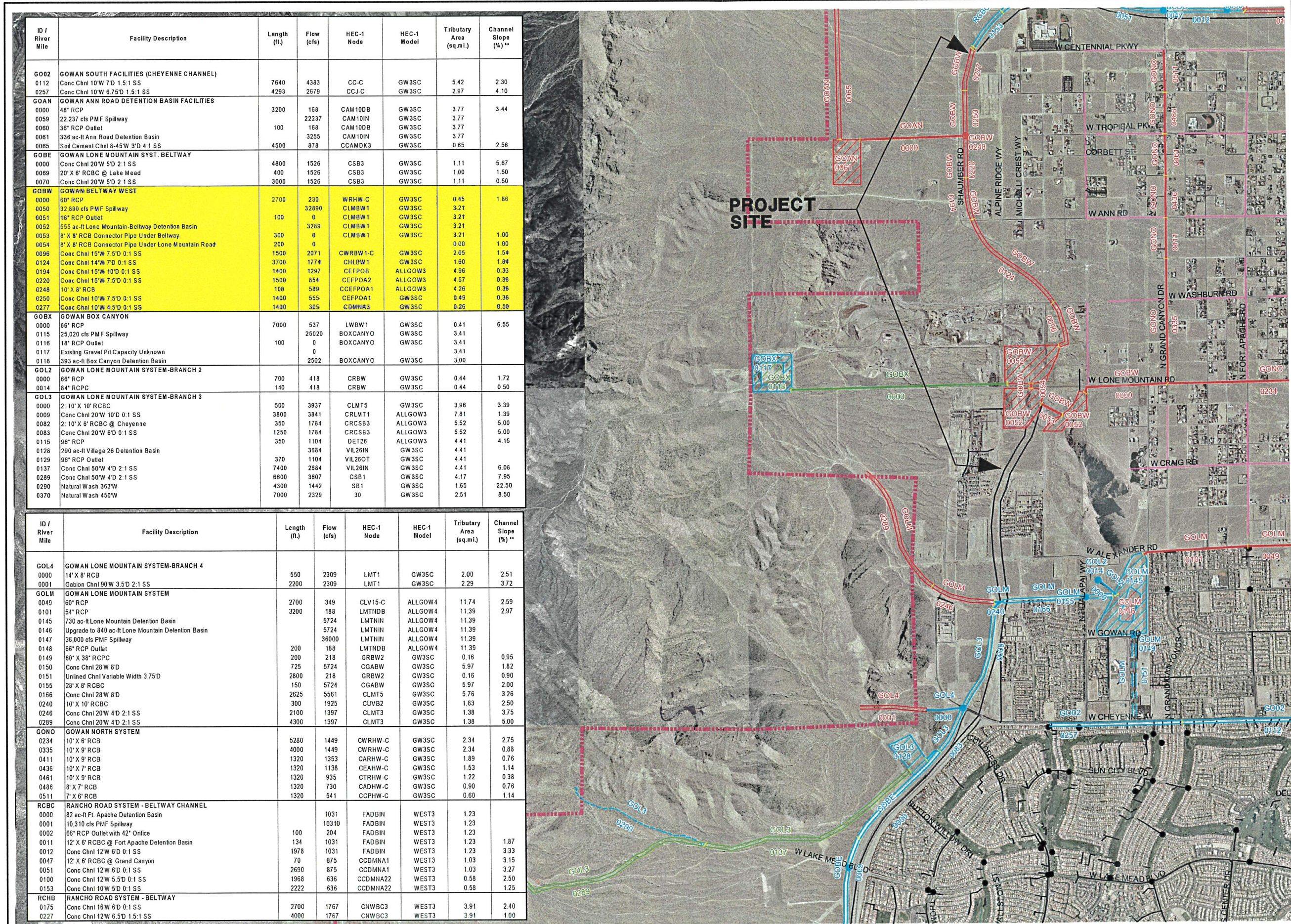
Engineers/Planners/Surveyors 1555 SOUTH RAINBOW BLVD., LAS VEGAS, NV 89146

F:\451-002\Drainage\fig\FIG2.dwg 02-10-04 07:36:24 wfelkins



WESTERN SEGMENT OF THE LAS VEGAS BELTWAY CRAIG ROAD TO HUALAPAI WAY	
FIGURE 2 LOCATION MAP	
 G.C. WALLACE, INC. Engineers/Planners/Surveyors 1555 SOUTH RAINBOW BLVD./LAS VEGAS, NV 89146	





RCB connector pipe under the Beltway. Facility GOBW 0054 is a 200 LF 8-foot wide by 8-foot high RCB connector pipe under Lone Mountain Road.

IV. PROJECT OBJECTIVES

The purpose of this memorandum is to present the results of the initial hydraulic modeling to conduct normal depth analysis and to prepare preliminary cost estimates for the Gowan Beltway West Channel and the Lone Mountain – Beltway Detention Basins and pertinent facilities.

The project has been divided into two phases. Phase 1, which was addressed in the hydrology report, consisted of providing estimated flows and their corresponding discharge locations to the Beltway Channel and the LMBW Detention Basins. Phase 2, which is addressed in this report, consists of providing hydraulic design of the future storm drain facilities and the design of the Beltway Channel.

The following tasks were performed to prepare this Phase 2 design memorandum:

- ♦ Provided Beltway Channel alignment and profile options based on existing topography and the proposed Western Beltway alignment.
- ♦ Identified inflow locations based on flows obtained from the Phase 1 hydrology study and provided three different storm drain facilities options to convey runoff to the Beltway Channel.
- ♦ Designed facilities necessary to convey runoff down the steep sides of the detention basins.
- ♦ Identified locations requiring erosion protection.
- ♦ Designed low flow storm drain facilities for the detention basins.

V. HYDROLOGY

The 2002 MPU hydrology was used as the basic source for the formation of the hydrologic model for the Phase 1 hydrology report (Reference 2, hereinafter referred to as the Hydrology Report).

To provide flexibility for future development, storm drain laterals conveying flow to the Beltway Channel were designed based on portions of the ultimate conditions drainage map (see Figure 5 in Hydrology Report) subbasins that may contribute flow

to those storm drain locations. However, the capacity at any particular location of the Beltway Channel was designed based on the flows from the Ultimate Condition HEC-1 nodes determined in the Hydrology Report.

A conceptual layout of the detention basins facilities was presented for regional flood control master planning purposes in the 2002 MPU. The 2002 MPU presented a configuration that showed three potential sites for interconnected detention basins. The volume for the combined basins was estimated to be 550 acre-foot for a nominal peak outflow. The peak outflow was listed as 0 cfs; however, the *Hydrologic Criteria and Drainage Design Manual, CCRFCD, August 1999* (Reference 7, hereinafter referred to as the Manual) states that the maximum drainage time for a regional detention basin is seven days, therefore, a minimum average outflow of approximately 40 cfs would be required per the Manual. The design of the LMBW Detention Basins was addressed in the Hydrology Report.

VI. REGIONAL FLOOD CONTROL FACILITY DESIGN

The detention basin system and associated collection and conveyance systems are set up in coordination with the beltway and are laid out along the upstream side of the beltway alignment in order to facilitate the protection of that major infrastructure and the acquisition of right-of-way for those public facilities.

Beltway Channel - The Gowan Beltway West Channel system extends along the upstream side of the Las Vegas Beltway from the south side of the Centennial Parkway interchange to the Lone Mountain – Beltway North Detention Basin located on the northwest quadrant of the Lone Mountain Road interchange. The channel system consists of several segments as noted above in the section on CCRFCD facilities. In this report two Beltway Channel alignment options are presented.

Alignment #1 consists of open channel from the Centennial Parkway alignment to the Washburn Avenue alignment. At the Washburn Avenue alignment, the channel transitions to a 10-foot-wide by 10-foot-high RCB and descends to the LMBW North Detention Basin. Channel geometry, normal depth, and rollwave calculations for the Beltway Channel Alignment #1 are included on Sheets A1-4 through A1-11 in Appendix A-1.

Alignment #2 consists of RCB from the Centennial Parkway alignment to the Ann

Road alignment. At the Ann Road alignment, the channel transitions to a 14-foot by 10-foot open channel to the Washburn Avenue alignment. At the Washburn alignment, the channel transitions to a 10-foot-wide by 10-foot-high RCB and descends to the LMBW North Detention Basin. Channel geometry, normal depth, and rollwave calculations for the Beltway Channel Alignment #2 are included on Sheets A2-4 through A2-11 in Appendix A-2.

At the Ann Road alignment, the two alternative channel alignments are presented. The first location would be utilized if the bridge abutment is constructed as a vertical abutment. The second channel alignment curves around the bridge abutment and extends outside the right-of-way as presented on the plans. See Sheet SD-7 in Appendix F.

Storm drain laterals are proposed to convey flow to the Beltway Channel. The proposed lateral sizes are prorated based on the ultimate conditions drainage subbasins that contribute flow to those storm drain locations. Inflow locations to the Beltway Channel were presented as Options A, B, and C. Grated inlets may be provided in lieu of manholes along the RCB sections of the channel alignment to intercept surface flow that is not conveyed in the storm drain laterals.

Option A consists of four inflow locations at the Centennial, Tropical, Ann, and Washburn alignments. At Centennial Parkway, a 15-foot-wide maintenance ramp will convey approximately 340 cfs to the Beltway Channel. At Tropical Parkway, a 66-inch RCP will convey approximately 320 cfs to the Beltway Channel. At Ann Road, an 8-foot-wide by 6-foot-high RCB will convey 670 cfs to the confluence with the Beltway Channel. At Washburn Road, a 60-inch RCP lateral will convey 620 cfs to the Beltway Channel.

Option B consists of seven inflow locations at the Centennial, Azure, Tropical, El Campo, Ann, Hammer and Washburn alignments. At Centennial Parkway, a 15-foot-wide maintenance road will convey 280 cfs to the Beltway Channel. At Azure Avenue, a 606-inch RCP will convey 240 cfs to the Beltway Channel. At Tropical Parkway, a 72-inch RCP will convey 370 cfs to the Beltway Channel. At El Campo, a 60-inch RCP will convey 280 cfs to the Beltway Channel. At Ann Road, an 8-foot-wide by 6-foot-high RCB will convey 670 cfs to the Beltway Channel section. At Hammer Road, 72-inch RCP lateral will convey 620 cfs to the Beltway Channel. At

Washburn Road, one 72-inch RCP lateral will convey 570 cfs to the Beltway Channel.

Option C consists of ten inflow locations at the Centennial, Regina, Azure, Tropical, El Campo, La Mancha, Ann, Stephen, Hammer, and Washburn alignments. At Centennial Parkway, a 15-foot-wide maintenance road will convey 200 cfs to the Beltway Channel. At Regina Avenue, a 48-inch RCP will convey 100 cfs to the Beltway Channel. At Azure Avenue, a 48-inch RCP will convey 100 cfs to the Beltway Channel. At Tropical Parkway, a 66-inch RCP will convey 250 cfs to the Beltway Channel. At El Campo, a 48-inch RCP lateral will convey 100 cfs to the Beltway Channel. At La Mancha, a 48-inch RCP lateral will convey 100 cfs to the Beltway Channel. At Ann Road, an 8-foot-wide by 6-foot-high RCB will convey 350 cfs to the Beltway Channel. At Stephen Road, a 48-inch RCP lateral will convey 200 cfs to the Beltway Channel. At Hammer Road, a 66-inch RCP lateral will convey 400 cfs to the Beltway Channel. At Washburn Road, a 72-inch RCP lateral will convey 570 cfs to the Beltway Channel.

Detention Basins - Since the detention basins are associated with the beltway layout, the design of the segment of the beltway in the vicinity of the Lone Mountain Road interchange has direct bearing on the layout of the detention basins.

A dual detention basin design located adjacent to the northwest and southwest quadrants of the Lone Mountain interchange is proposed for this project. The north detention basin will have an elongated shape and will serve as a joint conveyance/detention facility.

At the Washburn Avenue alignment, the Beltway Channel transitions to a 10-foot wide by 10-foot high RCB and conveys 2182 cfs to the north detention basin. An energy dissipater structure will be located at the inlet to the detention basin with riprap erosion protection downstream of the energy dissipater.

Along the western side of the north detention basin, a riprap-lined v-ditch will convey 98 cfs to a 20-foot wide concrete channel, which discharges to the detention basin. Erosion protection will be provided at the channel outfall. A 42-inch HDPE drain low flow system will be provided and will extend from the main channel outfall to an

From the Master Study for Lone Mountain West by VTN Nevada (Reference 4, hereinafter referred to as the Lone Mountain Master Study), the total 100-year street flow in Lone Mountain Road is 414 cfs (See Appendix C). In addition, 134 cfs is conveyed in the 42-inch RCP in Lone Mountain Road. Depressed curb and curb opening along Lone Mountain Road will divert 207 cfs in the north half of the street to a 20-foot wide concrete channel that will convey the runoff to the north detention basin.

For locations and details of facilities, see the plan and profile sheets in Appendix F. Normal depth and riprap calculations for the north detention basin facilities are included in the appendix.

The initial flows up to a magnitude of approximately 800 cfs from the Beltway Channel system will pass through the north basin to the balancing conduit that will convey the flows under Lone Mountain Road to the south detention basin. The bottom of the north detention basin will be approximately 10 feet higher than the bottom of the south basin. The north basin will not detain runoff for inflows less than 800 cfs unless the south detention basin has filled to a height above the bottom of the north detention basin. For inflows in excess of 800 cfs the north basin will detain a portion of the inflows.

From the Monument at Lone Mountain West Units 1, 3, 4, and 5 Study by VTN (Reference 5, hereinafter referred to as the Monument Study), 341 cfs is conveyed to the east end of Peaceful Dawn Avenue. A 20-foot wide concrete channel is proposed to convey the flow to triple 6-foot by 3-foot culverts. At the northwest corner of the south detention basin, the 42-inch RCP stub (134 cfs) previously mentioned, was designed as a part of the *Technical Drainage Study for Cliff Shadows Four-Plex* (Reference 6, hereinafter referred to as the LR Nelson Study). As part of this report, the 42-inch RCP is extended and drains to a 6-foot by 3-foot wide culvert. These flows combine (475 cfs) in a 30-foot wide concrete channel and are conveyed to a 60-foot-wide earthen-lined channel. The earthen-lined channel transitions to a 30-foot wide concrete channel and discharges to the lower section of the detention basin. Erosion protection will be provided at the outfall. A 24-inch HDPE drain low flow storm drain system will be provided in the earthen-lined channel.

A local facility (8-foot wide by 8-foot high RCB) designed by CH2M Hill conveys 753 cfs to the edge of the south detention basin. A double 54-inch RCP is proposed to convey the flow to the bottom of the south detention basin. A double impact basin energy dissipater will be provided at the outfall.

The LMBW detention basin outfall extends east from the 8-foot by 8-foot RCB balancing conduit. A 434 linear foot 36-inch RCP conveys 180 cfs under pressure to a 66-inch RCP. At the junction to the 66-inch RCP the flow in the pipe changes to a gravity flow condition. The flow is conveyed 324 linear feet to a 717 linear foot 72-inch RCP that connects to the proposed (Gowan North Channel) Phase IV. The onsite beltway storm drainage system connects to the outfall system at the junction with the 72-inch RCP.

Spillways – The PMP storms were analyzed in the Hydrology Memorandum and PMF flows were determined for the prescribed drainage areas for the north and south detention basins. As a part of this preliminary hydraulic study, a two-dimensional flow analysis was done to evaluate the probable flow paths for the PMF flows. Two analyses were done using the FLO-2D two-dimensional flow analysis computer program. The first analysis was done using the historic USGS 20-foot contour mapping for the area. This mapping predates the major gravel mining operations in the vicinity of Lone Mountain. The second analysis was done using the 5-foot contour mapping from Clark County that reflects modifications by the gravel mining operations and more closely represents current topography. Both of the analyses showed much of the PMF flows from the Box Canyon drainage area bypassing the detention basins and flowing north of the Washburn Road alignment. The results of these analyses are contained in Appendix D. Based on the results of the FLO-2D analyses, the maximum flow that impacts the north detention basin from a PMP storm over the North Detention Basin PMF Drainage Area is 4,400 cfs. Since the smaller localized PMF drainage area for the south detention basin generated a flow of approximately 8,300 cfs, it was determined that both detention basins will be designed to discharge a PMF flow of at least that magnitude. (An analysis was done for the north basin to verify that in the event that the entire PMF flow from the Box Canyon area was diverted to the north basin that it could safely pass with no freeboard.) The preliminary FlowMaster analyses of the spillways for the detention basins are contained in Appendix D.

The initial overflow for both detention basins will be at the north side of the north detention basin since the balancing conduit will convey flow from the south basin to the north basin in the event that water ponds in the south basin above the maximum projected water surface elevation of 2738 (overflow discharge from the south basin does not occur until the minimum ramp elevation of approximately 2741 is reached). A peak flow of approximately 600 cfs could convey through the balancing the conduit from the south basin to the north basin and discharge from the north side of the north basin before the ponding elevation of 2741 was exceeded in the south basin. (In excess of 600 cfs will discharge over the spillway at the north end of the north basin for a ponding elevation of approximately 1-foot above the minimum elevation of the crest of the concrete spillway weir.)

The Nevada State Dam Safety has indicated two main criteria for a detention basin to be categorized as a "below grade" basin that with reduced risk of failure and a lower probability of creating an adverse impact on downstream properties. The first requirement is that the detention volume be located below the natural grade so that potential energy is not added into the system that would substantially exceed the energy for natural conditions. The planned storage volumes for both of the detention basins are substantially below the natural grade, and therefore, both basins comply with the first requirement. The second requirement is that the grading of the embankments, downstream from where overflow will discharge from the detention basins in the event of a PMF flow, represents a minimal risk of failure. The typical measure of reduced risk is having a slope that is sufficiently flat (typically in the order of 10:1 or less) and/or sufficiently massive and erosion resistant such that minimal erosion protection is required. The discharge from the south basin will occur over the southbound beltway ramp for the Lone Mountain interchange. The top width of the ramp in the location of the overflow is greater than 40 feet and the paving for the ramp will have a relatively high resistance to erosion. In order to further ensure the integrity of the embankment in location where overflow will occur, a 10-foot concrete weir is proposed with 3-feet deep cutoff wall at each side of the weir apron. A similar concrete spillway weir is proposed at the north side of the north detention basin where overflow will discharge from that basin. The initial overflow will occur to the north and as the depth of the overflow increases, overflow will begin to spill over the beltway ramp at that location. The representation of the detention basins as "below

grade" will need concurrence of the reviewing agencies including Clark County Regional Flood Control District and State of Nevada Dam Safety.

Concrete slope paving is considered in the locations of the potential overflow from the detention basins on the downstream side of the beltway ramps to provide protection for the ramps against damage from erosion.

Cost Estimates – Preliminary cost estimates were prepared for the regional facilities addressed in this report. The cost estimates were based on the two different channel alignments utilizing the recommended storm drain lateral Option B.

VII. CONCLUSIONS AND RECOMMENDATIONS

1. The project facilities are not located in a FEMA-designated Special Flood Hazard Area.
2. The Gowan Beltway West Channel system will have design flows ranging from approximately 520 cfs at the north end to 2,180 cfs at the south end.
3. The detention basin facilities will include two basins located on the northwest and southwest quadrants of the Lone Mountain Road interchange. The peak storage volume for the detention basin on the northwest quadrant will be approximately 150 acre-feet. The peak storage volume for the detention basin on the southwest quadrant will be approximately 500 acre-feet.
4. A dual level outfall is planned for the Lone Mountain - Beltway Detention Basins to minimize adverse impacts to downstream facilities. The lower level outfall will restrict peak discharge for the combined detention basins to approximately 47 cfs for the level of storage that will collect to the basins for the design storm that encompasses the watershed for the Gowan Detention Basins. The second level outfall will increase the discharge to approximately 180 cfs maximum as the storage volume increases from a volume of 320 acre-feet to 650 acre-feet. This will provide for a storm centered over tributary watershed for the Lone Mountain - Beltway Detention Basins to discharge from the basins in approximately seven days while minimizing adverse impacts on the Gowan North system.
5. Two Beltway Channel alignment and profile options were presented based on the existing topography and the proposed Western Beltway alignment. The first option is an open channel system from the Centennial Parkway alignment to the inlet system at the north detention basin. The second option is a box culvert system from Centennial Parkway to immediately south of Ann Road and an open channel system from that point to the inlet system to the north detention basin. Option #2 is the recommended alternative that is shown on the drawings. Option #2 was selected to avert the need to acquire additional right-of-way to accommodate the depressed beltway and the required access roadway and manway for an open channel system.

6. Minor amounts of additional right-of-way will be required to provide for the proposed channel alignment at Ann Road that curves around the proposed bridge abutment at the west side of the Ann Road alignment and to accommodate the channel access roads/ramps at the proposed locations.
7. Three storm drain lateral inflow options to the Beltway Channel were presented in this report. Option A consists of four inflow locations at the Centennial, Tropical, Ann, and Washburn alignments. Option B consists of seven inflow locations at the Centennial, Azure, Tropical, El Campo, Ann, Hammer, and Washburn alignments. Option C consists of ten inflow locations at the Centennial, Regina, Azure, Tropical, El Campo, La Mancha, Ann, Stephen, Hammer, and Washburn alignments. Option B is the recommended alternative shown in the drawings.
8. The LMBW detention basin outfall extends east from the 8-foot by 8-foot RCB balancing conduit. A 434 linear foot 36-inch RCP conveys 180 cfs under pressure to a 66-inch RCP. At the junction to the 66-inch RCP the flow in the pipe changes to a gravity flow condition. The flow is conveyed 324 linear feet to a 717 linear foot 72-inch RCP that connects to the proposed (Gowan North Channel) Phase IV. The onsite beltway storm drainage system connects to the outfall system at the junction with the 72-inch RCP.
9. For the South Detention Basin, a 590-linear foot, 10-foot wide concrete spillway weir is proposed (with 3-feet deep cutoff wall at each side of the weir apron). The spillway weir will be centered about the low point on the beltway ramp. A similar concrete spillway weir is proposed at the north side of the north detention basin where overflow will discharge from that basin.

VIII. REFERENCES

1. PBS&J, Inc., G. C. Wallace, Inc., and Louis Berger Group, Inc. Clark County Regional Flood Control District, The 2002 Master Plan Update of the Las Vegas Valley. September 2002.
2. G. C. Wallace, Inc. *Technical Memorandum – Hydrologic Analysis Western Segment of the Las Vegas Beltway – Craig road to Hualapai Way*. March 2004.
3. Clark County Regional Flood Control District (CCRFCD) *Hydrologic Criteria and Drainage Design Manual*. August 1999.
4. VTN, Nevada, *Master Study for Lone Mountain West*. April 1999.
5. VTN, Nevada, *Monument at Lone Mountain West Units 1,3, 4, and 5*. August 2000.
6. L. R. Nelson, Inc. *Technical Drainage Study for Cliff Shadows Four-Plex*. December 2003.
7. FLO-2D Software, Inc. FLO-2D, Version 2003.06. Revised July 2003.

APPENDIX

APPENDIX A

Beltway Channel Hydraulics

A-1 Channel Alignment #1

A-2 Channel Alignment #2

APPENDIX A-1

Channel Alignment #1

Beltway Channel Exhibits
Flowmaster Calculations

STA 730+00 (10' wide, Q = 2182 cfs)
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 730+00 (10' wide, Q = 2182 cfs) - min radius = 0 feet
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.018000 ft/ft
Discharge	2,182.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	7.81 ft
Elevation Range	0.00 to 10.00
Flow Area	78.1 ft ²
Wetted Perimeter	25.62 ft
Top Width	10.00 ft
Actual Depth	7.81 ft
Critical Elevation	11.40 ft
Critical Slope	0.007098 ft/ft
Velocity	27.94 ft/s
Velocity Head	12.13 ft
Specific Energy	19.94 ft
Froude Number	1.76
Flow Type	Supercritical

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+10	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+10	0.00
0+10	10.00

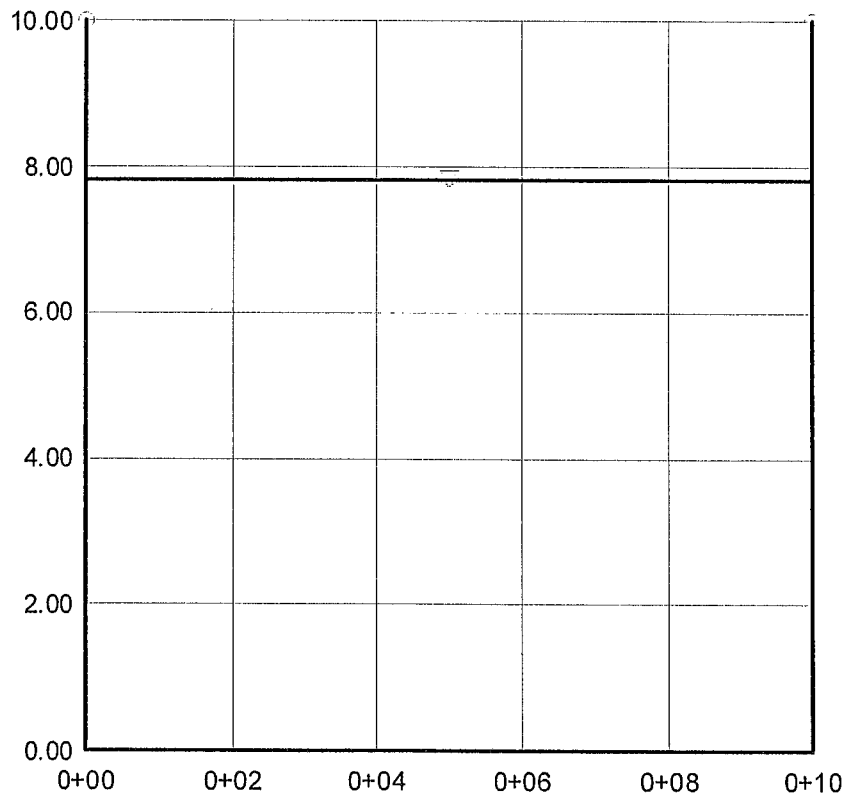
STA 730+00 (10' wide, Q = 2182 cfs)
Cross Section for Irregular Channel

Project Description

Worksheet	STA 730+00 (10' wide, Q = 2182 cfs) - min radius = 0 feet
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.015
Channel Slope	0.018000 ft/ft
Water Surface Elevation	7.81 ft
Elevation Range	0.00 to 10.00
Discharge	2,182.00 cfs



V:1
H:1
NTS

STA 734+00 (10' wide, Q = 2182 cfs)
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 734+00 (10' wide, Q = 2182 cfs) - min radius = 500 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.018000 ft/ft
Discharge	2,182.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	7.81 ft
Elevation Range	0.00 to 10.00
Flow Area	78.1 ft ²
Wetted Perimeter	25.62 ft
Top Width	10.00 ft
Actual Depth	7.81 ft
Critical Elevation	11.40 ft
Critical Slope	0.007098 ft/ft
Velocity	27.94 ft/s
Velocity Head	12.13 ft
Specific Energy	19.94 ft
Froude Number	1.76
Flow Type	Supercritical

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+10	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+10	0.00
0+10	10.00

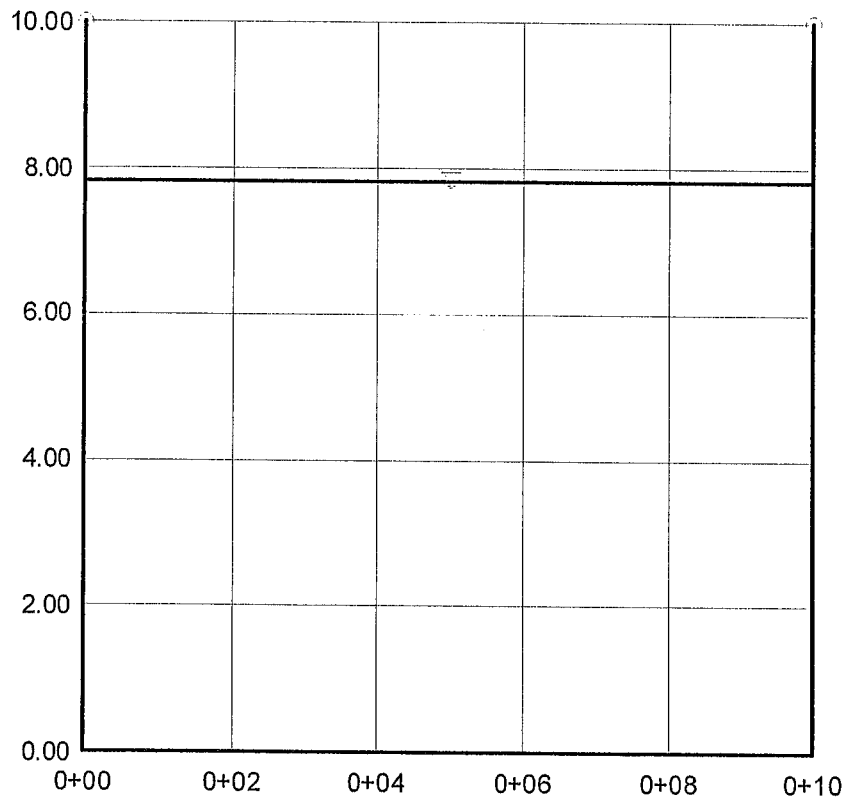
STA 734+00 (10' wide, Q = 2182 cfs) **Cross Section for Irregular Channel**

Project Description

Worksheet	STA 734+00 (10' wide, Q = 2182 cfs) - min radius = 500 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.015
Channel Slope	0.018000 ft/ft
Water Surface Elevation	7.81 ft
Elevation Range	0.00 to 10.00
Discharge	2,182.00 cfs



V:1
H:1
NTS

STA 735+00 (10' wide, Q = 2182 cfs) - min radius = 500 ft
Worksheet for Irregular Channel

Project Description

Worksheet	STA 735+00 (10' wide, Q = 2182 cfs) - min radius = 500 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Channel Slope	0.050000 ft/ft
Discharge	2,182.00 cfs

Options

Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results

Mannings Coefficient	0.015
Water Surface Elevation	5.26 ft
Elevation Range	0.00 to 10.00
Flow Area	52.6 ft ²
Wetted Perimeter	20.52 ft
Top Width	10.00 ft
Actual Depth	5.26 ft
Critical Elevation	11.40 ft
Critical Slope	0.007098 ft/ft
Velocity	41.49 ft/s
Velocity Head	26.75 ft
Specific Energy	32.01 ft
Froude Number	3.19
Flow Type	Supercritical

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+10	0.015

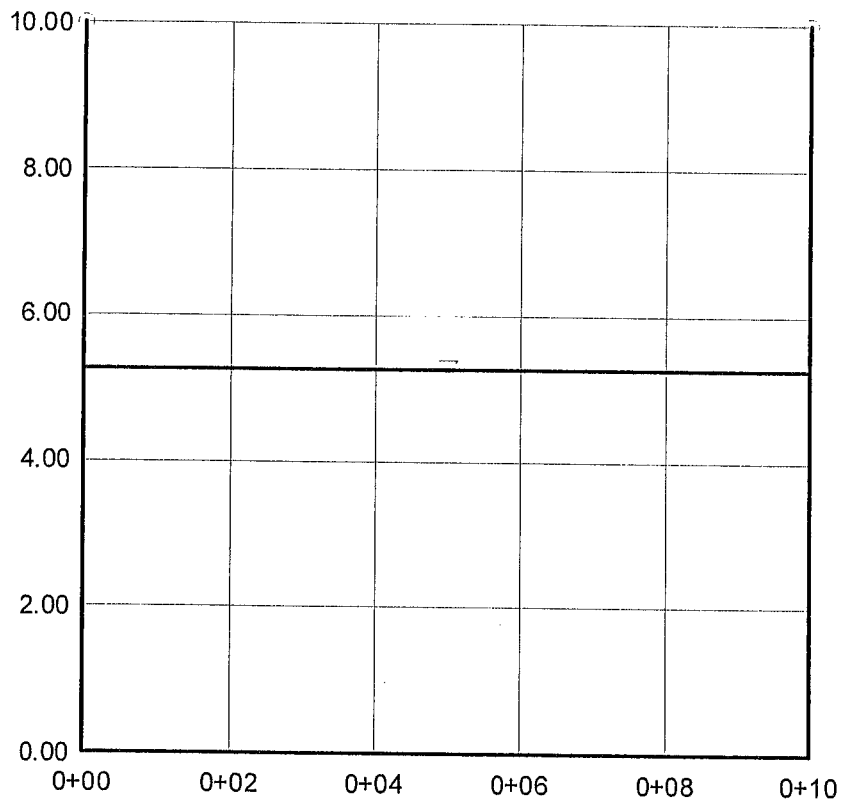
Natural Channel Points

Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+10	0.00
0+10	10.00

STA 735+00 (10' wide, Q = 2182 cfs) - min radius = 500 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 735+00 (10' wide, Q = 2182 cfs) - min radius = 500 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.050000 ft/ft
Water Surface Elevation	5.26 ft
Elevation Range	0.00 to 10.00
Discharge	2,182.00 cfs



V:1
H:1
NTS

STA 735+00 (10' wide, Q = 2182 cfs) - min radius = 500 ft
Worksheet for Irregular Channel

Project Description

Worksheet	STA 738+00 (10' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Channel Slope	0.050000 ft/ft
Discharge	2,182.00 cfs

Options

Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results

Mannings Coefficient	0.015
Water Surface Elevation	5.26 ft
Elevation Range	0.00 to 10.00
Flow Area	52.6 ft ²
Wetted Perimeter	20.52 ft
Top Width	10.00 ft
Actual Depth	5.26 ft
Critical Elevation	11.40 ft
Critical Slope	0.007098 ft/ft
Velocity	41.49 ft/s
Velocity Head	26.75 ft
Specific Energy	32.01 ft
Froude Number	3.19
Flow Type	Supercritical

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+10	0.015

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+10	0.00
0+10	10.00

STA 738+00 (10' wide, Q = 2182 cfs) - min radius = 2853.50 ft

Worksheet for Irregular Channel

Project Description	
Worksheet	STA 738+00 (10' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.050000 ft/ft
Discharge	2,182.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	5.26 ft
Elevation Range	0.00 to 10.00
Flow Area	52.6 ft ²
Wetted Perimeter	20.52 ft
Top Width	10.00 ft
Actual Depth	5.26 ft
Critical Elevation	11.40 ft
Critical Slope	0.007098 ft/ft
Velocity	41.49 ft/s
Velocity Head	26.75 ft
Specific Energy	32.01 ft
Froude Number	3.19
Flow Type	Supercritical

