DRAINAGE DITCH DESIGN

The drainage ditch designs consist of, in general, a narrative description, design parameters, flow calculations, flowline profile and cross-section for each ditch. The design parameters include drainage area, design storm information, curve number and channel dimensions. Due to the relatively large size of their drainage areas, flow calculations are used to derive the design peak flow rate for each diversion. The design peak flows for the smaller Ditches No. 1 through No. 5 are approximated using SCS peak flow rate graphs or modeled using HEC-HMS computer program. This information is then used within Manning's Equation to determine the specific flow characteristics of each ditch.

The design storms used for the ditches are: 10-year/24-hour for temporary ditches not associated with refuse disposal areas and 100-year/24-hour for the permanent Stream Diversion, ~~and~~ Waste Disposal Site Diversion, and ditches associated with refuse disposal areas. The ditches are designed to maintain flow velocities during design storm peak flows under 4.0 fps in earthen channels and less than 12 fps in rock. In earthen channels where gradient slopes result in peak velocities exceeding 4.0 fps, rock checks and/or other stabilizing structures will be installed to mitigate erosion. Side slopes will be constructed with slopes of 2H:1V or flatter in earthen channels and 1H:1V or flatter in rock. Channel bottoms will be controlled with rock riprap where deemed necessary. The ditch spoil will be graded and seeded as soon as possible. These measures will serve to reduce erosion of the spoil and the sediment load in the ditch conveyance. See Plate VI-10 for drainage ditch locations.

TEMPORARY DITCH NO. 1

Ditch No. 1 collects runoff from a small drainage area north of the Existing Coal Stockpile/Temporary Development Waste Disposal Site (Stockpile/Disposal Site) conveying it west and then south to a confluence with Temporary Ditch No. 2. The ditch parallels Ditch No. 2 but at a lower elevation. Drainage area to Ditch No 1 consists of the out slope of the berm forming Ditch No. 2 as well as some undisturbed area. Runoff from the Stockpile/Disposal Site does not enter Ditch No. 1. Total drainage area to Ditch No. 1 is 1.1 acres.

Since this ditch does not convey refuse area drainage and would be classified as a miscellaneous ditch, the 10-year, 24-hour storm event is required for the design. The ditch is included in the HEC-HMS 100-year, 6-hour computer model for Ditch No. 2 to verify the ditch is adequate. Flow depths and velocities are checked using the 100-year event runoff.

Ditch No. 1 consists of a steep section and a flat section (Ditches 1A and 1B), respectively. A portion of Ditch 1A is a natural drainage channel and a portion is excavated as shown on *Figure VI-27*. Drainage area for Ditch 1A is designated as HYDD-1 in the HEC-HMS model and the area for Ditch 1B is HYDD-2. From the HEC-HMS model shown for Ditch No. 2 design, flows for the sections are 0.6 cfs and 1.1 cfs. Both sections are modeled as triangular even though some areas have a small bottom width. The sections have 4:1 side slopes and a Manning's "n" of 0.030. The steep section has a flow gradient of 0.048 feet/foot (ft/ft) and the gradient for the flat section is 0.009 ft/ft.

Using Manning's Open Channel Flow Equation:

$$Q = \frac{1.49}{n} (A) (R)^{2/3} (s)^{0.5}$$

where A = area (ft^2)
R = area/wetted perimeter
s = ditch gradient

From trial and error, flow depth and velocity for each section are:

Steep section – 0.25-foot flow depth at 2.6 fps
Flat section – 0.42-foot flow depth at 1.6 fps

Ditch No. 1 is adequately sized for the 100-year event. See *Figures VI-27, 27A,* and *27B* for profile and cross section of Ditch No. 1. The *Pond No. 8, Plan View and Drainage Map* drawing in *Appendix VI-7* shows the plan view of this structure.

TEMPORARY DITCH NO. 2

Ditch No. 2 intercepts runoff from the Stockpile/Disposal Site and conveys it to Culvert B after combining with discharge from Ditch No. 1. Discharge from Culvert B is directed to Sediment Pond No. 8. Total drainage area for Ditch No. 2 is 6.2 acres. The 100-year, 6-hour storm event is used to design the ditch per Utah Department of Natural Resources regulations 746.212.

The ditch consists of three sections designated Ditches 2A, 2B, and 2C. Ditch 2A intercepts runoff from the east and north sides of the disposal area. An undisturbed portion of this drainage area (Area A on the *Pond No. 8, Plan View and Drainage Map*) lies east of the refuse area. Runoff from Area A is shown as HYD2A on the HEC-HMS computer model. Area B (HYD2B) consists of the east and north out slopes of the refuse pile. Total drainage area for Ditch 2A is 2.0 acres. Ditch 2A has a bottom width of 2 feet with 2:1 side slopes and a flow gradient averaging 0.0425 ft/ft. Peak flow in this section from the HMS model is 2.7 cfs. This flow is routed through the next section (Ditch 2B).

Ditch 2B intercepts drainage from Area C (HYD2C) consisting of the south and west sides of the refuse pile and the flat area west of the pile. The top of the pile has been graded to direct runoff to the south and avoid the steeper ditch section (Ditch 2A). The peak flow from Ditch 2A and runoff from Area C is 10.1 cfs. Ditch 2B has a bottom width of 2 feet with 2:1 side slopes and a flow gradient of 0.0068 ft/ft. A rock-lined channel at the end of Ditch 2B conveys the flow down a slope to Ditch 2C, combining with discharge from Ditch 1.

Peak flow for Ditch 2C is 11.1 cfs. This section has a 3-foot bottom width with 2:1 side slopes and a 0.029 ft/ft flow gradient. The channel is cut in bedrock, making it adequate for the 4.8 fps flow velocity.

