APPENDIX D

Urban HEC-1 Example

APPENDIX D. URBAN HEC-1 EXAMPLE

GIVEN

In this example (none of the data given in this example necessarily reflect actual conditions in this area of Vacaville), a hypothetical residential development is proposed for an area of Vacaville between the Southern Pacific Railroad and Putah South Canal along a creek (see Figure D-1). The development area is 58.0 acres, and 261 homes will be constructed. The down stream storm drainage system is already at capacity. To comply with the City's storm drainage standard requiring that the project result in no increase in peak flow from the 100-year storm, an on-line detention basin will be constructed just upstream of Putah South Canal. The current land use of the development area is open grassy fields.

At the location of the proposed detention basin, culverts crossing Putah South Canal are twin 6 feet tall by 6 feet wide box culverts, with 45-degree wing walls (the culvert data are for this example, and are not the actual culvert data). The culvert inlet flow line is at elevation 108 feet, and the basin top can be no higher than elevation 120 feet. A freeboard of 1.5 feet must also be maintained.

REQUIRED

Determine the increase in peak flow from the development parcel for the 100-year storm, and size the detention basin to comply with the City's requirement of no increase in peak flow for the 100-year storm.

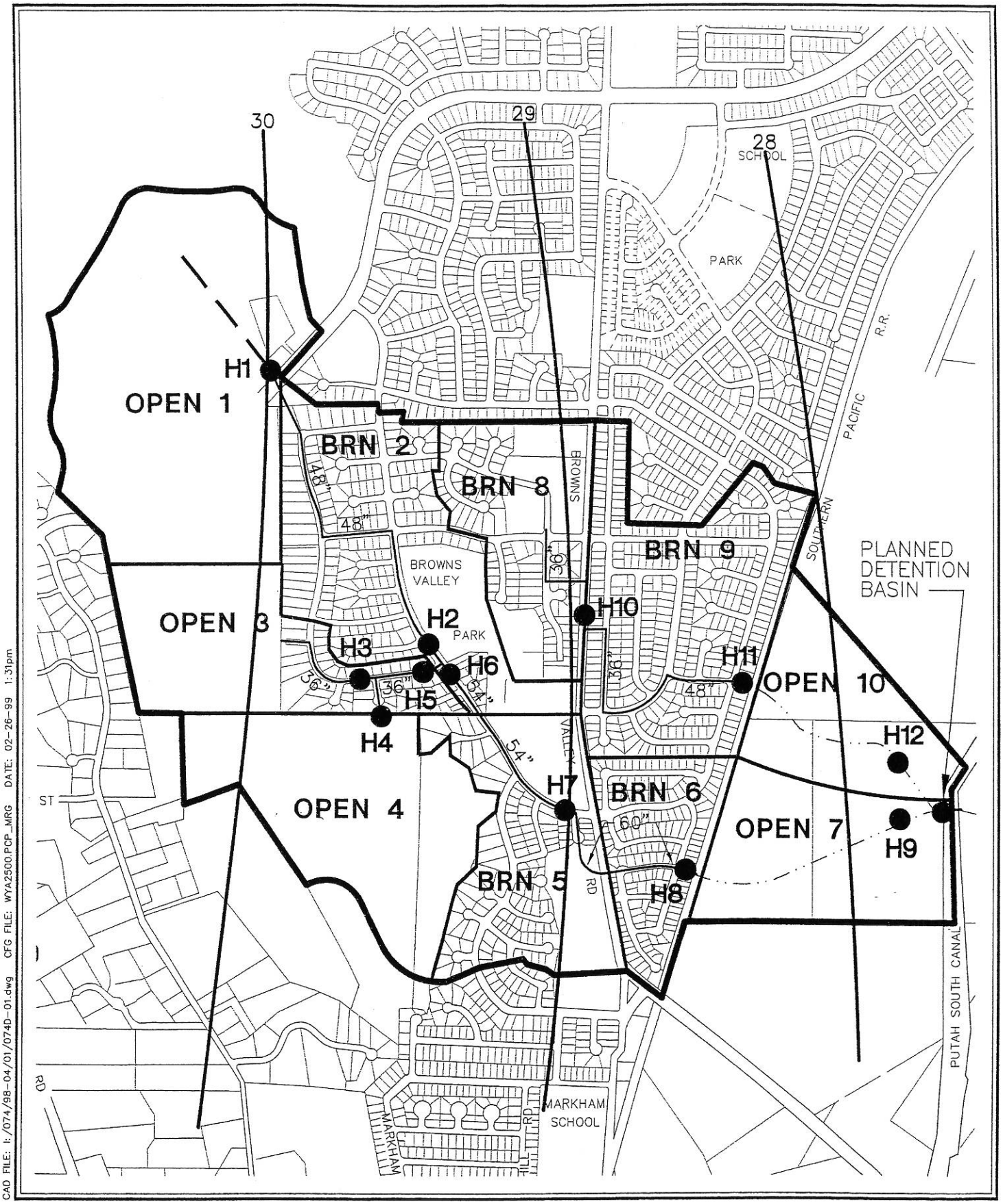
SOLUTION

The watershed and subsheds shown on Figure D-1 have been delineated using city storm drainage system maps. Pipe sizes, materials, and slopes have been determined from the storm drainage system design drawings. Although the area of development is only 58 acres, HEC-1 must be used for the analysis because the system includes a detention basin (see Table 3-1). For sizing detention basins hydrographs are required, but the rational method predicts only peak flows, not complete hydrographs.

Model Development

The steps in developing the HEC-1 model are discussed below. The HEC-1 data input file for the 100-year, 48-hour storm event is presented at the end of this appendix.

Rainfall and Losses. The MAP over this watershed average 28 inches per year. The PH record data are read from Table 3-4B, and are summarized in Table D-1. These data were entered on PH data records as shown in the model input files (at the end of this appendix).



CAD FILE: I:/074/98-04/01/074D-01.dwg CFG FILE: WYA2500.PCP_MRG DATE: 02-26-99 1:31pm

LEGEND:

- SUBSHED BOUNDARY
- 36" PIPE WITH SIZE DESIGNATIONS
- **BRN 2** SUBSHED LABEL