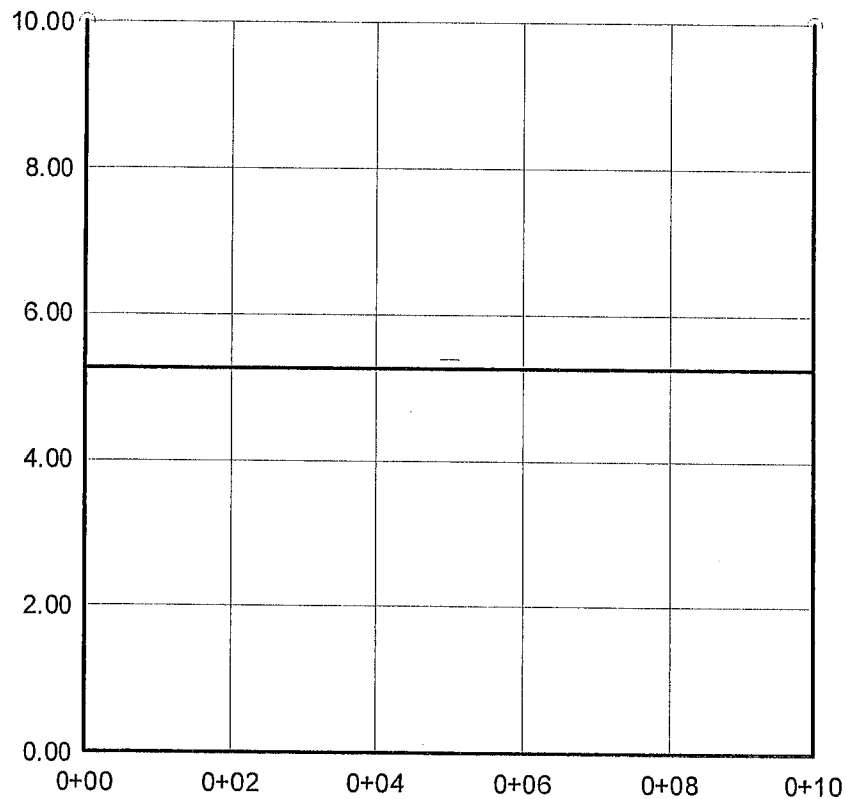
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+10	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+10	0.00
0+10	10.00

STA 738+00 (10' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 738+00 (10' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.050000 ft/ft
Water Surface Elevation	5.26 ft
Elevation Range	0.00 to 10.00
Discharge	2,182.00 cfs



V:1
H:1
NTS

STA 743+50 (14' wide, Q = 2182 cfs)
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 743+50 (14' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.050000 ft/ft
Discharge	2,182.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	3.84 ft
Elevation Range	0.00 to 10.00
Flow Area	53.8 ft ²
Wetted Perimeter	21.68 ft
Top Width	14.00 ft
Actual Depth	3.84 ft
Critical Elevation	9.11 ft
Critical Slope	0.004769 ft/ft
Velocity	40.58 ft/s
Velocity Head	25.59 ft
Specific Energy	29.44 ft
Froude Number	3.65
Flow Type	Supercritical

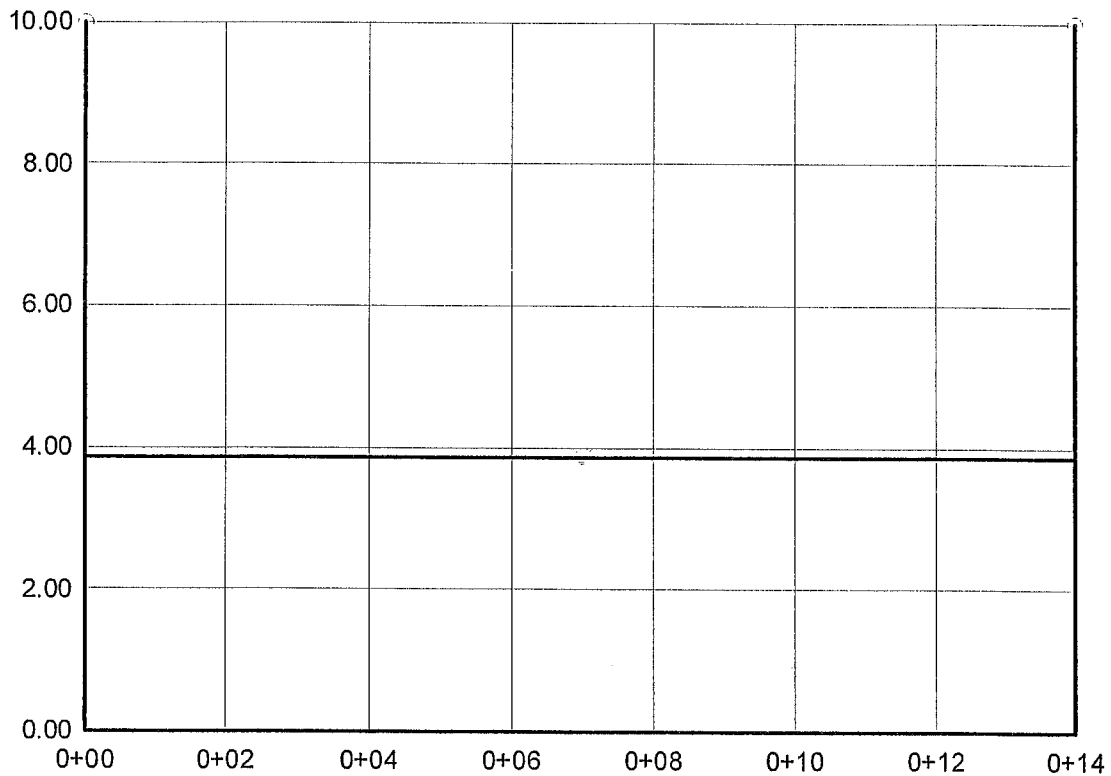
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

**STA 743+50 (14' wide, Q = 2182 cfs)
Cross Section for Irregular Channel**

Project Description	
Worksheet	STA 743+50 (14' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.050000 ft/ft
Water Surface Elevation	3.84 ft
Elevation Range	0.00 to 10.00
Discharge	2,182.00 cfs



V:1
H:1
NTS

STA 746+00 (14' wide, Q = 1864 cfs)
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 746+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.050000 ft/ft
Discharge	1,864.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	3.44 ft
Elevation Range	0.00 to 10.00
Flow Area	48.2 ft²
Wetted Perimeter	20.88 ft
Top Width	14.00 ft
Actual Depth	3.44 ft
Critical Elevation	8.20 ft
Critical Slope	0.004571 ft/ft
Velocity	38.68 ft/s
Velocity Head	23.25 ft
Specific Energy	26.69 ft
Froude Number	3.68
Flow Type	Supercritical

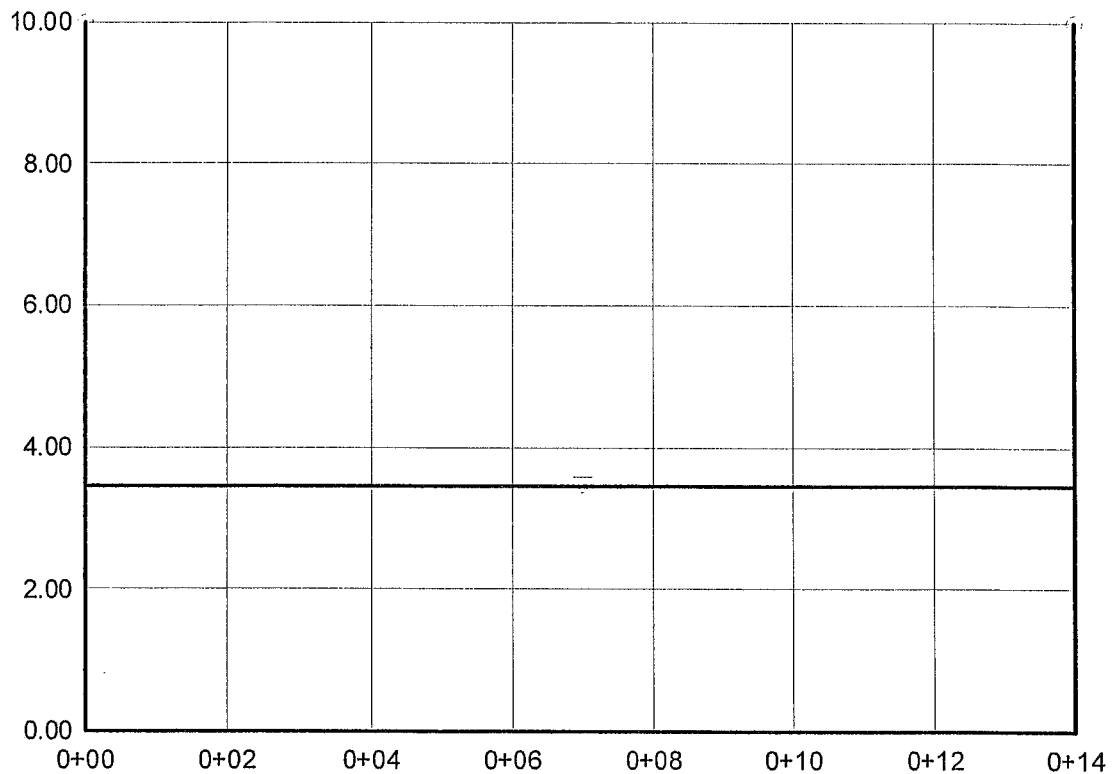
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

STA 746+00 (14' wide, Q = 1864 cfs) **Cross Section for Irregular Channel**

Project Description	
Worksheet	STA 746+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.050000 ft/ft
Water Surface Elevation	3.44 ft
Elevation Range	0.00 to 10.00
Discharge	1,864.00 cfs



V:1
H:1
NTS

STA 752+00 (14' wide, Q = 1864 cfs)

Worksheet for Irregular Channel

Project Description

Worksheet	STA 752+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Channel Slope	0.025000 ft/ft
Discharge	1,864.00 cfs

Options

Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results

Mannings Coefficient	0.015
Water Surface Elevation	4.39 ft
Elevation Range	0.00 to 10.00
Flow Area	61.4 ft ²
Wetted Perimeter	22.77 ft
Top Width	14.00 ft
Actual Depth	4.39 ft
Critical Elevation	8.20 ft
Critical Slope	0.004571 ft/ft
Velocity	30.35 ft/s
Velocity Head	14.31 ft
Specific Energy	18.70 ft
Froude Number	2.55
Flow Type	Supercritical

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

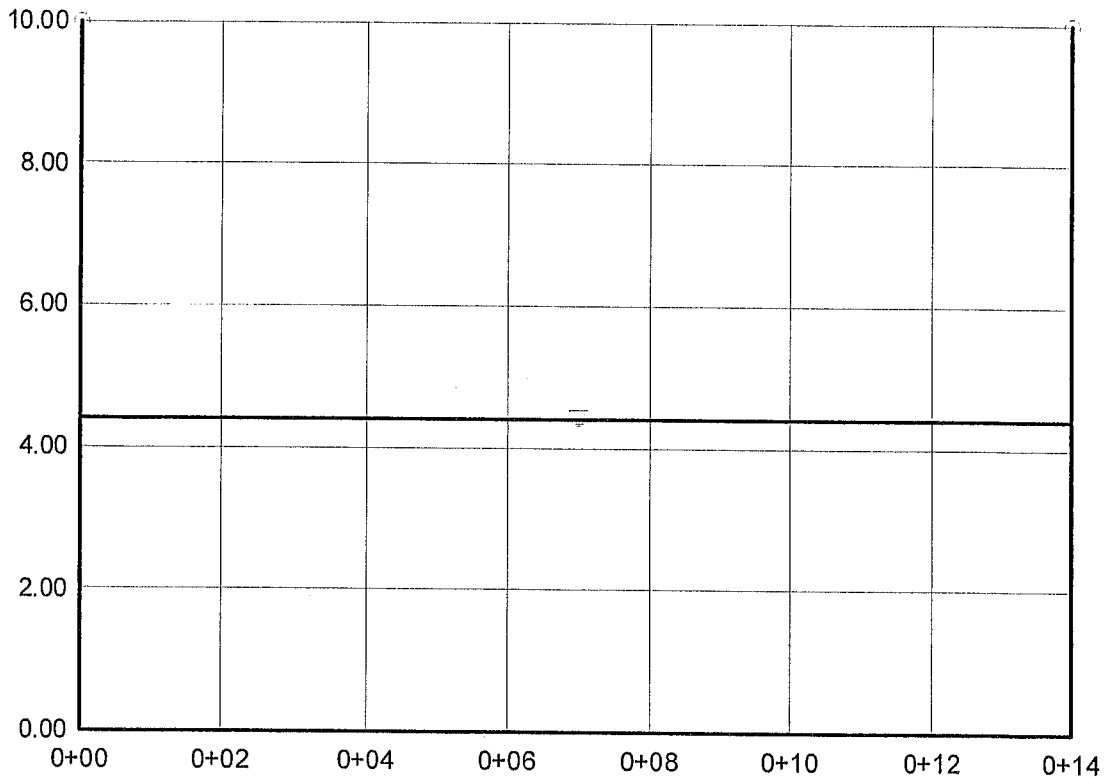
**STA 752+00 (14' wide, Q = 1864 cfs)
Cross Section for Irregular Channel**

Project Description

Worksheet	STA 752+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.015
Channel Slope	0.025000 ft/ft
Water Surface Elevation	4.39 ft
Elevation Range	0.00 to 10.00
Discharge	1,864.00 cfs



V:1
H:1
NTS

STA 760+00 (14' wide, Q = 1864 cfs) - min radius = 0 ft
Worksheet for Irregular Channel

Project Description

Worksheet	STA 760+00 (14' wide, Q = 1864 cfs) - min radius = 0 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Channel Slope	0.025000 ft/ft
Discharge	1,864.00 cfs

Options

Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results

Mannings Coefficient	0.015
Water Surface Elevation	4.39 ft
Elevation Range	0.00 to 10.00
Flow Area	61.4 ft ²
Wetted Perimeter	22.77 ft
Top Width	14.00 ft
Actual Depth	4.39 ft
Critical Elevation	8.20 ft
Critical Slope	0.004571 ft/ft
Velocity	30.35 ft/s
Velocity Head	14.31 ft
Specific Energy	18.70 ft
Froude Number	2.55
Flow Type	Supercritical

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

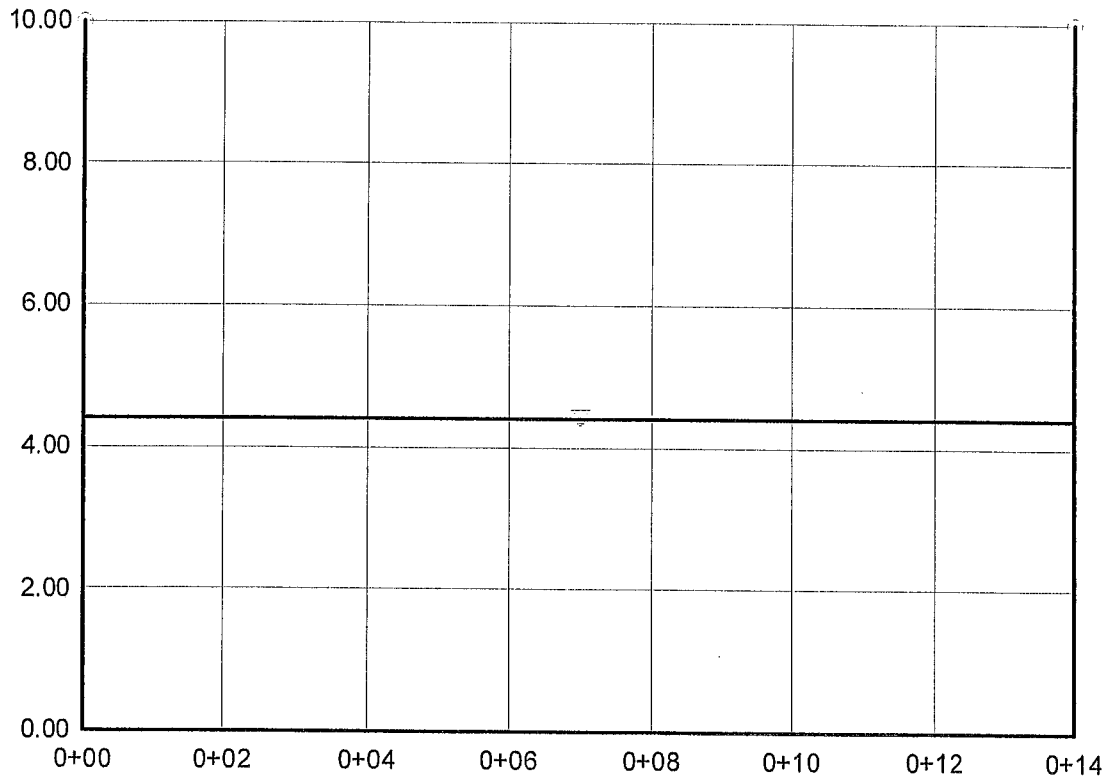
STA 760+00 (14' wide, Q = 1864 cfs) - min radius = 0 ft
Cross Section for Irregular Channel

Project Description

Worksheet	STA 760+00 (14' wide, Q = 1864 cfs) - min radius = 0 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.015
Channel Slope	0.025000 ft/ft
Water Surface Elevation	4.39 ft
Elevation Range	0.00 to 10.00
Discharge	1,864.00 cfs



V:1
H:1
NTS

STA 763+00 (14' wide, Q = 1864 cfs) - min radius = 3146.50 ft
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 763+00 (14' wide, Q = 1864 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.025000 ft/ft
Discharge	1,864.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	4.39 ft
Elevation Range	0.00 to 10.00
Flow Area	61.4 ft ²
Wetted Perimeter	22.77 ft
Top Width	14.00 ft
Actual Depth	4.39 ft
Critical Elevation	8.20 ft
Critical Slope	0.004571 ft/ft
Velocity	30.35 ft/s
Velocity Head	14.31 ft
Specific Energy	18.70 ft
Froude Number	2.55
Flow Type	Supercritical

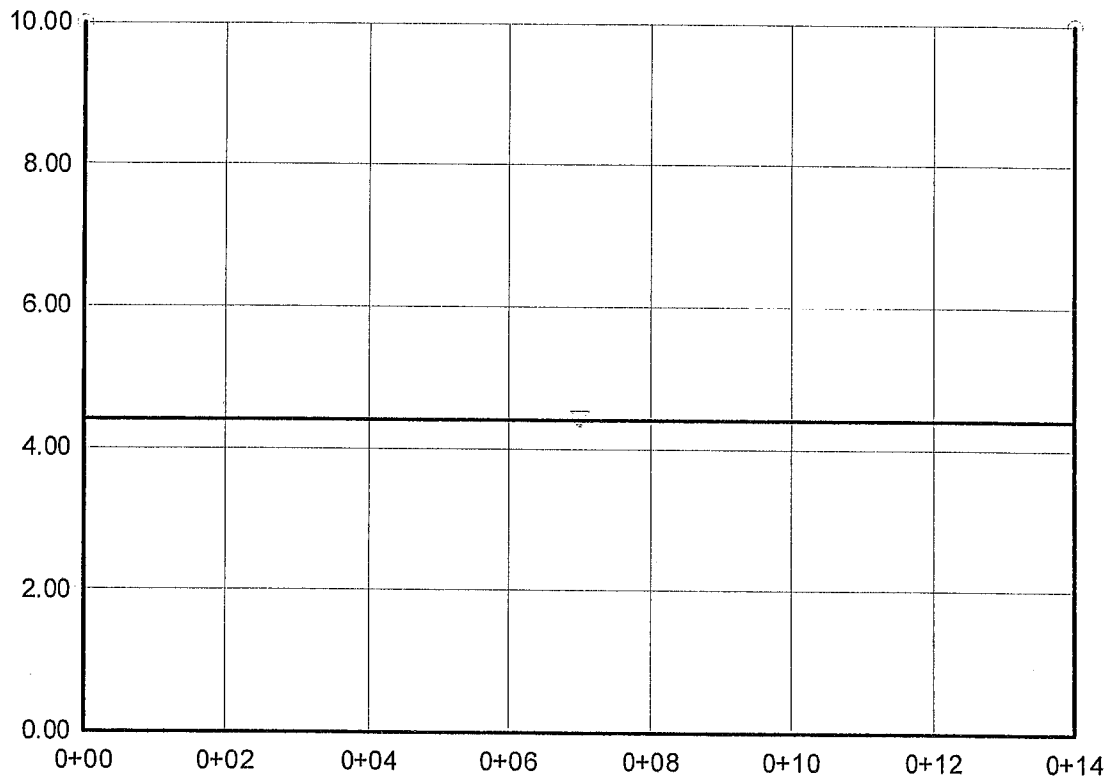
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

STA 763+00 (14' wide, Q = 1864 cfs) - min radius = 3146.50 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 763+00 (14' wide, Q = 1864 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.025000 ft/ft
Water Surface Elevation	4.39 ft
Elevation Range	0.00 to 10.00
Discharge	1,864.00 cfs



V:1
H:1
NTS

STA 766+00 (14' wide, Q = 1761 cfs)
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 766+00 (14' wide, Q = 1761 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.025000 ft/ft
Discharge	1,761.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	4.21 ft
Elevation Range	0.00 to 10.00
Flow Area	59.0 ft ²
Wetted Perimeter	22.43 ft
Top Width	14.00 ft
Actual Depth	4.21 ft
Critical Elevation	7.89 ft
Critical Slope	0.004506 ft/ft
Velocity	29.85 ft/s
Velocity Head	13.84 ft
Specific Energy	18.06 ft
Froude Number	2.56
Flow Type	Supercritical

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

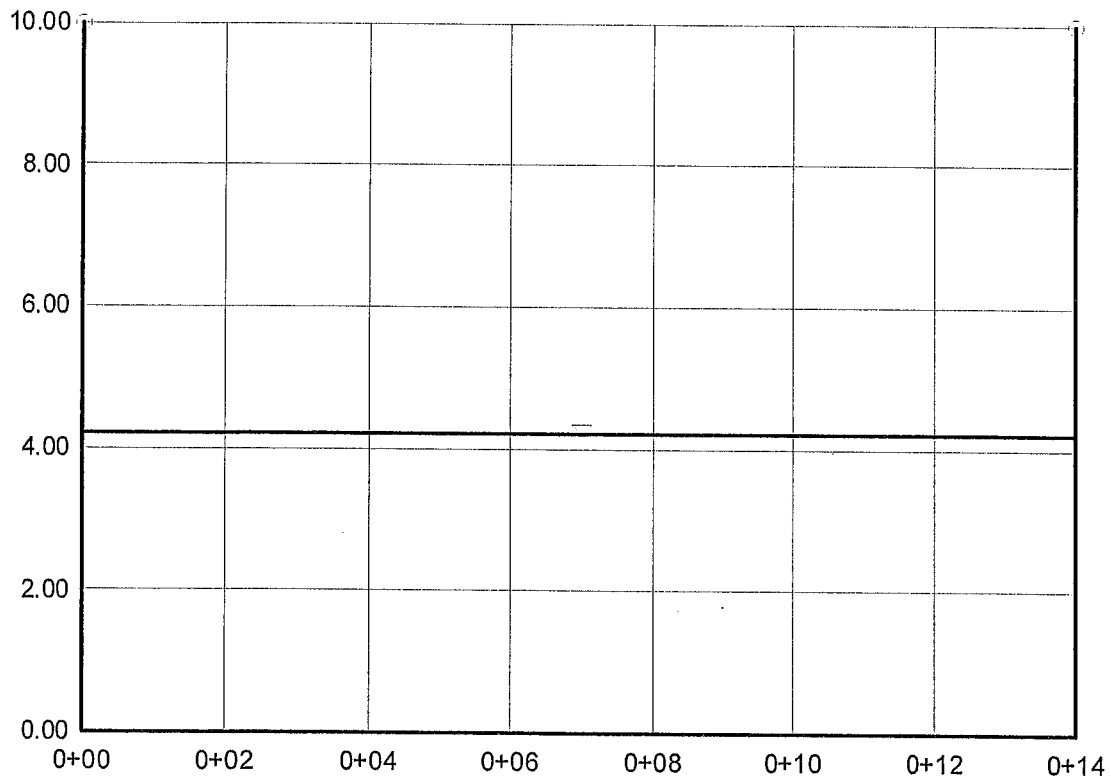
STA 766+00 (14' wide, Q = 1761 cfs) **Cross Section for Irregular Channel**

Project Description

Worksheet	STA 766+00 (14' wide, Q = 1761 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.015
Channel Slope	0.025000 ft/ft
Water Surface Elevation	4.21 ft
Elevation Range	0.00 to 10.00
Discharge	1,761.00 cfs



V:1
H:1
NTS

STA 780+00 (14' wide, Q = 1761 cfs)

Worksheet for Irregular Channel

Project Description	
Worksheet	STA 780+00 (14' wide, Q = 1761 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.006000 ft/ft
Discharge	1,761.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	7.08 ft
Elevation Range	0.00 to 10.00
Flow Area	99.2 ft²
Wetted Perimeter	28.17 ft
Top Width	14.00 ft
Actual Depth	7.08 ft
Critical Elevation	7.89 ft
Critical Slope	0.004506 ft/ft
Velocity	17.76 ft/s
Velocity Head	4.90 ft
Specific Energy	11.98 ft
Froude Number	1.18
Flow Type	Supercritical

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

STA 788+50 (14' wide, Q = 986 cfs)
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 788+50 (14' wide, Q = 986 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.006000 ft/ft
Discharge	986.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	4.63 ft
Elevation Range	0.00 to 8.00
Flow Area	64.9 ft ²
Wetted Perimeter	23.27 ft
Top Width	14.00 ft
Actual Depth	4.63 ft
Critical Elevation	5.36 ft
Critical Slope	0.003999 ft/ft
Velocity	15.20 ft/s
Velocity Head	3.59 ft
Specific Energy	8.22 ft
Froude Number	1.24
Flow Type	Supercritical

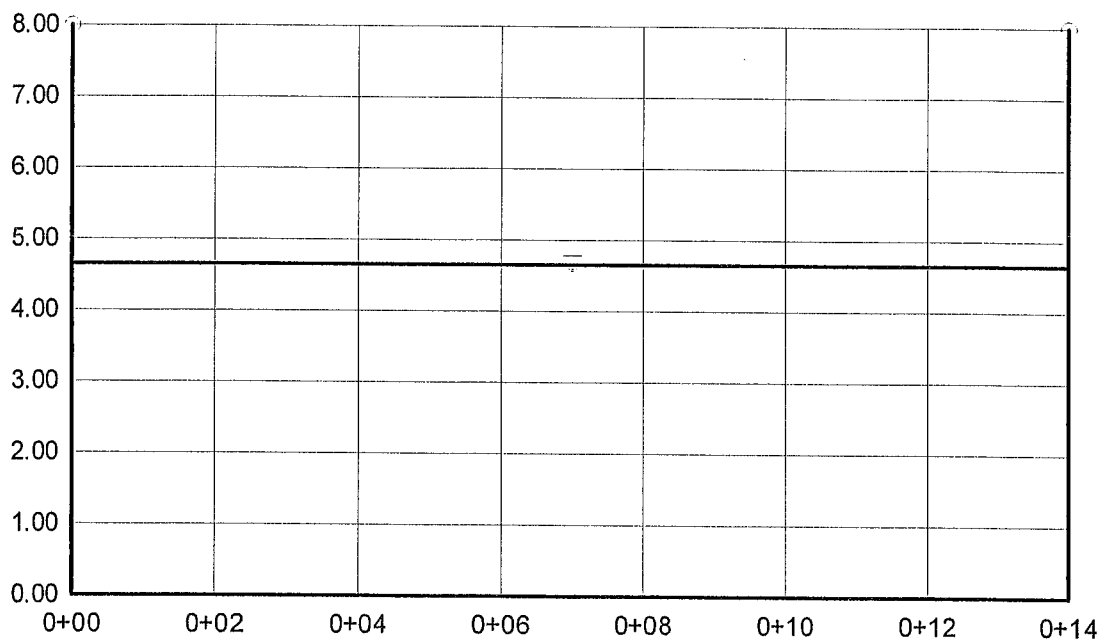
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	8.00
0+00	0.00
0+14	0.00
0+14	8.00

STA 788+50 (14' wide, Q = 986 cfs)
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 788+50 (14' wide, Q = 986 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.006000 ft/ft
Water Surface Elevation	4.63 ft
Elevation Range	0.00 to 8.00
Discharge	986.00 cfs



V:1
H:1
NTS

STA 809+50 (14' wide, Q = 729 cfs) **Worksheet for Irregular Channel**

Project Description

Worksheet	STA 809+50 (14' wide, Q = 729 cfs) - min radius = 0 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Channel Slope	0.008200 ft/ft
Discharge	729.00 cfs

Options

Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results

Mannings Coefficient	0.015
Water Surface Elevation	3.36 ft
Elevation Range	0.00 to 8.00
Flow Area	47.0 ft ²
Wetted Perimeter	20.72 ft
Top Width	14.00 ft
Actual Depth	3.36 ft
Critical Elevation	4.38 ft
Critical Slope	0.003831 ft/ft
Velocity	15.50 ft/s
Velocity Head	3.73 ft
Specific Energy	7.09 ft
Froude Number	1.49
Flow Type	Supercritical

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	8.00
0+00	0.00
0+14	0.00
0+14	8.00

APPENDIX A-2

Channel Alignment #2

Beltway Channel Exhibits
Flowmaster Calculations

STA 730+00 (10' wide, Q = 2182 cfs) - min radius = 0 feet
Worksheet for Irregular Channel

Project Description

Worksheet	STA 730+00 (10' wide, Q = 2182 cfs) - min radius = 0 feet
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Channel Slope	0.018000 ft/ft
Discharge	2,182.00 cfs

Options

Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results

Mannings Coefficient	0.015
Water Surface Elevation	7.81 ft
Elevation Range	0.00 to 10.00
Flow Area	78.1 ft ²
Wetted Perimeter	25.62 ft
Top Width	10.00 ft
Actual Depth	7.81 ft
Critical Elevation	11.40 ft
Critical Slope	0.007098 ft/ft
Velocity	27.94 ft/s
Velocity Head	12.13 ft
Specific Energy	19.94 ft
Froude Number	1.76
Flow Type	Supercritical

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+10	0.015

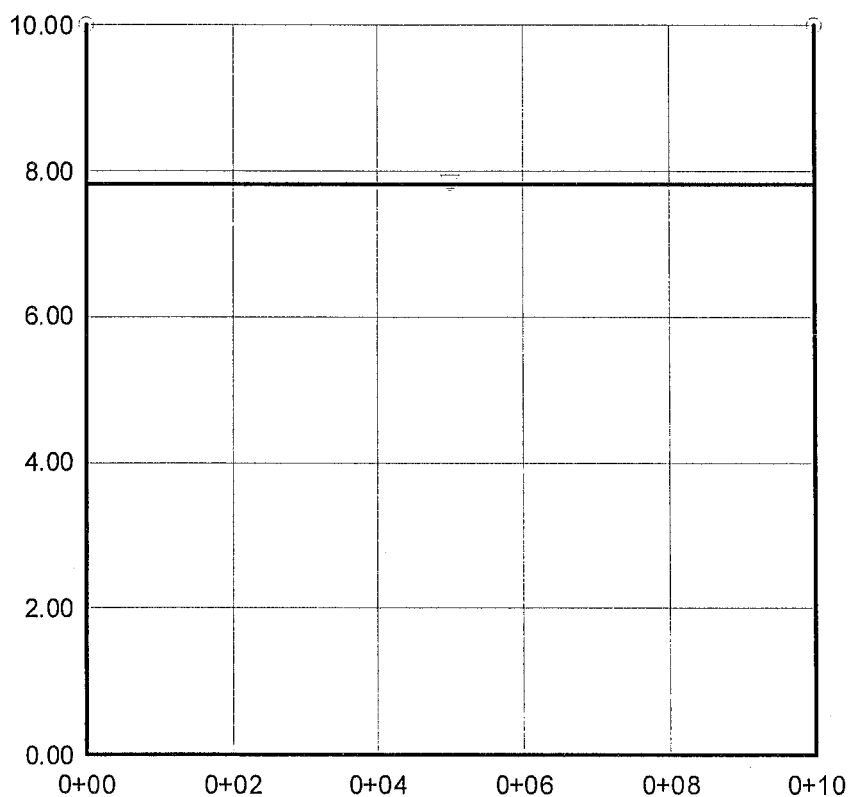
Natural Channel Points

Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+10	0.00
0+10	10.00

STA 730+00 (10' wide, Q = 2182 cfs) - min radius = 0 feet
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 730+00 (10' wide, Q = 2182 cfs) - min radius = 0 feet
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.018000 ft/ft
Water Surface Elevation	7.81 ft
Elevation Range	0.00 to 10.00
Discharge	2,182.00 cfs



V:1
H:1
NTS

STA 736+00 (10' wide, Q = 2182 cfs) - min radius = 500 ft
Worksheet for Irregular Channel

Project Description

Worksheet	STA 736+00 (10' wide, Q = 2182 cfs) - min radius = 500 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Channel Slope	0.050000 ft/ft
Discharge	2,182.00 cfs

Options

Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results

Mannings Coefficient	0.015
Water Surface Elevation	5.26 ft
Elevation Range	0.00 to 10.00
Flow Area	52.6 ft ²
Wetted Perimeter	20.52 ft
Top Width	10.00 ft
Actual Depth	5.26 ft
Critical Elevation	11.40 ft
Critical Slope	0.007098 ft/ft
Velocity	41.49 ft/s
Velocity Head	26.75 ft
Specific Energy	32.01 ft
Froude Number	3.19
Flow Type	Supercritical

