APPENDIX A7

HYDROLOGY AND HYDRAULIC ANALYSIS

INTERIM REMOVAL ACTION

MWH, 2010

CALCULATION COVER SHEET

MWH

PROJECT TITLE:	UNC NECR IRA CONSTRUCTION PLAN
PROJECT NO:	1006690
CALCULATION TITLE:	Hydrology and Hydraulic Analysis

	NAME	DATE
PREPARED BY:	Leland Fuhrig	5/8/2009
CHECKED BY:	Jed Thompson	5/8/2009
REVIEWED BY:	Jed Thompson	5/8/2009

REVISIONS				
DATE	**PURPOSE**	**PREPARED BY**	**CHECKED BY**	**REVIEWED BY**

Hydrologic and hydraulic calculations presented here were prepared for the design of storm water control and the engineered channel for the Northeast Church Rock Interim Removal Action (IRA). Runoff from the top surface NECR-1 will be routed to and captured in Pond 3. The regrading of NECR-1 will include outslope construction around the north and west perimeters. Runoff from the outslope will be captured in a toe channel and routed to a sediment pond to the west of the facility to reduce sediment loading to the Unnamed Arroyo. A pond catching the runoff from the Trailer park area and the area bounded by Red Water Pond Rd., Highway 566, NECR-1, and the removal area, will be constructed to reduce sediment loading to the east portion of the Step Out Area.

The Army Corps of Engineers HEC-HMS model was used to calculate peak flows which were used to design diversion channels for surface water control. Three separate simulations were run in HEC-HMS. The first was a 100-yr, 24-hr storm event (2.9 inches total precipitation per NOAA Atlas 14, type II storm) using the existing topography at the Site (Table 2.1). The second simulation was an analysis of back-to-back 100-yr, 24-hr storms to evaluate the possibility of Pond 3 overtopping (Table 2.2), and the third simulation included the above described modifications to the Site (Table 2.3). Complete HEC-HMS inputs and outputs are listed in Appendix A. A figure showing the locations of the features modeled is attached.

Table 2.1
NECR Mine 100-yr 24-hr Peak Flows

Hydrologic Element	Peak Discharge (CFS)
Culvert 1	60.9
Culvert 2	82.9
Drainage Between Culverts	60.4
Home Sites	37
Junction-1	73.9
Junction-2	37
Unnamed Arroyo High Subbasin	233.6
Unnamed Arroyo Low Subbasin	73.9
Main Low Drainage	0
Pond 1	0
Pond 1 Subbasin	31.6
Pond 2	0
Pond 2 Subbasin	11.7
Pond 3	0
Subbasin Between Roads	22.5
Trailer Park	60.9

Table 2.2
NECR Mine 100-yr 24-hr Peak Flows

Hydrologic Element	Peak Discharge (CFS)
Culvert 1	87.9
Culvert 2	119.3
Drainage Between Culverts	86.9
Home Sites	53.3
Junction-1	256.8

Table 2.2 NECR Mine 100-yr 24-hr Peak Flows	
Hydrologic Element	**Peak Discharge (CFS)**
Junction-2	53.3
Main Low Drainage	242.5
Pond 1	0
Pond 1 Subbasin	45.5
Pond 2	0
Pond 2 Subbasin	16.3
Pond 3	242.8
Subbasin Between Roads	32.4
Trailer Park	87.9
Unnamed Arroyo High Subbasin	346.8
Unnamed Arroyo Low Subbasin	109.3

Table 2.3 NECR Mine 100-yr 24-hr Peak Flows: Modified	
Hydrologic Element	**Peak Discharge (CFS)**
Culvert 1	60.9
Culvert 2	14.8
Drainage Between Culverts	60.7
Home Sites	37
Junction-1	54.6
Junction-2	37
Unnamed Arroyo High Subbasin	233.6
Unnamed Arroyo Low Subbasin	54.6
Main Low Drainage	0
NECR-1	14.8
NECR-1 outslope	3.1
NECR-1 outslope catch	3.1
N Red Water Pond Subb	14.8
Pond 1	0
Pond 1 Subbasin	31.6
Pond 2	0
Pond 2 Subbasin	11.7
Pond 3	0
Subbasin Between Roads	9.9
TP, N of 566 area catch	67.9
Trailer Park	60.9

Each hydrologic analysis was performed assuming that Ponds 1, 2, and 3 would remain in place and would be empty at the start of the design storm event.