Flow depths and velocities are calculated using Manning's Open Channel Flow Equation.

$$Q = \frac{1.49}{n} (A) (R)2/3 (s)0.5$$

where A = area (ft2)
R = area/wetted perimeter
s = ditch gradient
n = roughness factor (0.030)

Using trial and error, flow depths and velocities are:

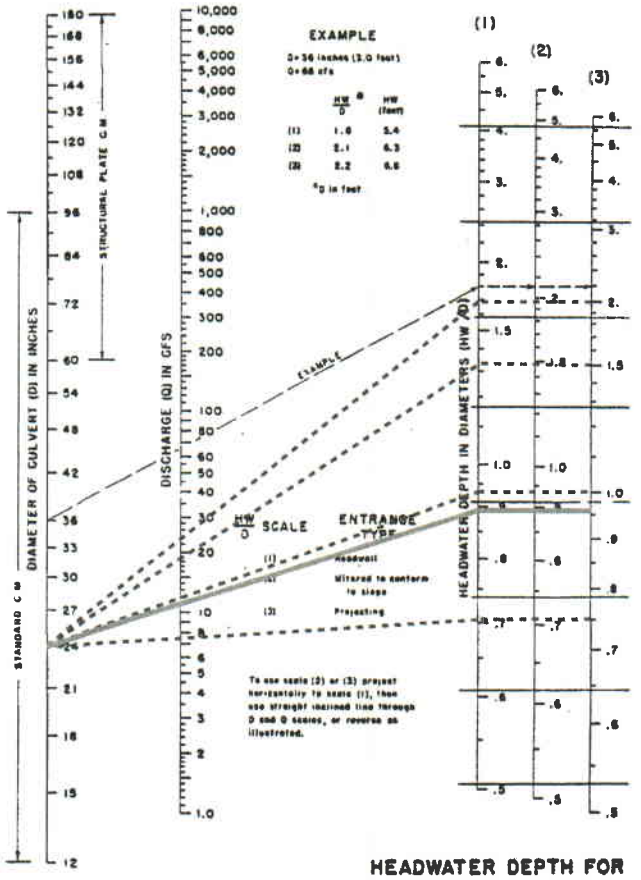
Ditch 2-A – 0.3-foot flow depth at 3.8 fps
Ditch 2-B – 0.9-foot flow depth at 2.9 fps
Ditch 2-C – 0.6-foot flow depth at 4.8 fps

See *Figures VI-27, 27A,* and *27B* for profile and cross sections of Ditch No. 2. The *Pond No. 8, Plan View and Drainage Map* in *Appendix VI-7* shows the plan view of this structure.

CULVERT B

Culvert B is an existing 24-inch corrugated metal pipe (CMP) conveying drainage from Ditch No. 2 under the road to the Stockpile/Disposal Site. Invert elevation of the pipe is 5939.6 and the top of road/top of ditch elevation is 5943.2, allowing a flow depth of 3.6 feet before overtopping.

From the HEC-HMS computer model for Ditches 1 and 2, the 100-year, 6-hour event peak flow to Culvert B is 11.1 cfs. A series of discharges to headwater depths from the nomograph shown below were input into the model. From the nomograph and HEC-HMS output, the headwater depth required to achieve 11.1 cfs is 1.9 feet. The culvert is, therefore, adequate to convey the peak discharge without overtopping.



HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

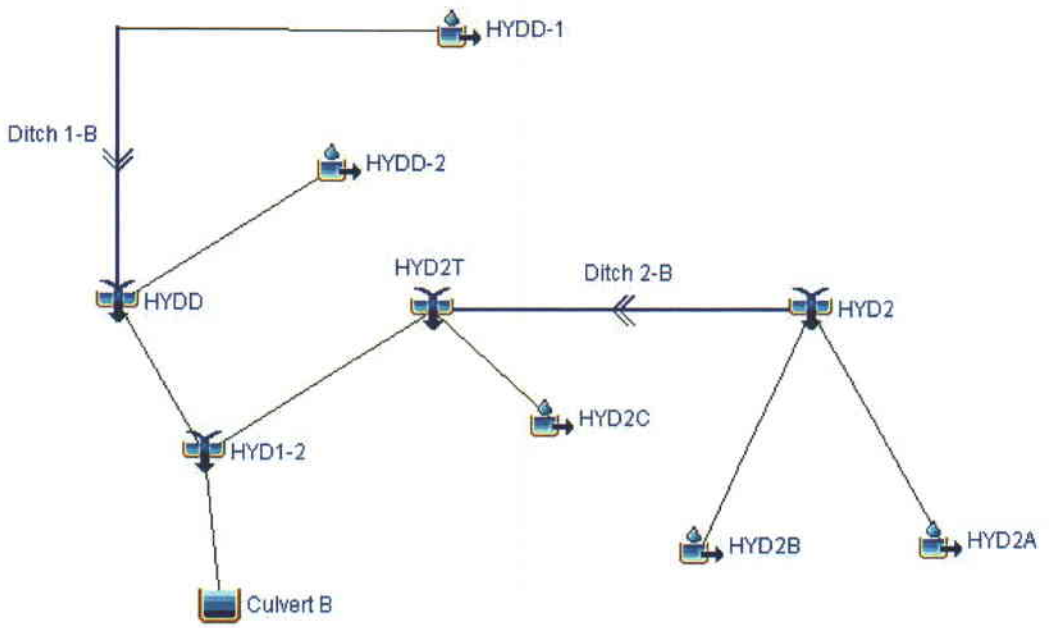
(From Ref. Hyd. Eng. Circular No. 5, USBRP, 1965)

HEC-HMS HYDROLOGIC MODEL

Due to the limited printing capability of the public version of HEC-HMS, screen images of the HEC-HMS input and output are presented along with subbasin hydrologic parameters used in the model. The watershed and subbasins are shown on *Pond No. 8, Plan View and Drainage Map* in *Appendix VI-7*. Pond No. 8 was sized using results from an HEC-1 computer model presented in *Appendix IV-9 – Sediment Pond No. 8*. The total drainage area reporting to Pond No. 8 does not significantly change under this evaluation of Temporary Ditches No. 1 and 2. Therefore, the Pond No. 8 design has not been revised.

Ditch No. 2 intercepts and conveys drainage from the Stockpile/Disposal Site. Per Utah regulations, the structure is designed to handle the 100-year, 6-hour storm event. Total rainfall for the 100-year, 6-hour storm is 1.80 inches. The same rainfall distribution used in the original HEC-1 model is used in this HEC-HMS model. A computational time interval of one minute was used due to the small lag times in the subbasins.