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+10	0.015

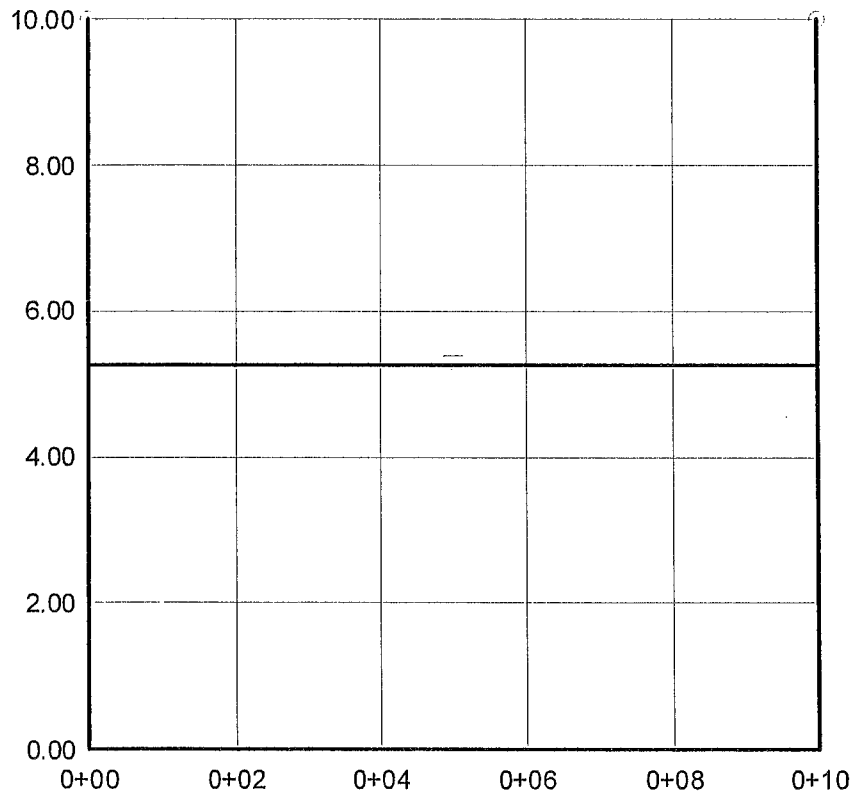
Natural Channel Points

Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+10	0.00
0+10	10.00

STA 736+00 (10' wide, Q = 2182 cfs) - min radius = 500 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 736+00 (10' wide, Q = 2182 cfs) - min radius = 500 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.050000 ft/ft
Water Surface Elevation	5.26 ft
Elevation Range	0.00 to 10.00
Discharge	2,182.00 cfs



V:1
H:1
NTS

STA 739+00 (10' wide, Q = 2182 cfs) - min radius = 2853.50 ft

Worksheet for Irregular Channel

Project Description	
Worksheet	STA 739+00 (10' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.050000 ft/ft
Discharge	2,182.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	5.26 ft
Elevation Range	0.00 to 10.00
Flow Area	52.6 ft ²
Wetted Perimeter	20.52 ft
Top Width	10.00 ft
Actual Depth	5.26 ft
Critical Elevation	11.40 ft
Critical Slope	0.007098 ft/ft
Velocity	41.49 ft/s
Velocity Head	26.75 ft
Specific Energy	32.01 ft
Froude Number	3.19
Flow Type	Supercritical

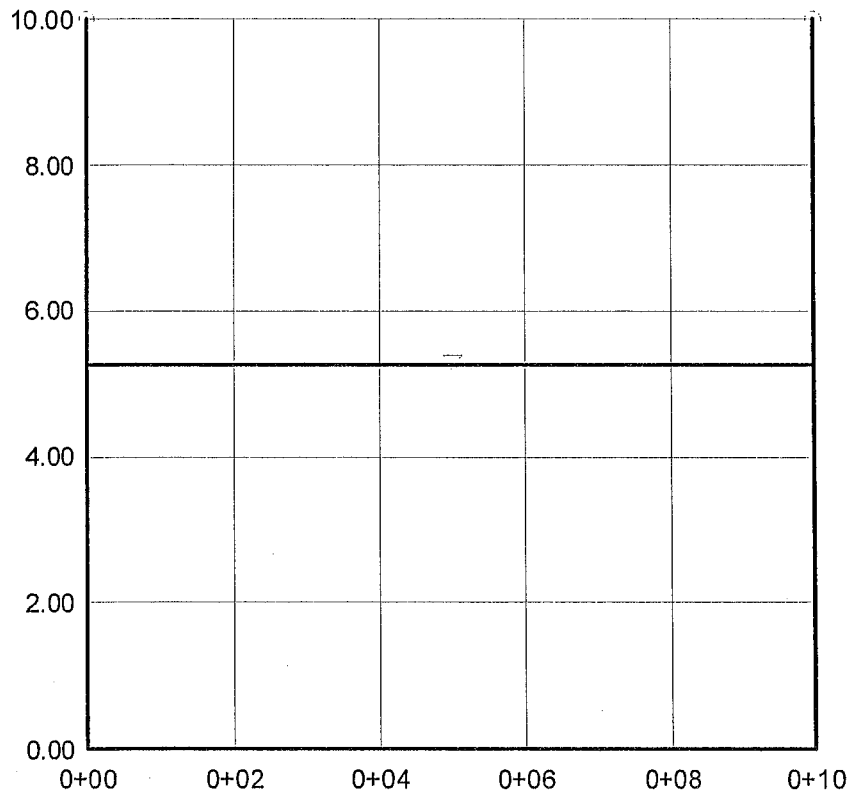
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+10	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+10	0.00
0+10	10.00

STA 739+00 (10' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 739+00 (10' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.050000 ft/ft
Water Surface Elevation	5.26 ft
Elevation Range	0.00 to 10.00
Discharge	2,182.00 cfs



V:1
H:1
NTS

STA 743+00 (14' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 743+00 (14' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.050000 ft/ft
Discharge	2,182.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	3.84 ft
Elevation Range	0.00 to 10.00
Flow Area	53.8 ft ²
Wetted Perimeter	21.68 ft
Top Width	14.00 ft
Actual Depth	3.84 ft
Critical Elevation	9.11 ft
Critical Slope	0.004769 ft/ft
Velocity	40.58 ft/s
Velocity Head	25.59 ft
Specific Energy	29.44 ft
Froude Number	3.65
Flow Type	Supercritical

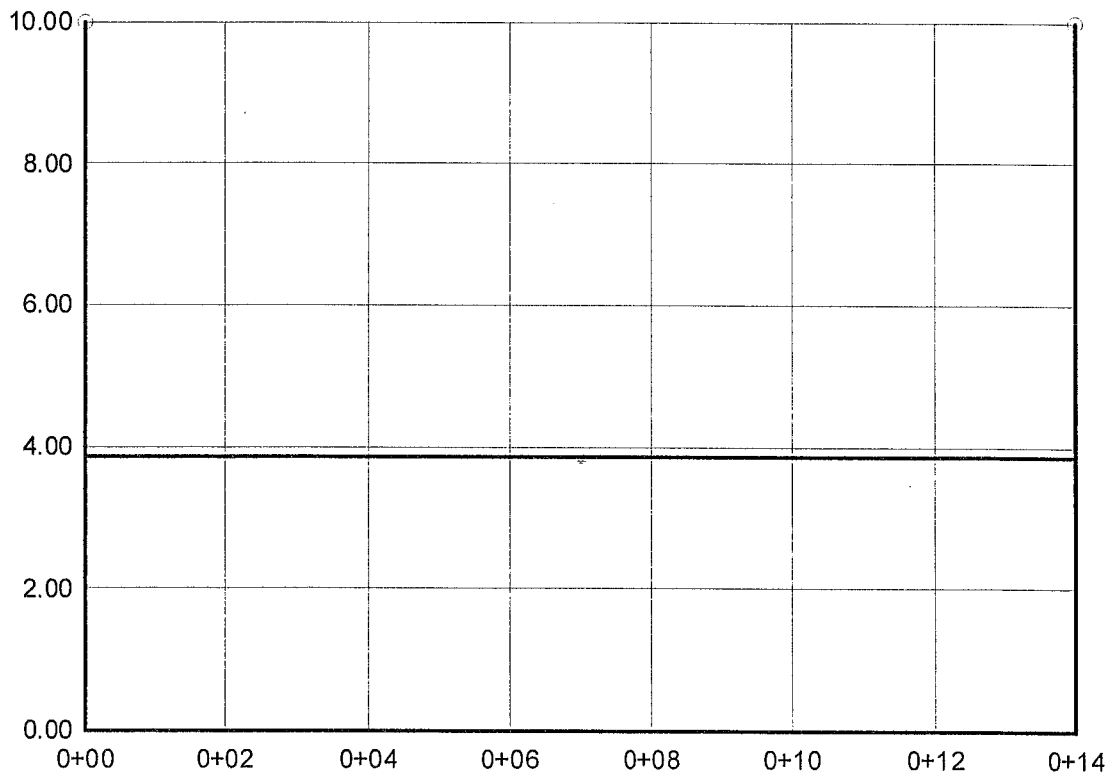
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

STA 743+00 (14' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 743+00 (14' wide, Q = 2182 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.050000 ft/ft
Water Surface Elevation	3.84 ft
Elevation Range	0.00 to 10.00
Discharge	2,182.00 cfs



V:1
H:1
NTS

STA 746+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft

Worksheet for Irregular Channel

Project Description	
Worksheet	STA 746+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.050000 ft/ft
Discharge	1,864.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	3.44 ft
Elevation Range	0.00 to 10.00
Flow Area	48.2 ft ²
Wetted Perimeter	20.88 ft
Top Width	14.00 ft
Actual Depth	3.44 ft
Critical Elevation	8.20 ft
Critical Slope	0.004571 ft/ft
Velocity	38.68 ft/s
Velocity Head	23.25 ft
Specific Energy	26.69 ft
Froude Number	3.68
Flow Type	Supercritical

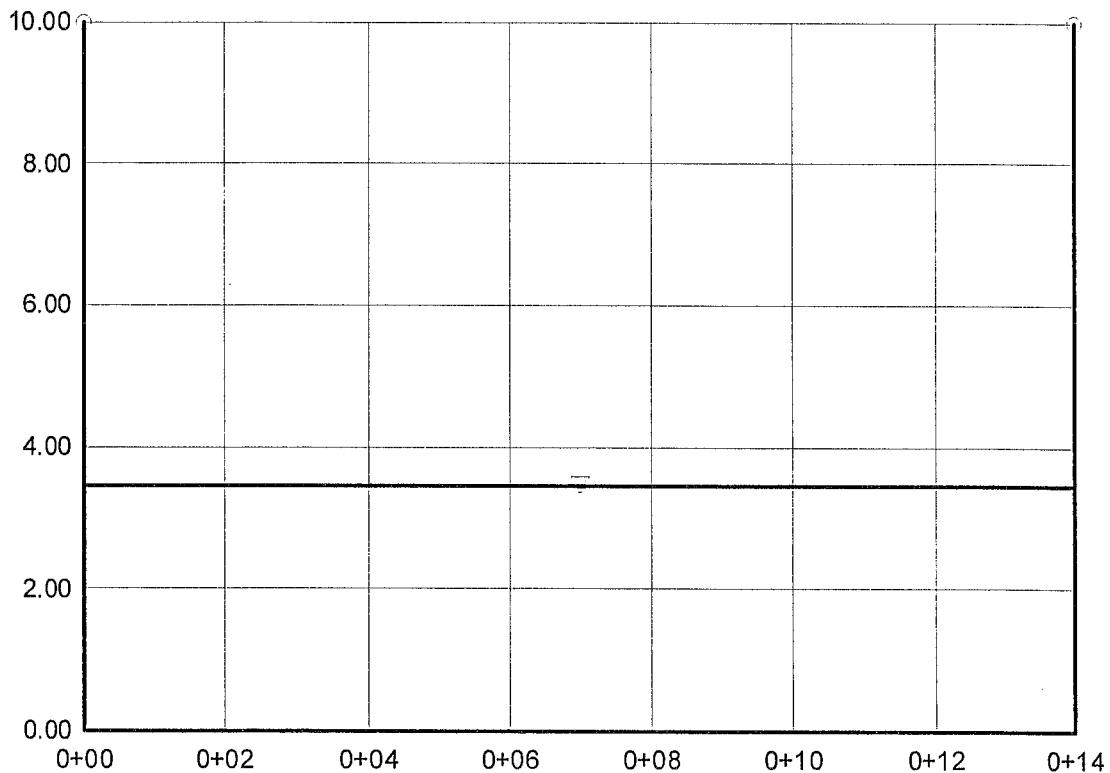
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

STA 746+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 746+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.050000 ft/ft
Water Surface Elevation	3.44 ft
Elevation Range	0.00 to 10.00
Discharge	1,864.00 cfs



V:1
H:1
NTS

STA 752+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 752+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.025000 ft/ft
Discharge	1,864.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	4.39 ft
Elevation Range	0.00 to 10.00
Flow Area	61.4 ft ²
Wetted Perimeter	22.77 ft
Top Width	14.00 ft
Actual Depth	4.39 ft
Critical Elevation	8.20 ft
Critical Slope	0.004571 ft/ft
Velocity	30.35 ft/s
Velocity Head	14.31 ft
Specific Energy	18.70 ft
Froude Number	2.55
Flow Type	Supercritical

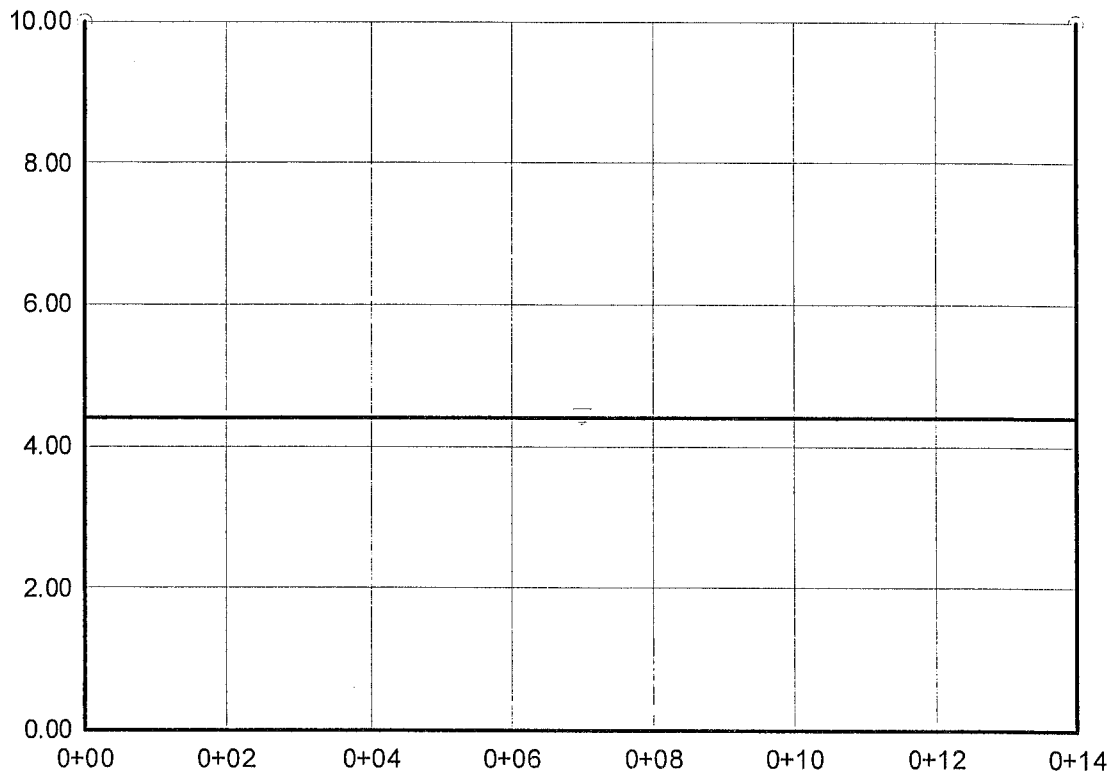
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

STA 752+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 752+00 (14' wide, Q = 1864 cfs) - min radius = 2853.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.025000 ft/ft
Water Surface Elevation	4.39 ft
Elevation Range	0.00 to 10.00
Discharge	1,864.00 cfs



V:1
H:1
NTS

STA 760+00 (14' wide, Q = 1864 cfs) - min radius = 0 ft
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 760+00 (14' wide, Q = 1864 cfs) - min radius = 0 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.025000 ft/ft
Discharge	1,864.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	4.39 ft
Elevation Range	0.00 to 10.00
Flow Area	61.4 ft ²
Wetted Perimeter	22.77 ft
Top Width	14.00 ft
Actual Depth	4.39 ft
Critical Elevation	8.20 ft
Critical Slope	0.004571 ft/ft
Velocity	30.35 ft/s
Velocity Head	14.31 ft
Specific Energy	18.70 ft
Froude Number	2.55
Flow Type	Supercritical

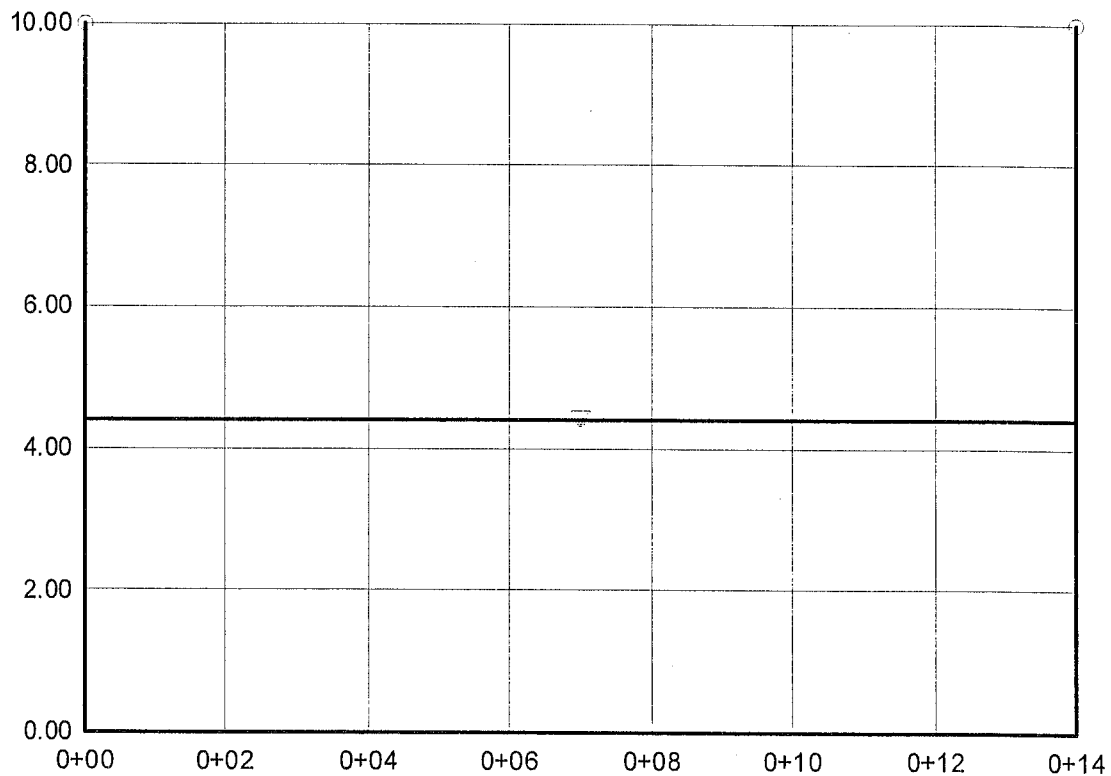
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

STA 760+00 (14' wide, Q = 1864 cfs) - min radius = 0 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 760+00 (14' wide, Q = 1864 cfs) - min radius = 0 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.025000 ft/ft
Water Surface Elevation	4.39 ft
Elevation Range	0.00 to 10.00
Discharge	1,864.00 cfs



V:1
H:1
NTS

STA 766+00 (14' wide, Q = 1761 cfs) - min radius = 3146.50 ft
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 766+00 (14' wide, Q = 1761 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.025000 ft/ft
Discharge	1,761.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	4.21 ft
Elevation Range	0.00 to 10.00
Flow Area	59.0 ft ²
Wetted Perimeter	22.43 ft
Top Width	14.00 ft
Actual Depth	4.21 ft
Critical Elevation	7.89 ft
Critical Slope	0.004506 ft/ft
Velocity	29.85 ft/s
Velocity Head	13.84 ft
Specific Energy	18.06 ft
Froude Number	2.56
Flow Type	Supercritical

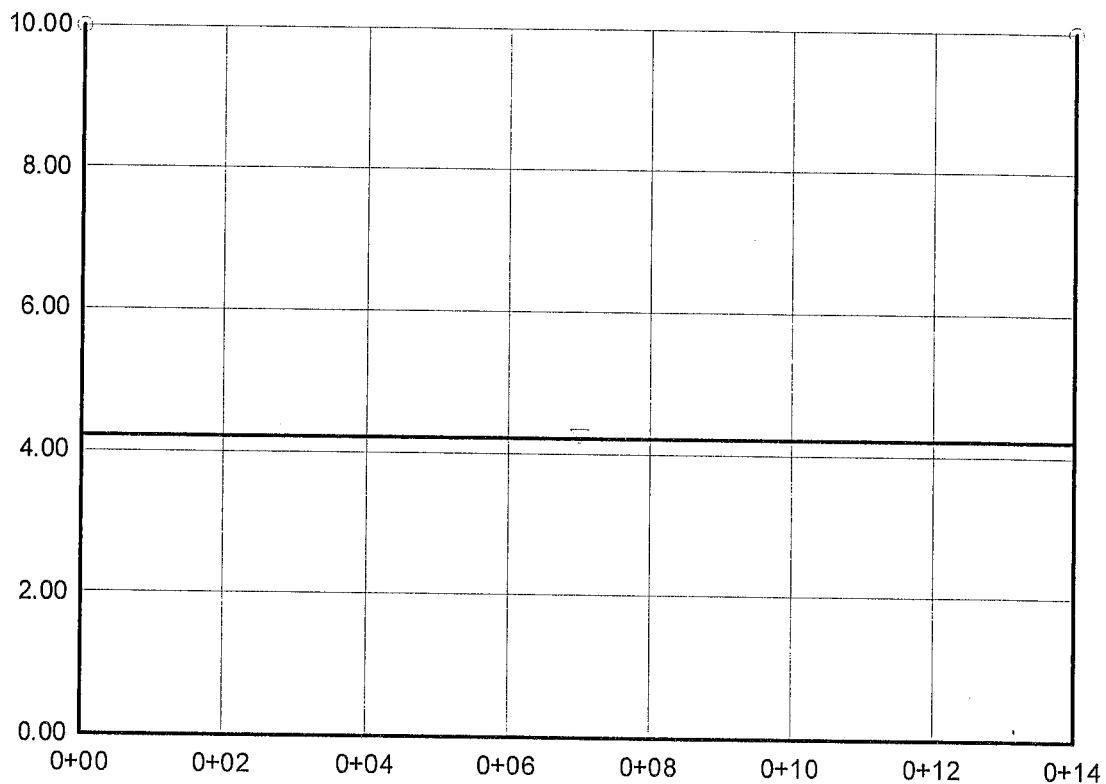
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

STA 766+00 (14' wide, Q = 1761 cfs) - min radius = 3146.50 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 766+00 (14' wide, Q = 1761 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.025000 ft/ft
Water Surface Elevation	4.21 ft
Elevation Range	0.00 to 10.00
Discharge	1,761.00 cfs



V:1
H:1
NTS

STA 778+00 (14' wide, Q = 1761 cfs) - min radius = 3146.50 ft
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 778+00 (14' wide, Q = 1761 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.006000 ft/ft
Discharge	1,761.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	7.08 ft
Elevation Range	0.00 to 10.00
Flow Area	99.2 ft ²
Wetted Perimeter	28.17 ft
Top Width	14.00 ft
Actual Depth	7.08 ft
Critical Elevation	7.89 ft
Critical Slope	0.004506 ft/ft
Velocity	17.76 ft/s
Velocity Head	4.90 ft
Specific Energy	11.98 ft
Froude Number	1.18
Flow Type	Supercritical

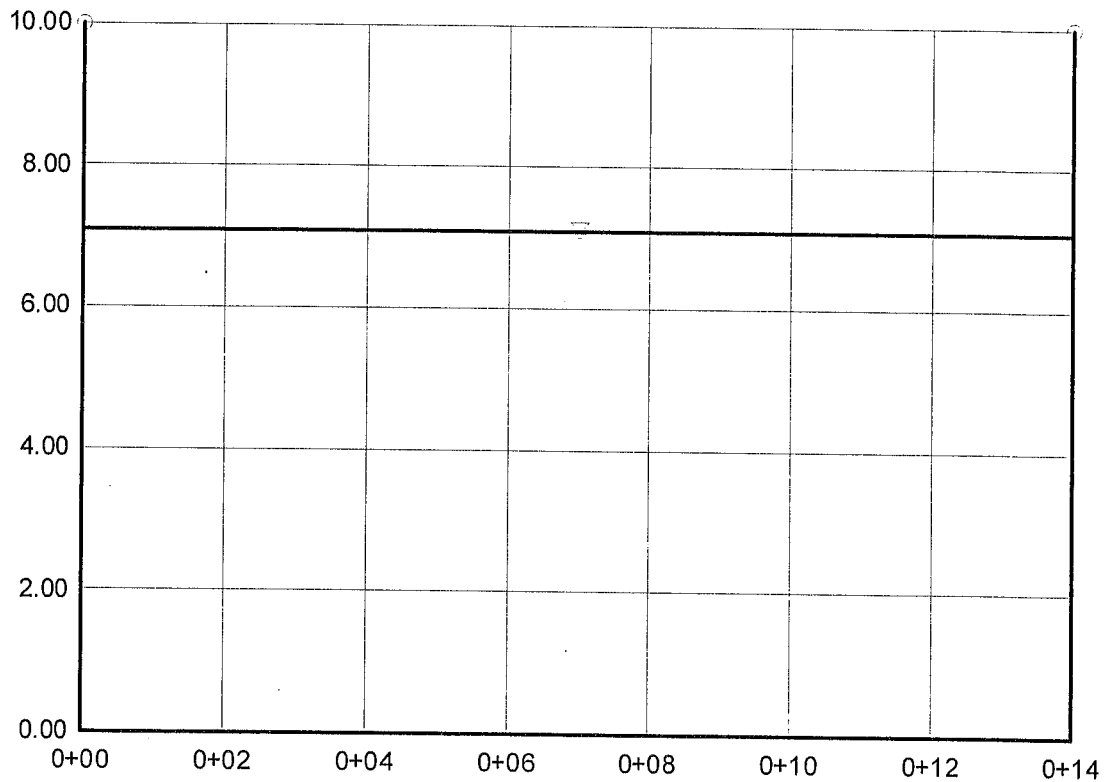
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	10.00
0+00	0.00
0+14	0.00
0+14	10.00

STA 778+00 (14' wide, Q = 1761 cfs) - min radius = 3146.50 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 778+00 (14' wide, Q = 1761 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.006000 ft/ft
Water Surface Elevation	7.08 ft
Elevation Range	0.00 to 10.00
Discharge	1,761.00 cfs



V:1
H:1
NTS

STA 784+00 (12' wide, Q = 1266 cfs) - min radius = 3166 ft
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 784+00 (12' wide, Q = 1266 cfs) - min radius = 3166 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.006000 ft/ft
Discharge	1,266.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	6.45 ft
Elevation Range	0.00 to 8.00
Flow Area	77.4 ft ²
Wetted Perimeter	24.91 ft
Top Width	12.00 ft
Actual Depth	6.45 ft
Critical Elevation	7.02 ft
Critical Slope	0.004811 ft/ft
Velocity	16.35 ft/s
Velocity Head	4.15 ft
Specific Energy	10.61 ft
Froude Number	1.13
Flow Type	Supercritical

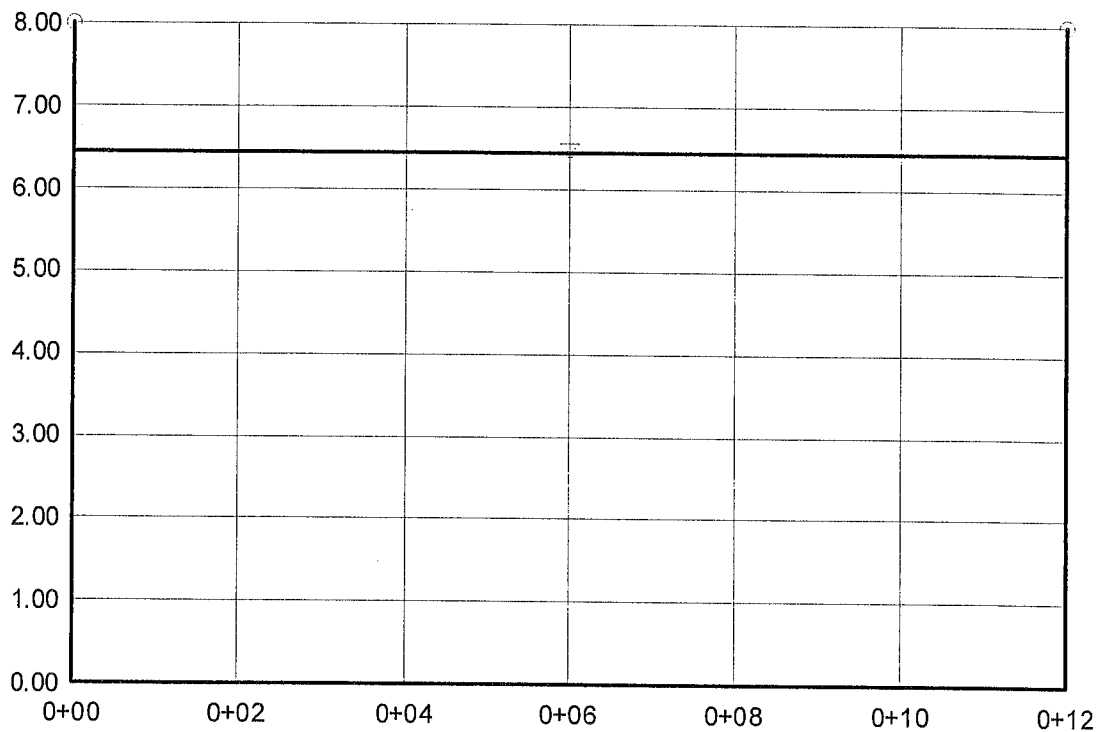
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+12	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	8.00
0+00	0.00
0+12	0.00
0+12	8.00

STA 784+00 (12' wide, Q = 1266 cfs) - min radius = 3166 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 784+00 (12' wide, Q = 1266 cfs) - min radius = 3166 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.006000 ft/ft
Water Surface Elevation	6.45 ft
Elevation Range	0.00 to 8.00
Discharge	1,266.00 cfs



V:1
H:1
NTS

STA 788+50 (12' wide, Q = 986 cfs) - min radius = 3146.50 ft
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 788+50 (12' wide, Q = 986 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.006000 ft/ft
Discharge	986.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	5.35 ft
Elevation Range	0.00 to 8.00
Flow Area	64.2 ft²
Wetted Perimeter	22.71 ft
Top Width	12.00 ft
Actual Depth	5.35 ft
Critical Elevation	5.94 ft
Critical Slope	0.004532 ft/ft
Velocity	15.35 ft/s
Velocity Head	3.66 ft
Specific Energy	9.01 ft
Froude Number	1.17
Flow Type	Supercritical

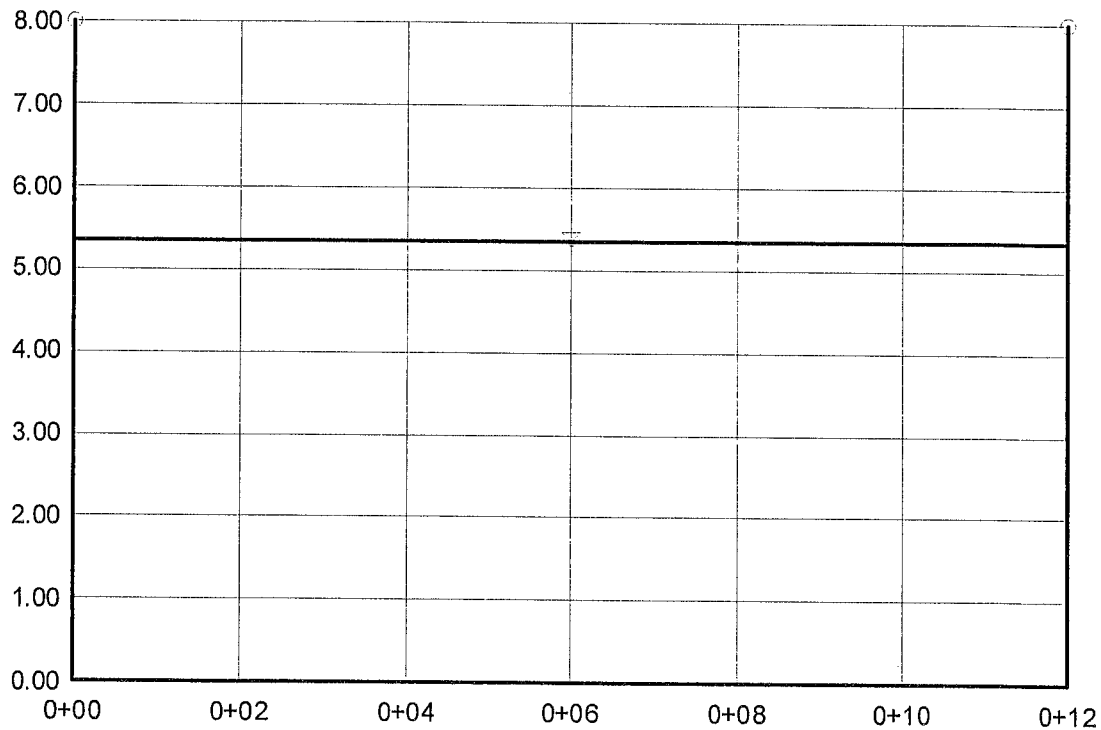
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+12	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	8.00
0+00	0.00
0+12	0.00
0+12	8.00

STA 788+50 (12' wide, Q = 986 cfs) - min radius = 3146.50 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 788+50 (12' wide, Q = 986 cfs) - min radius = 3146.50 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.006000 ft/ft
Water Surface Elevation	5.35 ft
Elevation Range	0.00 to 8.00
Discharge	986.00 cfs



V:1
H:1
NTS

STA 809+50 (10' wide, Q = 729 cfs) - min radius = 0 ft
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 809+50 (10' wide, Q = 729 cfs) - min radius = 0 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.006000 ft/ft
Discharge	729.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	5.12 ft
Elevation Range	0.00 to 8.00
Flow Area	51.2 ft ²
Wetted Perimeter	20.24 ft
Top Width	10.00 ft
Actual Depth	5.12 ft
Critical Elevation	5.49 ft
Critical Slope	0.004991 ft/ft
Velocity	14.24 ft/s
Velocity Head	3.15 ft
Specific Energy	8.27 ft
Froude Number	1.11
Flow Type	Supercritical