- ● HYDROGRAPH LOCATION AND LABEL

N

0 550 1100

SCALE IN FEET

Figure D-1

Solano County Water Agency Hydrology Manual

HEC 1/HEC HMS EXAMPLE

WEST YOST & ASSOCIATES

Table D-1. 100-Year Storm Event
Hypothetical Precipitation (PH) Record Data

Duration	PH Record Data 28-Inch MAP
5-minute	0.59
15-minute	0.95
1-hour	1.72
2-hour	2.32
3-hour	2.76
6-hour	3.72
12-hour	5.01
1-day	6.74
2-day	9.17

Initial and constant precipitation losses were estimated for the subsheds using the subshed land uses and Tables 3-5 and 3-6. The results are summarized in Table D-2. These data were entered on LU data records as shown in the model input files (at the end of this appendix). The impervious percentages for the LU records are summarized in Table D-3.

Table D-2. Precipitation and Losses

Subshed Name	Mean Annual Precipitation, inches	Initial Loss		Constant Loss		
		Land Use	Initial Loss for Pervious Areas,[a] inches	% Hydrologic Soil Group C[b]	% Hydrologic Soil Group D[c]	Average Constant Loss Rate, in/hr
OPEN 1	30	Wooded	0.4	100	0	0.10
BRN 2	30	Residential	0.3	30	70	0.04
OPEN 3	30	Wooded	0.4	80	20	0.08
OPEN 4	30	Wooded	0.4	95	5	0.10
BRN 5	29	Residential	0.3	50	50	0.06
BRN 6	29	Residential	0.3	25	75	0.04
OPEN 7	28	Field	0.2	40	60	0.05
BRN 8	29	Residential	0.3	95	5	0.10
BRN 9	29	Residential	0.3	90	10	0.09
OPEN 10	28	Field	0.2	85	15	0.09

[a] Initial losses based on values of 0.2" for fields with minimal vegetation, 0.3" for lawn grass, and 0.4" for wooded areas as shown in Table 3-5.
[b] Constant loss rate for hydrologic soil group C is 0.10 in/hr from Table 3-6.
[c] Constant loss rate for hydrologic soil group D is 0.02 in/hr from Table 3-6.

Table D-3. Subshed Percent Impervious[a]

Subshed Name	Area, acres				Average Percent Impervious, %
	Residential	Commercial	Park	Open	
Percent Impervious:	40	90	8	3	
OPEN 1	—	—	—	128	3.0
BRN 2	82	—	20.4	—	33.6
OPEN 3	18.4	—	—	26.4	18.2
OPEN 4	—	—	—	64	3.0
BRN 5	34.9	12.6	10.1	—	45.3
BRN 6	38.4	—	—	—	40.0
OPEN 7	—	—	—	57.6	3.0
BRN 8	57.5	—	6.5	—	36.8
BRN 9	83.2	—	—	—	40.0
OPEN 10	—	—	—	45.6	3.0

[a] Impervious percentages are from Table 3-7.

Snyder's Method. The coefficients for Snyder's method were calculated using Equations 3-5 and 3-6, and are summarized in Table D-4. The undeveloped subsheds have a development adjustment of 0.00 and the developed subsheds have a development adjustment of 0.01. Subsheds OPEN 1, OPEN 3, and OPEN 4 have slopes between 10 and 20 percent and thus have slope adjustments of 0.01. The Snyder coefficients were entered into the model on "US" data records.