Refuse Area HEC-HMS Network Diagram:



Subbasin Hydrology:

Description of Subbasins:

HYD2A	Unaffected area east of Stockpile/Disposal Site (Area A)
HYD2B	Stockpile/Disposal Site, east and north outslopes (Area B)
HYD2C	Remaining Stockpile/Disposal Site and area west of pile (Area C)
HYDD-1	Unaffected area north of Stockpile/Disposal Site (Area D)
HYDD-2	Affected area west of Ditch 2B (Area D)

Subbasin Parameters:

Subbasin ID	Area (ac)	Area (mi^2)	CN	S	L (ft)	Y (%)	l_T (min)
HYD2A	1.3	0.0020	80	2.50	450	20	2.2
HYD2B	0.7	0.0011	90	1.11	80	30	0.3
HYD2C	4.2	0.0066	90	1.11	600	5	4.0
HYDD-1	0.5	0.0008	80	2.50	60	10	0.6
HYDD-2	0.6	0.0009	80	2.50	35	25	0.3

CN = SCS Curve Number
S = (1000/CN) – 10
L = Hydraulic Length of Watershed
Y = Average land slope
lT = SCS lag time in hours = (L0.8 (S + 1)0.7)/(1900 Y0.5)

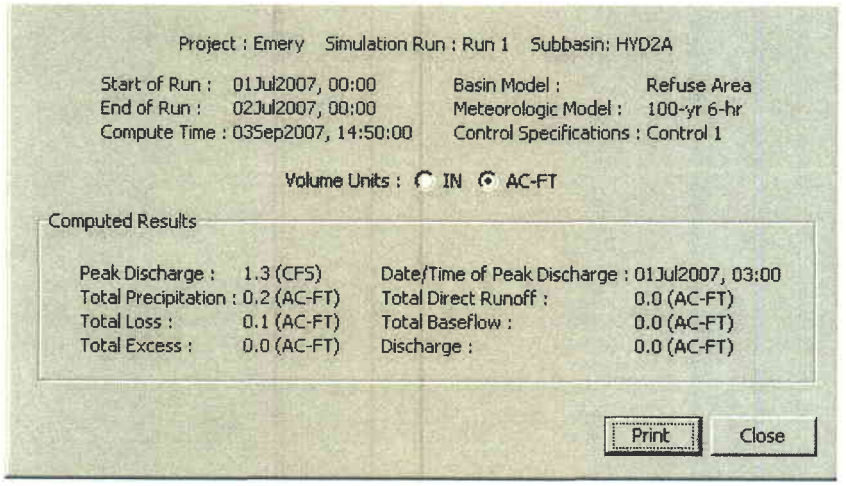
Ditch Geometry:

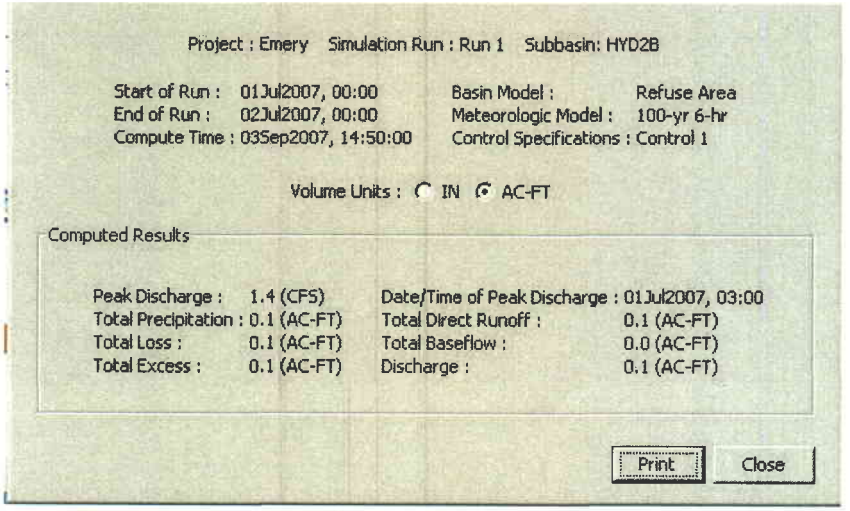
Ditch ID	Length (ft)	Bottom (ft)	Side Slope (xH:1V)	Flow Gradient (ft V:1 ft H)	Manning's "n"	Lining
Ditch 2A	670	2	2	0.0425	0.030	Earthen
Ditch 2B	600	2	2	0.0068	0.030	Earthen
Ditch 2C	120	3	2	0.0292	0.030	Rock
Ditch 1A	495	0	4	0.0480	0.030	Earthen
Ditch 1B	595	0	4	0.0090	0.030	Earthen

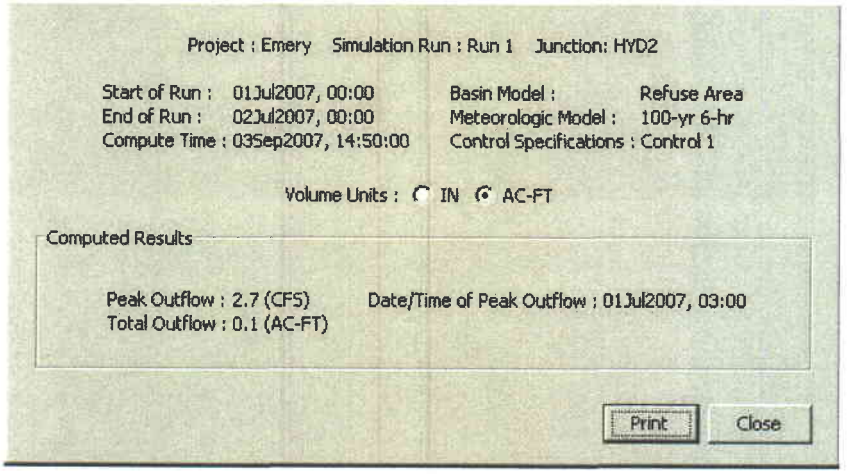
Not all ditches were included in the HEC-HMS model.

A small rock-lined channel at the end of Ditch 2B was not modeled. The channel conveys flow from Ditch 2B to Ditch 2C.