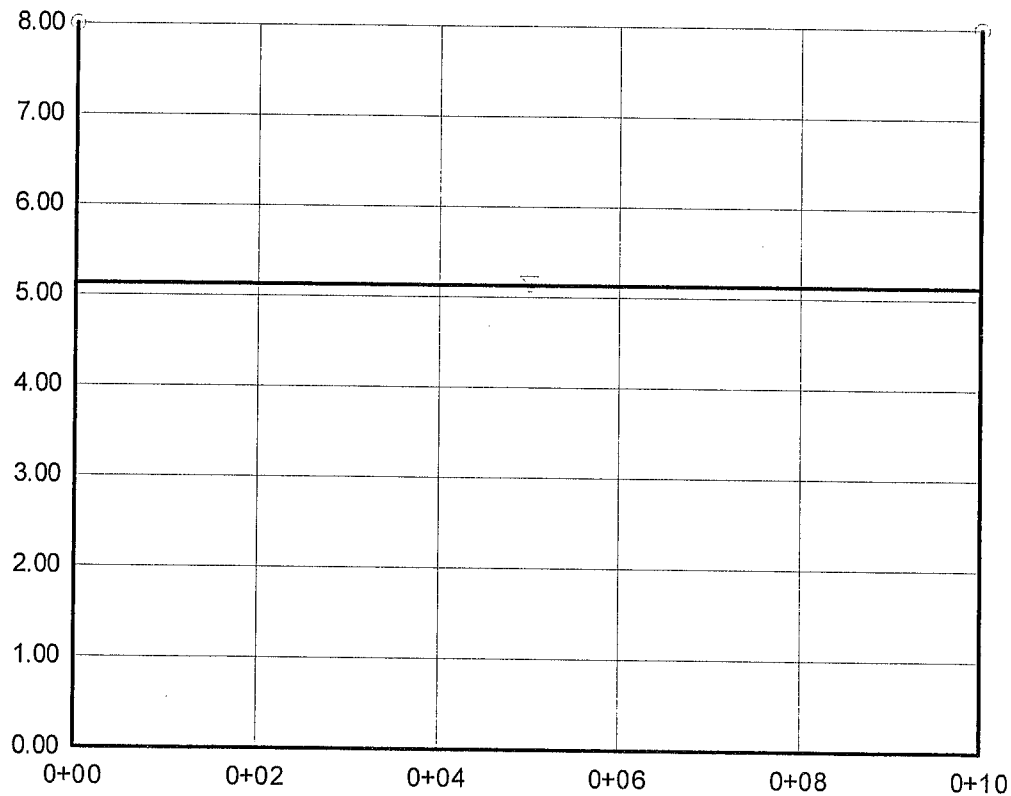
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+10	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	8.00
0+00	0.00
0+10	0.00
0+10	8.00

STA 809+50 (10' wide, Q = 729 cfs) - min radius = 0 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 809+50 (10' wide, Q = 729 cfs) - min radius = 0 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.006000 ft/ft
Water Surface Elevation	5.12 ft
Elevation Range	0.00 to 8.00
Discharge	729.00 cfs



V:1
H:1
NTS

STA 812+00 (10' wide, Q = 729 cfs) - min radius = 0 ft
Worksheet for Irregular Channel

Project Description	
Worksheet	STA 812+00 (10' wide, Q = 729 cfs) - min radius = 0 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.007500 ft/ft
Discharge	729.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	4.71 ft
Elevation Range	0.00 to 6.00
Flow Area	47.1 ft ²
Wetted Perimeter	19.42 ft
Top Width	10.00 ft
Actual Depth	4.71 ft
Critical Elevation	5.49 ft
Critical Slope	0.004991 ft/ft
Velocity	15.48 ft/s
Velocity Head	3.73 ft
Specific Energy	8.43 ft
Froude Number	1.26
Flow Type	Supercritical

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+10	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	6.00
0+00	0.00
0+10	0.00
0+10	6.00

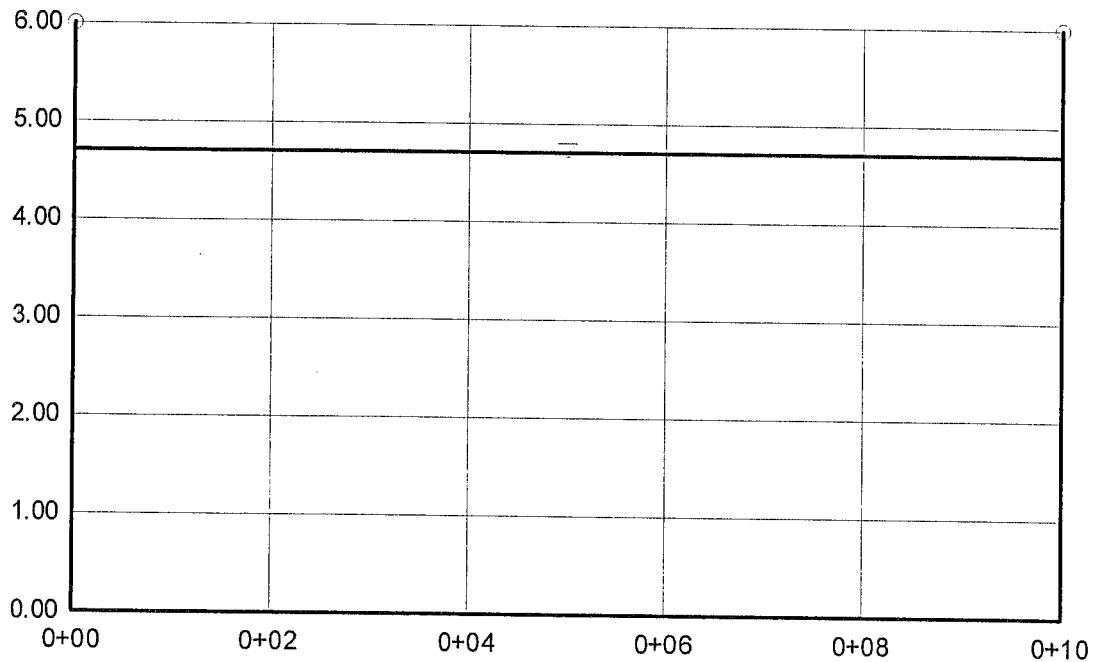
STA 812+00 (10' wide, Q = 729 cfs) - min radius = 0 ft
Cross Section for Irregular Channel

Project Description

Worksheet	STA 812+00 (10' wide, Q = 729 cfs) - min radius = 0 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.015
Channel Slope	0.007500 ft/ft
Water Surface Elevation	4.71 ft
Elevation Range	0.00 to 6.00
Discharge	729.00 cfs

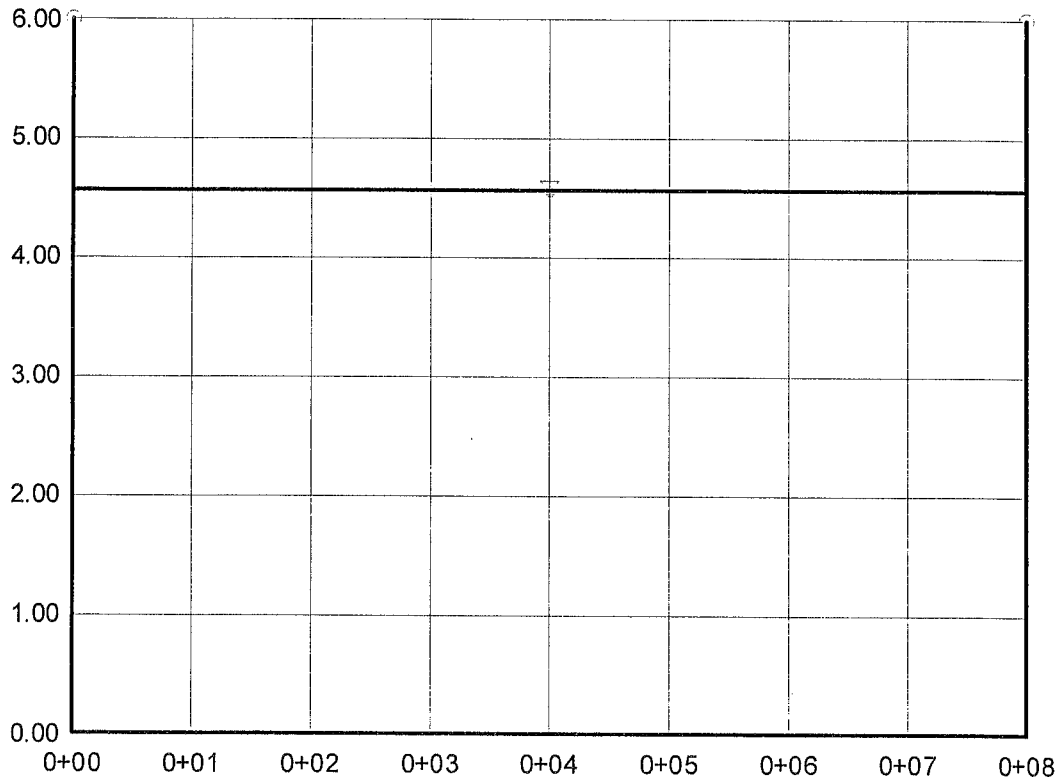


V:1
H:1
NTS

STA 826+00 (8' wide, Q = 518 cfs) - min radius = 3166 ft
Cross Section for Irregular Channel

Project Description	
Worksheet	STA 826+00 (8' wide, Q = 518 cfs) - min radius = 3166 ft
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.007500 ft/ft
Water Surface Elevation	4.56 ft
Elevation Range	0.00 to 6.00
Discharge	518.00 cfs



V:1
H:1
NTS

APPENDIX B

Beltway Channel Storm Drain Lateral Hydraulics

- B-1 Storm Drain Lateral Option A
- B-2 Storm Drain Lateral Option B
- B-3 Storm Drain Lateral Option C

APPENDIX B-1

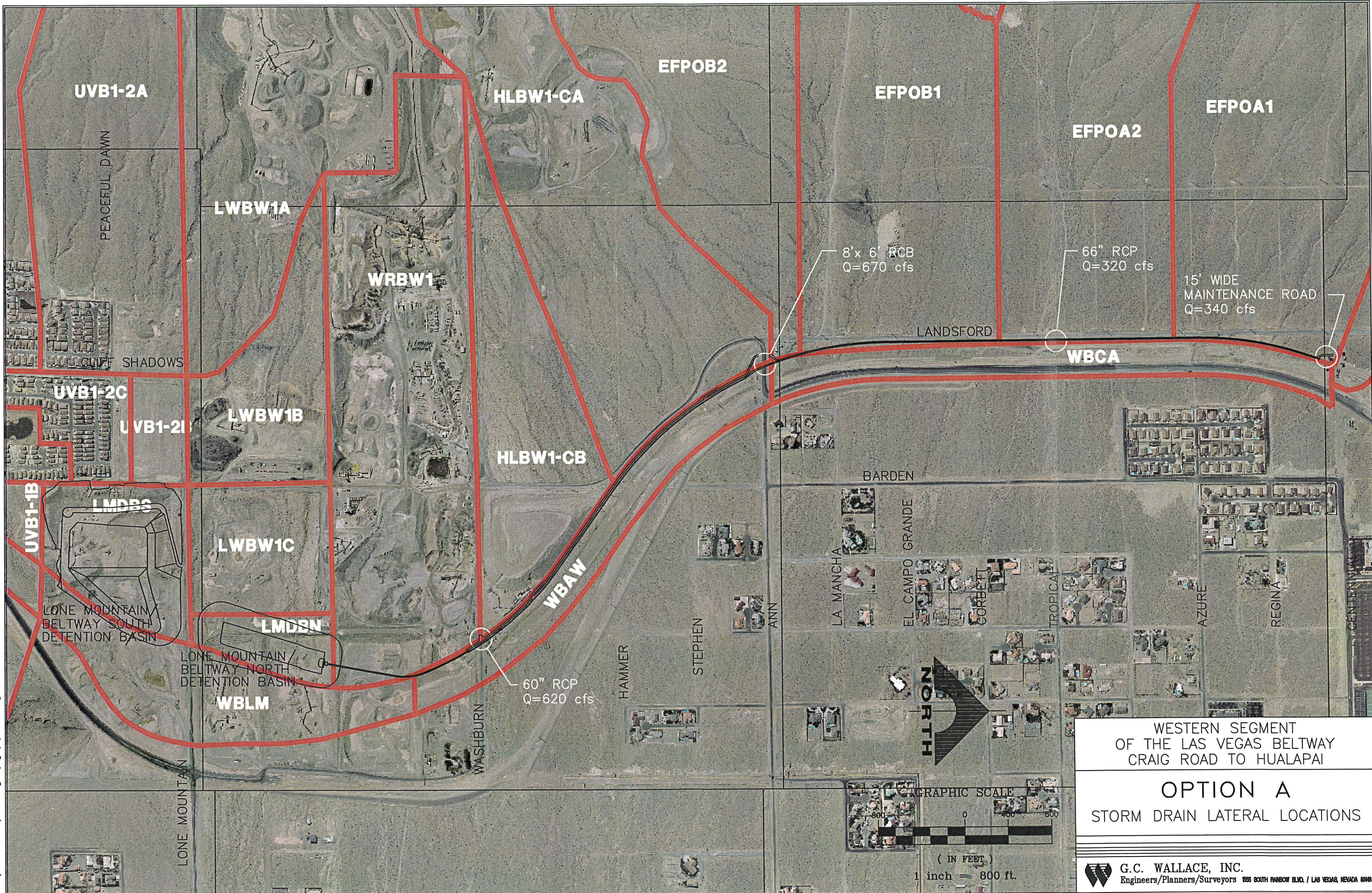
Storm Drain Lateral Option A

Storm Drain Lateral Locations Figure
Flowmaster Calculations

jldwig

04-20-04 11:25:41

F:\451-002\Drainage\fig\Op_A.dwg



WESTERN SEGMENT
OF THE LAS VEGAS BELTWAY
CRAIG ROAD TO HUALAPAI

OPTION A
STORM DRAIN LATERAL LOCATIONS



G.C. WALLACE, INC.
Engineers/Planners/Surveyors 1535 SOUTH RAINBOW BLVD. / LAS VEGAS, NEVADA 89106

OP_A Centennial (Q= 340 cfs)
Worksheet for Rectangular Channel

Project Description	
Worksheet	OP_A Centennial (Q= 340 cfs)
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.015
Channel Slope	0.020000 ft/ft
Bottom Width	15.00 ft
Discharge	340.00 cfs

Results	
Depth	1.43 ft
Flow Area	21.5 ft ²
Wetted Perimeter	17.86 ft
Top Width	15.00 ft
Critical Depth	2.52 ft
Critical Slope	0.003545 ft/ft
Velocity	15.84 ft/s
Velocity Head	3.90 ft
Specific Energy	5.33 ft
Froude Number	2.33
Flow Type	Supercritical

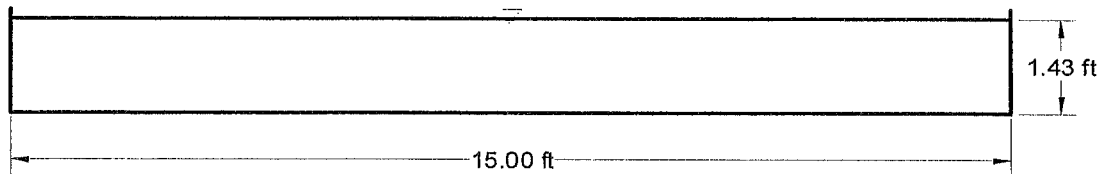
OP_A Centennial (Q= 340 cfs)
Cross Section for Rectangular Channel

Project Description

Worksheet	OP_A Centennial (Q= 340 cfs)
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.015
Channel Slope	0.020000 ft/ft
Depth	1.43 ft
Bottom Width	15.00 ft
Discharge	340.00 cfs



V:1
H:1
NTS

OP_A Tropical (Q = 320 cfs) **Worksheet for Circular Channel**

Project Description	
Worksheet	OP_A Tropical (Q = 320 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

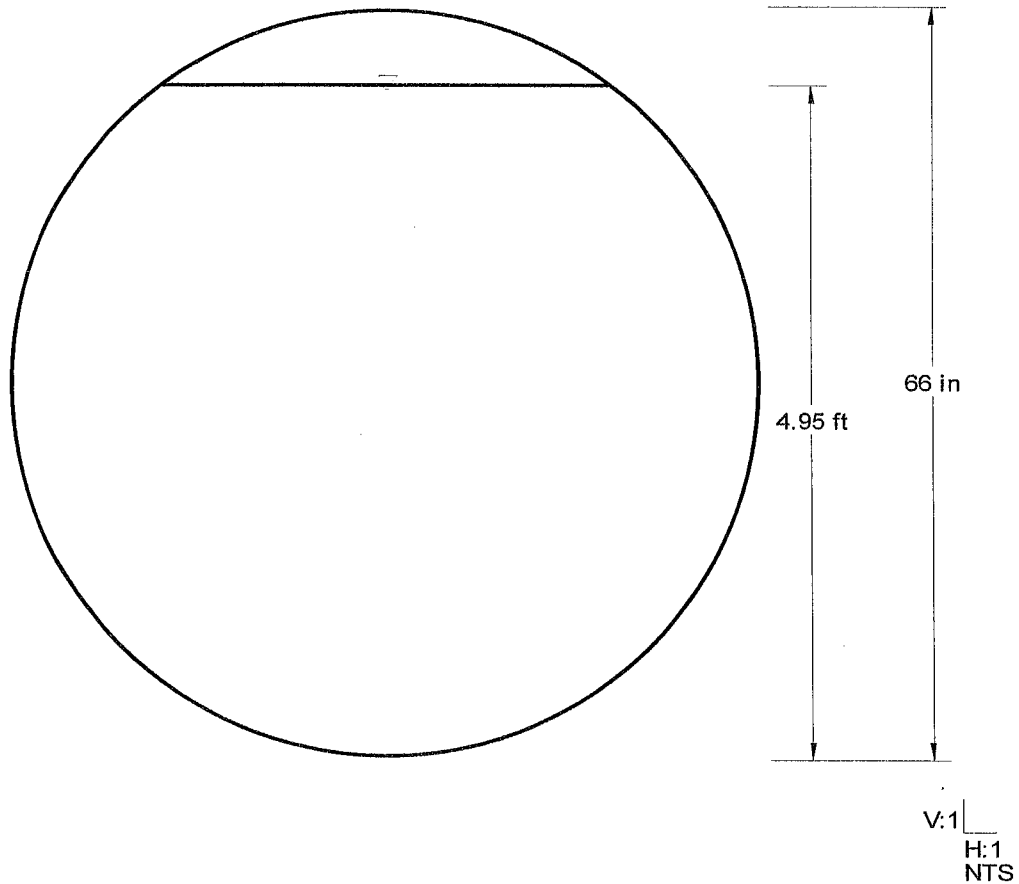
Input Data	
Mannings Coefficient	0.013
Channel Slope	0.008000 ft/ft
Diameter	66 in
Discharge	320.00 cfs

Results	
Depth	4.95 ft
Flow Area	22.5 ft ²
Wetted Perimeter	13.73 ft
Top Width	0.00 ft
Critical Depth	4.88 ft
Percent Full	89.9 %
Critical Slope	0.008099 ft/ft
Velocity	14.22 ft/s
Velocity Head	3.14 ft
Specific Energy	8.09 ft
Froude Number	0.96
Maximum Discharg	323.08 cfs
Discharge Full	300.34 cfs
Slope Full	0.009082 ft/ft
Flow Type	Subcritical

OP_A Tropical (Q = 320 cfs)
Cross Section for Circular Channel

Project Description	
Worksheet	OP_A Tropical (Q = 320 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.008000 ft/ft
Depth	4.95 ft
Diameter	66 in
Discharge	320.00 cfs



OP_A UPSTREAM OF ANN CONFLUENCE (Q=1266 CFS)
Worksheet for Irregular Channel

Project Description	
Worksheet	OP_A UPSTREAM OF ANN CONFLUENCE (Q
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.006000 ft/ft
Discharge	1,266.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	6.45 ft
Elevation Range	0.00 to 8.00
Flow Area	77.4 ft ²
Wetted Perimeter	24.91 ft
Top Width	12.00 ft
Actual Depth	6.45 ft
Critical Elevation	7.02 ft
Critical Slope	0.004811 ft/ft
Velocity	16.35 ft/s
Velocity Head	4.15 ft
Specific Energy	10.61 ft
Froude Number	1.13
Flow Type	Supercritical

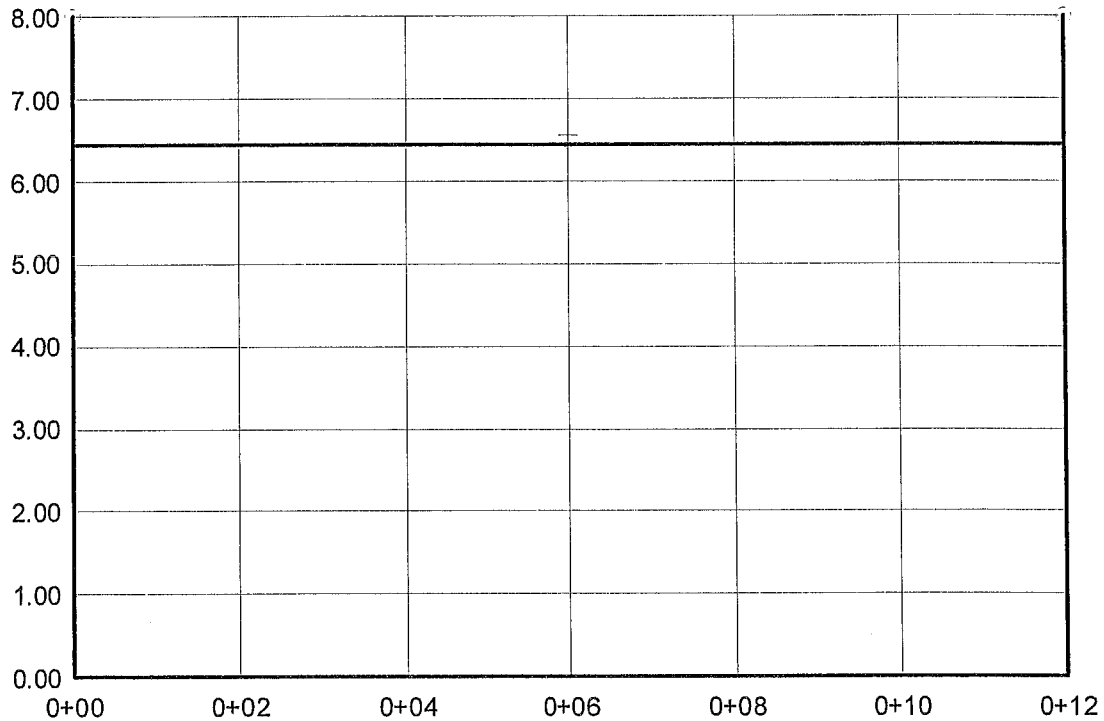
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+12	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	8.00
0+00	0.00
0+12	0.00
0+12	8.00

OP_A UPSTREAM OF ANN CONFLUENCE (Q=1266 CFS) **Cross Section for Irregular Channel**

Project Description	
Worksheet	OP_A UPSTREAM OF ANN CONFLUENCE (Q
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.006000 ft/ft
Water Surface Elevation	6.45 ft
Elevation Range	0.00 to 8.00
Discharge	1,266.00 cfs



V:1
H:1
NTS

OP_A ANN INFLOW (Q=670 CFS)
Worksheet for Rectangular Channel

Project Description	
Worksheet	OP_A ANN INFLOW (Q=670
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.015
Channel Slope	0.009000 ft/ft
Bottom Width	8.00 ft
Discharge	670.00 cfs

Results	
Depth	5.18 ft
Flow Area	41.4 ft ²
Wetted Perimeter	18.36 ft
Top Width	8.00 ft
Critical Depth	6.02 ft
Critical Slope	0.006131 ft/ft
Velocity	16.17 ft/s
Velocity Head	4.06 ft
Specific Energy	9.24 ft
Froude Number	1.25
Flow Type	Supercritical

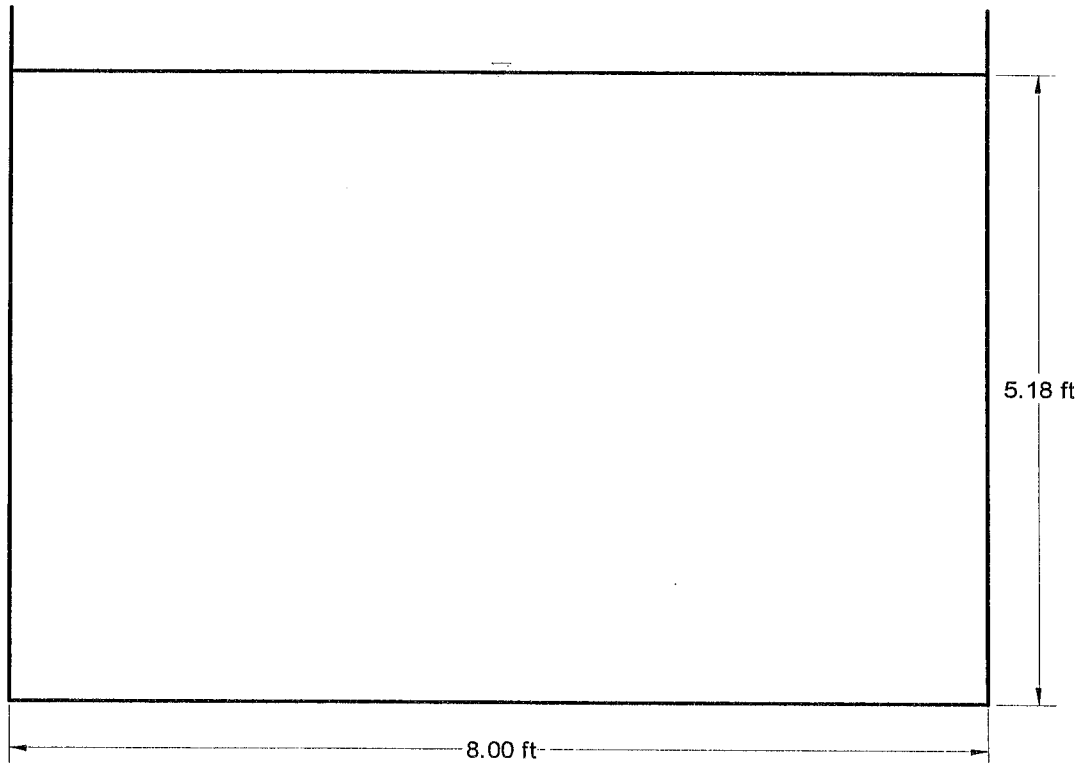
OP_A ANN INFLOW (Q=670 CFS)
Cross Section for Rectangular Channel

Project Description

Worksheet	OP_A ANN INFLOW (Q=670
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.015
Channel Slope	0.009000 ft/ft
Depth	5.18 ft
Bottom Width	8.00 ft
Discharge	670.00 cfs



V:1
H:1
NTS

OP_A Washburn (Q = 620 cfs)
Worksheet for Circular Channel

Project Description	
Worksheet	OP_A Washburn (Q = 620 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.013
Channel Slope	0.060000 ft/ft
Diameter	60 in
Discharge	620.00 cfs

Results	
Depth	3.98 ft
Flow Area	16.7 ft ²
Wetted Perimeter	11.01 ft
Top Width	0.00 ft
Critical Depth	4.98 ft
Percent Full	79.5 %
Critical Slope	0.053720 ft/ft
Velocity	37.02 ft/s
Velocity Head	21.30 ft
Specific Energy	25.28 ft
Froude Number	3.20
Maximum Discharg	686.21 cfs
Discharge Full	637.92 cfs
Slope Full	0.056677 ft/ft
Flow Type	Supercritical

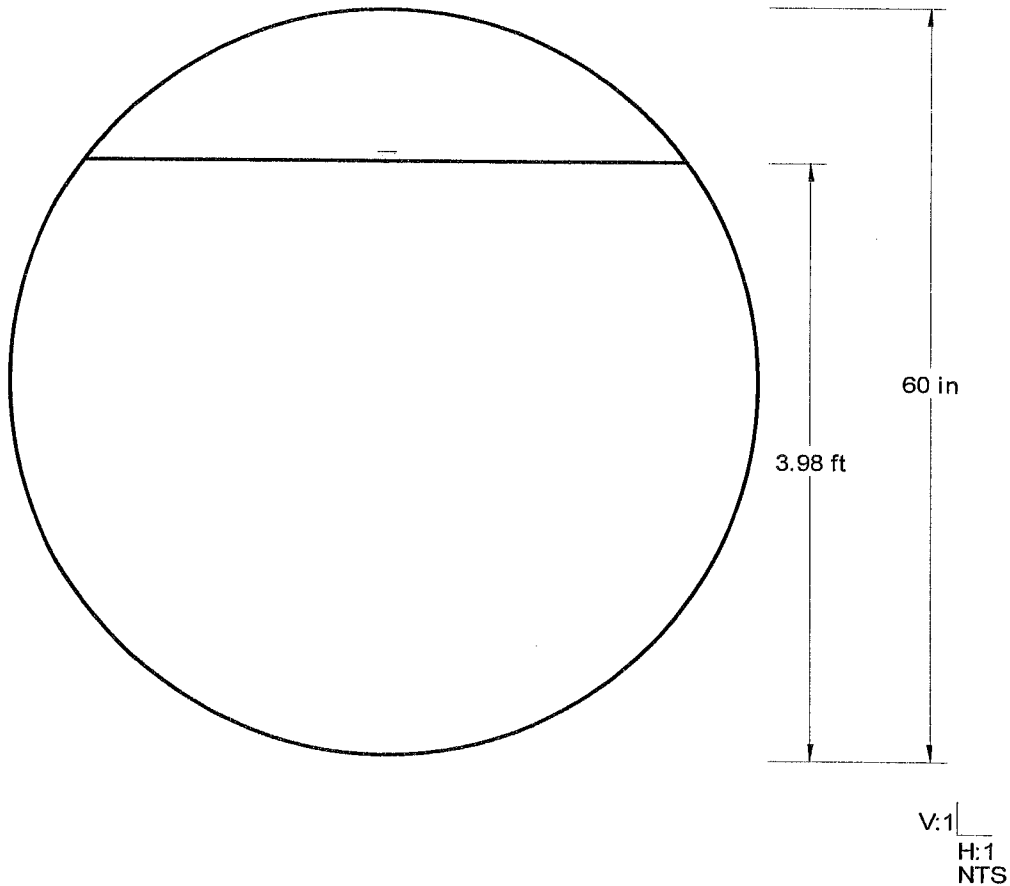
OP_A Washburn (Q = 620 cfs)
Cross Section for Circular Channel

Project Description

Worksheet	OP_A Washburn (Q = 620 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.013
Channel Slope	0.060000 ft/ft
Depth	3.98 ft
Diameter	60 in
Discharge	620.00 cfs



APPENDIX B-2

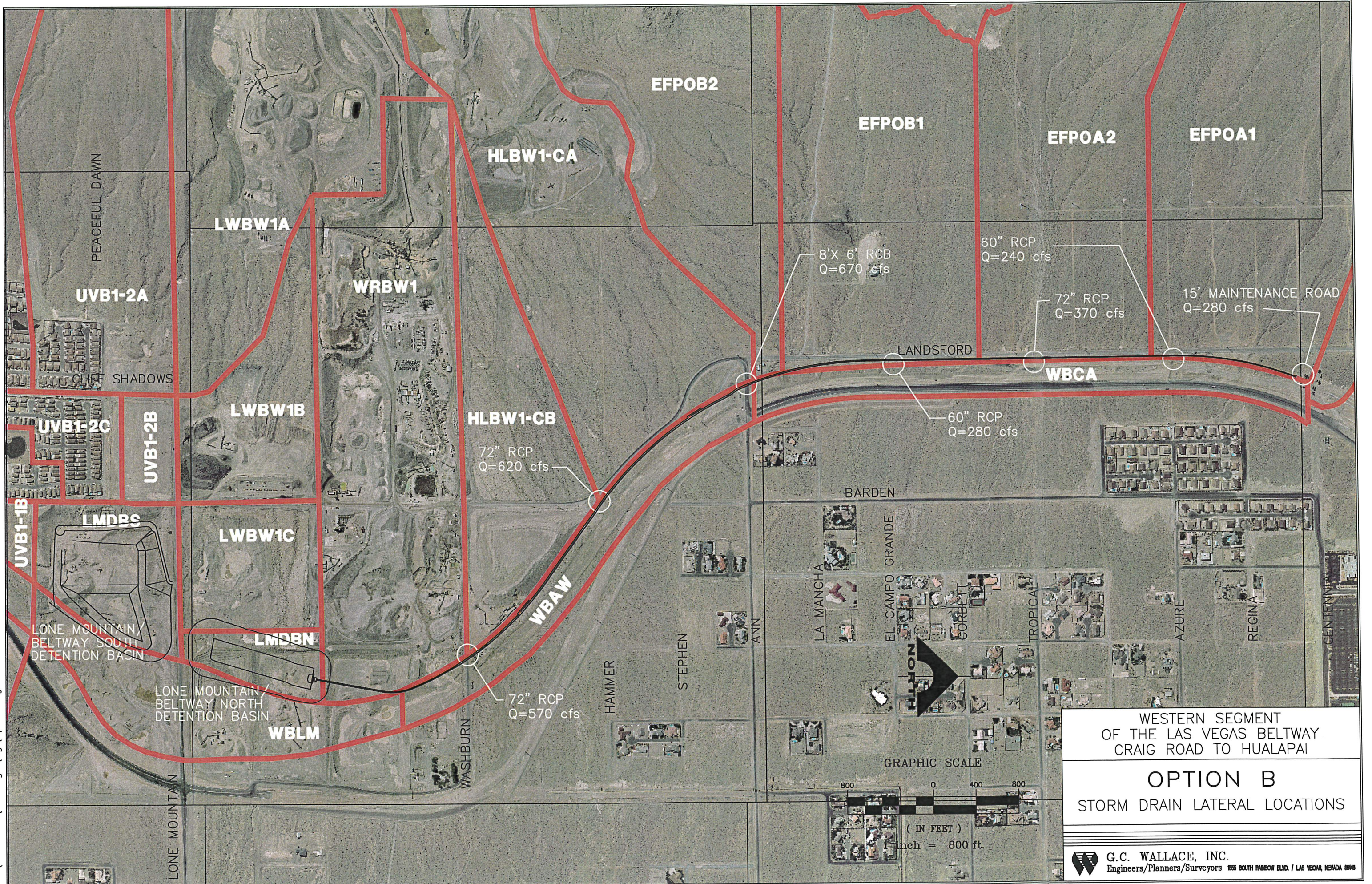
Storm Drain Lateral Option B

Storm Drain Lateral Locations Figure
Flowmaster Calculations

jldwig

04-20-04 14:08:21

F:\451-002\Drainage\fig\Op_B.dwg



WESTERN SEGMENT
OF THE LAS VEGAS BELTWAY
CRAIG ROAD TO HUALAPAI

OPTION B
STORM DRAIN LATERAL LOCATIONS



G.C. WALLACE, INC.
Engineers/Planners/Surveyors 1555 SOUTH RAINBOW BLVD. / LAS VEGAS, NEVADA 89106