Junction-1 represents the outfall of the Unnamed Arroyo into the Pipeline Arroyo, north of the Home Sites. The zero discharge from Pond 3 reflects the Pond's ability to store the entire volume of water from the Unnamed Arroyo high subbasin. Riprap for the Unnamed Arroyo was sized using the 1991 U.S. Army Corps of Engineers Method (Appendix B). The flow for the channel was assumed to be the full flow the currently reports to Pond 3. This flow was deemed to be conservative for any final remedial scenario. The finished unnamed arroyo channel was assumed to be trapezoidal with a 20 foot wide bottom, 2H:1V side slopes and a channel grade of 3.3% (matching the current grade). Minimum riprap D_{50} of 7.5 inches is required for the Unnamed Arroyo.

Culvert Analysis:

Using the HY-8 7.0 computer program, a variety of sizes and numbers of culverts were evaluated to find the appropriate configuration to use at the Site. Two feet of soil cover will be placed atop the culverts and it was determined that three, two foot diameter corrugated steel culverts were necessary to maintain a minimum of one foot of freeboard below the elevation of the road. The input parameters for the road crossing are shown below (elevations used assume the bottom of the culvert outlet is 0 ft):

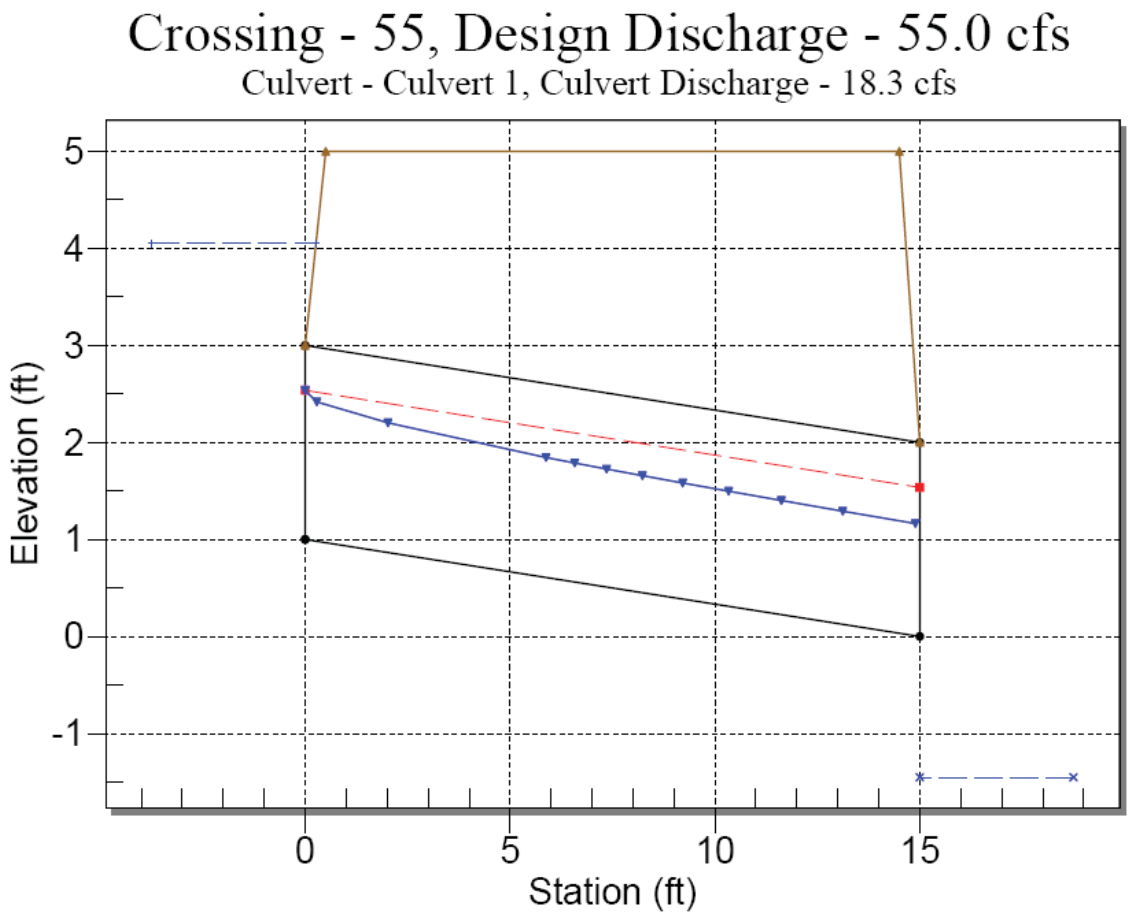
Crossing Properties		
Parameter	**Value**	**Units**
Minimum Flow	0	cfs
Design Flow	55	cfs
Maximum Flow	55	cfs
Channel Type	Trapezoidal Channel	
Bottom Width	20	ft
Channel Slope	0.033	ft/ft
Manning's n (channel)	0.035	
Channel Invert Elevation	-2	ft
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0	ft
Crest Length	20	ft
Crest Elevation	5	Ft
Roadway Surface	Gravel	
Top Width	14	ft