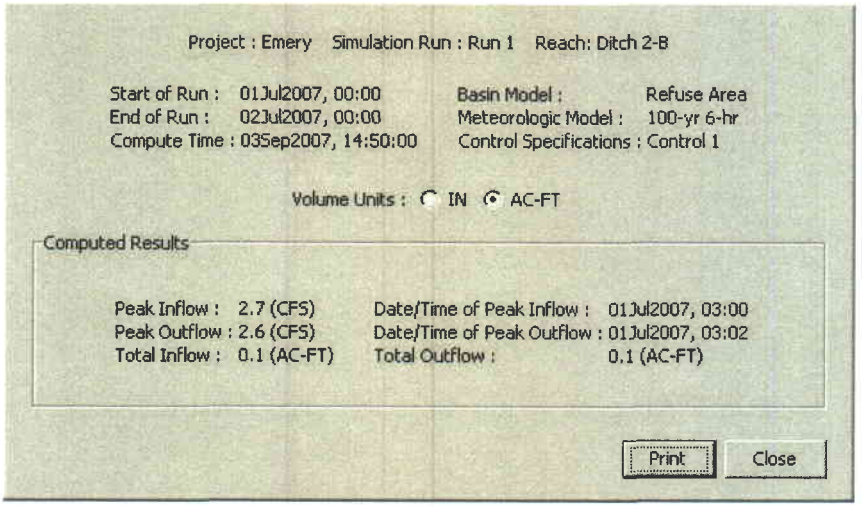
HEC-HMS Output:

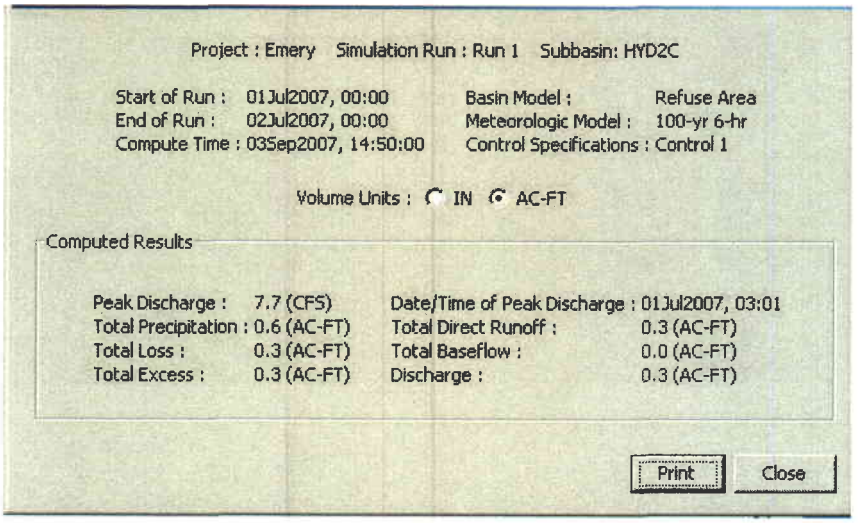


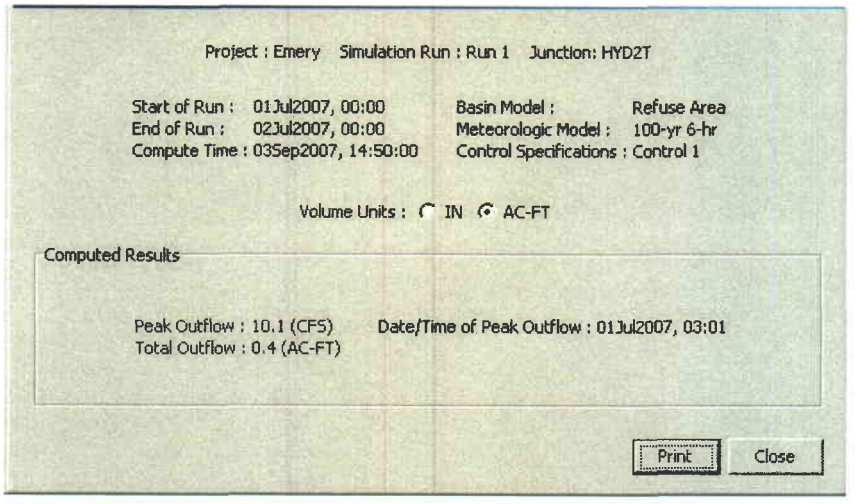




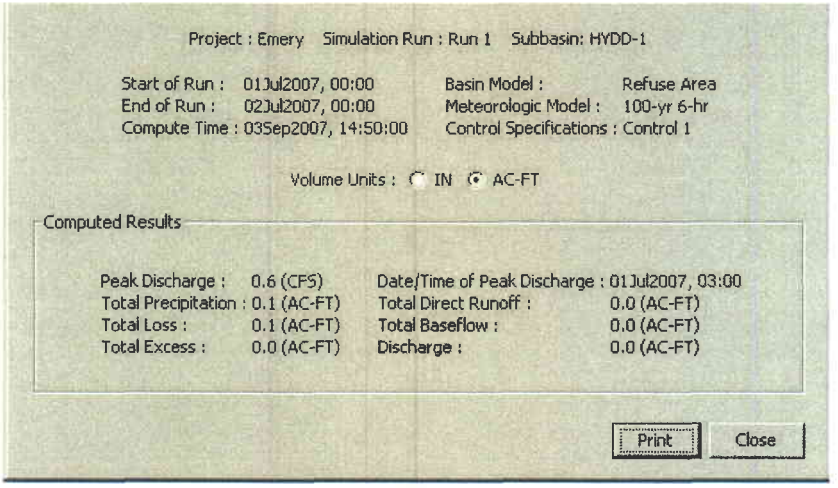
HEC-HMS Output (continued):