OP_B Centennial (Q = 280 cfs)
Worksheet for Rectangular Channel

Project Description	
Worksheet	OP_B Centennial (Q = 280 cfs)
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

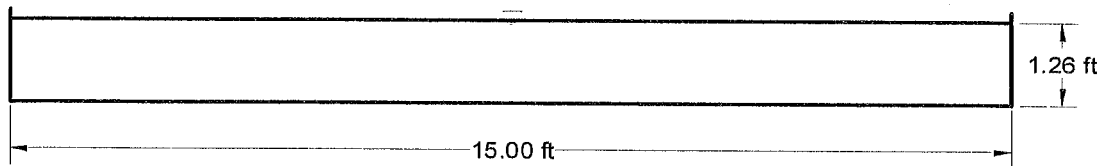
Input Data	
Mannings Coefficient	0.015
Channel Slope	0.020000 ft/ft
Bottom Width	15.00 ft
Discharge	280.00 cfs

Results	
Depth	1.26 ft
Flow Area	19.0 ft ²
Wetted Perimeter	17.53 ft
Top Width	15.00 ft
Critical Depth	2.21 ft
Critical Slope	0.003552 ft/ft
Velocity	14.76 ft/s
Velocity Head	3.39 ft
Specific Energy	4.65 ft
Froude Number	2.31
Flow Type	Supercritical

OP_B Centennial (Q = 280 cfs)
Cross Section for Rectangular Channel

Project Description	
Worksheet	OP_B Centennial (Q = 280 cfs)
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.020000 ft/ft
Depth	1.26 ft
Bottom Width	15.00 ft
Discharge	280.00 cfs



V:1
H:1
NTS

OP_B Azure (Q = 240 cfs)
Worksheet for Circular Channel

Project Description	
Worksheet	OP_B Azure (Q = 240 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

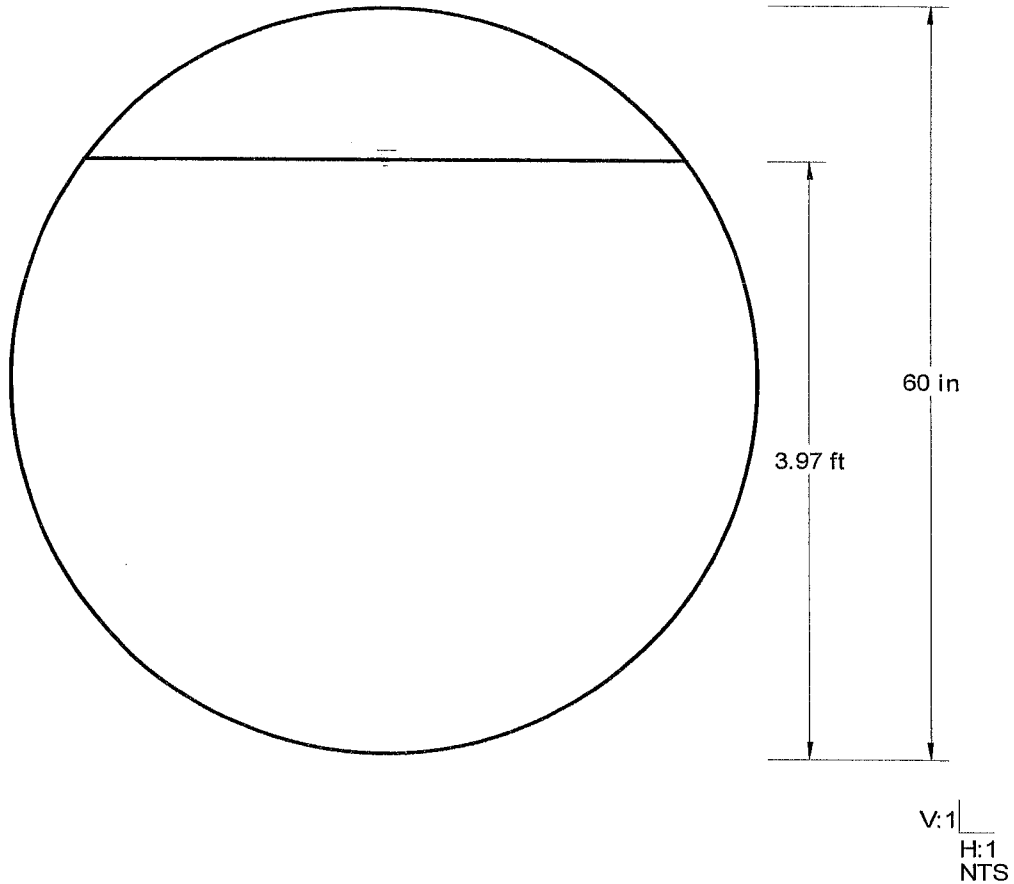
Input Data	
Mannings Coefficient	0.013
Channel Slope	0.009000 ft/ft
Diameter	60 in
Discharge	240.00 cfs

Results	
Depth	3.97 ft
Flow Area	16.7 ft ²
Wetted Perimeter	11.01 ft
Top Width	0.00 ft
Critical Depth	4.36 ft
Percent Full	79.5 %
Critical Slope	0.007729 ft/ft
Velocity	14.34 ft/s
Velocity Head	3.19 ft
Specific Energy	7.17 ft
Froude Number	1.24
Maximum Discharg	265.77 cfs
Discharge Full	247.06 cfs
Slope Full	0.008493 ft/ft
Flow Type	Supercritical

OP_B Azure (Q = 240 cfs)
Cross Section for Circular Channel

Project Description	
Worksheet	OP_B Azure (Q = 240 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.009000 ft/ft
Depth	3.97 ft
Diameter	60 in
Discharge	240.00 cfs



OP_B Tropical (Q = 370 cfs)
Worksheet for Circular Channel

Project Description	
Worksheet	OP_B Tropical (Q = 370 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.013
Channel Slope	0.007000 ft/ft
Diameter	72 in
Discharge	370.00 cfs

Results	
Depth	5.20 ft
Flow Area	26.0 ft ²
Wetted Perimeter	14.36 ft
Top Width	0.00 ft
Critical Depth	5.18 ft
Percent Full	86.6 %
Critical Slope	0.007026 ft/ft
Velocity	14.22 ft/s
Velocity Head	3.14 ft
Specific Energy	8.34 ft
Froude Number	0.99
Maximum Discharg	381.14 cfs
Discharge Full	354.31 cfs
Slope Full	0.007634 ft/ft
Flow Type	Subcritical

OP_B El Campo (Q = 280 cfs)
Worksheet for Circular Channel

Project Description	
Worksheet	OP_B El Campo (Q = 280 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.013
Channel Slope	0.010000 ft/ft
Diameter	60 in
Discharge	280.00 cfs

Results	
Depth	4.65 ft
Flow Area	19.0 ft ²
Wetted Perimeter	13.02 ft
Top Width	0.00 ft
Critical Depth	4.59 ft
Percent Full	93.0 %
Critical Slope	0.010048 ft/ft
Velocity	14.72 ft/s
Velocity Head	3.37 ft
Specific Energy	8.01 ft
Froude Number	0.95
Maximum Discharg	280.14 cfs
Discharge Full	260.43 cfs
Slope Full	0.011560 ft/ft
Flow Type	Subcritical

OP_B UPSTREAM OF ANN CONFLUENCE (Q = 1266 cfs)
Worksheet for Irregular Channel

Project Description	
Worksheet	OP_B UPSTREAM OF ANN CONFLUENCE (Q =
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.006000 ft/ft
Discharge	1,266.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	6.45 ft
Elevation Range	0.00 to 8.00
Flow Area	77.4 ft ²
Wetted Perimeter	24.91 ft
Top Width	12.00 ft
Actual Depth	6.45 ft
Critical Elevation	7.02 ft
Critical Slope	0.004811 ft/ft
Velocity	16.35 ft/s
Velocity Head	4.15 ft
Specific Energy	10.61 ft
Froude Number	1.13
Flow Type	Supercritical

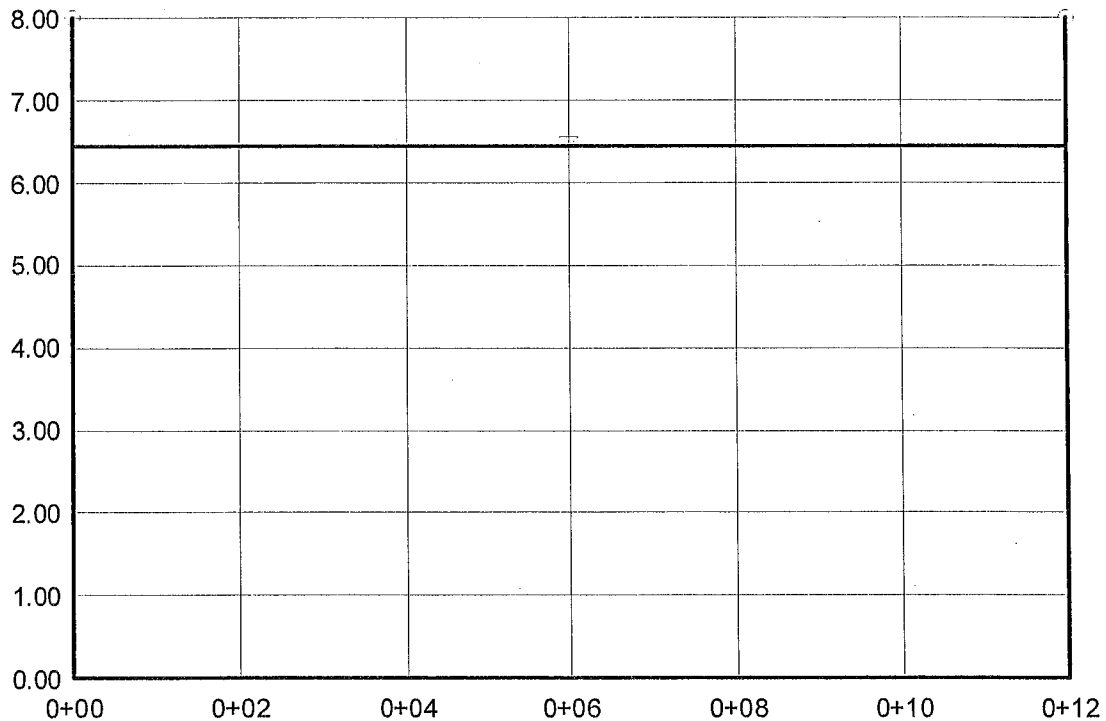
Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+12	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	8.00
0+00	0.00
0+12	0.00
0+12	8.00

OP_B UPSTREAM OF ANN CONFLUENCE (Q = 1266 cfs)
Cross Section for Irregular Channel

Project Description	
Worksheet	OP_B UPSTREAM OF ANN CONFLUENCE (Q =
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.006000 ft/ft
Water Surface Elevation	6.45 ft
Elevation Range	0.00 to 8.00
Discharge	1,266.00 cfs



V:1
H:1
NTS

OP_B ANN INFLOW (Q = 670 cfs) **Worksheet for Rectangular Channel**

Project Description	
Worksheet	OP_B ANN INFLOW (Q = 670 c
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

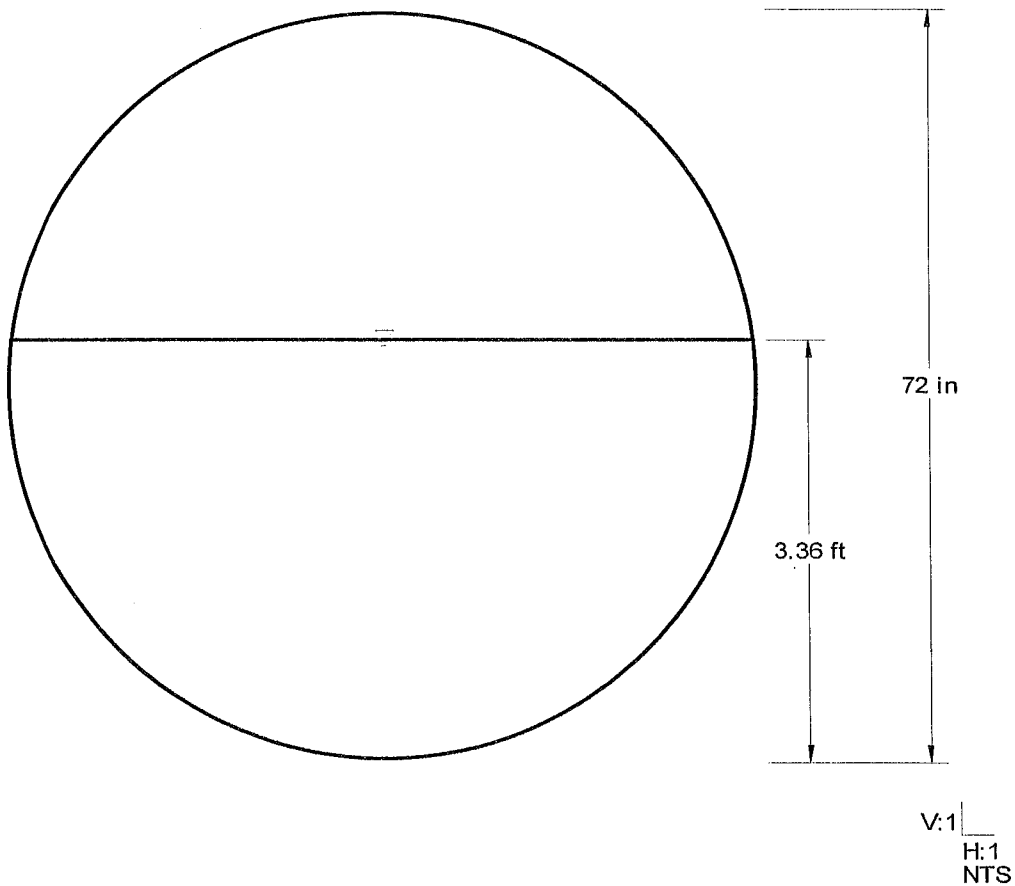
Input Data	
Mannings Coefficient	0.015
Channel Slope	0.009000 ft/ft
Bottom Width	8.00 ft
Discharge	670.00 cfs

Results	
Depth	5.18 ft
Flow Area	41.4 ft ²
Wetted Perimeter	18.36 ft
Top Width	8.00 ft
Critical Depth	6.02 ft
Critical Slope	0.006131 ft/ft
Velocity	16.17 ft/s
Velocity Head	4.06 ft
Specific Energy	9.24 ft
Froude Number	1.25
Flow Type	Supercritical

OP_B Washburn (Q = 570 cfs)
Cross Section for Circular Channel

Project Description	
Worksheet	OP_B Washburn (Q = 570 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.050000 ft/ft
Depth	3.36 ft
Diameter	72 in
Discharge	570.00 cfs



APPENDIX B-3

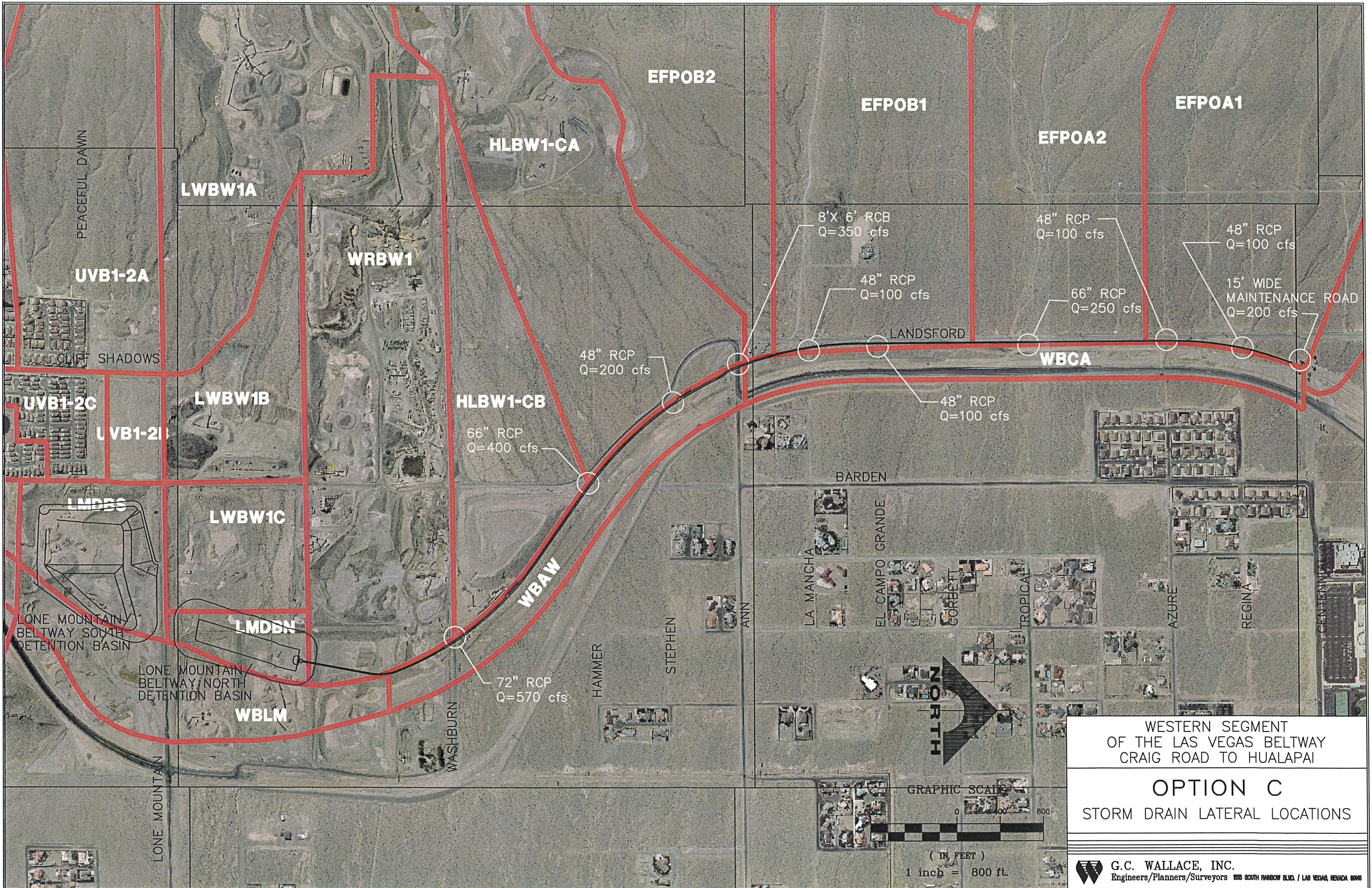
Storm Drain Lateral Option C

Storm Drain Lateral Locations Figure
Flowmaster Calculations

Judwig

04-20-04 15:02:05

F:\451-002\Drainage\fig\Op_C.dwg



WESTERN SEGMENT
OF THE LAS VEGAS BELTWAY
CRAIG ROAD TO HUALAPAI

OPTION C

STORM DRAIN LATERAL LOCATIONS

G.C. WALLACE, INC.
Engineers/Planners/Surveyors 1555 SOUTH RAINBOW BLVD. / LAS VEGAS, NEVADA 89108

OP_C Centennial (Q = 200 cfs)
Worksheet for Rectangular Channel

Project Description	
Worksheet	OP_C Centennial (Q = 200 cfs)
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

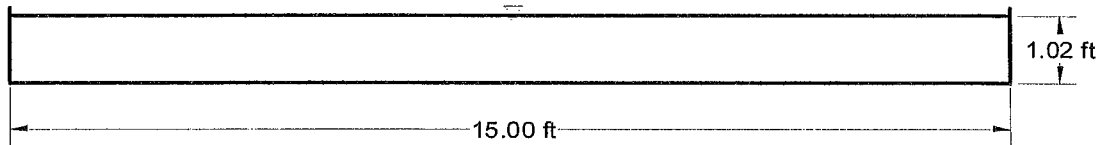
Input Data	
Mannings Coefficient	0.015
Channel Slope	0.020000 ft/ft
Bottom Width	15.00 ft
Discharge	200.00 cfs

Results	
Depth	1.02 ft
Flow Area	15.3 ft ²
Wetted Perimeter	17.04 ft
Top Width	15.00 ft
Critical Depth	1.77 ft
Critical Slope	0.003596 ft/ft
Velocity	13.05 ft/s
Velocity Head	2.65 ft
Specific Energy	3.67 ft
Froude Number	2.28
Flow Type	Supercritical

OP_C Centennial (Q = 200 cfs)
Cross Section for Rectangular Channel

Project Description	
Worksheet	OP_C Centennial (Q = 200 cfs)
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.020000 ft/ft
Depth	1.02 ft
Bottom Width	15.00 ft
Discharge	200.00 cfs



V:1
H:1
NTS

OP_C Regina (Q = 100 cfs)
Worksheet for Circular Channel

Project Description	
Worksheet	OP_C Regina (Q = 100 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

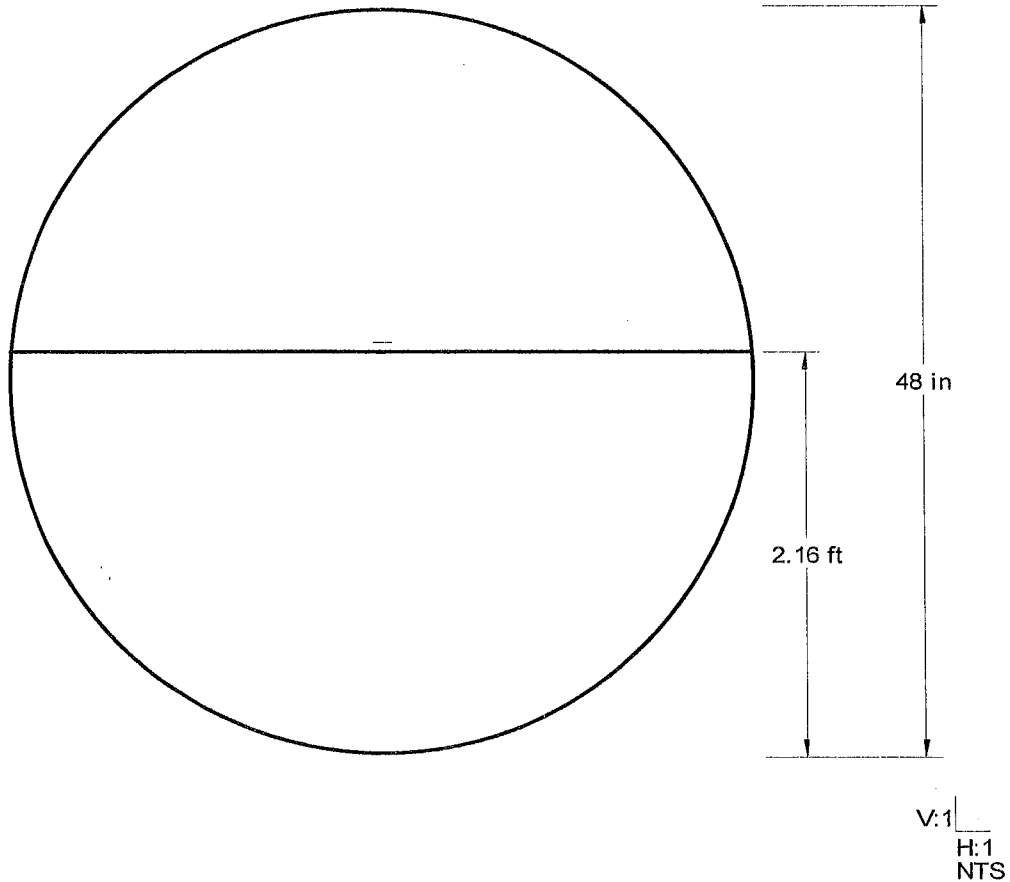
Input Data	
Mannings Coefficient	0.013
Channel Slope	0.015000 ft/ft
Diameter	48 in
Discharge	100.00 cfs

Results	
Depth	2.16 ft
Flow Area	6.9 ft ²
Wetted Perimeter	6.60 ft
Top Width	0.00 ft
Critical Depth	3.03 ft
Percent Full	54.0 %
Critical Slope	0.005695 ft/ft
Velocity	14.45 ft/s
Velocity Head	3.24 ft
Specific Energy	5.40 ft
Froude Number	1.93
Maximum Discharg	189.23 cfs
Discharge Full	175.92 cfs
Slope Full	0.004847 ft/ft
Flow Type	Supercritical

OP_C Regina (Q = 100 cfs)
Cross Section for Circular Channel

Project Description	
Worksheet	OP_C Regina (Q = 100 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.015000 ft/ft
Depth	2.16 ft
Diameter	48 in
Discharge	100.00 cfs



OP_C Azure (Q = 100 cfs)
Worksheet for Circular Channel

Project Description

Worksheet	OP_C Azure (Q = 100 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Mannings Coefficient	0.013
Channel Slope	0.015000 ft/ft
Diameter	48 in
Discharge	100.00 cfs

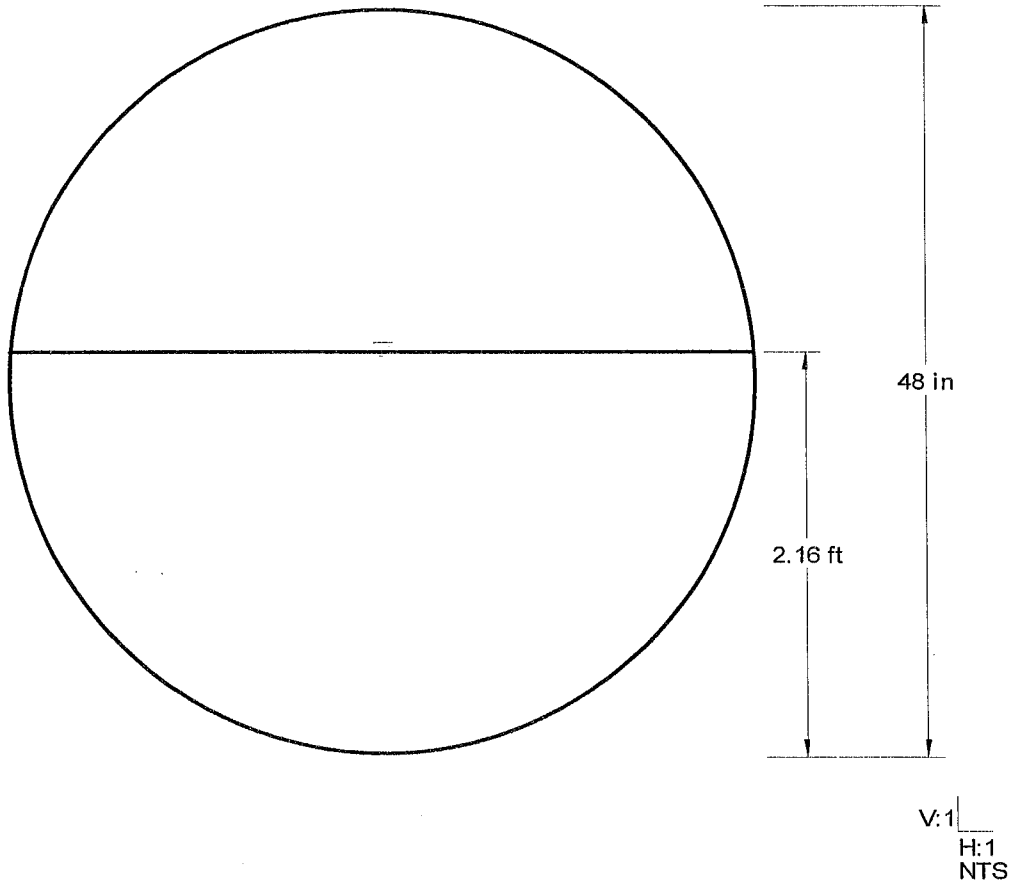
Results

Depth	2.16 ft
Flow Area	6.9 ft ²
Wetted Perimeter	6.60 ft
Top Width	0.00 ft
Critical Depth	3.03 ft
Percent Full	54.0 %
Critical Slope	0.005695 ft/ft
Velocity	14.45 ft/s
Velocity Head	3.24 ft
Specific Energy	5.40 ft
Froude Number	1.93
Maximum Discharg	189.23 cfs
Discharge Full	175.92 cfs
Slope Full	0.004847 ft/ft
Flow Type	Supercritical

OP_C Azure (Q = 100 cfs)
Cross Section for Circular Channel

Project Description	
Worksheet	OP_C Azure (Q = 100 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.015000 ft/ft
Depth	2.16 ft
Diameter	48 in
Discharge	100.00 cfs



OP_C Tropical (Q = 250 cfs)
Worksheet for Circular Channel

Project Description	
Worksheet	OP_C Tropical (Q = 250 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

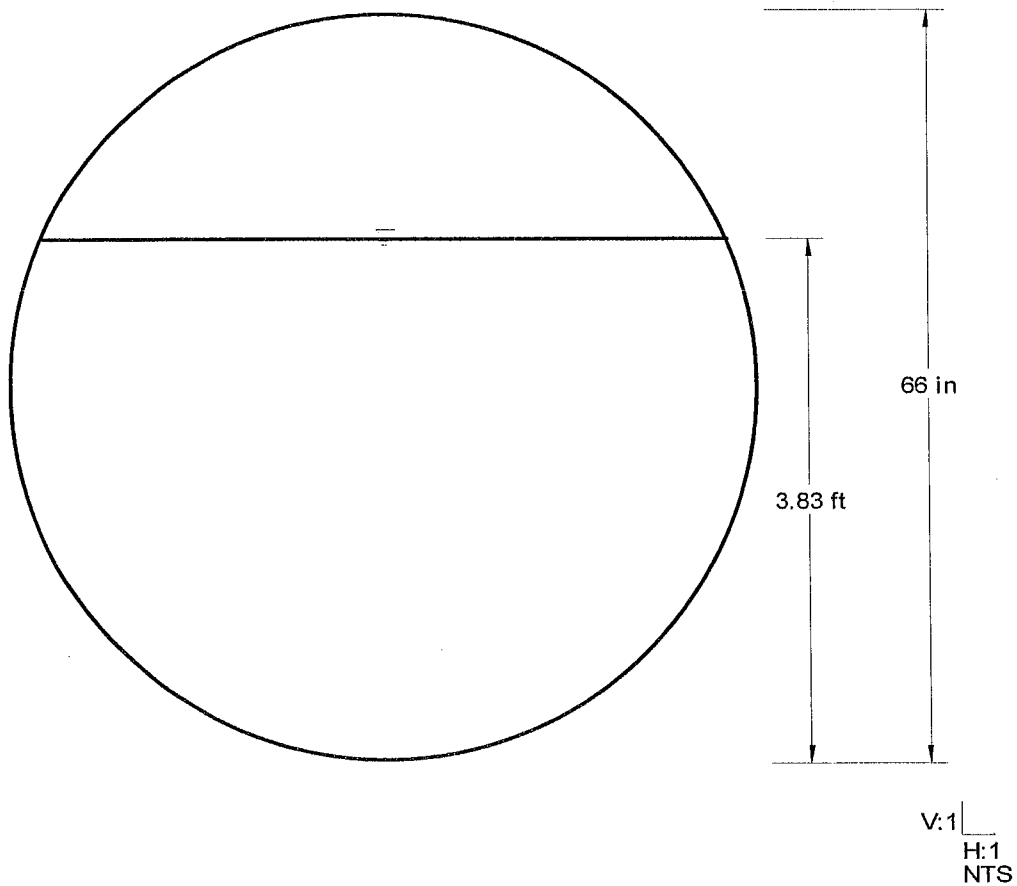
Input Data	
Mannings Coefficient	0.013
Channel Slope	0.008000 ft/ft
Diameter	66 in
Discharge	250.00 cfs

Results	
Depth	3.83 ft
Flow Area	17.7 ft ²
Wetted Perimeter	10.87 ft
Top Width	0.00 ft
Critical Depth	4.41 ft
Percent Full	69.7 %
Critical Slope	0.005774 ft/ft
Velocity	14.14 ft/s
Velocity Head	3.11 ft
Specific Energy	6.94 ft
Froude Number	1.33
Maximum Discharg	323.08 cfs
Discharge Full	300.34 cfs
Slope Full	0.005543 ft/ft
Flow Type	Supercritical

OP_C Tropical (Q = 250 cfs)
Cross Section for Circular Channel

Project Description	
Worksheet	OP_C Tropical (Q = 250 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.008000 ft/ft
Depth	3.83 ft
Diameter	66 in
Discharge	250.00 cfs



OP_C El Campo (Q = 100 cfs)
Worksheet for Circular Channel

Project Description	
Worksheet	OP_C El Campo (Q = 100 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