Input parameters for each of the three culverts are as follows:

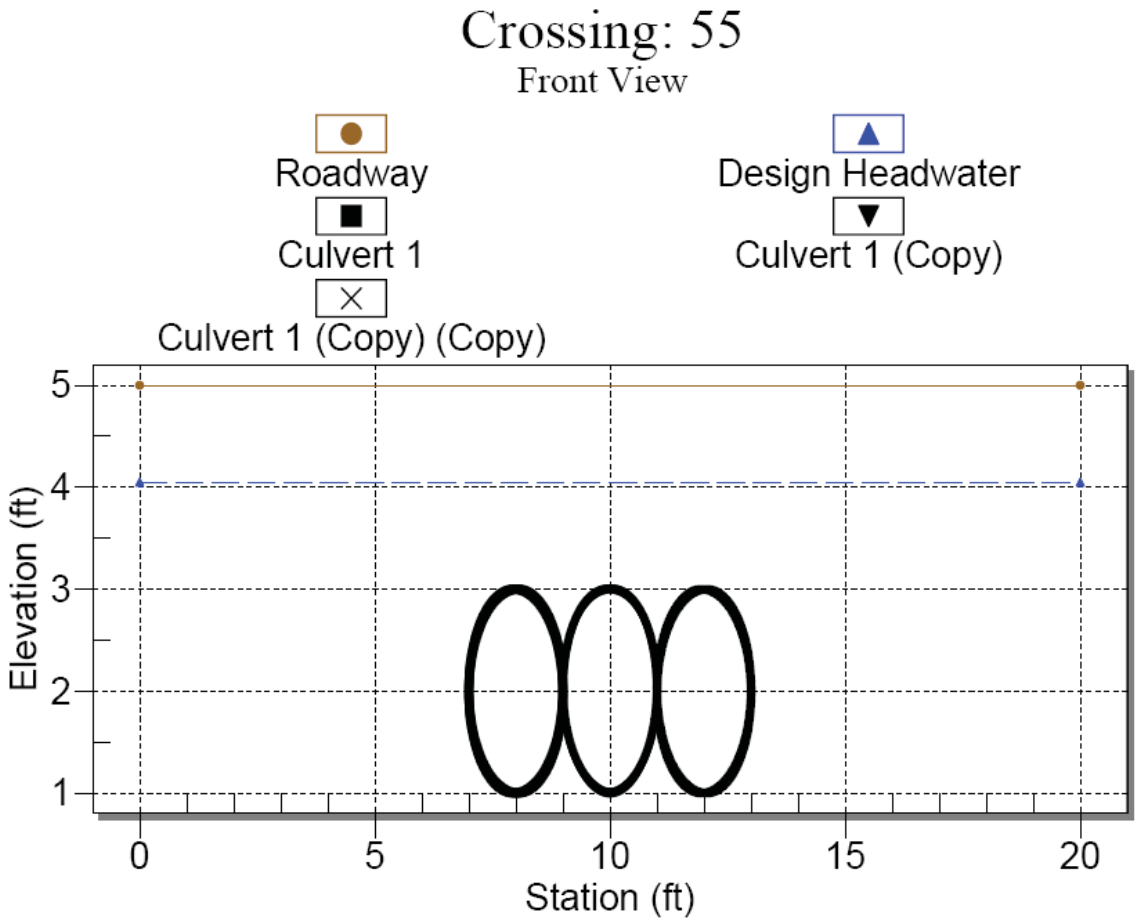
Culvert Properties		
Parameter	**Value**	**Units**
Shape	Circular	
Material	Corrugated Steel	

Culvert Properties		
Parameter	**Value**	**Units**
Diameter	2	ft
Manning's n	0.024	
Inlet Type	Conventional	
Inlet Edge Condition	Thin Edge Projecting	
Inlet Depression?	No	
Site Data Input Option	Culvert Invert Data	
Inlet Station	0	ft
Inlet Elevation	1	ft
Outlet Station	15	ft
Outlet Elevation	0	ft

Each of the three culverts had an identical output, with blue dashed lines representing the water levels, solid black lines as the culvert boundaries, the red dashed line showing critical depth, and brown lines representing ground surfaces, shown below:

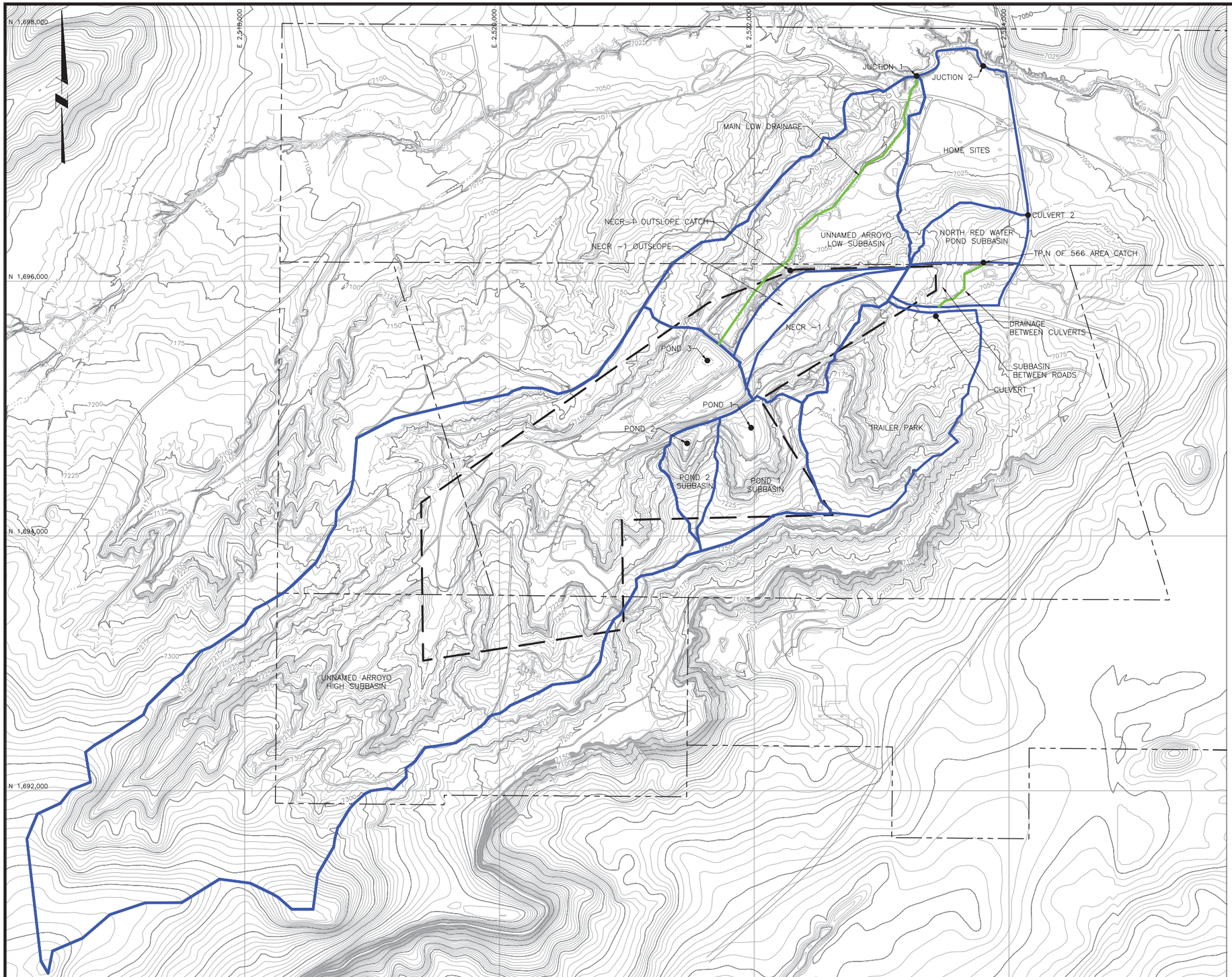


The culverts were placed immediately next to each other and in the center of the channel, as shown on the diagram below:



Note: Above figure is shown with 2 to 1 vertical exaggeration.

Figure



LEGEND:

- 7040 — EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
- PERMIT BOUNDARY
- APPROXIMATE OWNERSHIP BOUNDARY
- ROADS
- NATURAL DRAINAGE
- PHYSICAL STRUCTURE
- SUBBASIN BOUNDARY
- CHANNEL/REACH
- POINT FEATURER OR JUNCTION

SCALE
400 0 400 800 FEET
CONTOUR INTERVAL = 5 FEET

ISSUED FOR BID 5/29/09

ISSUE / REV	DESCRIPTION	TECH	ENG	DATE
B	ISSUED FOR BID	CHF	JET	05/29/09
A	DRAFT	CHF	JET	05/22/09

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DRAWING REFERENCE(S):
SURFACE TOPOGRAPHY GENERATED FROM AERIAL PHOTOGRAPHS DATED MAY 2007 BY COOPER AERIAL SURVEYS CO. AND USGS 10m DIGITAL ELEVATION MODELS (DEM).