Table D-4. Development of Snyder's Method Coefficients

Subshed Name	Lag Time			
	Area, acres	Percent Urbanization, %	Slope, ft/ft	Snyder's Lag,[a] hours
OPEN 1	128	0	0.050	0.88
BRN 2	102.4	100	0.020	0.23
OPEN 3	44.8	0	0.050	0.71
OPEN 4	64	0	0.050	0.77
BRN 5	57.6	100	0.020	0.21
BRN 6	38.4	100	0.005	0.22
OPEN 7	57.6	0	0.005	0.95
BRN 8	64	100	0.013	0.22
BRN 9	83.2	100	0.005	0.25
OPEN 10	45.6	0	0.005	0.90

[a] Snyder's standard lag time is calculated using Equation 3-6.

Routing. Hydrograph routing was performed using the Muskingum-Cunge routing method, as recommended in Section 3-4. Pipe sizes were obtained from storm drain system design drawings and an "n" value of 0.015 was assumed for all concrete pipes. The channel dimensions and n value were estimated during a site visit.

EXISTING CONDITION RESULTS

The HEC-1 model results (using the standard HEC modeling procedures recommended in Section 3-4) are presented in Table D-5. The peak flow at the site of the planned detention basin is 940 cfs. The HEC summary output is presented at the end of this appendix following the existing conditions HEC-1 input file.

Table D-5. HEC-1 Results

Analysis Point[(a)]	Peak Flow, cfs		
	Existing Conditions	With Development	With Development and Detention Basin
H 1	125	125	125
H 2	295	295	295
H 3 (OPEN 3)	60	60	60
H 4 (OPEN 4)	68	68	68
H 5	125	125	125
H 6	395	395	395
H 7	505	505	505
H 8	578	578	578
H 9	612	690	690
H 10	141	141	141
H 11	318	318	318
H 12	335	340	340
Detention Basin Site Discharge (CH9H12)	940	1,031	925

(a) Use Figure D-1 for locations of analysis points

DEVELOPMENT PROJECT

For the proposed development project, single family homes will be constructed in Subsheds OPEN 7 and OPEN 10. About 97 percent of Subshed OPEN 7 will be developed, resulting in the following changes to the HEC-1 data for Subshed OPEN 7:

- Initial loss rate changes from 0.20 inches to 0.30 inches

- Constant loss rate is unchanged at 0.05 inches
- Percent impervious changes from 3 percent to 39 percent
- Snyder's Lag changes from 0.95 hours to 0.26 hours

About 20 percent (9.2 acres out of 45.6 acres) of Subshed OPEN 10 will be developed, resulting in the following changes to the HEC-1 data:

- Initial loss rate changes from 0.20 inches to 0.22 inches
- Constant loss rate is unchanged at 0.09 inches
- Percent impervious changes from 3 percent to 10 percent
- Snyder's Lag changes from 0.90 hours to 0.77 hours

The HEC-1 input file, revised to include these changes, is presented at the end of this appendix. The peak flows are summarized in Table D-5 (the HEC-1 output summary is presented following the HEC-1 input file at the end of this appendix). As expected, the peak flows upstream of the development areas are unchanged. The peak flow at Analysis Point H9 (including Subshed OPEN 7) increased from 612 cfs to 690 cfs. The peak flow at Analysis Point H12 (including Subshed OPEN 10) increased from 335 cfs to 340 cfs. The peak flow from the detention basin site increased from 940 cfs to 1,031 cfs.

DETENTION BASIN

At the location of the proposed detention basin, culverts crossing Putah South Canal are twin 6 feet tall by 6 feet wide box culverts, with 45 degree wing walls. The culvert inlet flow line is at 108 feet and the basin top can be no higher than 120 feet. A freeboard of 1.5 feet must also be maintained. Thus, the maximum water depth allowable in the basin is 10.5 feet (108 feet to 118.5 feet elevation).

The detention basin has been modeled using the SA, SQ, and SE data records in the HEC-1 model. The SA record lists the detention basin surface areas corresponding to the water surface elevations listed on the SE record. Similarly, the SQ record lists the discharge flow rates corresponding to the water surface elevations listed on the SE record. The data for these records are summarized in Table D-6, and the input file is presented at the end of this appendix.

Table D-6. Detention Basin HEC-1 Record Data

Record ID	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7
SE (elevation), feet	108	110	112	114	116	118	120
SQ (flow), cfs	0	100	288	552	744	900	1,044
SA (area), acres	0	0.708	0.886	1.025	1.183	1.342	1.500

The SE data range from the bottom elevation of 108 feet to the top elevation of 120 feet. The SQ data are from a design chart for inlet controlled box culverts, and are the flow through twin 6 feet tall by 6 feet wide box culverts corresponding to water depths above the bottom elevation (0, 2.0, 4.0, 6.0, 8.0, 10.0, and 12.0 feet deep).