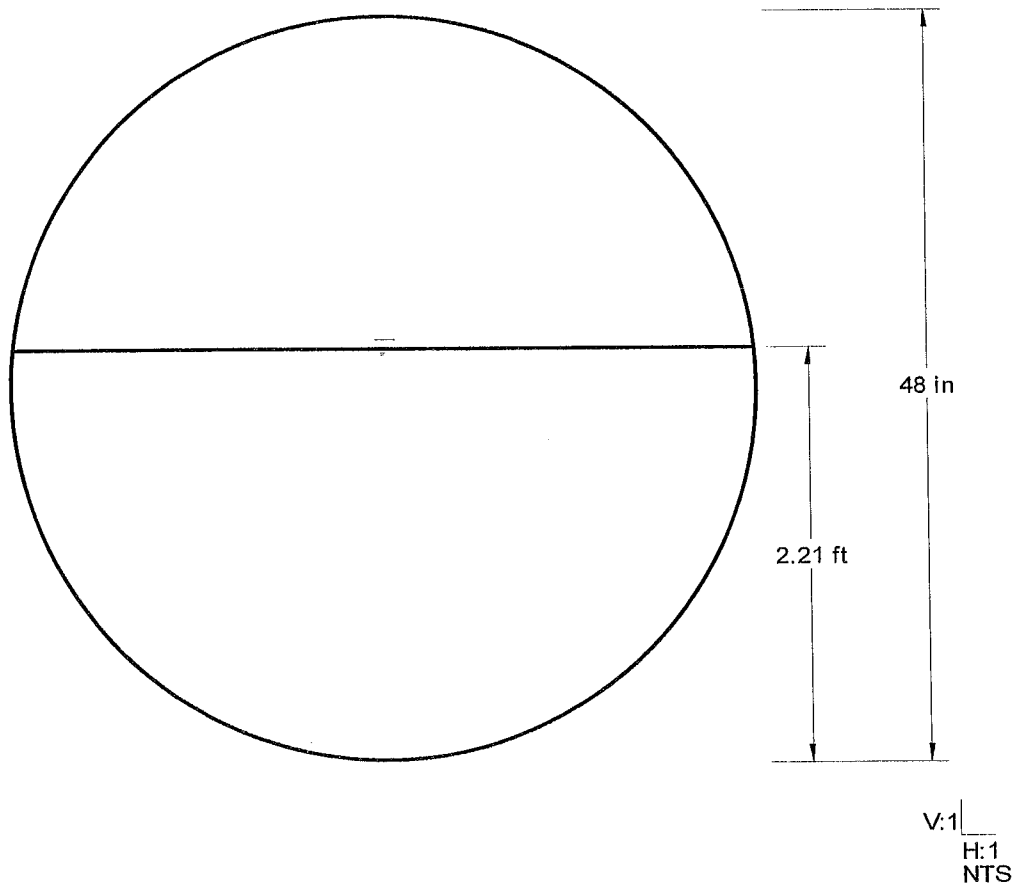
Input Data	
Mannings Coefficient	0.013
Channel Slope	0.014000 ft/ft
Diameter	48 in
Discharge	100.00 cfs

Results	
Depth	2.21 ft
Flow Area	7.1 ft ²
Wetted Perimeter	6.70 ft
Top Width	0.00 ft
Critical Depth	3.03 ft
Percent Full	55.2 %
Critical Slope	0.005695 ft/ft
Velocity	14.07 ft/s
Velocity Head	3.08 ft
Specific Energy	5.28 ft
Froude Number	1.86
Maximum Discharg	182.82 cfs
Discharge Full	169.95 cfs
Slope Full	0.004847 ft/ft
Flow Type	Supercritical

OP_C El Campo (Q = 100 cfs)
Cross Section for Circular Channel

Project Description	
Worksheet	OP_C El Campo (Q = 100 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.014000 ft/ft
Depth	2.21 ft
Diameter	48 in
Discharge	100.00 cfs



OP_C La Mancha (Q = 100 cfs)
Worksheet for Circular Channel

Project Description	
Worksheet	OP_C La Mancha (Q = 100 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

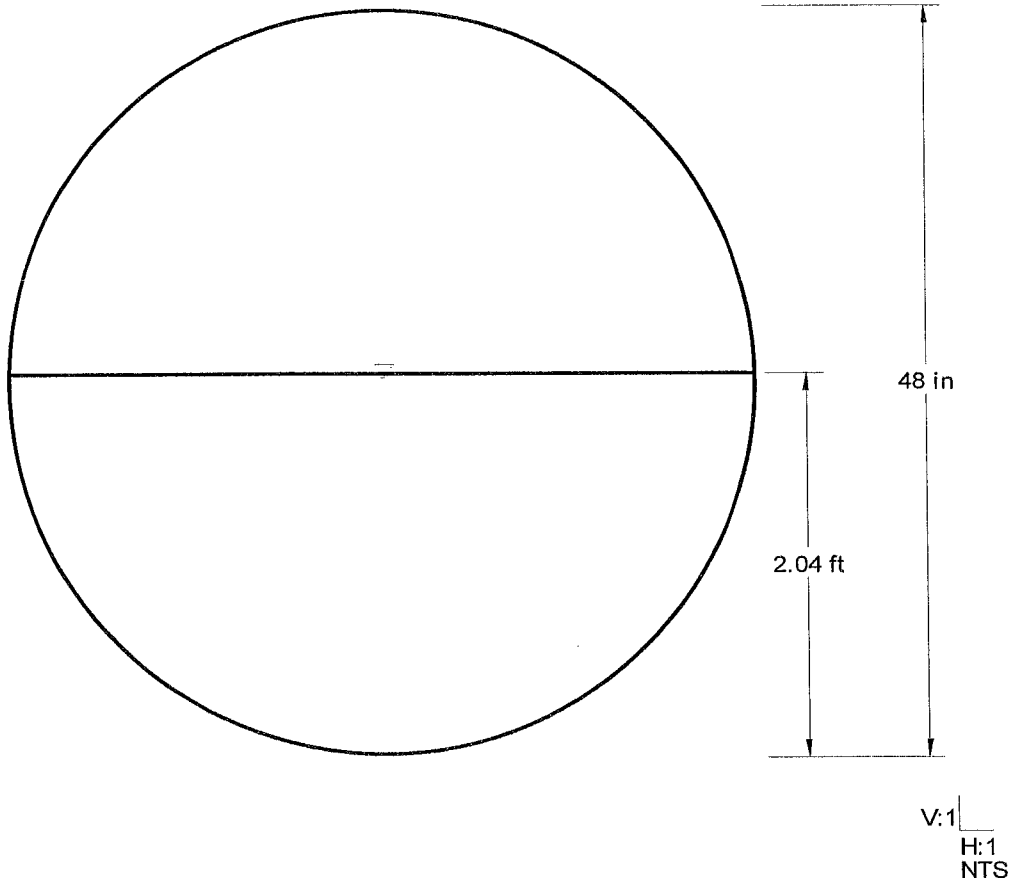
Input Data	
Mannings Coefficient	0.013
Channel Slope	0.018000 ft/ft
Diameter	48 in
Discharge	100.00 cfs

Results	
Depth	2.04 ft
Flow Area	6.5 ft ²
Wetted Perimeter	6.37 ft
Top Width	0.00 ft
Critical Depth	3.03 ft
Percent Full	51.1 %
Critical Slope	0.005695 ft/ft
Velocity	15.48 ft/s
Velocity Head	3.72 ft
Specific Energy	5.77 ft
Froude Number	2.15
Maximum Discharg	207.30 cfs
Discharge Full	192.71 cfs
Slope Full	0.004847 ft/ft
Flow Type	Supercritical

OP_C La Mancha (Q = 100 cfs)
Cross Section for Circular Channel

Project Description	
Worksheet	OP_C La Mancha (Q = 100 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.018000 ft/ft
Depth	2.04 ft
Diameter	48 in
Discharge	100.00 cfs



OP_C UPSTREAM OF ANN CONFLUENCE (Q = 1266 cfs)
Worksheet for Irregular Channel

Project Description	
Worksheet	OP_C UPSTREAM OF ANN CONFLUENCE (Q =
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.006000 ft/ft
Discharge	1,266.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	5.55 ft
Elevation Range	0.00 to 8.00
Flow Area	77.7 ft ²
Wetted Perimeter	25.10 ft
Top Width	14.00 ft
Actual Depth	5.55 ft
Critical Elevation	6.33 ft
Critical Slope	0.004184 ft/ft
Velocity	16.30 ft/s
Velocity Head	4.13 ft
Specific Energy	9.68 ft
Froude Number	1.22
Flow Type	Supercritical

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+14	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	8.00
0+00	0.00
0+14	0.00
0+14	8.00

OP_C ANN INFLOW (Q = 350 cfs)
Worksheet for Rectangular Channel

Project Description	
Worksheet	OP_C ANN INFLOW (Q = 350 c
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

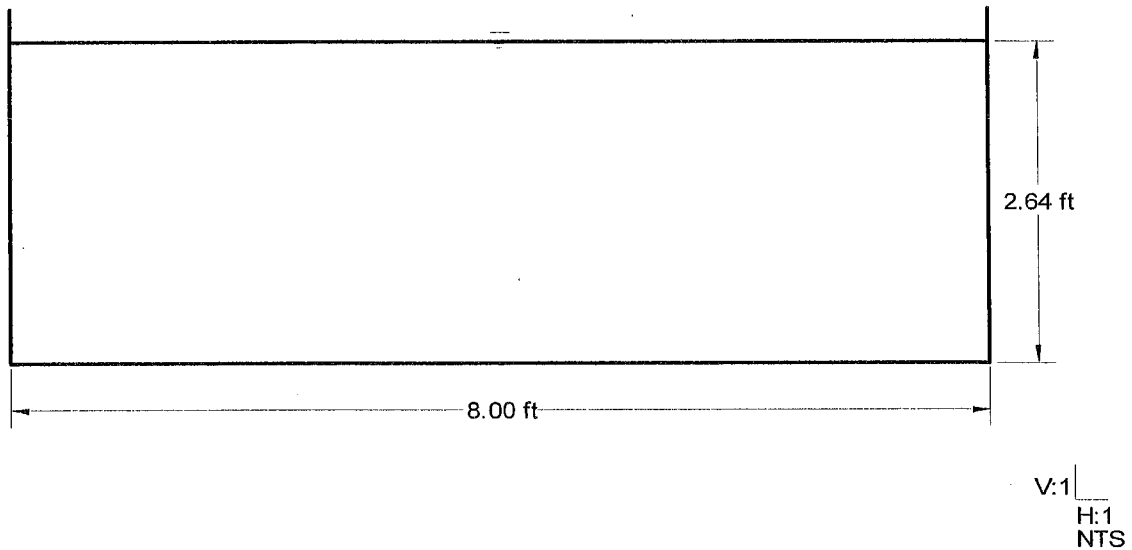
Input Data	
Mannings Coefficient	0.015
Channel Slope	0.015000 ft/ft
Bottom Width	8.00 ft
Discharge	350.00 cfs

Results	
Depth	2.64 ft
Flow Area	21.2 ft ²
Wetted Perimeter	13.29 ft
Top Width	8.00 ft
Critical Depth	3.90 ft
Critical Slope	0.005163 ft/ft
Velocity	16.54 ft/s
Velocity Head	4.25 ft
Specific Energy	6.90 ft
Froude Number	1.79
Flow Type	Supercritical

OP_C ANN INFLOW (Q = 350 cfs)
Cross Section for Rectangular Channel

Project Description	
Worksheet	OP_C ANN INFLOW (Q = 350 c
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.015000 ft/ft
Depth	2.64 ft
Bottom Width	8.00 ft
Discharge	350.00 cfs



OP_C Stephen (Q = 200 cfs)
Worksheet for Circular Channel

Project Description	
Worksheet	OP_C Stephen (Q = 200 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

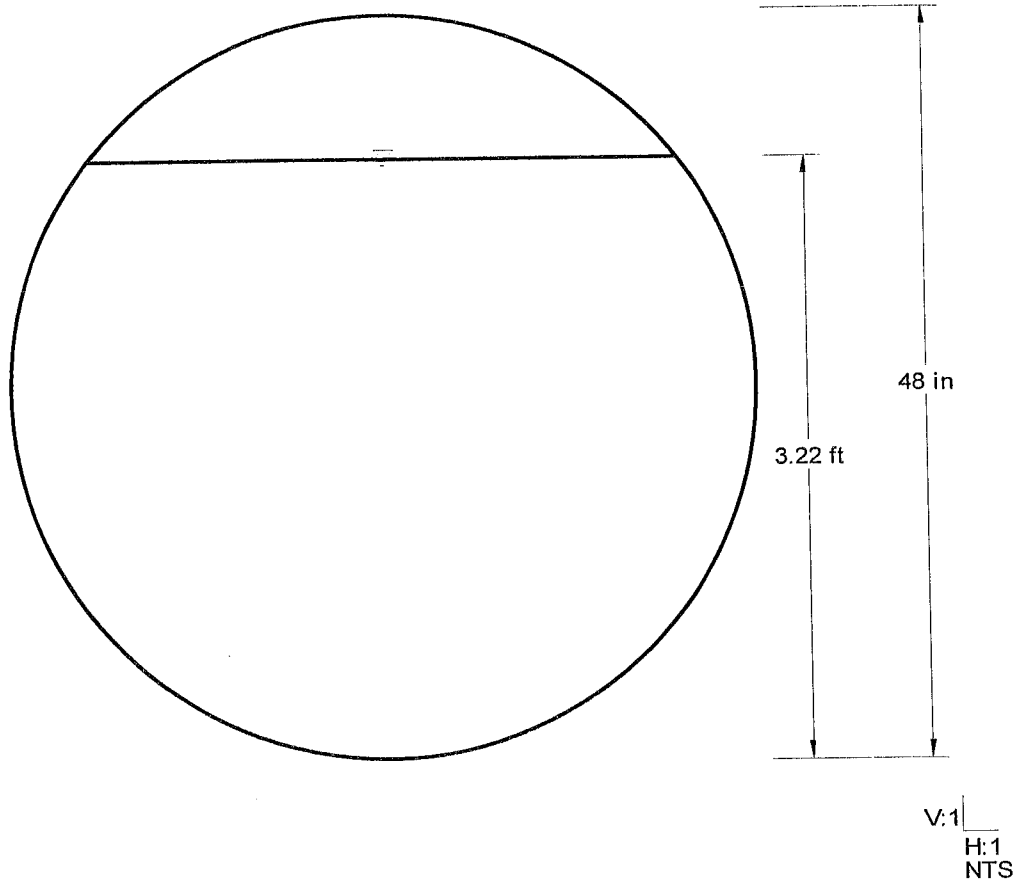
Input Data	
Mannings Coefficient	0.013
Channel Slope	0.020000 ft/ft
Diameter	48 in
Discharge	200.00 cfs

Results	
Depth	3.22 ft
Flow Area	10.9 ft ²
Wetted Perimeter	8.92 ft
Top Width	0.00 ft
Critical Depth	3.85 ft
Percent Full	80.6 %
Critical Slope	0.016914 ft/ft
Velocity	18.43 ft/s
Velocity Head	5.28 ft
Specific Energy	8.50 ft
Froude Number	1.75
Maximum Discharg	218.51 cfs
Discharge Full	203.13 cfs
Slope Full	0.019388 ft/ft
Flow Type	Supercritical

OP_C Stephen (Q = 200 cfs)
Cross Section for Circular Channel

Project Description	
Worksheet	OP_C Stephen (Q = 200 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.020000 ft/ft
Depth	3.22 ft
Diameter	48 in
Discharge	200.00 cfs



OP_C Hammer (Q = 400 cfs)
Worksheet for Circular Channel

Project Description	
Worksheet	OP_C Hammer (Q = 400 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

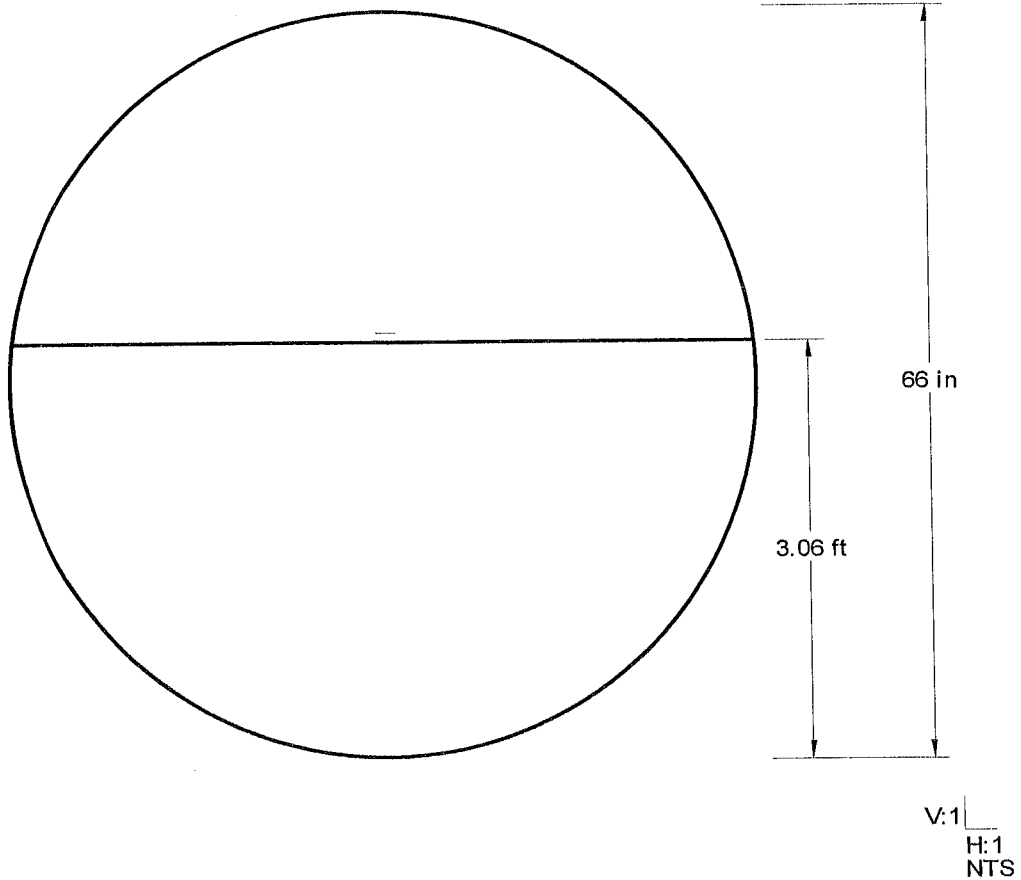
Input Data	
Mannings Coefficient	0.013
Channel Slope	0.040000 ft/ft
Diameter	66 in
Discharge	400.00 cfs

Results	
Depth	3.06 ft
Flow Area	13.6 ft ²
Wetted Perimeter	9.25 ft
Top Width	0.00 ft
Critical Depth	5.19 ft
Percent Full	55.6 %
Critical Slope	0.012270 ft/ft
Velocity	29.49 ft/s
Velocity Head	13.52 ft
Specific Energy	16.58 ft
Froude Number	3.30
Maximum Discharg	722.42 cfs
Discharge Full	671.58 cfs
Slope Full	0.014190 ft/ft
Flow Type	Supercritical

OP_C Hammer (Q = 400 cfs)
Cross Section for Circular Channel

Project Description	
Worksheet	OP_C Hammer (Q = 400 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.040000 ft/ft
Depth	3.06 ft
Diameter	66 in
Discharge	400.00 cfs



OP_C Washburn (Q = 570 cfs)
Worksheet for Circular Channel

Project Description	
Worksheet	OP_C Washburn (Q = 570 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

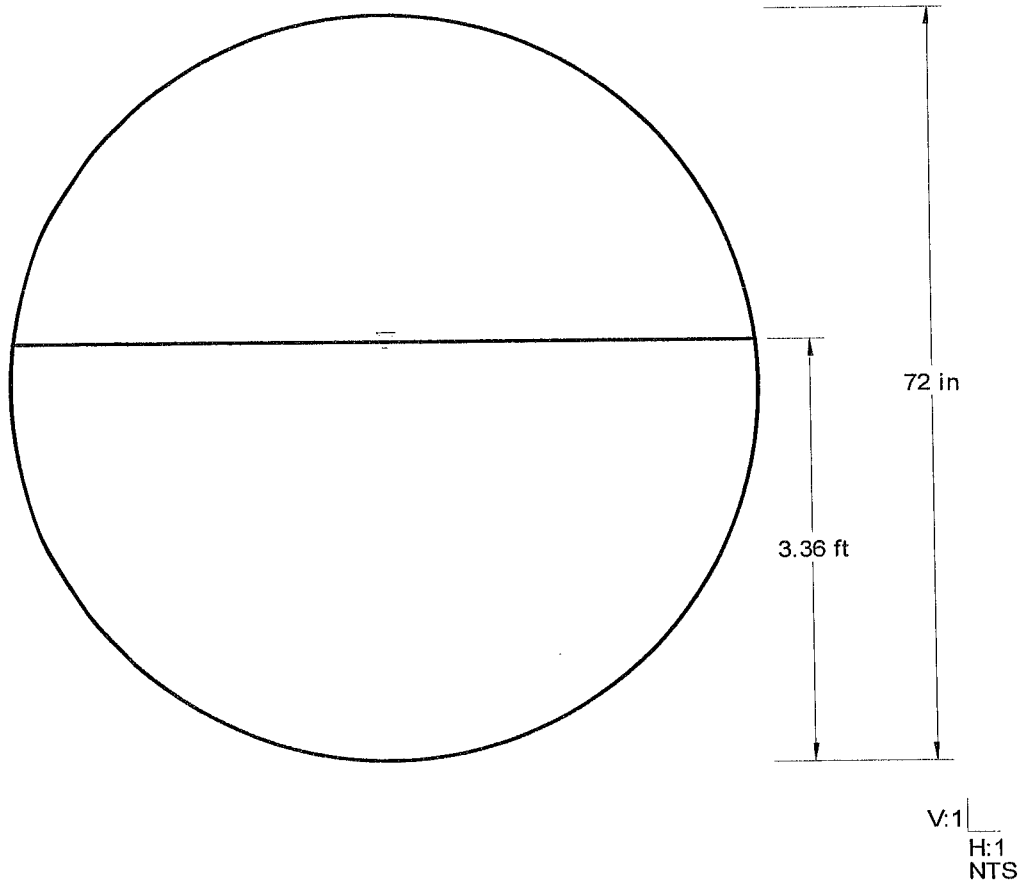
Input Data	
Mannings Coefficient	0.013
Channel Slope	0.050000 ft/ft
Diameter	72 in
Discharge	570.00 cfs

Results	
Depth	3.36 ft
Flow Area	16.3 ft ²
Wetted Perimeter	10.14 ft
Top Width	0.00 ft
Critical Depth	5.80 ft
Percent Full	55.9 %
Critical Slope	0.015876 ft/ft
Velocity	35.03 ft/s
Velocity Head	19.07 ft
Specific Energy	22.43 ft
Froude Number	3.74
Maximum Discharg	1,018.63 cfs
Discharge Full	946.94 cfs
Slope Full	0.018116 ft/ft
Flow Type	Supercritical

OP_C Washburn (Q = 570 cfs)
Cross Section for Circular Channel

Project Description	
Worksheet	OP_C Washburn (Q = 570 cfs)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.050000 ft/ft
Depth	3.36 ft
Diameter	72 in
Discharge	570.00 cfs



APPENDIX C

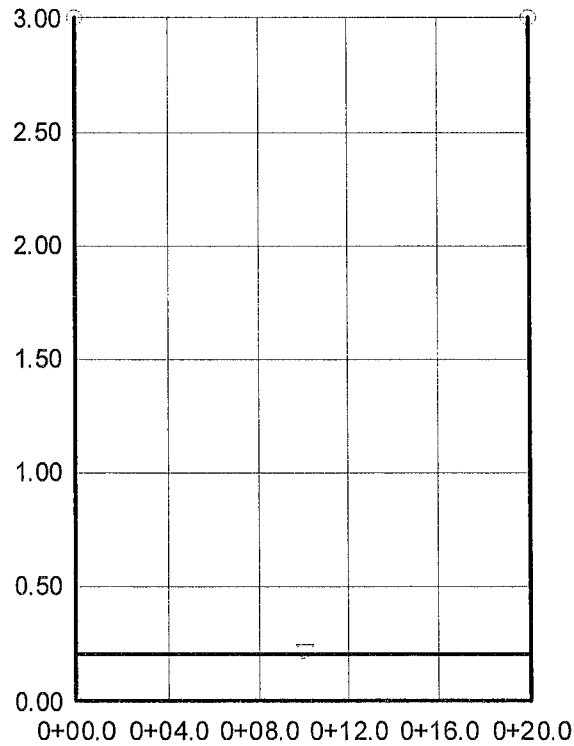
Detention Basin Facilities

Flowmaster Calculations
Erosion Protection Calculations
Outfall Calculation
Cost Analysis

North Detention Basin Flume (Q = 98 cfs) **Cross Section for Irregular Channel**

Project Description	
Worksheet	North Detention Basin Flume (Q = 98 cfs)
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.500000 ft/ft
Water Surface Elevation	0.20 ft
Elevation Range	0.00 to 3.00
Discharge	98.00 cfs



V:10.0
H:1
NTS

North Detention Basin Flume (Q = 98 cfs) **Worksheet for Irregular Channel**

Project Description	
Worksheet	North Detention Basin Flume (Q = 98 cfs)
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.500000 ft/ft
Discharge	98.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	0.20 ft
Elevation Range	0.00 to 3.00
Flow Area	4.1 ft ²
Wetted Perimeter	20.41 ft
Top Width	20.00 ft
Actual Depth	0.20 ft
Critical Elevation	0.91 ft
Critical Slope	0.003804 ft/ft
Velocity	23.98 ft/s
Velocity Head	8.93 ft
Specific Energy	9.14 ft
Froude Number	9.35
Flow Type	Supercritical

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00.0	0+20.0	0.015

Natural Channel Points	
Station (ft)	Elevation (ft)
0+00.0	3.00
0+00.0	0.00
0+20.0	0.00
0+20.0	3.00

North Detention Basin - Lone Mountain Road Flume

Worksheet for Rectangular Channel

Project Description

Worksheet	North Detention Basin - Lone Mountain Road Flume
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Mannings Coefficient	0.015
Channel Slope	0.250000 ft/ft
Bottom Width	20.00 ft
Discharge	207.00 cfs

Results

Depth	0.40 ft
Flow Area	7.9 ft ²
Wetted Perimeter	20.79 ft
Top Width	20.00 ft
Critical Depth	1.49 ft
Critical Slope	0.003453 ft/ft
Velocity	26.07 ft/s
Velocity Head	10.56 ft
Specific Energy	10.96 ft
Froude Number	7.29
Flow Type	Supercritical

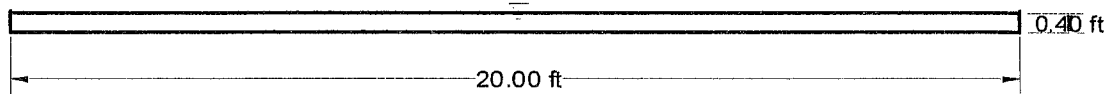
**North Detention Basin - Lone Mountain Road Flume
Cross Section for Rectangular Channel**

Project Description

Worksheet	North Detention Basin - Lone Mountain Road Flume
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.015
Channel Slope	0.250000 ft/ft
Depth	0.40 ft
Bottom Width	20.00 ft
Discharge	207.00 cfs



V:1
H:1
NTS

Balancing Conduit Outfall

Worksheet for Rectangular Channel

Project Description	
Worksheet	Balancing Conduit Outfall
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.015
Channel Slope	0.015000 ft/ft
Bottom Width	8.00 ft
Discharge	800.00 cfs

Results	
Depth	4.88 ft
Flow Area	39.0 ft ²
Wetted Perimeter	17.75 ft
Top Width	8.00 ft
Critical Depth	6.77 ft
Critical Slope	0.006494 ft/ft
Velocity	20.51 ft/s
Velocity Head	6.54 ft
Specific Energy	11.41 ft
Froude Number	1.64
Flow Type	Supercritical

Balancing Conduit Outfall

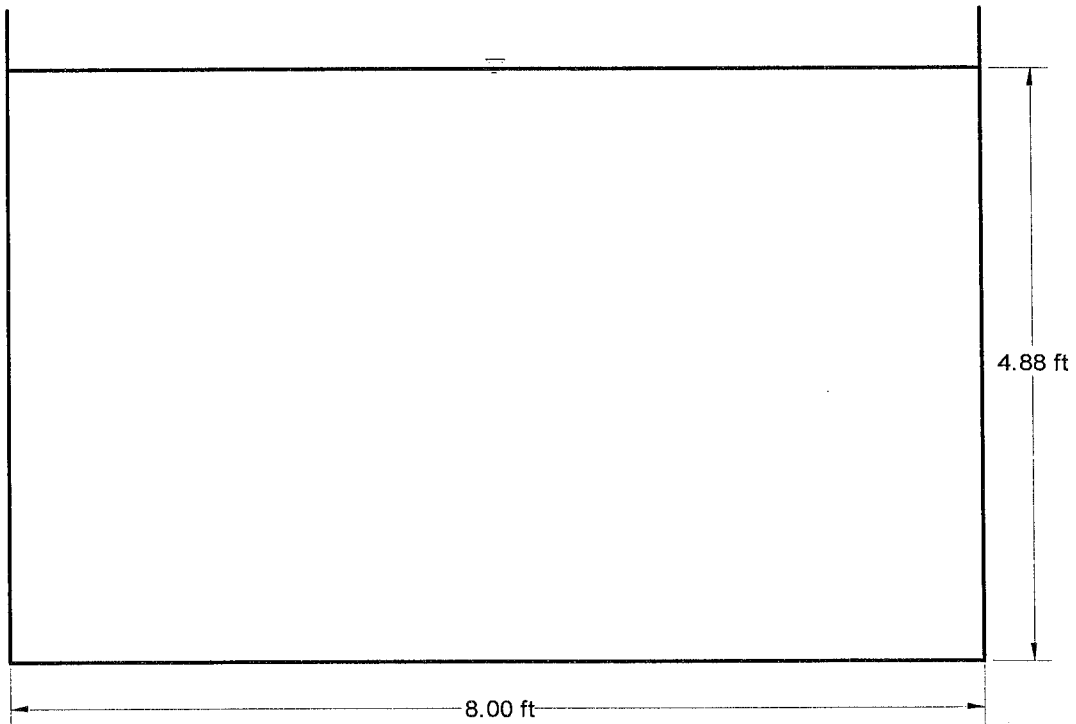
Cross Section for Rectangular Channel

Project Description

Worksheet	Balancing Conduit Outfall
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.015
Channel Slope	0.015000 ft/ft
Depth	4.88 ft
Bottom Width	8.00 ft
Discharge	800.00 cfs



V:1
H:1
NTS

Earthen Channel - South Detention Basin (LOW FLOW) **Worksheet for Circular Channel**

Project Description	
Worksheet	Earthen Channel - South Detention Basin (LOW FLOW)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

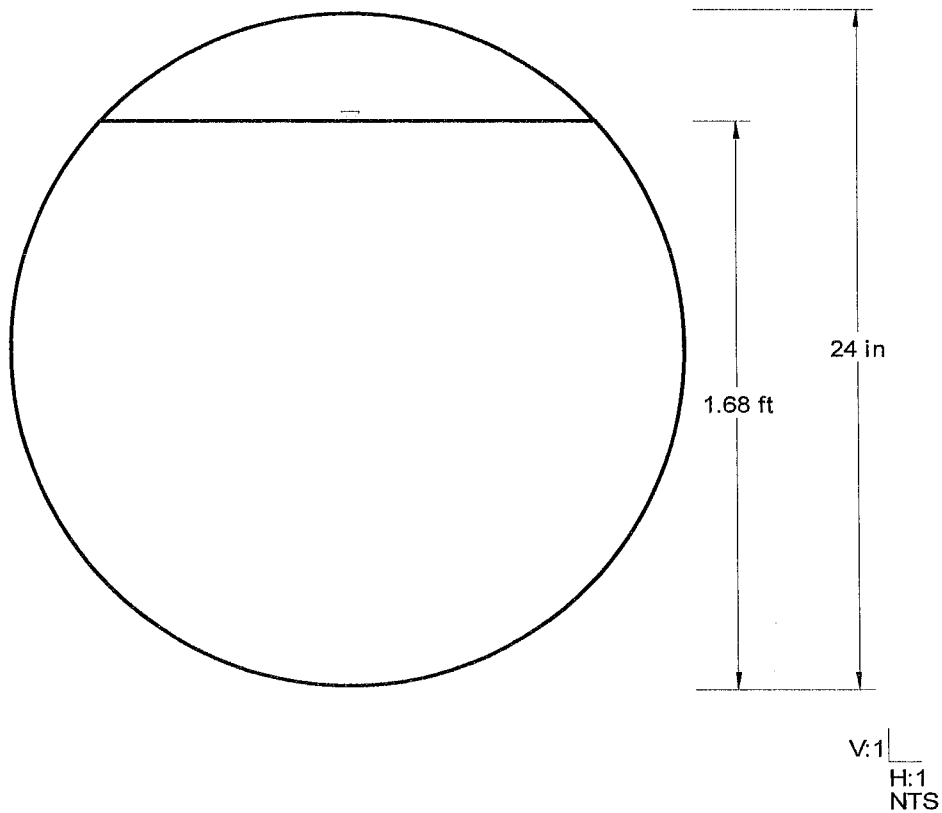
Input Data	
Mannings Coefficient	0.020
Channel Slope	0.010000 ft/ft
Diameter	24 in
Discharge	15.00 cfs

Results	
Depth	1.68 ft
Flow Area	2.8 ft²
Wetted Perimeter	4.63 ft
Top Width	0.00 ft
Critical Depth	1.40 ft
Percent Full	83.9 %
Critical Slope	0.014955 ft/ft
Velocity	5.33 ft/s
Velocity Head	0.44 ft
Specific Energy	2.12 ft
Froude Number	0.68
Maximum Discharge	15.82 cfs
Discharge Full	14.70 cfs
Slope Full	0.010407 ft/ft
Flow Type	Subcritical

Earthen Channel - South Detention Basin (LOW FLOW)
Cross Section for Circular Channel

Project Description	
Worksheet	Earthen Channel - South Detention Basin (LOW FLOW)
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.020
Channel Slope	0.010000 ft/ft
Depth	1.68 ft
Diameter	24 in
Discharge	15.00 cfs



Earthen Channel - South Detention Basin **Worksheet for Irregular Channel**

Project Description

Worksheet	Earthen Channel - South Detention Basin
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Channel Slope	0.010000 ft/ft
Discharge	475.00 cfs

Options

Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results

Mannings Coefficient	0.030
Water Surface Elevation	1.73 ft
Elevation Range	0.00 to 3.00
Flow Area	74.0 ft²
Wetted Perimeter	50.23 ft
Top Width	49.81 ft
Actual Depth	1.73 ft
Critical Elevation	1.65 ft
Critical Slope	0.011785 ft/ft
Velocity	6.42 ft/s
Velocity Head	0.64 ft
Specific Energy	2.37 ft
Froude Number	0.93
Flow Type	Subcritical