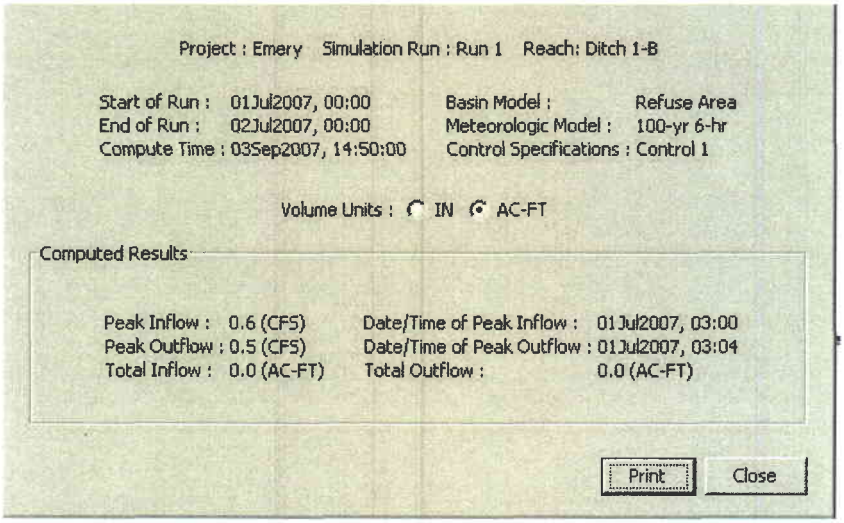


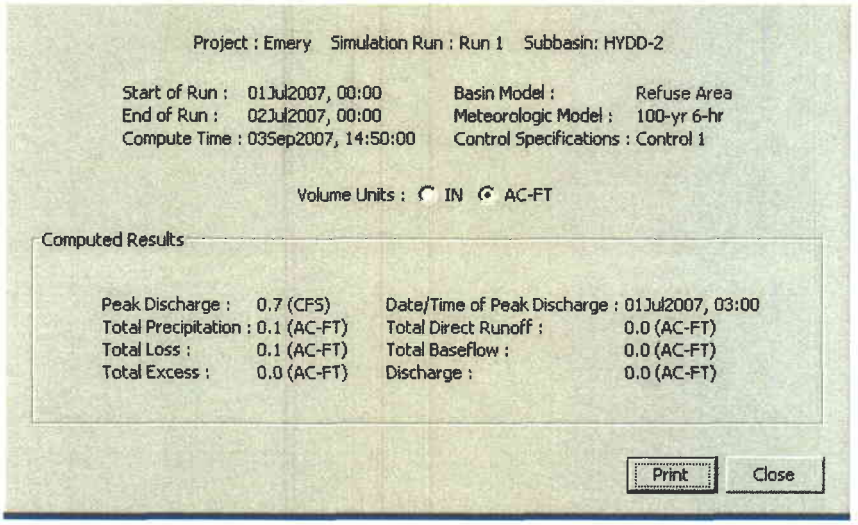




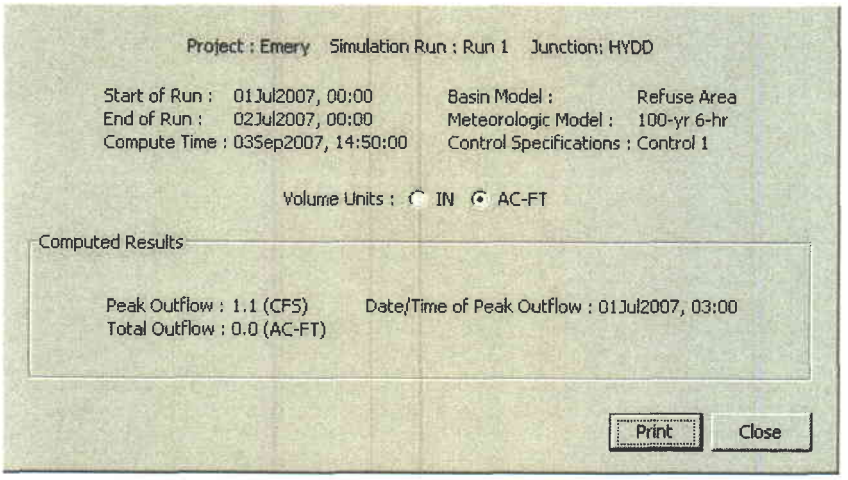
HEC-HMS Output (continued):