PROJECTION:
STATE PLANE COORADINATES

ZONE:
NEW MEXICO WEST

DATUM:
NAD 83

UNITS:
US FEET

DESIGNED BY	J.THOMPSON	05/29/09
DRAWN BY	C.FOWLER	05/29/09
CHECKED BY	J.THOMPSON	05/29/09
APPROVED BY	J.THOMPSON	05/29/09
PROJECT MANAGER	T.LEESON	05/29/09
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

unc
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Gallup, New Mexico 87305-3077

PROJECT LOCATION
NORTHEAST CHURCH ROCK MINE

PROJECT
INTERIM REMOVAL ACTION CONSTRUCTION PLAN

TITLE
BASIN MAP

MWH

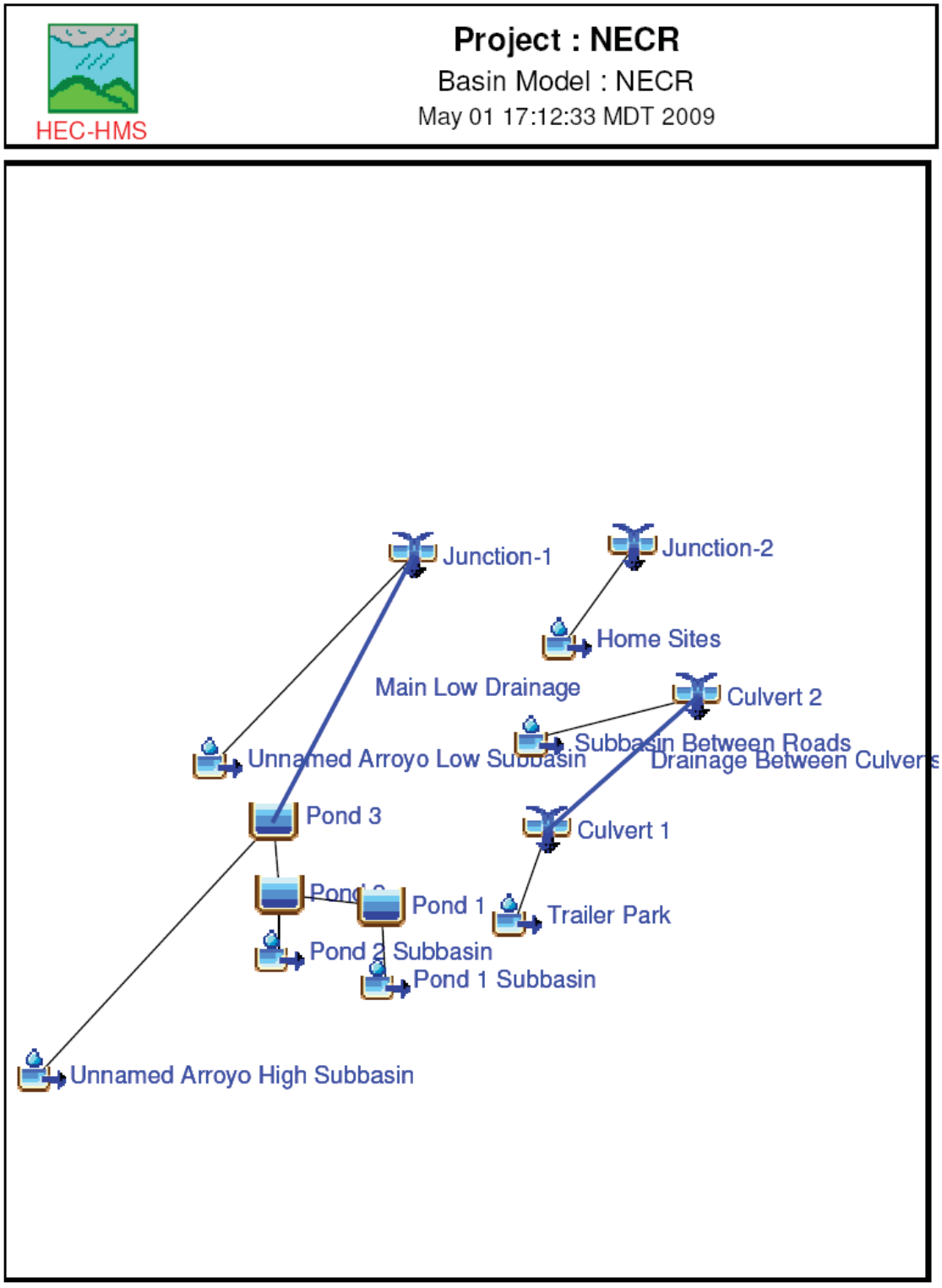
FIGURE 1 | REVISION B

FILE NAME
1006690D013

N:\Design-Drafting\Clients_Q-Z\United Nuclear Corporation\1006690 NECR IRAWP\013-Sheet Set\1006690D013