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+60	0.030

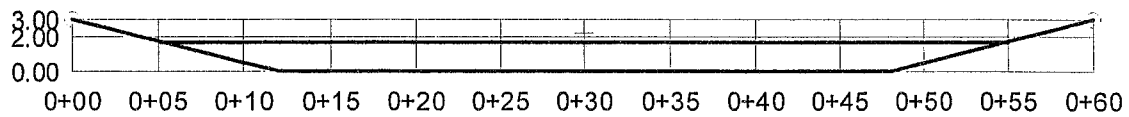
Natural Channel Points

Station (ft)	Elevation (ft)
0+00	3.00
0+12	0.00
0+48	0.00
0+60	3.00

Earthen Channel - South Detention Basin **Cross Section for Irregular Channel**

Project Description	
Worksheet	Earthen Channel - South Detention Basin
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.030
Channel Slope	0.010000 ft/ft
Water Surface Elevation	1.73 ft
Elevation Range	0.00 to 3.00
Discharge	475.00 cfs



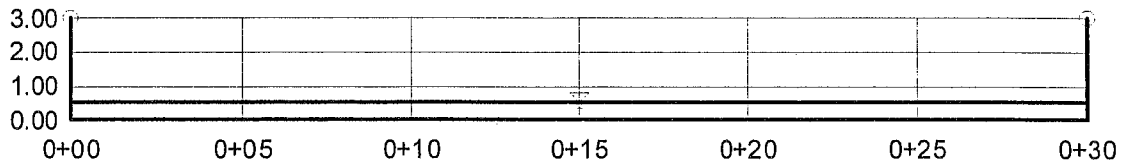
V:1
H:1
NTS

Peaceful Dawn Flume - South Detention Basin

Cross Section for Irregular Channel

Project Description	
Worksheet	Peaceful Dawn Flume - South Detention Basin
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.015
Channel Slope	0.250000 ft/ft
Water Surface Elevation	0.51 ft
Elevation Range	0.00 to 3.00
Discharge	475.00 cfs



V:1
H:1
NTS

Peaceful Dawn Flume - South Detention Basin

Worksheet for Irregular Channel

Project Description	
Worksheet	Peaceful Dawn Flume - South Detention Basin
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Channel Slope	0.250000 ft/ft
Discharge	475.00 cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Results	
Mannings Coefficient	0.015
Water Surface Elevation	0.51 ft
Elevation Range	0.00 to 3.00
Flow Area	15.3 ft ²
Wetted Perimeter	31.02 ft
Top Width	30.00 ft
Actual Depth	0.51 ft
Critical Elevation	1.98 ft
Critical Slope	0.003080 ft/ft
Velocity	30.97 ft/s
Velocity Head	14.90 ft
Specific Energy	15.42 ft
Froude Number	7.64
Flow Type	Supercritical

Roughness Segments		
Start Station	End Station	Mannings Coefficient
0+00	0+30	0.015

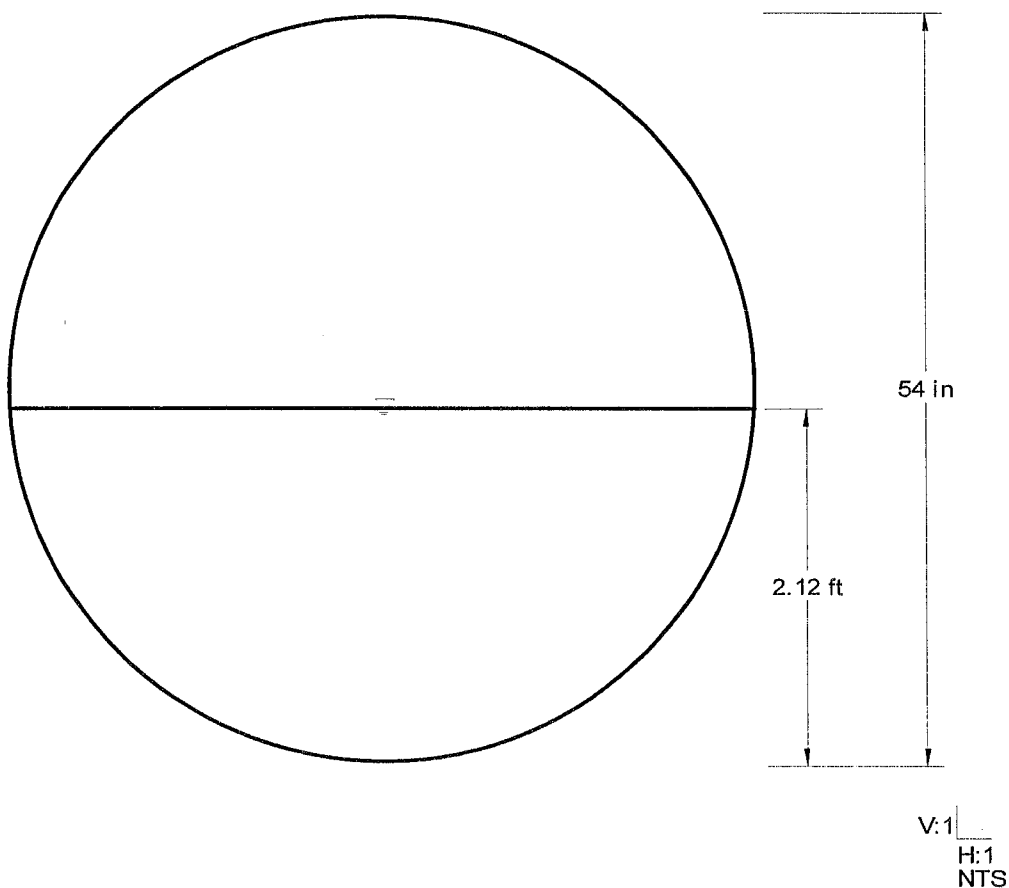
Natural Channel Points	
Station (ft)	Elevation (ft)
0+00	3.00
0+00	0.00
0+30	0.00
0+30	3.00

South Channel Flume

Cross Section for Circular Channel

Project Description	
Worksheet	South Channel Flume
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.013
Channel Slope	0.180000 ft/ft
Depth	2.12 ft
Diameter	54 in
Discharge	377.00 cfs



South Channel Flume

Worksheet for Circular Channel

Project Description	
Worksheet	South Channel Flume
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.013
Channel Slope	0.180000 ft/ft
Diameter	54 in
Discharge	377.00 cfs

Results	
Depth	2.12 ft
Flow Area	7.4 ft ²
Wetted Perimeter	6.81 ft
Top Width	0.00 ft
Critical Depth	4.45 ft
Percent Full	47.1 %
Critical Slope	0.033820 ft/ft
Velocity	51.13 ft/s
Velocity Head	40.62 ft
Specific Energy	42.75 ft
Froude Number	7.04
Maximum Discharge	897.43 cfs
Discharge Full	834.27 cfs
Slope Full	0.036757 ft/ft
Flow Type	Supercritical

South Detention Basin - Lone Mountain Road Flume **Worksheet for Rectangular Channel**

Project Description	
Worksheet	South Detention Basin - Lone Mountain Road Flume
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.015
Channel Slope	0.250000 ft/ft
Bottom Width	20.00 ft
Discharge	207.00 cfs

Results	
Depth	0.40 ft
Flow Area	7.9 ft ²
Wetted Perimeter	20.79 ft
Top Width	20.00 ft
Critical Depth	1.49 ft
Critical Slope	0.003453 ft/ft
Velocity	26.07 ft/s
Velocity Head	10.56 ft
Specific Energy	10.96 ft
Froude Number	7.29
Flow Type	Supercritical

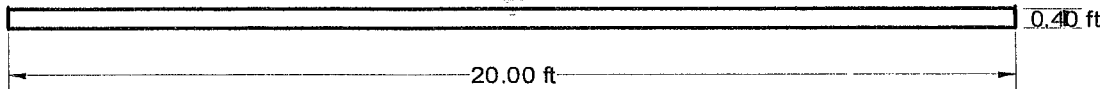
South Detention Basin - Lone Mountain Road Flume **Cross Section for Rectangular Channel**

Project Description

Worksheet	South Detention Basin - Lone Mountain Road Flume
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data

Mannings Coefficient	0.015
Channel Slope	0.250000 ft/ft
Depth	0.40 ft
Bottom Width	20.00 ft
Discharge	207.00 cfs



V:1
H:1
NTS

Outfall Analysis

$$H = V^2/2g + H_L$$

$$H_L = H_E + H_F + H_{EXP}$$

$$H_E = 0.2 (V^2/2g)$$

$$H_F = 29.1 (n^2) (L/r^{4/3}) (V^2/2g)$$

$$H_{EXP} = K_e (V^2/2g) ((A_2/A_1) - 1)^2 \quad - \quad K_e = 0.8, \quad A_2 = 23.75 \text{ FT}^2$$

$$V = Q_{MAX}/A_1 = 180/7.07 = 25.46 \text{ fps} \quad - \quad \text{FOR } 36" \text{ RCP}$$

$$r = A/WP = D/4 = 3/4$$

$$n = 0.010 - 0.013 \text{ (SMOOTH/NEW RCP TO ROUGH/OLD RCP)}$$

$$H \sim 37 \text{ FT}$$

$$V^2/2g = 10.06$$

$$H_E = 2.0 \text{ FT}$$

$$H_{EXP} = 3.97$$

$$H_F = 37 - (10.06 + 2.0 + 3.97) = 20.97 \text{ FT}$$

$$L = 434 \text{ FT} \quad - \quad \text{FOR } n \sim 0.0105$$

**WESTERN SEGMENT OF THE LAS VEGAS BELTWAY
CRAIG ROAD TO HUALAPAI WAY - ALIGNMENT 1**

FACILITIES COST ESTIMATE

FACILITY #	SHEET #	FACILITY DESCRIPTION	QUANTITY	UNIT	COST	TOTAL
1A	SD-1	TRANSITION 40' WIDE TO 20' WIDE RCC FLUME	119	CY	\$70.00	\$8,330.00
1B	SD-1	20' WIDE RCC FLUME	222	CY	\$70.00	\$15,540.00
1C	SD-1	(3) - 6'X3' RCB	210	LF	\$300.00	\$63,000.00
1D	SD-1	30' WIDE RCC FLUME	178	CY	\$70.00	\$12,460.00
1E	SD-1	GROUTED RIPRAP TRANSITION	96	CY	\$75.00	\$7,200.00
1F	SD-1	36" HDPE LOW FLOW CHANNEL	430	LF	\$90.00	\$38,700.00
1G	SD-1	30' WIDE RCC CHANNEL	385	CY	\$70.00	\$26,950.00
1H	SD-1	RIPRAP D50=12"	67	CY	\$52.00	\$3,484.00
2A	SD-1, 20	42" RCP STORM DRAIN	660	LF	\$105.00	\$69,300.00
2B	SD-1	6'X3' RCB	50	LF	\$300.00	\$15,000.00
3A	SD-2	(2) - 54" RCP STORM DRAIN	620	LF	\$145.00	\$89,900.00
3B	SD-2	ENERGY DISSIPATOR	1	LS	\$48,000.00	\$48,000.00
4A	SD-2, 20	54" RCP STORM DRAIN	1500	LF	\$145.00	\$217,500.00
5A	SD-2, 3	8'x8' RCB BALANCING CONDUIT	680	LF	\$533.00	\$362,440.00
5B	SD-3	NORTH DB RIPRAP - RIP RAP D50=12"	47	CY	\$52.00	\$2,444.00
5C	SD-2	SOUTH DB RIPRAP - RIP RAP D50=12"	47	CY	\$52.00	\$2,444.00
6A	SD-3	20' WIDE CHANNEL - RIP RAP D50=6"	59	CY	\$40.00	\$2,360.00
6B	SD-3	20' WIDE FLUME - CONCRETE	4600	SF	\$11.00	\$50,600.00
6C	SD-3	RIP RAP - D50=12"	44	CY	\$52.00	\$2,288.00
7A	SD-11	15' WIDE MAINTENANCE ACCESS RAMP	2	LS	\$31,875.00	\$63,750.00
7B	SD-10, 11	MAIN CHANNEL 12'x6' CHAN (STA 824+00 TO 833+50)	950	LF	\$336.00	\$319,200.00
7C	SD-9, 10	MAIN CHANNEL 12'x7' CHAN (STA 810+00 TO 824+00)	1400	LF	\$370.00	\$518,000.00
7D	SD-10	AZURE INFLOW 66" RCP	50	LF	\$160.00	\$8,000.00
7E	SD-8, 9	MAIN CHANNEL 14'x8' CHAN (STA 790+00 TO 810+00)	2000	LF	\$426.00	\$852,000.00
7F	SD-9	TROPICAL INFLOW 66" RCP	50	LF	\$160.00	\$8,000.00
7G	SD-7, 8	MAIN CHANNEL 14'x10' CHANNEL (STA 781+50 TO 790+00)	850	LF	\$494.00	\$419,900.00
7H	SD-8	EL CAMPO 48" RCP LATERAL	50	LF	\$125.00	\$6,250.00
7I	SD-7	MAIN CHANNEL 14'x10' CHANNEL (STA 779+50 TO 781+50)	200	LF	\$494.00	\$98,800.00
7J	SD-7	ANN - 8'X8' RCB	100	LF	\$533.00	\$53,300.00
7K	SD-6, 7	MAIN CH 14'x10' CHANNEL (STA 763+00 TO 779+50)	1650	LF	\$494.00	\$815,100.00
7L	SD-6	HAMMER (2) - 72" RCP LATERAL	200	LF	\$165.00	\$33,000.00
7M	SD-5, 6	MAIN CH 14'x10' CHANNEL (STA 743+00 TO 763+00)	2000	LF	\$494.00	\$988,000.00
7N	SD-5	WASHBURN - 72" RCP LATERAL	100	LF	\$165.00	\$16,500.00
7O	SD-4, 5	MAIN CHANNEL 10'x10' RCB (STA 728+50 TO 743+00)	1450	LF	\$667.00	\$967,150.00
7P	SD-4	ENERGY DISSIPATOR	1	LS	\$67,000.00	\$67,000.00
8A	SD-2	30' WIDE RCC FLUME	600	CY	\$70.00	\$42,000.00
8B	SD-2	RIPRAP - D50=12"	44	CY	\$52.00	\$2,288.00
8C	SD-2	2' CURB OPENING SECTIONS	30	EA	\$1,150.00	\$34,500.00

9A	SD-3	30' WIDE RCC FLUME	511	CY	\$70.00	\$35,770.00
9B	SD-3	RIPRAP - D50=12"	44	CY	\$52.00	\$2,288.00
9C	SD-3	2' CURB OPENING SECTIONS	30	EA	\$1,150.00	\$34,500.00
	SD-1 TO 3	EXCAVATION	1204000	CY	\$2.00	\$2,408,000.00
	SD-1 TO 3	EMBANKMENT	880000	CY	\$4.00	\$3,520,000.00
					TOTAL	\$12,351,236.00

**WESTERN SEGMENT OF THE LAS VEGAS BELTWAY
CRAIG ROAD TO HUALAPAI WAY - ALIGNMENT 2**

FACILITIES COST ESTIMATE

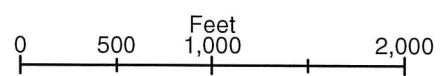
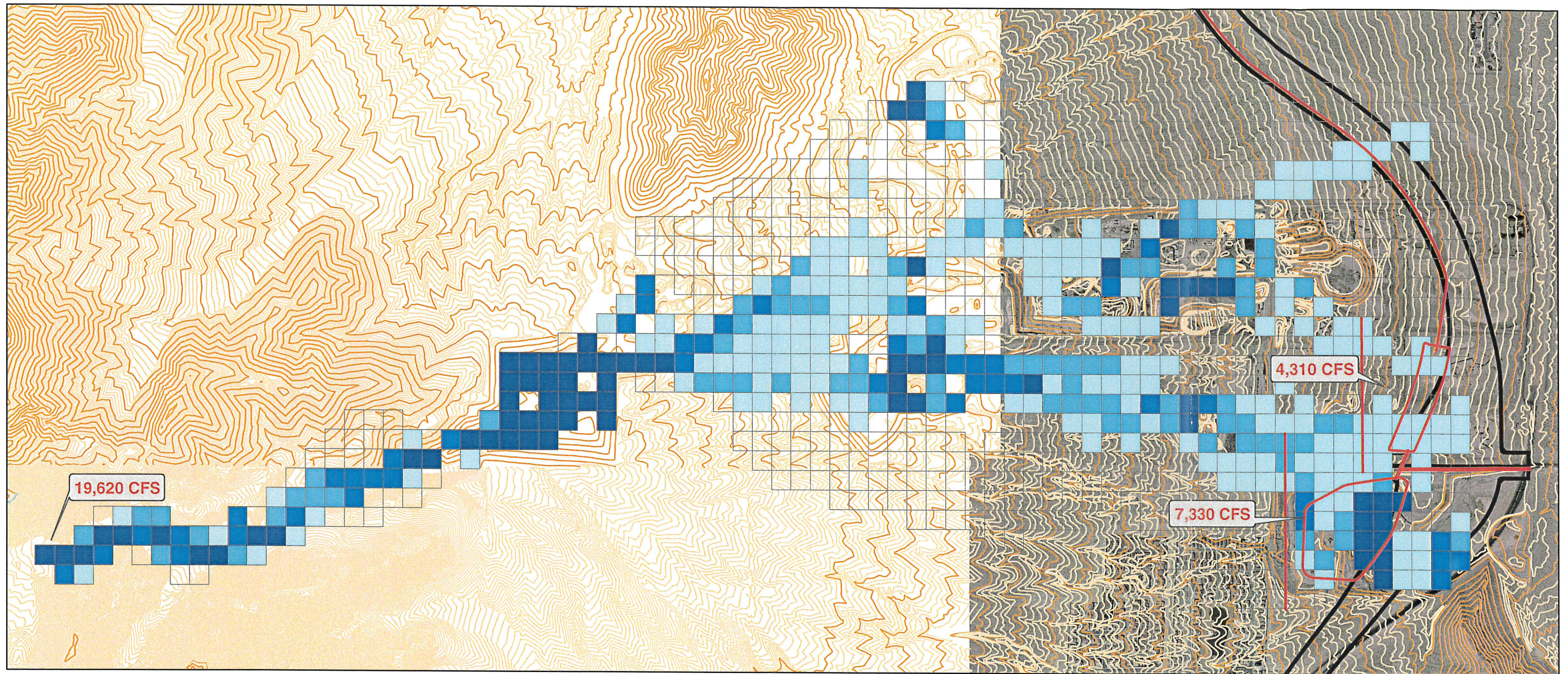
FACILITY #	SHEET #	FACILITY DESCRIPTION	QUANTITY	UNIT	COST	TOTAL
1A	SD-1	TRANSITION 40' WIDE TO 20' WIDE RCC FLUME	119	CY	\$70.00	\$8,330.00
1B	SD-1	20' WIDE RCC FLUME	222	CY	\$70.00	\$15,540.00
1C	SD-1	(3) - 6'X3' RCB	210	LF	\$300.00	\$63,000.00
1D	SD-1	30' WIDE RCC FLUME	178	CY	\$70.00	\$12,460.00
1E	SD-1	GROUTED RIPRAP TRANSITION	96	CY	\$75.00	\$7,200.00
1F	SD-1	36" HDPE LOW FLOW CHANNEL	430	LF	\$90.00	\$38,700.00
1G	SD-1	30' WIDE RCC CHANNEL	385	CY	\$70.00	\$26,950.00
1H	SD-1	RIPRAP D50=12"	67	CY	\$52.00	\$3,484.00
2A	SD-1, 20	42" RCP STORM DRAIN	660	LF	\$105.00	\$69,300.00
2B	SD-1	6'X3' RCB	50	LF	\$300.00	\$15,000.00
3A	SD-2	(2) - 54" RCP STORM DRAIN	620	LF	\$145.00	\$89,900.00
3B	SD-2	ENERGY DISSIPATOR	1	LS	\$48,000.00	\$48,000.00
4A	SD-2, 20	54" RCP STORM DRAIN	1500	LF	\$145.00	\$217,500.00
5A	SD-2, 3	8'x8' RCB BALANCING CONDUIT	680	LF	\$533.00	\$362,440.00
5B	SD-3	NORTH DB RIPRAP - RIP RAP D50=12"	47	CY	\$52.00	\$2,444.00
5C	SD-2	SOUTH DB RIPRAP - RIP RAP D50=12"	47	CY	\$52.00	\$2,444.00
6A	SD-3	20' WIDE CHANNEL - RIP RAP D50=6"	59	CY	\$40.00	\$2,360.00
6B	SD-3	20' WIDE FLUME - CONCRETE	4600	SF	\$11.00	\$50,600.00
6C	SD-3	RIP RAP - D50=12"	44	CY	\$52.00	\$2,288.00
7A	SD-11	15' WIDE MAINTENANCE ACCESS RAMP	2	LS	\$31,875.00	\$63,750.00
7B	SD-10, 11	MAIN CHANNEL 8'x6' RCB (STA 824+00 TO 833+50)	950	LF	\$466.00	\$442,700.00
7C	SD-9, 10	MAIN CHANNEL 10'x6' RCB (STA 810+00 TO 824+00)	1400	LF	\$533.00	\$746,200.00
7D	SD-10	AZURE INFLOW 66" RCP	50	LF	\$160.00	\$8,000.00
7E	SD-8, 9	MAIN CHANNEL 10'x8' RCB (STA 790+00 TO 810+00)	2000	LF	\$600.00	\$1,200,000.00
7F	SD-9	TROPICAL INFLOW 66" RCP	50	LF	\$160.00	\$8,000.00
7G	SD-7, 8	MAIN CHANNEL 12'x8' RCB (STA 781+50 TO 790+00)	850	LF	\$667.00	\$566,950.00
7H	SD-8	EL CAMPO 48" RCP LATERAL	50	LF	\$125.00	\$6,250.00
7I	SD-7	MAIN CHANNEL 14'x8' RCB (STA 779+50 TO 781+50)	200	LF	\$733.00	\$146,600.00
7J	SD-7	ANN - 8'X8' RCB	100	LF	\$533.00	\$53,300.00
7K	SD-6, 7	MAIN CH 14'x10' CHANNEL(STA 763+00 TO 779+50)	1650	LF	\$494.00	\$815,100.00
7L	SD-6	HAMMER (2) - 72" RCP LATERAL	200	LF	\$165.00	\$33,000.00
7M	SD-5, 6	MAIN CH 14'x10' CHANNEL (STA 743+00 TO 763+00)	2000	LF	\$494.00	\$988,000.00
7N	SD-5	WASHBURN - 72" RCP LATERAL	100	LF	\$165.00	\$16,500.00
7O	SD-4, 5	MAIN CHANNEL 10'x10' RCB (STA 728+50 TO 743+00)	1450	LF	\$667.00	\$967,150.00
7P	SD-4	ENERGY DISSIPATOR	1	LS	\$67,000.00	\$67,000.00
8A	SD-2	30' WIDE RCC FLUME	600	CY	\$70.00	\$42,000.00
8B	SD-2	RIPRAP - D50=12"	44	CY	\$52.00	\$2,288.00
8C	SD-2	2' CURB OPENING SECTIONS	30	EA	\$1,150.00	\$34,500.00

9A	SD-3	30' WIDE RCC FLUME	511	CY	\$70.00	\$35,770.00
9B	SD-3	RIPRAP - D50=12"	44	CY	\$52.00	\$2,288.00
9C	SD-3	2' CURB OPENING SECTIONS	30	EA	\$1,150.00	\$34,500.00
	SD-1 TO 3	EXCAVATION	1204000	CY	\$2.00	\$2,408,000.00
	SD-1 TO 3	EMBANKMENT	880000	CY	\$4.00	\$3,520,000.00
					TOTAL	\$13,245,786.00

APPENDIX D

Spillway Facilities

FLO-2D Figures
Flowmaster Calculations

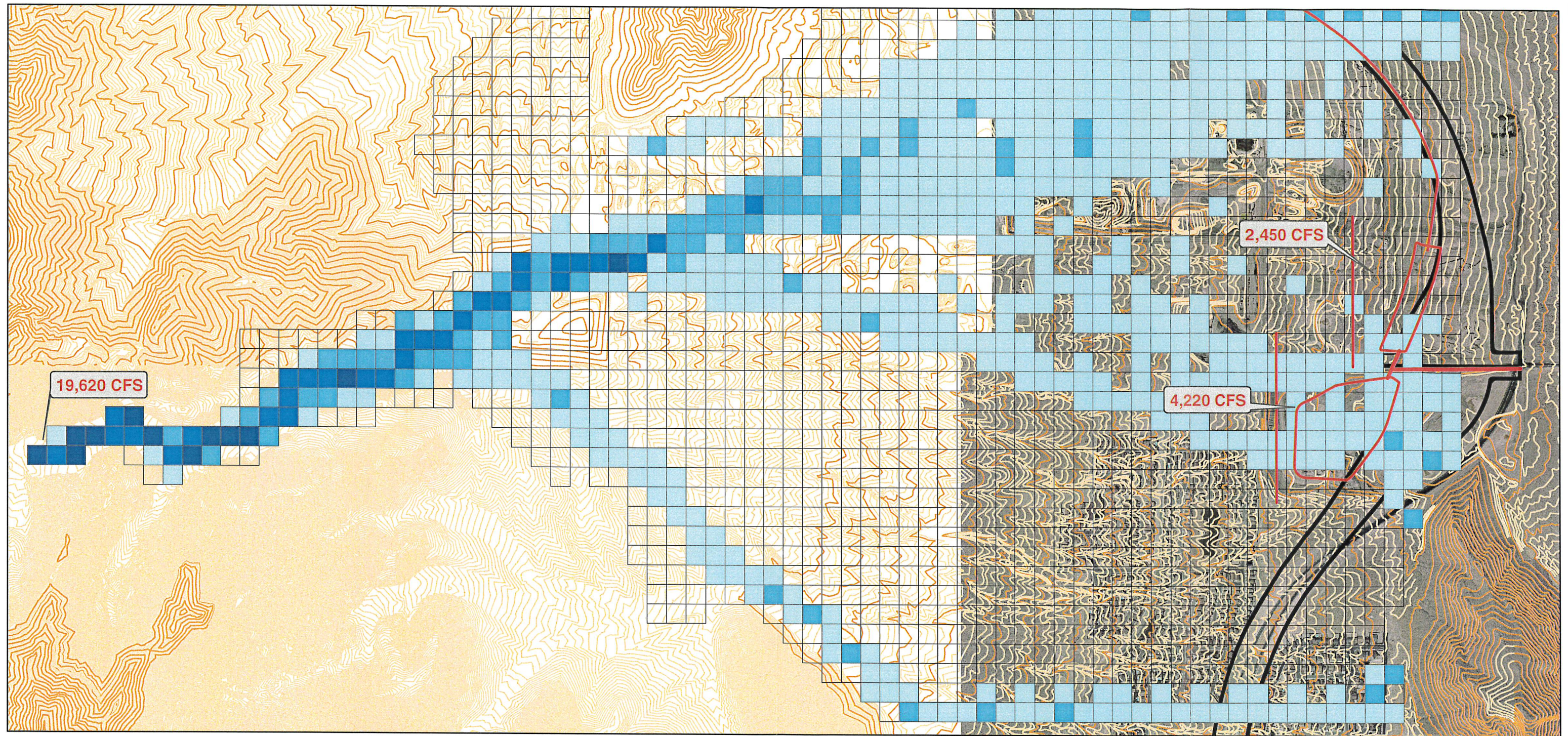


FLO-2D ANALYSIS

WITH 5-FOOT CLARK
COUNTY CONTOURS

 G.C. WALLACE, INC.
Engineers/Planners/Surveyors 1555 SOUTH HARBOR BLVD., LAS VEGAS, NEVADA 89145

G:\451-002\DRAINAGE\GIS\FLO-2D-5.MXD



0 500 1,000 2,000
Feet

FLO-2D ANALYSIS

WITH 20-FOOT USGS
CONTOURS

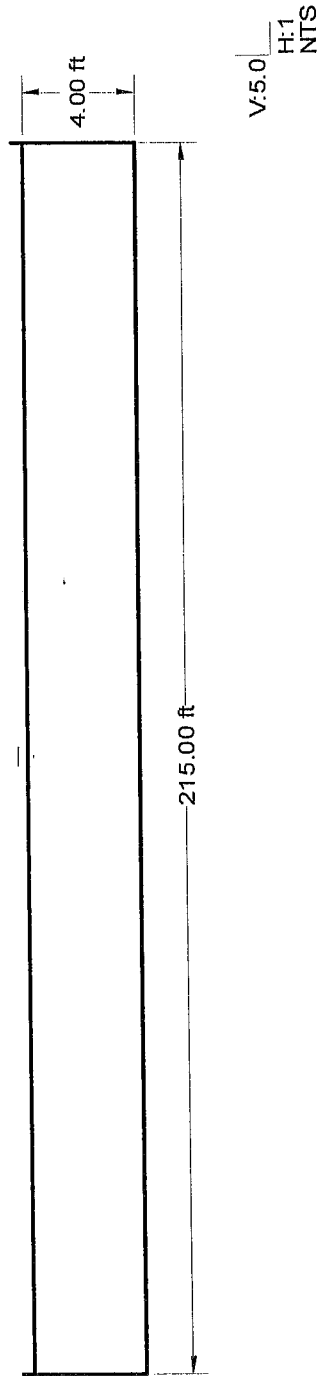
 G.C. WALLACE, INC.
Engineers/Planners/Surveyors 1000 SOUTH HANSON BLVD., LAS VEGAS, NEVADA 89146

G:\451-002\DRAINAGE\GIS\FLO-2D-20.MXD

NORTH SPILLWAY - SECTION 1 Cross Section for Broad Crested Weir

Project Description	
Worksheet	NORTH SPILLWAY - SECTION 1
Type	Broad Crested Weir
Solve For	Discharge

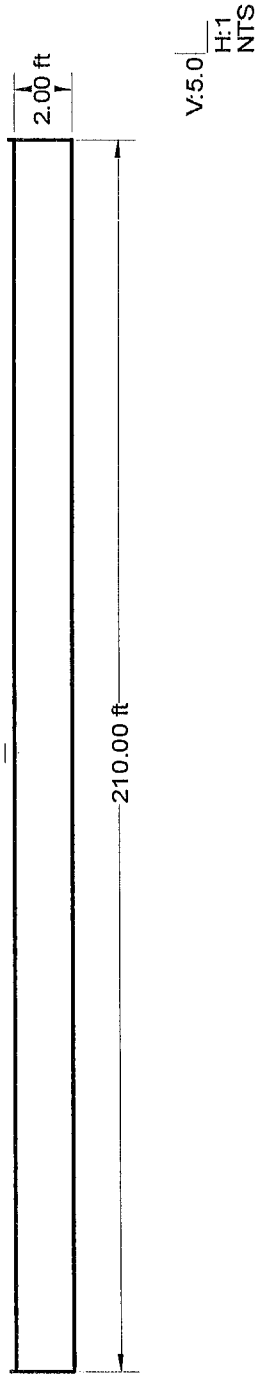
Section Data	
Discharge	5,309.64 cfs
Headwater Elevation	2,742.00 ft
Crest Elevation	2,738.00 ft
Tailwater Elevation	2,741.00 ft
Crest Surface Type	Paved
Crest Breadth	10.00 ft
Crest Length	215.00 ft



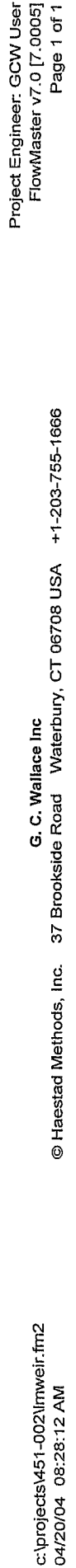
NORTH SPILLWAY - SECTION 2 Cross Section for Broad Crested Weir

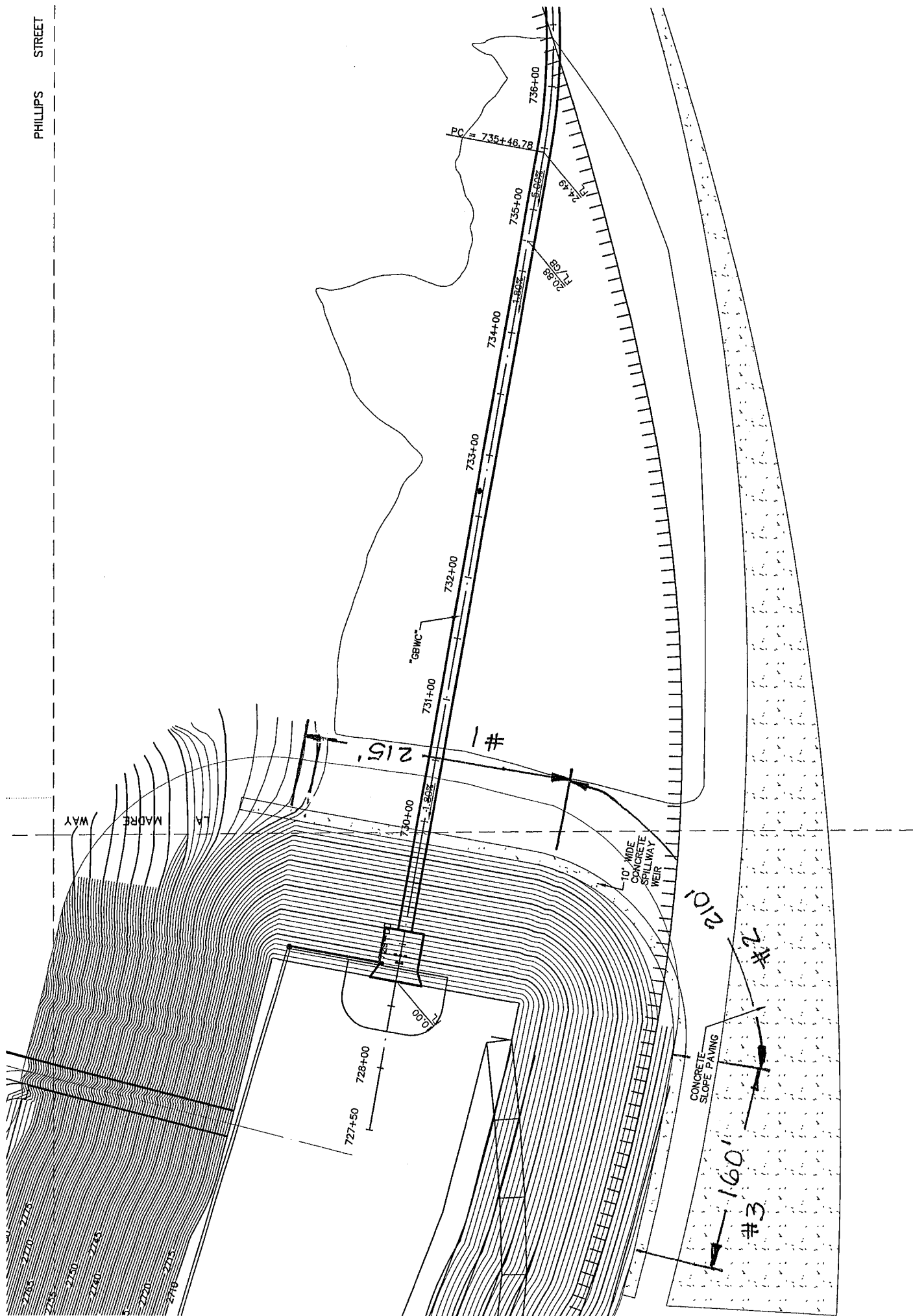
Project Description	
Worksheet	NORTH SPILLWAY - SECTION 2
Type	Broad Crested Weir
Solve For	Discharge