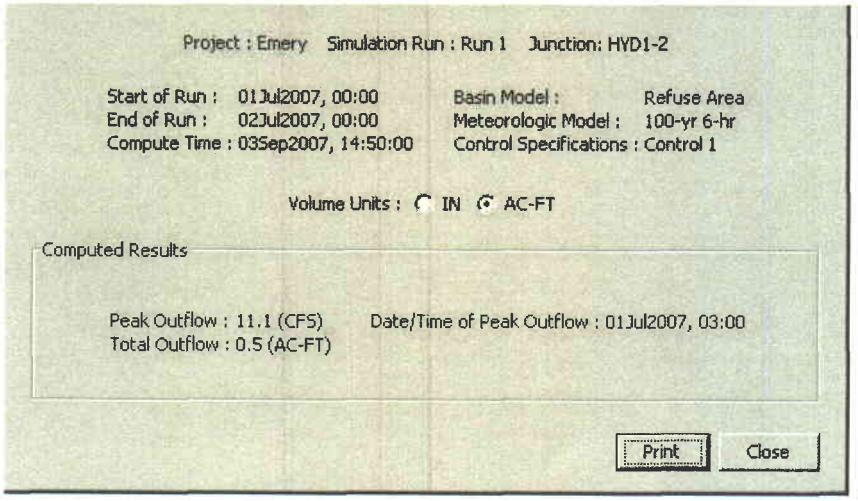


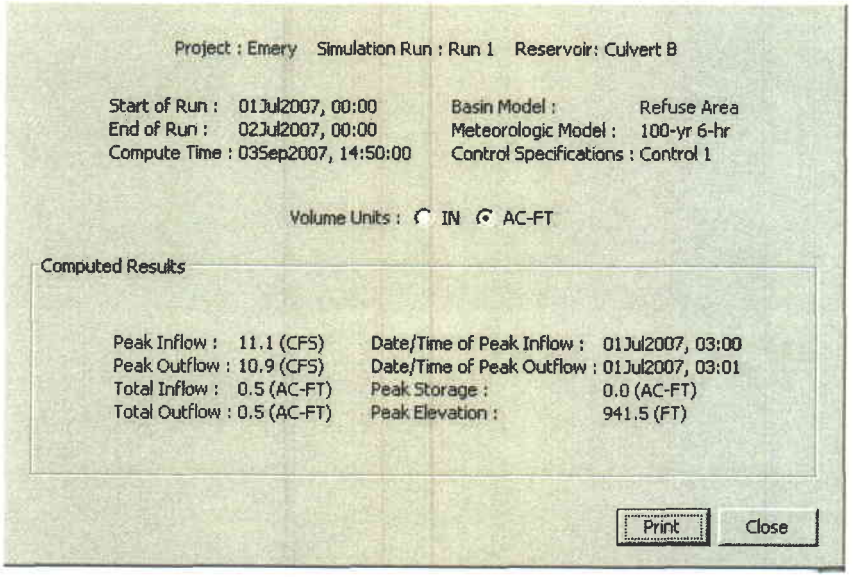




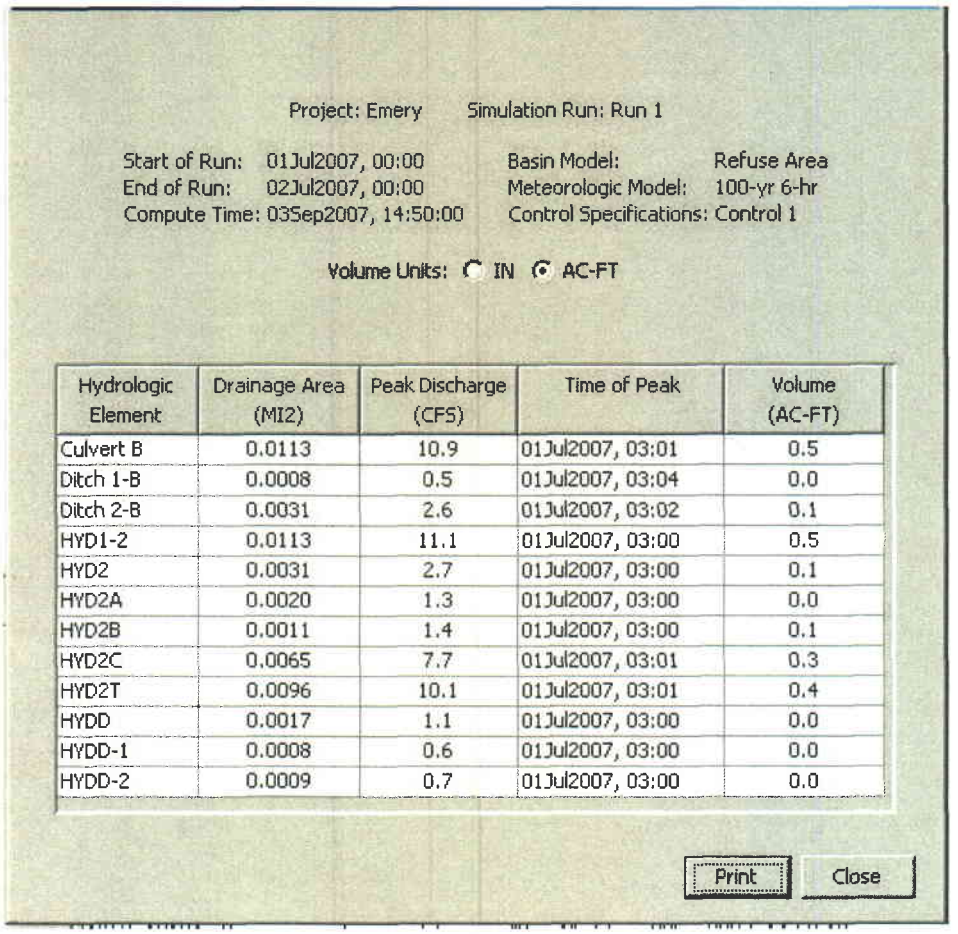
HEC-HMS Output (continued):







Summary of HEC-HMS Results:



Project: Emery Simulation Run: Run 1

Start of Run: 01Jul2007, 00:00
End of Run: 02Jul2007, 00:00
Compute Time: 03Sep2007, 14:50:00

Basin Model: Refuse Area
Meteorologic Model: 100-yr 6-hr
Control Specifications: Control 1

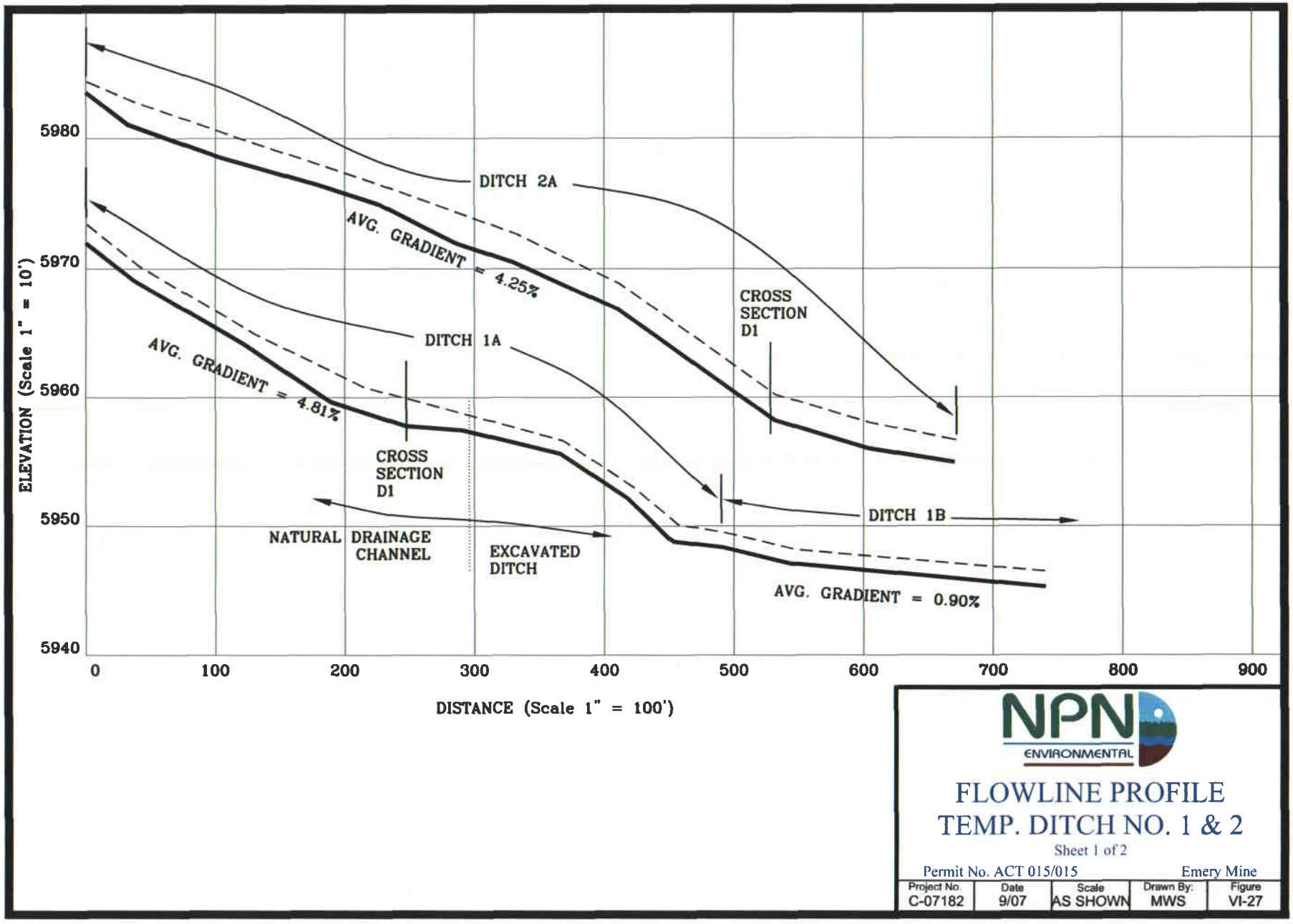
Volume Units: ○ IN ◉ AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Culvert B	0.0113	10.9	01Jul2007, 03:01	0.5
Ditch 1-B	0.0008	0.5	01Jul2007, 03:04	0.0
Ditch 2-B	0.0031	2.6	01Jul2007, 03:02	0.1
HYD1-2	0.0113	11.1	01Jul2007, 03:00	0.5
HYD2	0.0031	2.7	01Jul2007, 03:00	0.1
HYD2A	0.0020	1.3	01Jul2007, 03:00	0.0
HYD2B	0.0011	1.4	01Jul2007, 03:00	0.1
HYD2C	0.0065	7.7	01Jul2007, 03:01	0.3
HYD2T	0.0096	10.1	01Jul2007, 03:01	0.4
HYDD	0.0017	1.1	01Jul2007, 03:00	0.0
HYDD-1	0.0008	0.6	01Jul2007, 03:00	0.0
HYDD-2	0.0009	0.7	01Jul2007, 03:00	0.0