Using several trial runs, the required size of the detention basin was determined. The basin is square with an area of 1.50 acres, has a top elevation of 120 feet, a bottom elevation of 108 feet, and 4:1 side slopes down to an elevation of 110 feet. The basin areas corresponding to the SE record data are also shown in Table D-6.

As shown in Table D-5, the peak outflow from the detention basin is 925 cfs, which is less than the maximum permissible flow of 940 cfs. The basin fills to a maximum WSEL of 118.35 feet, which is under the maximum allowable level of 118.5 feet. Thus, the 1.5-acre detention basin satisfies the requirement for no increase in the 100-year peak flow. The HEC-1 output summary is presented following the input data file.

ATTACHMENT D-1

Existing Conditions HEC-1 Input File and Output Summary

```
ID     SOLANO COUNTY WATER AGENCY HEC 1 EXAMPLE
ID     BASED ON AN AREA AROUND BROWNS VALLEY SCHOOL IN VACAVILLE
ID     DRAINAGE CONDITIONS/FACILITIES MODIFIED FOR ILLUSTRATION PURPOSES
ID     EXISTING CONDITIONS
ID     100-YEAR,24-HOUR STORM EVENT
*
*FREE
*DIAGRAM
IT 5,01JAN99,0000,,03JAN99,0000
IO 1
*
KK OPEN1
KM HILLS WEST OF WRENTHAM DRIVE (MAP=28 IN)
KM AREA TO BE DEVELOPED
BA 0.20
PH 100,,0.59,0.95,1.72,2.32,2.76,3.72,5.01,6.74
PH 9.17
LU 0.40,0.10,3
US 0.88,0.45
*
KK H1
RD 700,0.060,0.040,,TRAP,4,2.5
*
KK BRN2
KM RESIDENTIAL AREA AROUND WRENTHAM DRIVE (MAP=28 IN)
BA 0.16
LU 0.30,0.04,34
US 0.23,0.45
*
KK CO1B2
KM COMBINE OPEN1 AND BRN2
HC2
*
KK H2
KM ROUTE TO LOCATION HB2
RD 3240,0.010,0.015,,CIRC,4.0
*
KK OPEN3
KM HILLS WEST OF WRENTHAM DRIVE (MAP=28 IN)
KM AREA TO BE DEVELOPED
BA 0.07
LU 0.40,0.08,18
US 0.55,0.45
*
KK OPEN4
KM HILLS WEST OF WRENTHAM DRIVE (MAP=28 IN)
KM AREA TO BE DEVELOPED (HYDROGRAPH HB4)
BA 0.1
LU 0.40,0.10,3
US 0.77,0.45
*
KK CO3O4
KM COMBINE OPEN3 AND OPEN4
HC 2
*
KK H5
RD 600,0.010,0.015,,CIRC,3.0
*
KK H6
KM COMBINE OPEN3/OPEN4 WITH OPEN1/BRN2
HC 2
*
KK ROUTE
RD 1680,0.010,0.015,,CIRC,4.5
*
KK BRN5
KM RUNOFF FROM URBAN AREA BRN5 (MAP = 28 IN)
BA 0.09
LU 0.3,0.06,45
US 0.21,0.45
*
KK H7
KM COMBINE HYDROGRAPH H6 WITH BRN5
HC 2
*
KK RH7
RD 1200,0.005,0.015,,CIRC,5.0
```

```
*
KK BRN6
KM URBAN AREA BETWEEN BROWNS VALLEY ROAD AND RR TRACKS (MAP = 28 IN)
BA 0.06
LU 0.30,0.04,40
US 0.22,0.45
*
KK H8
KM COMBINE HYDROGRAPH H7 WITH BRN6
HC 2
*
KK OPEN7
KM RUNOFF FROM RURAL AREA EAST OF RXR (MAP = 28 IN)
BA 0.09
LU 0.20,0.05,3
US 0.95,0.45
*
KK CO7H8
KM COMBINE HYDROGRAPH H8 WITH OPEN7
HC 2
*
KK H9
RD 1920,0.006,0.030,,TRAP,6,2.0
*
KK BRN8
KM RUNOFF FROM URBAN AREA WEST OF BROWN'S VALLEY ROAD (MAP = 28 IN)
BA 0.10
LU 0.30,0.10,37
US 0.22,0.45
*
KK H10
KM ROUTE TO LOCATION H10
RD 1200,0.008,0.015,,CIRC,3.0
*
KK BRN9
KM RUNOFF FROM URBAN AREA BROWNS VALLEY ROAD AND RR TRACKS (MAP = 28 IN)
BA 0.13
LU 0.30,0.09,40
US 0.25,0.45
*
KK CB9H10
KM COMBINE BRN 9 WITH HYDROGRAPH H10
HC 2
*
KK H11
RD 1680,0.008,0.015,,CIRC,3.0
RD 720,0.008,0.015,,CIRC,4.0
*
KK OPEN10
KM RUNOFF FROM RURAL AREA EAST OF RR TRACKS (MAP = 28 IN)
BA 0.07
LU 0.20,0.09,3
US 0.90,0.45
*
KK CH11O10
KM COMBINE HYDROGRAPH HB11 AND OPEN10
HC 2
*
KK H12
KM ROUTE TO PLANNED DETENTION BASIN
RD 1800,0.005,0.030,,TRAP,6,2.0
*
KK CH9H12
KM COMBINE HYDROGRAPH H9 AND HYDROGRAPH H12 FOR FLOW INTO DETENTION BASIN
HC 2
ZZ
```