Appendix A

Schematic for Runs 1 & 2:



Run 1: 100 yr 24-hr

Inputs:

Subbasin	Initial Abstraction (in)	Curve Number	Impervious %	Lag Time (min)
Home Sites	0	80	0	11.5
Main Channel High Subbasin	0	80	0	46.1
Main Channel Low Subbasin	0	80	0	19.2
Pond 1 Subbasin	0	80	0	7.1
Pond 2 Subbasin	0	80	0	4.9
Subbasin Between Roads	0	80	0	11.2
Trailer Park	0	80	0	9.7

Reach	Length (ft)	Slope (ft/ft)	Manning's n
Drainage Between Culverts	1044	0.038	0.035
Main Low Drainage	2731	0.033	0.035

Outputs:

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (CFS)	Time of Peak	Volume (in)
Culvert 1	0.0585	60.9	01Jan2000, 12:05	1.56
Culvert 2	0.0808	82.9	01Jan2000, 12:05	1.56
Drainage Between Culverts	0.0585	60.4	01Jan2000, 12:05	1.56
Home Sites	0.037	37	01Jan2000, 12:05	1.56
Junction-1	0.666727	73.9	01Jan2000, 12:10	0.23
Junction-2	0.037	37	01Jan2000, 12:05	1.56
Unnamed Arroyo High Subbasin	0.534	233.6	01Jan2000, 12:40	1.56
Unnamed Arroyo Low Subbasin	0.0968	73.9	01Jan2000, 12:10	1.56
Main Low Drainage	0.569927	0	01Jan2000, 00:00	0
Pond 1	0.0267	0	01Jan2000, 00:00	0
Pond 1 Subbasin	0.0267	31.6	01Jan2000, 12:00	1.56
Pond 2	0.035927	0	01Jan2000, 00:00	0
Pond 2 Subbasin	0.009227	11.7	01Jan2000, 12:00	1.56
Pond 3	0.569927	0	01Jan2000, 00:00	0
Subbasin Between Roads	0.0223	22.5	01Jan2000, 12:05	1.56
Trailer Park	0.0585	60.9	01Jan2000, 12:05	1.56

Run 2: Back-to-back 100 yr 24-hr storms

Inputs:

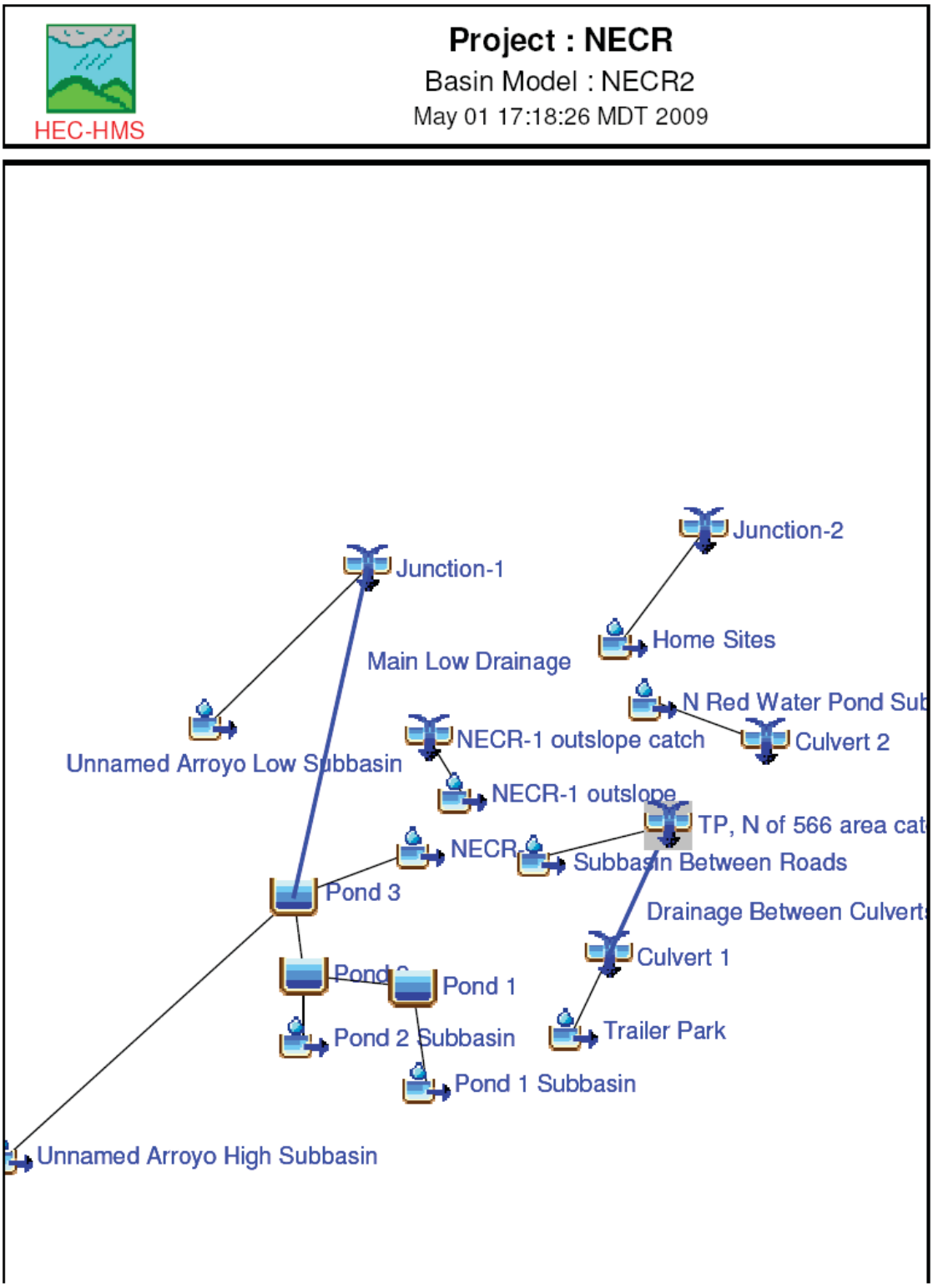
Subbasin	Initial Abstraction (in)	Curve Number	Impervious %	Lag Time (min)
Home Sites	0	80	0	11.5
Main Channel High Subbasin	0	80	0	46.1
Main Channel Low Subbasin	0	80	0	19.2
Pond 1 Subbasin	0	80	0	7.1
Pond 2 Subbasin	0	80	0	4.9
Subbasin Between Roads	0	80	0	11.2
Trailer Park	0	80	0	9.7

Reach	Length (ft)	Slope (ft/ft)	Manning's n
Drainage Between Culverts	1044	0.038	0.035
Main Low Drainage	2731	0.033	0.035

Outputs:

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (CFS)	Time of Peak	Volume (in)
Culvert 1	0.0585	87.9	02Jan2000, 12:05	4.04
Culvert 2	0.0808	119.3	02Jan2000, 12:10	4.04
Drainage Between Culverts	0.0585	86.9	02Jan2000, 12:10	4.04
Home Sites	0.037	53.3	02Jan2000, 12:10	4.04
Junction-1	0.666727	256.8	02Jan2000, 13:15	2.58
Junction-2	0.037	53.3	02Jan2000, 12:10	4.04
Main Low Drainage	0.569927	242.5	02Jan2000, 13:15	2.34
Pond 1	0.0267	0	01Jan2000, 00:00	0
Pond 1 Subbasin	0.0267	45.5	02Jan2000, 12:05	4.04
Pond 2	0.035927	0	01Jan2000, 00:00	0
Pond 2 Subbasin	0.009227	16.3	02Jan2000, 12:05	4.04
Pond 3	0.569927	242.8	02Jan2000, 13:10	2.34
Subbasin Between Roads	0.0223	32.4	02Jan2000, 12:10	4.04
Trailer Park	0.0585	87.9	02Jan2000, 12:05	4.04
Unnamed Arroyo High Subbasin	0.534	346.8	02Jan2000, 12:45	4.04
Unnamed Arroyo Low Subbasin	0.0968	109.3	02Jan2000, 12:15	4.04

Schematic for Run 3:



Run 3: Modified basins, 100 yr 24 hr storm

Inputs:

Subbasin	Initial Abstraction (in)	Curve Number	Impervious %	Lag Time (min)
Home Sites	0	80	0	11.5
Main Channel High Subbasin	0	80	0	46.1
Main Channel Low Subbasin	0	80	0	21.2
NECR-1	0	80	0	21.2
NECR-1 outslope	0	80	0	8.3
N Red Water Pond Subb	0	80	0	7.1
Pond 1 Subbasin	0	80	0	7.1
Pond 2 Subbasin	0	80	0	4.9
Subbasin Between Roads	0	80	0	5.6
Trailer Park	0	80	0	9.7

Reach	Length (ft)	Slope (ft/ft)	Manning's n
Drainage Between Culverts	490	0.061	0.035
Main Low Drainage	2731	0.033	0.035

Outputs:

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (CFS)	Time of Peak	Volume (in)
Culvert 1	0.0585	60.9	01Jan2000, 12:05	1.56
Culvert 2	0.0125	14.8	01Jan2000, 12:00	1.56
Drainage Between Culverts	0.0585	60.7	01Jan2000, 12:05	1.56
Home Sites	0.037	37	01Jan2000, 12:05	1.56
Junction-1	0.665697	54.6	01Jan2000, 12:15	0.18
Junction-2	0.037	37	01Jan2000, 12:05	1.56
Unnamed Arroyo High Subbasin	0.534	233.6	01Jan2000, 12:40	1.56
Unnamed Arroyo Low Subbasin	0.07537	54.6	01Jan2000, 12:15	1.56
Main Low Drainage	0.590327	0	01Jan2000, 00:00	0
NECR-1	0.0204	14.8	01Jan2000, 12:15	1.56
NECR-1 outslope	0.0028	3.1	01Jan2000, 12:00	1.56
NECR-1 outslope catch	0.0028	3.1	01Jan2000, 12:00	1.56
N Red Water Pond Subb	0.0125	14.8	01Jan2000, 12:00	1.56
Pond 1	0.0267	0	01Jan2000, 00:00	0
Pond 1 Subbasin	0.0267	31.6	01Jan2000, 12:00	1.56
Pond 2	0.035927	0	01Jan2000, 00:00	0
Pond 2 Subbasin	0.009227	11.7	01Jan2000, 12:00	1.56
Pond 3	0.590327	0	01Jan2000, 00:00	0
Subbasin Between Roads	0.00796	9.9	01Jan2000, 12:00	1.56
TP, N of 566 area catch	0.06646	67.9	01Jan2000, 12:05	1.56
Trailer Park	0.0585	60.9	01Jan2000, 12:05	1.56

Appendix B

NORMAL DEPTH CALCULATION AND RIPRAP SIZING USING 1991 COE STEEP METHOD

For channels with slopes between 2 and 10 percent

FILE: riprap-coe_steep.xls
PROJECT: NECR IRA
LOCATION: Gallup, NM

Channel hydraulic properties (input):

Flow (cfs):	233.6	
Assumed D-50 (in.):	7.5	(must be greater than or equal to calculated D50)
Manning's n:	0.0350	
Bottom Width (ft):	20	
Right Side Slope, z:	2	
Left Side Slope, z:	2	
Channel Slope (ft/ft):	0.033	
Rock Specific Gravity:	2.6	
Angle of Repose (degrees):	41	

Solve

variable:	formula:
1.2562	0.00

Channel Hydraulic Results:

Depth (ft) =	1.256
Hydraulic Radius (ft) =	1.104
Cross-Sectional Area (sq ft) =	28.28
Average Velocity (fps) =	8.26
Topwidth (ft) =	25.02
Froude Number =	1.37
Flow Condition:	supercritical

INPUT COEFFICIENTS: (see manual for description)

Safety Factor, S_f:	1.1	(PMP=1.0; othewise 1.1)
Stability Coefficient, C_s:	0.3	(angular rock= 0.30; rounded rock=0.375)
Vertical Velocity Distribution Coefficient, C_v:	1	(1.0 for straight channels; 1.283-0.2*log(R/W) for outside of bends) (R=center-line radius of bend, W=water surface width)
Thickness Coefficient, C_T:	1.0	
Taken steepest Side Slope (H:1V):	2	
side slope angle (deg):	26.6	
Channel Bed Angle (deg):	1.89	
Side Slope Correction Factor, K_1:	0.938	

Calculated values:

Velocity (fps):	8.260	
Depth (ft):	1.256	
D-30 rock size (ft):	0.51	
D-30 rock size (in):	6.1	
D-50 rock size (ft):	0.608	(assuming D50 = 1.2 * D30, per Maynord paper)
D-50 rock size (in):	7.3	(must be less than or equal to assumed D50)

Ref: COE, 1991. Hydraulic Design of Flood Control Channels, EM 1110-2-1601
Ref: Stephen T. Maynord, Steep Stream Riprap Design