Section Data	
Discharge	1,820.52 cfs
Headwater Elevation	2,742.00 ft
Crest Elevation	2,740.00 ft
Tailwater Elevation	2,741.00 ft
Crest Surface Type	Paved
Crest Breadth	10.00 ft
Crest Length	210.00 ft



Project Description	
Worksheet	NORTH SPILLWAY - SECTION 1
Type	Broad Crested Weir
Solve For	Discharge
Section Data	
Discharge	223.29 cfs
Headwater Elevation	2,742.00 ft
Crest Elevation	2,741.50 ft
Tailwater Elevation	2,741.00 ft
Crest Surface Type	Paved
Crest Breadth	10.00 ft
Crest Length	210.00 ft

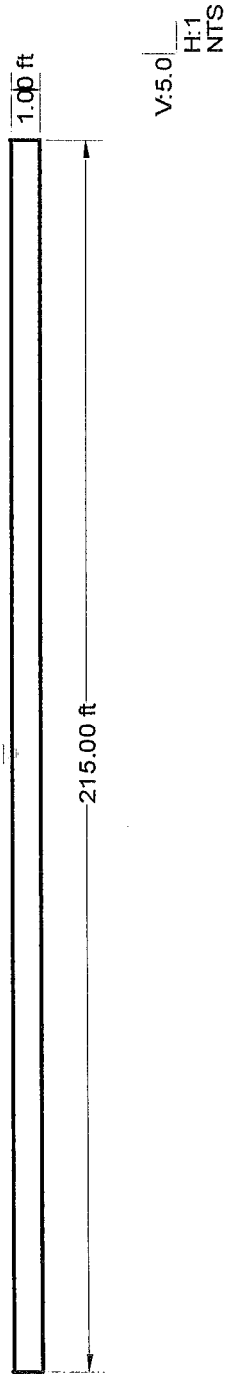




NORTH SPILLWAY - SECTION 1 Cross Section for Broad Crested Weir

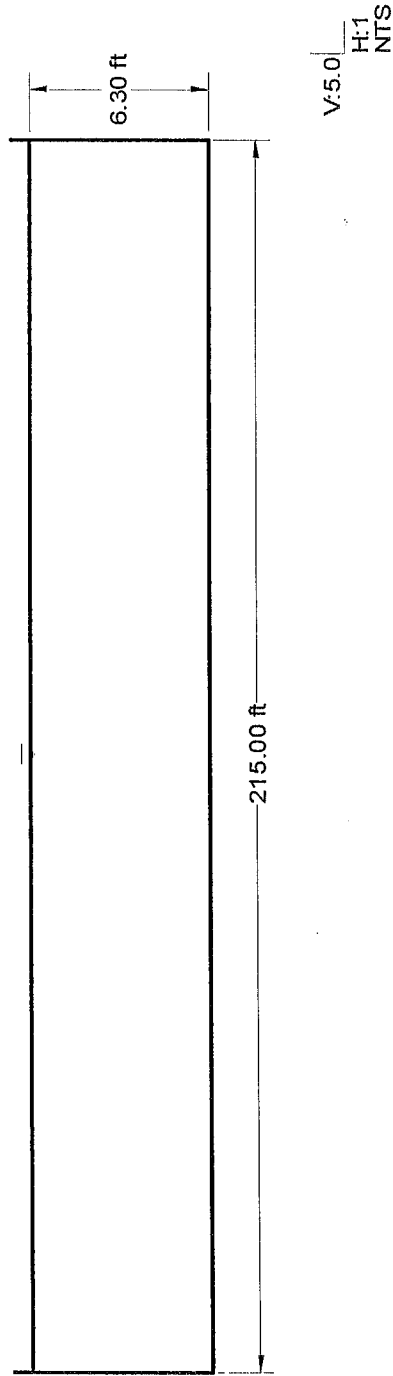
Project Description	
Worksheet	NORTH SPILLWAY - SECTION 1
Type	Broad Crested Weir
Solve For	Discharge

Section Data	
Discharge	652.95 cfs
Headwater Elevation	2,739.00 ft
Crest Elevation	2,738.00 ft
Tailwater Elevation	2,738.70 ft
Crest Surface Type	Paved
Crest Breadth	10.00 ft
Crest Length	215.00 ft



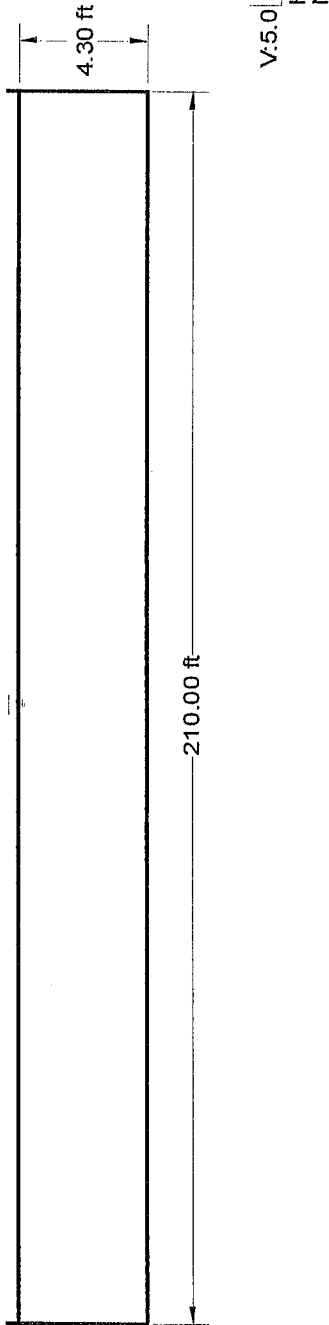
NORTH SPILLWAY - SECTION 1 Cross Section for Broad Crested Weir

Project Description	
Worksheet	NORTH SPILLWAY - SECTION 1
Type	Broad Crested Weir
Solve For	Discharge
Section Data	
Discharge	10,495.08 cfs
Headwater Elevation	2,744.30 ft
Crest Elevation	2,738.00 ft
Tailwater Elevation	2,738.70 ft
Crest Surface Type	Paved
Crest Breadth	10.00 ft
Crest Length	215.00 ft



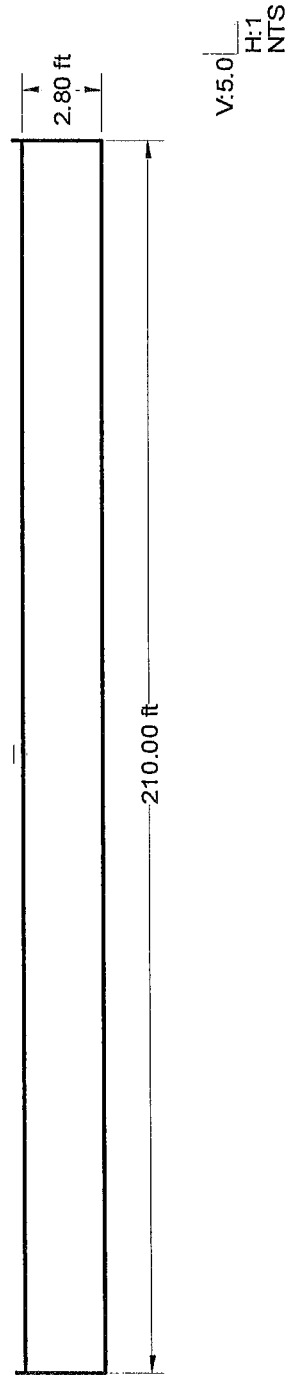
NORTH SPILLWAY - SECTION 2

Project Description		NORTH SPILLWAY - SECTION 10
Worksheet		Broad Crested Weir
Type		Discharge
Solve For		
Section Data		
Discharge	5,780.41 cfs	
Headwater Elevation	2,744.30 ft	
Crest Elevation	2,740.00 ft	
Tailwater Elevation	2,741.00 ft	
Crest Surface Type	Paved	
Crest Breadth	10.00 ft	
Crest Length	210.00 ft	



NORTH SPILLWAY - SECTION 3

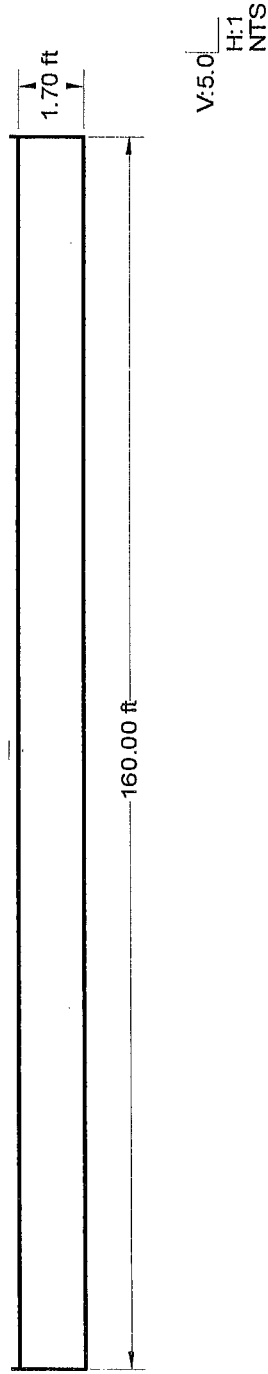
Project Description	NORTH SPILLWAY - SECTION 1	
Worksheet	Broad Crested Weir	
Type	Discharge	
Solve For		
Section Data		
Discharge	3,035.37 cfs	
Headwater Elevation	2,744.30 ft	
Crest Elevation	2,741.50 ft	
Tailwater Elevation	2,741.00 ft	
Crest Surface Type	Paved	
Crest Breadth	10.00 ft	
Crest Length	210.00 ft	



SOUTH SPILLWAY - SECTION 1 **Cross Section for Broad Crested Weir**

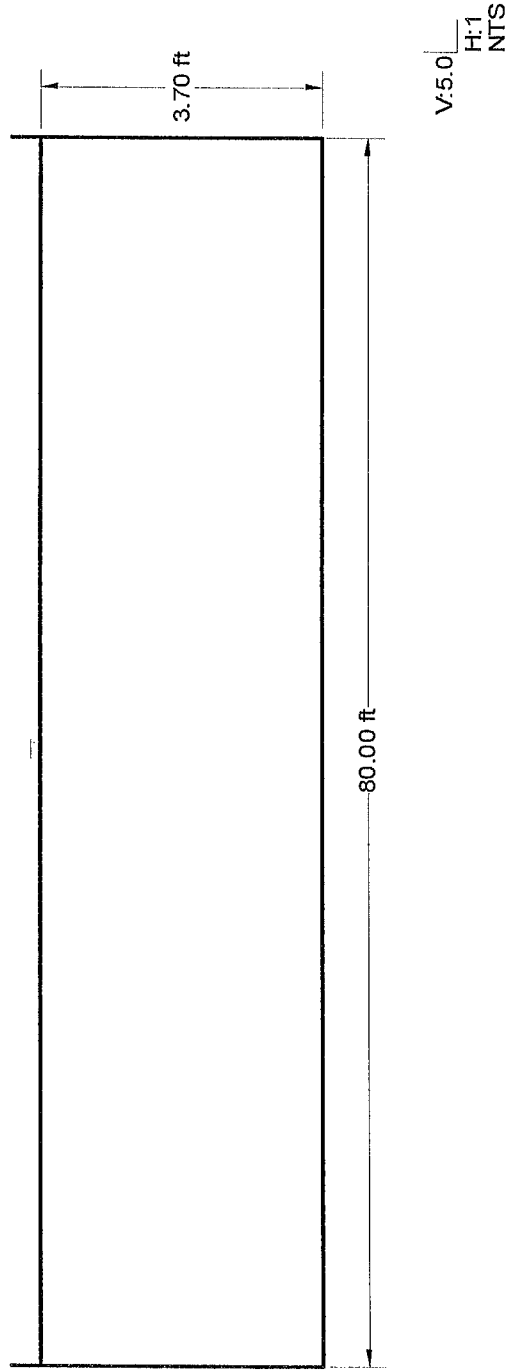
Project Description	
Worksheet	SOUTH SPILLWAY - SECTION 1
Type	Broad Crested Weir
Solve For	Discharge

Section Data	
Discharge	1,084.39 cfs
Headwater Elevation	2,745.20 ft
Crest Elevation	2,743.50 ft
Tailwater Elevation	2,744.00 ft
Crest Surface Type	Paved
Crest Breadth	10.00 ft
Crest Length	160.00 ft



SOUTH SPILLWAY - SECTION 2 Cross Section for Broad Crested Weir

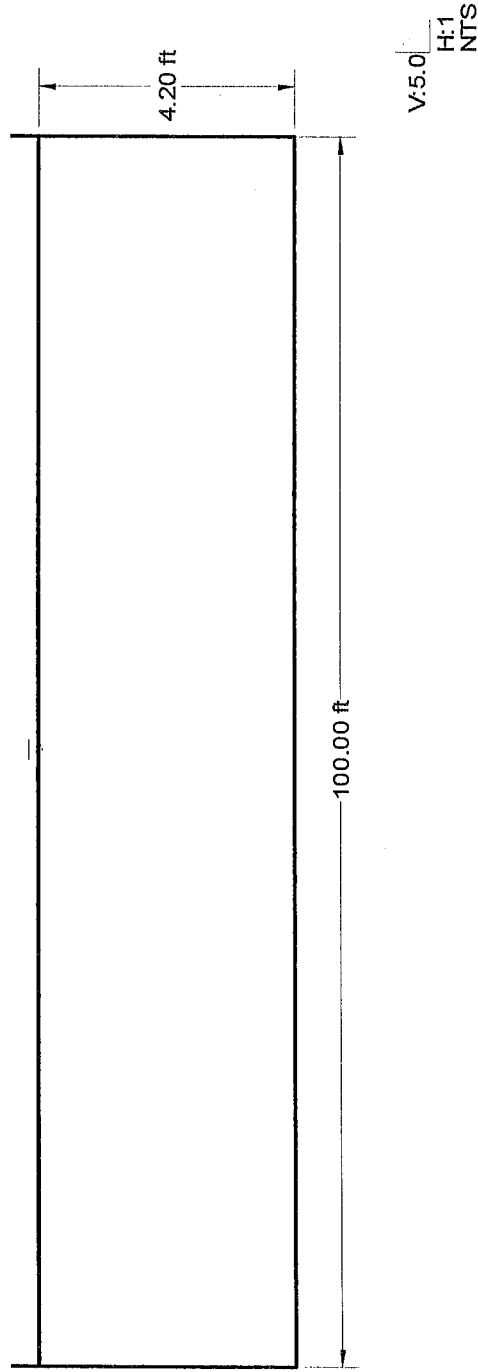
Project Description		
Worksheet	SOUTH SPILLWAY - SECTION 2	
Type	Broad Crested Weir	
Solve For	Discharge	
Section Data		
Discharge	1,757.64 cfs	
Headwater Elevation	2,745.20 ft	
Crest Elevation	2,741.50 ft	
Tailwater Elevation	2,744.00 ft	
Crest Surface Type	Paved	
Crest Breadth	10.00 ft	
Crest Length	80.00 ft	



SOUTH SPILLWAY - SECTION 3 Cross Section for Broad Crested Weir

Project Description		
Worksheet	SOUTH SPILLWAY - SECTION 3	
Type	Broad Crested Weir	
Solve For	Discharge	

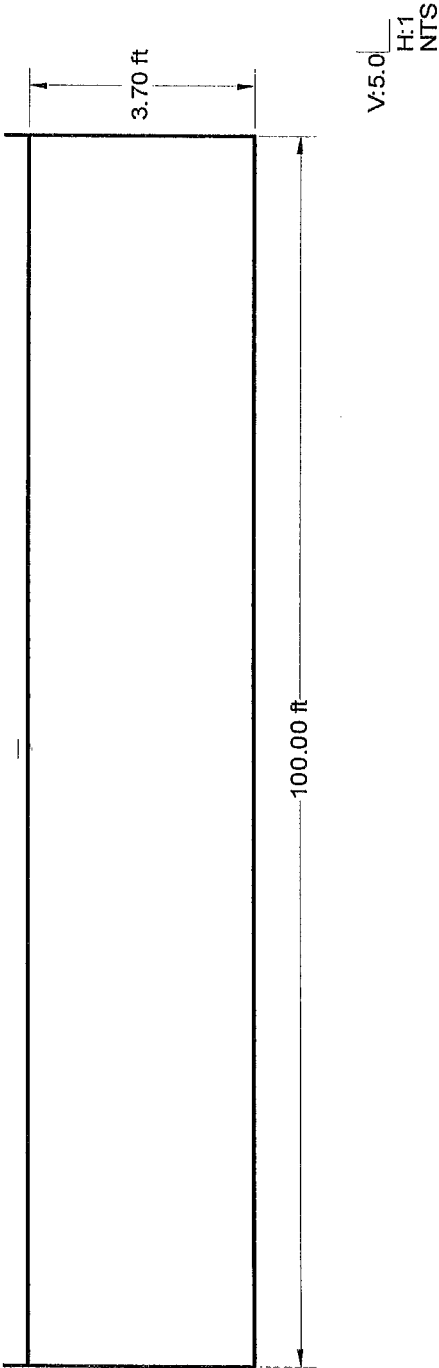
Section Data		
Discharge	2,657.12	cfs
Headwater Elevation	2,745.20	ft
Crest Elevation	2,741.00	ft
Tailwater Elevation	2,744.00	ft
Crest Surface Type	Paved	
Crest Breadth	10.00	ft
Crest Length	100.00	ft



SOUTH SPILLWAY - SECTION 4 **Cross Section for Broad Crested Weir**

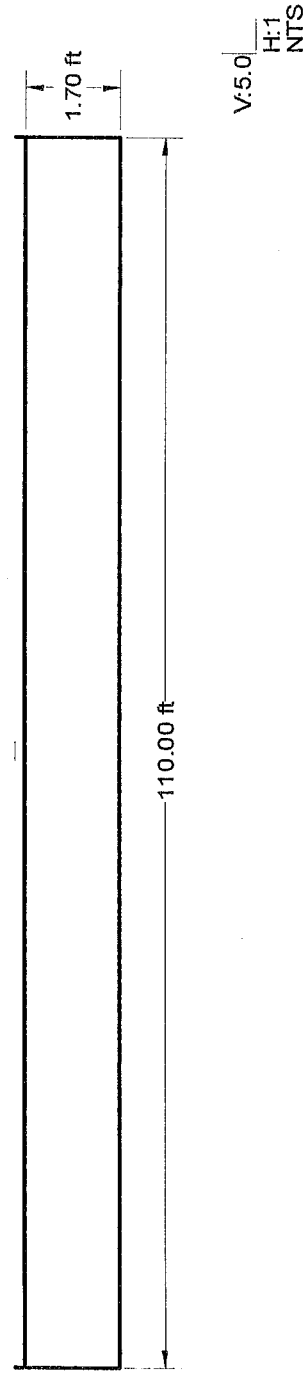
Project Description		
Worksheet	SOUTH SPILLWAY - SECTION 4	
Type	Broad Crested Weir	
Solve For	Discharge	

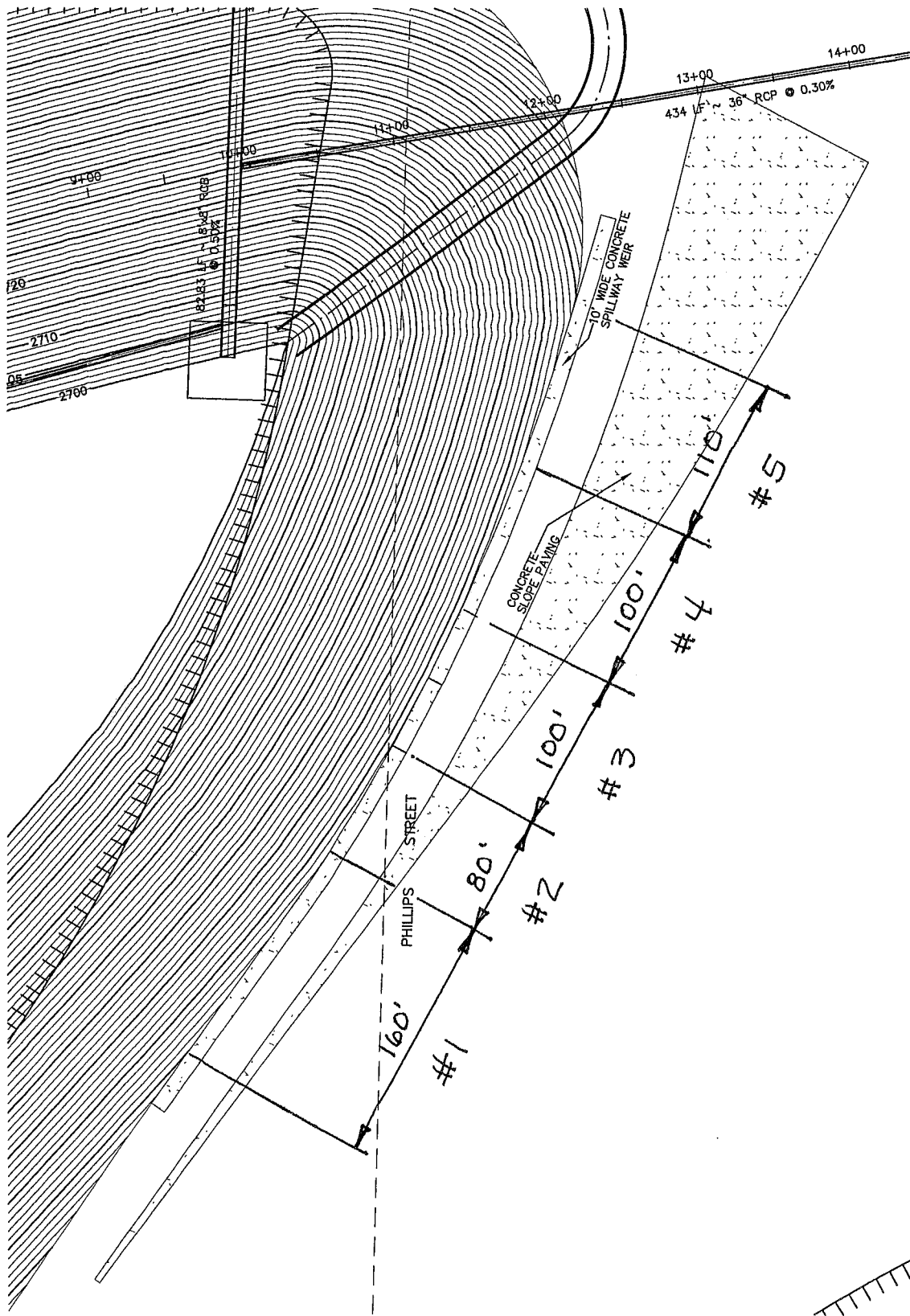
Section Data		
Discharge	2,197.05	cfs
Headwater Elevation	2,745.20	ft
Crest Elevation	2,741.50	ft
Tailwater Elevation	2,744.00	ft
Crest Surface Type	Paved	
Crest Breadth	10.00	ft
Crest Length	100.00	ft



SOUTH SPILLWAY - SECTION 5

Project Description	SOUTH SPILLWAY - SECTION 1		
Worksheet	Broad Crested Weir		
Type	Discharge		
Solve For			
Section Data			
Discharge	745.52	cfs	
Headwater Elevation	2,745.20	ft	
Crest Elevation	2,743.50	ft	
Tailwater Elevation	2,744.00	ft	
Crest Surface Type	Paved		
Crest Breadth	10.00	ft	
Crest Length	110.00	ft	





APPENDIX E

Reference Materials

**ADDENDUM #1 TO THE
TECHNICAL DRAINAGE
STUDY
for
CLIFF SHADOWS FOUR-PLEX
CITY OF LAS VEGAS, NEVADA
Project Number: 1281-001-032
December 2003**

Prepared For: Cliff Shadows Properties, LLC
2775 South Jones Boulevard, Suite 101
Las Vegas, NV 89146
(702) 873-7834

Prepared By: David W. Trushaw, P.E.
L.R. Nelson Consulting Engineers
3035 E. Patrick Lane, Suite 9
Las Vegas, Nevada 89120
(702) 798-7978

**ADDENDUM #5 TO THE
TECHNICAL HYDROLOGY STUDY**

FOR

**MONUMENT @ LONE MOUNTAIN WEST
UNITS 1 AND 5**

CITY OF LAS VEGAS, NEVADA

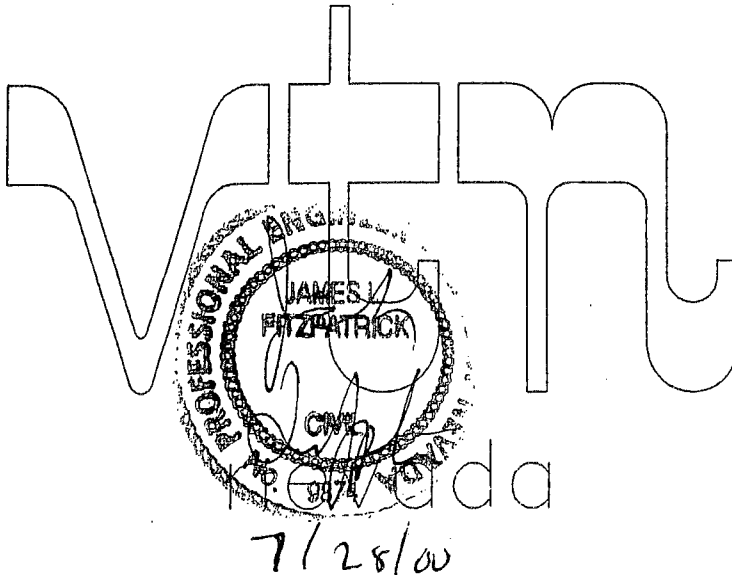
W.O. #5630

Prepared for:

STANPARK HOMES, INC.

Submitted to:

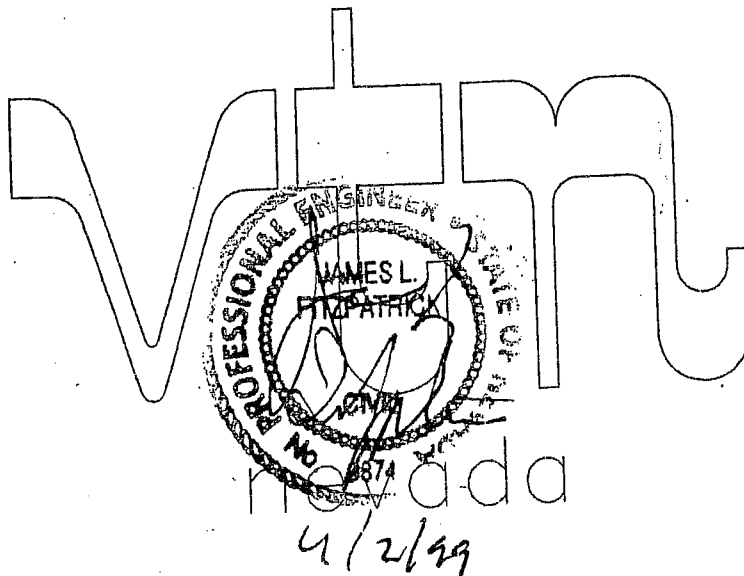
**PUBLIC WORKS DEPT.
CITY OF LAS VEGAS, NV.**



MASTER DRAINAGE STUDY
FOR
LONE MOUNTAIN WEST
CITY OF LAS VEGAS, NEVADA
W.O. #5545

Prepared for:
FOCUS GROUP

Submitted to:
PUBLIC WORKS DEPT.
CITY OF LAS VEGAS, NV.



LONE MOUNTAIN RD: 100 YR FLOW

Worksheet for Irregular Channel

Project Description	
Project File	j:\haestad\fmw\5545.fm2
Worksheet	100' R/W STREET- NORMAL CROWN
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

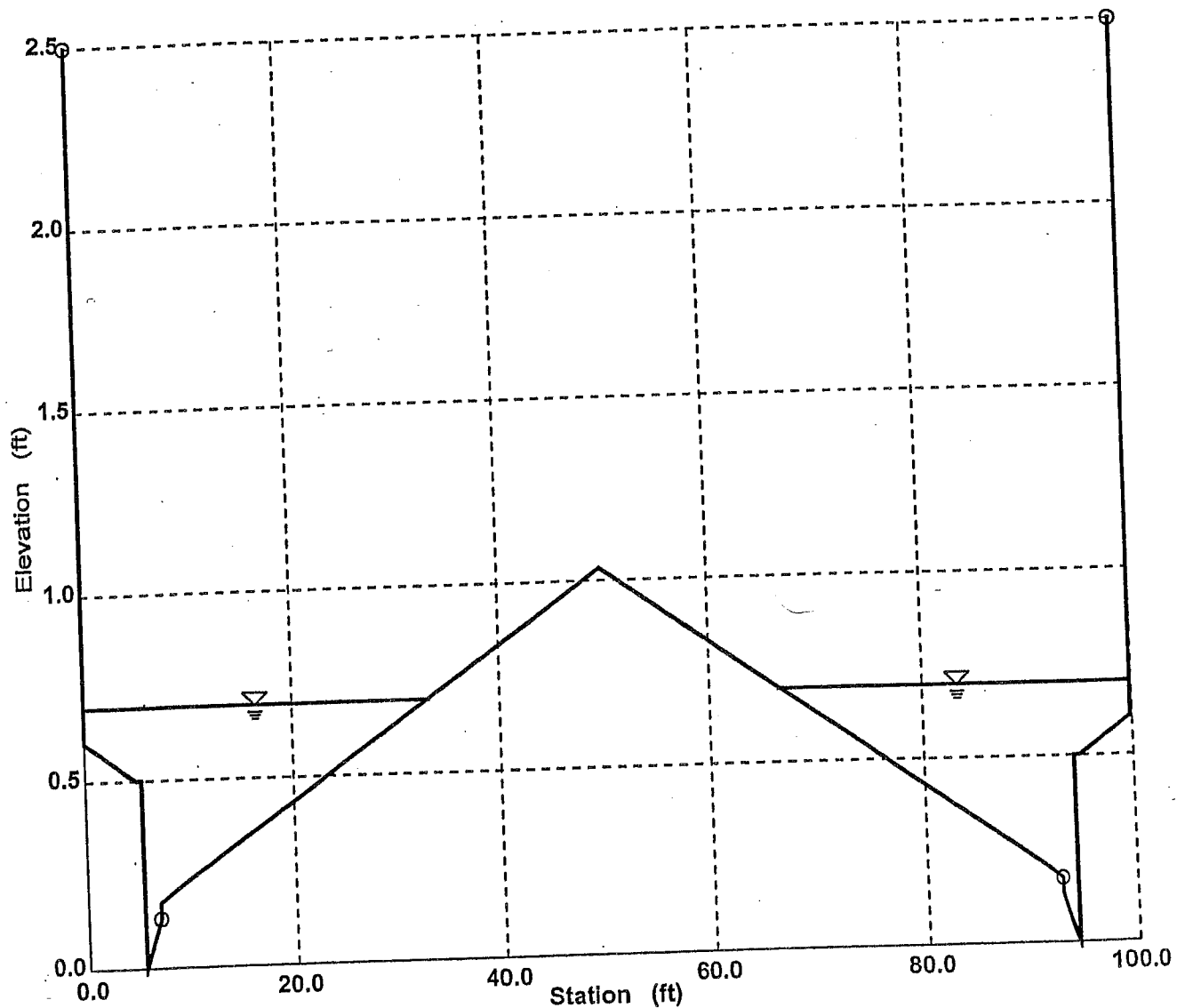
Input Data				
Channel Slope		0.057000 ft/ft		
Elevation range: 0.00 ft to 2.50 ft.				
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
0.00	2.50	0.00	7.02	0.013
0.01	0.60	7.02	92.99	0.016
5.01	0.50	92.99	100.00	0.013
5.51	0.50			
5.52	0.00			
7.02	0.13			
7.02	0.17			
50.00	1.03			
92.99	0.17			
93.00	0.13			
94.49	0.00			
94.50	0.50			
95.00	0.50			
99.99	0.60			
100.00	2.50			
Discharge	414.00	cfs		

Results		
Wtd. Mannings Coefficient	0.015	
Water Surface Elevation	0.91	ft
Flow Area	34.00	ft ²
Wetted Perimeter	89.77	ft
Top Width	88.07	ft
Height	0.91	ft
Critical Depth	1.39	ft
Critical Slope	0.003845	ft/ft
Velocity	12.18	ft/s
Velocity Head	2.30	ft
Specific Energy	3.21	ft
Froude Number	3.45	
Flow is supercritical.		
Flow is divided.		

LONE MOUNTAIN RD: 10YR FLOW Cross Section for Irregular Channel

Project Description	
Project File	j:\haestad\fmw\5545.fm2
Worksheet	100' R/W STREET- NORMAL CROWN
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Section Data	
Wtd. Mannings Coefficient	0.015
Channel Slope	0.057000 ft/ft
Water Surface Elevation	0.70 ft
Discharge	162.00 cfs



APPENDIX F

Plan and Profile Sheets