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	OPEN1	125.	13.33	64.	23.	22.	.20		
+	ROUTED TO	H1	125.	13.33	64.	23.	22.	.20		
+	HYDROGRAPH AT	BRN2	231.	12.67	61.	26.	25.	.16		
+	2 COMBINED AT	CO1B2	299.	12.75	123.	49.	47.	.36		
+	ROUTED TO	H2	295.	12.75	123.	49.	47.	.36		
+	HYDROGRAPH AT	OPEN3	60.	13.00	25.	9.	9.	.07		
+	HYDROGRAPH AT	OPEN4	68.	13.25	32.	12.	11.	.10		
+	2 COMBINED AT	CO3O4	125.	13.17	57.	21.	20.	.17		
+	ROUTED TO	H5	125.	13.17	57.	21.	20.	.17		
+	2 COMBINED AT	H6	395.	12.83	180.	70.	67.	.53		
+	ROUTED TO	ROUTE	395.	12.92	180.	69.	67.	.53		
+	HYDROGRAPH AT	BRN5	136.	12.67	34.	14.	14.	.09		
+	2 COMBINED AT	H7	505.	12.83	214.	84.	81.	.62		
+	ROUTED TO	RH7	502.	12.83	214.	84.	81.	.62		
+	HYDROGRAPH AT	BRN6	88.	12.67	23.	10.	9.	.06		
+	2 COMBINED AT	H8	578.	12.83	236.	93.	90.	.68		
+	HYDROGRAPH AT	OPEN7	57.	13.42	31.	13.	12.	.09		
+	2 COMBINED AT	CO7H8	616.	12.83	267.	106.	103.	.77		
+	ROUTED TO	H9	612.	12.92	267.	106.	102.	.77		
+	HYDROGRAPH AT	BRN8	145.	12.67	36.	14.	13.	.10		
+	ROUTED TO	H10	141.	12.75	36.	14.	13.	.10		
+	HYDROGRAPH AT	BRN9	179.	12.75	47.	19.	18.	.13		
+	2 COMBINED AT	CB9H10	320.	12.75	83.	33.	32.	.23		
+	ROUTED TO	H11	318.	12.75	83.	33.	32.	.23		
+	HYDROGRAPH AT	OPEN10	44.	13.33	23.	9.	8.	.07		
+	2 COMBINED AT	CH11O10	344.	12.75	105.	41.	40.	.30		
+	ROUTED TO	H12	335.	12.83	105.	41.	40.	.30		
+	2 COMBINED AT	CH9H12	940.	12.83	371.	147.	142.	1.07		