Print Close

Summary of Ditch Flows:

Ditch	Peak Flow (cfs)	Peak Flow Depth (ft)	Peak Velocity (fps)
Ditch 2-A	2.7	0.3	3.8
Ditch 2-B	10.1	0.9	2.8
Ditch 1-A	0.6	0.3	2.6
Ditch 1-B	1.1	0.4	1.6
Ditch 2-C	11.1	0.6	4.8



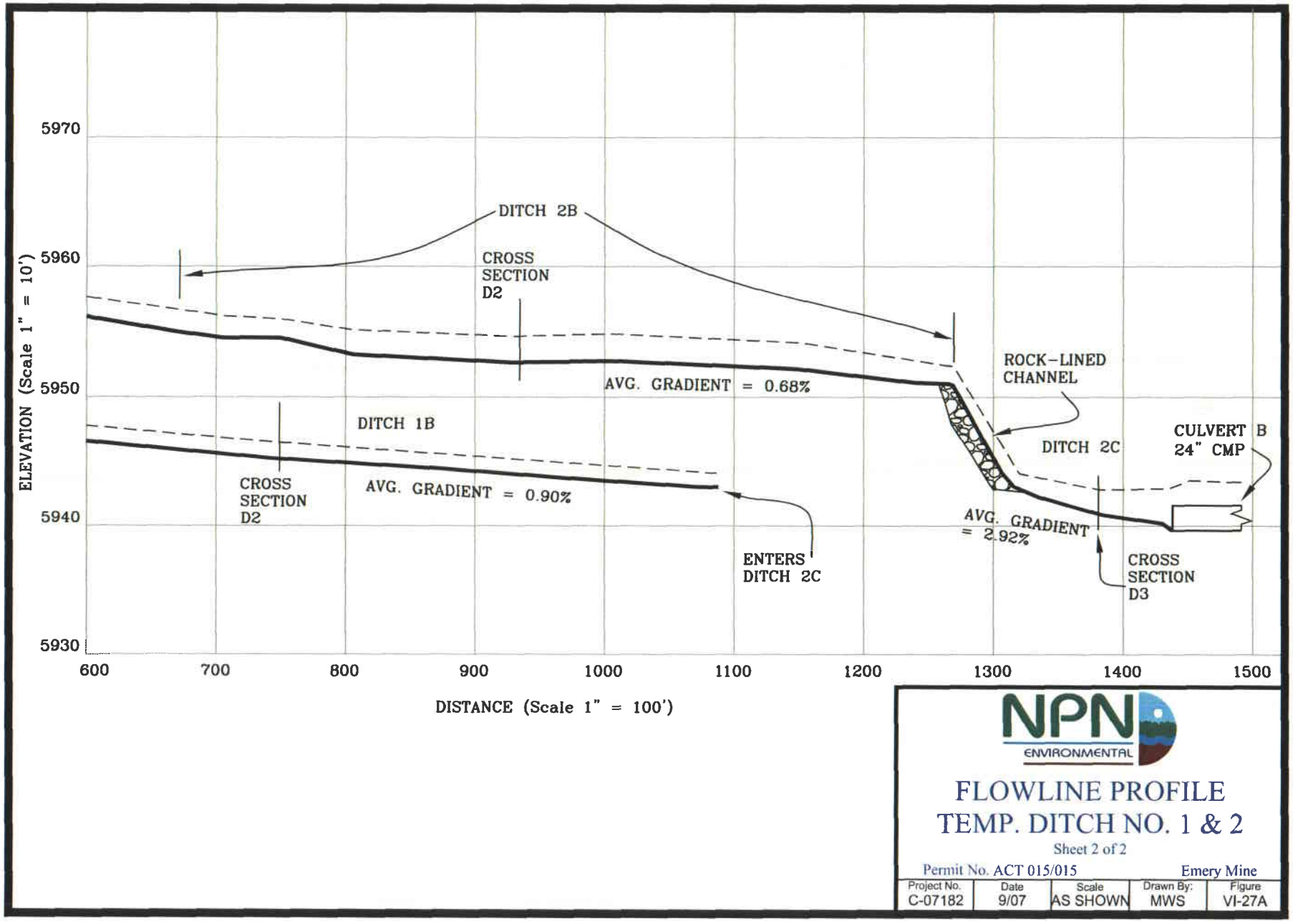
NPN ENVIRONMENTAL

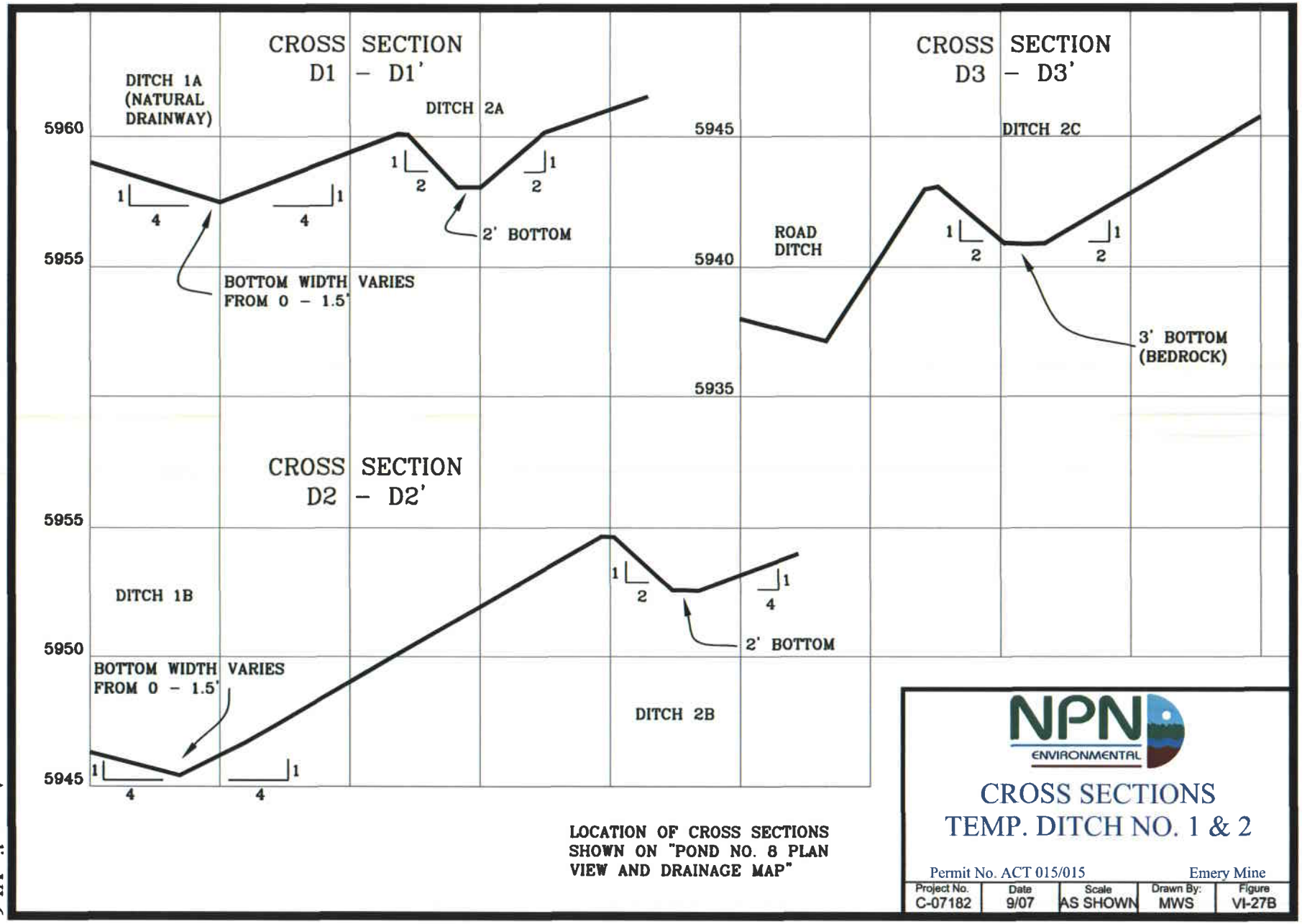
FLOWLINE PROFILE TEMP. DITCH NO. 1 & 2

Sheet 1 of 2

Permit No. ACT 015/015 Emery Mine

Project No.	Date	Scale	Drawn By:	Figure
C-07182	9/07	AS SHOWN	MWS	VI-27


5970
5960
5950
5940
5930
ELEVATION (Scale 1" = 10')
600
700
800
900
1000
1100
1200
1300
1400
1500
DISTANCE (Scale 1" = 100')
DITCH 2B
CROSS SECTION D2
AVG. GRADIENT = 0.68%
ROCK-LINED CHANNEL
DITCH 2C
CULVERT B 24" CMP
DITCH 1B
CROSS SECTION D2
AVG. GRADIENT = 0.90%
ENTERS DITCH 2C
AVG. GRADIENT = 2.92%
CROSS SECTION D3
NPN ENVIRONMENTAL
FLOWLINE PROFILE
TEMP. DITCH NO. 1 & 2
Sheet 2 of 2
Permit No. ACT 015/015
Emery Mine
Project No. C-07182
Date 9/07
Scale AS SHOWN
Drawn By: MWS
Figure VI-27A


CROSS SECTION
D1 – D1'
DITCH 1A
(NATURAL
DRAINWAY)
DITCH 2A
5960
5955
1
4
1
4
1
2
1
2
2' BOTTOM
BOTTOM WIDTH VARIES
FROM 0 – 1.5'
CROSS SECTION
D3 – D3'
DITCH 2C
5945
5940
5935
ROAD
DITCH
1
2
1
2
3' BOTTOM
(BEDROCK)
CROSS SECTION
D2 – D2'
5955
5950
5945
DITCH 1B
1
2
1
4
2' BOTTOM
BOTTOM WIDTH VARIES
FROM 0 – 1.5'
DITCH 2B
1
4
1
4
LOCATION OF CROSS SECTIONS
SHOWN ON "POND NO. 8 PLAN
VIEW AND DRAINAGE MAP"
NPN
ENVIRONMENTAL
CROSS SECTIONS
TEMP. DITCH NO. 1 & 2
Permit No. ACT 015/015
Emery Mine
Project No. C-07182
Date 9/07
Scale AS SHOWN
Drawn By: MWS
Figure VI-27B