ATTACHMENT D-2

Developed Conditions HEC-1 Input File and Output Summary

```
ID     SOLANO COUNTY WATER AGENCY HEC 1 EXAMPLE
ID     BASED ON AN AREA AROUND BROWNS VALLEY SCHOOL IN VACAVILLE
ID     DRAINAGE CONDITIONS/FACILITIES MODIFIED FOR ILLUSTRATION PURPOSES
ID     DEVELOPED CONDITIONS
ID     100-YEAR,24-HOUR STORM EVENT
*
*FREE
*DIAGRAM
IT 5,01JAN99,0000,,03JAN99,0000
IO 1
*
KK OPEN1
KM HILLS WEST OF WRENTHAM DRIVE (MAP=28 IN)
KM AREA TO BE DEVELOPED
BA 0.20
PH 100,,0.59,0.95,1.72,2.32,2.76,3.72,5.01,6.74
PH 9.17
LU 0.40,0.10,3
US 0.88,0.45
*
KK H1
RD 700,0.060,0.040,,TRAP,4,2.5
*
KK BRN2
KM RESIDENTIAL AREA AROUND WRENTHAM DRIVE (MAP=28 IN)
BA 0.16
LU 0.30,0.04,34
US 0.23,0.45
*
KK CO1B2
KM COMBINE OPEN1 AND BRN2
HC2
*
KK H2
KM ROUTE TO LOCATION HB2
RD 3240,0.010,0.015,,CIRC,4.0
*
KK OPEN3
KM HILLS WEST OF WRENTHAM DRIVE (MAP=28 IN)
KM AREA TO BE DEVELOPED
BA 0.07
LU 0.40,0.08,18
US 0.55,0.45
*
KK OPEN4
KM HILLS WEST OF WRENTHAM DRIVE (MAP=28 IN)
KM AREA TO BE DEVELOPED (HYDROGRAPH HB4)
BA 0.1
LU 0.40,0.10,3
US 0.77,0.45
*
KK CO3O4
KM COMBINE OPEN3 AND OPEN4
HC 2
*
KK H5
RD 600,0.010,0.015,,CIRC,3.0
*
KK H6
KM COMBINE OPEN3/OPEN4 WITH OPEN1/BRN2
HC 2
*
KK ROUTE
RD 1680,0.010,0.015,,CIRC,4.5
*
KK BRN5
KM RUNOFF FROM URBAN AREA BRN5 (MAP = 28 IN)
BA 0.09
LU 0.3,0.06,45
US 0.21,0.45
*
KK H7
KM COMBINE HYDROGRAPH H6 WITH BRN5
HC 2
*
KK RH7
```

```
RD 1200,0.005,0.015,,CIRC,5.0
*
KK BRN6
KM URBAN AREA BETWEEN BROWNS VALLEY ROAD AND RR TRACKS (MAP = 28 IN)
BA 0.06
LU 0.30,0.04,40
US 0.22,0.45
*
KK H8
KM COMBINE HYDROGRAPH H7 WITH BRN6
HC 2
*
KK OPEN7
KM RUNOFF FROM RURAL AREA EAST OF RXR (MAP = 28 IN)
BA 0.09
LU 0.30,0.05,39
US 0.26,0.45
*
KK CO7H8
KM COMBINE HYDROGRAPH H8 WITH OPEN7
HC 2
*
KK H9
RD 1920,0.006,0.030,,TRAP,6,2.0
*
KK BRN8
KM RUNOFF FROM URBAN AREA WEST OF BROWN'S VALLEY ROAD (MAP = 28 IN)
BA 0.10
LU 0.30,0.10,37
US 0.22,0.45
*
KK H10
KM ROUTE TO LOCATION H10
RD 1200,0.008,0.015,,CIRC,3.0
*
KK BRN9
KM RUNOFF FROM URBAN AREA BROWNS VALLEY ROAD AND RR TRACKS (MAP = 28 IN)
BA 0.13
LU 0.30,0.09,40
US 0.25,0.45
*
KK CB9H10
KM COMBINE BRN 9 WITH HYDROGRAPH H10
HC 2
*
KK H11
RD 1680,0.008,0.015,,CIRC,3.0
RD 720,0.008,0.015,,CIRC,4.0
*
KK OPEN10
KM RUNOFF FROM RURAL AREA EAST OF RR TRACKS (MAP = 28 IN)
BA 0.07
LU 0.22,0.09,10
US 0.77,0.45
*
KK CH11O10
KM COMBINE HYDROGRAPH HB11 AND OPEN10
HC 2
*
KK H12
KM ROUTE TO PLANNED DETENTION BASIN
RD 1800,0.005,0.030,,TRAP,6,2.0
*
KK CH9H12
KM COMBINE HYDROGRAPH H9 AND HYDROGRAPH H12 FOR FLOW INTO DETENTION BASIN
HC 2
*
ZZ
```

RUNOFF SUMMARY

FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	OPEN1	125.	13.33	64.	23.	22.	.20		
+	ROUTED TO	H1	125.	13.33	64.	23.	22.	.20		
+	HYDROGRAPH AT	BRN2	231.	12.67	61.	26.	25.	.16		
+	2 COMBINED AT	CO1B2	299.	12.75	123.	49.	47.	.36		
+	ROUTED TO	H2	295.	12.75	123.	49.	47.	.36		
+	HYDROGRAPH AT	OPEN3	60.	13.00	25.	9.	9.	.07		
+	HYDROGRAPH AT	OPEN4	68.	13.25	32.	12.	11.	.10		
+	2 COMBINED AT	CO3O4	125.	13.17	57.	21.	20.	.17		
+	ROUTED TO	H5	125.	13.17	57.	21.	20.	.17		
+	2 COMBINED AT	H6	395.	12.83	180.	70.	67.	.53		
+	ROUTED TO	ROUTE	395.	12.92	180.	69.	67.	.53		
+	HYDROGRAPH AT	BRN5	136.	12.67	34.	14.	14.	.09		
+	2 COMBINED AT	H7	505.	12.83	214.	84.	81.	.62		
+	ROUTED TO	RH7	502.	12.83	214.	84.	81.	.62		
+	HYDROGRAPH AT	BRN6	88.	12.67	23.	10.	9.	.06		
+	2 COMBINED AT	H8	578.	12.83	236.	93.	90.	.68		
+	HYDROGRAPH AT	OPEN7	122.	12.75	34.	14.	14.	.09		
+	2 COMBINED AT	CO7H8	693.	12.83	270.	108.	104.	.77		
+	ROUTED TO	H9	690.	12.83	270.	107.	104.	.77		
+	HYDROGRAPH AT	BRN8	145.	12.67	36.	14.	13.	.10		
+	ROUTED TO	H10	141.	12.75	36.	14.	13.	.10		
+	HYDROGRAPH AT	BRN9	179.	12.75	47.	19.	18.	.13		
+	2 COMBINED AT	CB9H10	320.	12.75	83.	33.	32.	.23		
+	ROUTED TO	H11	318.	12.75	83.	33.	32.	.23		
+	HYDROGRAPH AT	OPEN10	49.	13.25	23.	9.	8.	.07		
+	2 COMBINED AT	CH11O10	349.	12.75	106.	42.	40.	.30		
+	ROUTED TO	H12	340.	12.83	106.	41.	40.	.30		
+	2 COMBINED AT	CH9H12	1031.	12.83	375.	149.	144.	1.07		

ATTACHMENT D-3

Developed and Detained Conditions HEC-1 Input File and Output Summary

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ID     SOLANO COUNTY WATER AGENCY HEC 1 EXAMPLE
ID     BASED ON AN AREA AROUND BROWNS VALLEY SCHOOL IN VACAVILLE
ID     DRAINAGE CONDITIONS/FACILITIES MODIFIED FOR ILLUSTRATION PURPOSES
ID     DETAINED CONDITIONS
ID     100-YEAR,24-HOUR STORM EVENT
*
*FREE
*DIAGRAM
IT 5,01JAN99,0000,,03JAN99,0000
IO 1
*
KK OPEN1
KM HILLS WEST OF WRENTHAM DRIVE (MAP=28 IN)
KM AREA TO BE DEVELOPED
BA 0.20
PH 100,,0.59,0.95,1.72,2.32,2.76,3.72,5.01,6.74
PH 9.17
LU 0.40,0.10,3
US 0.88,0.45
*
KK H1
RD 700,0.060,0.040,,TRAP,4,2.5
*
KK BRN2
KM RESIDENTIAL AREA AROUND WRENTHAM DRIVE (MAP=28 IN)
BA 0.16
LU 0.30,0.04,34
US 0.23,0.45
*
KK CO1B2
KM COMBINE OPEN1 AND BRN2
HC2
*
KK H2
KM ROUTE TO LOCATION HB2
RD 3240,0.010,0.015,,CIRC,4.0
*
KK OPEN3
KM HILLS WEST OF WRENTHAM DRIVE (MAP=28 IN)
KM AREA TO BE DEVELOPED
BA 0.07
LU 0.40,0.08,18
US 0.55,0.45
*
KK OPEN4
KM HILLS WEST OF WRENTHAM DRIVE (MAP=28 IN)
KM AREA TO BE DEVELOPED (HYDROGRAPH HB4)
BA 0.1
LU 0.40,0.10,3
US 0.77,0.45
*
KK CO3O4
KM COMBINE OPEN3 AND OPEN4
HC 2
*
KK H5
RD 600,0.010,0.015,,CIRC,3.0
*
KK H6
KM COMBINE OPEN3/OPEN4 WITH OPEN1/BRN2
HC 2
*
KK ROUTE
RD 1680,0.010,0.015,,CIRC,4.5
*
KK BRN5
KM RUNOFF FROM URBAN AREA BRN5 (MAP = 28 IN)
BA 0.09
LU 0.3,0.06,45
US 0.21,0.45
*
KK H7
KM COMBINE HYDROGRAPH H6 WITH BRN5
HC 2
*
KK RH7
RD 1200,0.005,0.015,,CIRC,5.0
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*
KK BRN6
KM URBAN AREA BETWEEN BROWNS VALLEY ROAD AND RR TRACKS (MAP = 28 IN)
BA 0.06
LU 0.30,0.04,40
US 0.22,0.45
*
KK H8
KM COMBINE HYDROGRAPH H7 WITH BRN6
HC 2
*
KK OPEN7
KM RUNOFF FROM RURAL AREA EAST OF RXR (MAP = 28 IN)
BA 0.09
LU 0.30,0.05,39
US 0.26,0.45
*
KK CO7H8
KM COMBINE HYDROGRAPH H8 WITH OPEN7
HC 2
*
KK H9
RD 1920,0.006,0.030,,TRAP,6,2.0
*
KK BRN8
KM RUNOFF FROM URBAN AREA WEST OF BROWN'S VALLEY ROAD (MAP = 28 IN)
BA 0.10
LU 0.30,0.10,37
US 0.22,0.45
*
KK H10
KM ROUTE TO LOCATION H10
RD 1200,0.008,0.015,,CIRC,3.0
*
KK BRN9
KM RUNOFF FROM URBAN AREA BROWNS VALLEY ROAD AND RR TRACKS (MAP = 28 IN)
BA 0.13
LU 0.30,0.09,40
US 0.25,0.45
*
KK CB9H10
KM COMBINE BRN 9 WITH HYDROGRAPH H10
HC 2
*
KK H11
RD 1680,0.008,0.015,,CIRC,3.0
RD 720,0.008,0.015,,CIRC,4.0
*
KK OPEN10
KM RUNOFF FROM RURAL AREA EAST OF RR TRACKS (MAP = 28 IN)
BA 0.07
LU 0.22,0.09,10
US 0.77,0.45
*
KK CH11O10
KM COMBINE HYDROGRAPH HB11 AND OPEN10
HC 2
*
KK H12
KM ROUTE TO PLANNED DETENTION BASIN
RD 1800,0.005,0.030,,TRAP,6,2.0
*
KK CH9H12
KM COMBINE HYDROGRAPH H9 AND HYDROGRAPH H12 FOR FLOW INTO DETENTION BASIN
HC 2
*
KK DETENTION
RS 1,STOR,0,0
SA 0,0.708,0.866,1.025,1.183,1.342,1.500
SQ 0,100,288,552,744,900,1044
SE 108,110,112,114,116,118,120
*
ZZ
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RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	OPEN1	125.	13.33	64.	23.	22.	.20		
+	ROUTED TO	H1	125.	13.33	64.	23.	22.	.20		
+	HYDROGRAPH AT	BRN2	231.	12.67	61.	26.	25.	.16		
+	2 COMBINED AT	CO1B2	299.	12.75	123.	49.	47.	.36		
+	ROUTED TO	H2	295.	12.75	123.	49.	47.	.36		
+	HYDROGRAPH AT	OPEN3	60.	13.00	25.	9.	9.	.07		
+	HYDROGRAPH AT	OPEN4	68.	13.25	32.	12.	11.	.10		
+	2 COMBINED AT	CO3O4	125.	13.17	57.	21.	20.	.17		
+	ROUTED TO	H5	125.	13.17	57.	21.	20.	.17		
+	2 COMBINED AT	H6	395.	12.83	180.	70.	67.	.53		
+	ROUTED TO	ROUTE	395.	12.92	180.	69.	67.	.53		
+	HYDROGRAPH AT	BRN5	136.	12.67	34.	14.	14.	.09		
+	2 COMBINED AT	H7	505.	12.83	214.	84.	81.	.62		
+	ROUTED TO	RH7	502.	12.83	214.	84.	81.	.62		
+	HYDROGRAPH AT	BRN6	88.	12.67	23.	10.	9.	.06		
+	2 COMBINED AT	H8	578.	12.83	236.	93.	90.	.68		
+	HYDROGRAPH AT	OPEN7	122.	12.75	34.	14.	14.	.09		
+	2 COMBINED AT	CO7H8	693.	12.83	270.	108.	104.	.77		
+	ROUTED TO	H9	690.	12.83	270.	107.	104.	.77		
+	HYDROGRAPH AT	BRN8	145.	12.67	36.	14.	13.	.10		
+	ROUTED TO	H10	141.	12.75	36.	14.	13.	.10		
+	HYDROGRAPH AT	BRN9	179.	12.75	47.	19.	18.	.13		
+	2 COMBINED AT	CB9H10	320.	12.75	83.	33.	32.	.23		
+	ROUTED TO	H11	318.	12.75	83.	33.	32.	.23		
+	HYDROGRAPH AT	OPEN10	49.	13.25	23.	9.	8.	.07		
+	2 COMBINED AT	CH11O10	349.	12.75	106.	42.	40.	.30		
+	ROUTED TO	H12	340.	12.83	106.	41.	40.	.30		
+	2 COMBINED AT	CH9H12	1031.	12.83	375.	149.	144.	1.07		
+	ROUTED TO	DETENTIO	925.	13.00	375.	149.	144.	1.07		
+									118.35	13.00