APPENDIX 7-10

Peak Flow Simulation Results

UtahAmerican Energy, Inc.

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INTRODUCTION:

The following simulation was prepared to provide a characterization of the variation of flow as a result of differing rainfall return periods within each drainage basin within the Lila Canyon Permit Area. Surface waters in or adjacent to the permit area have not exhibited flow on a long term basis and therefore were characterized as intermittent or ephemeral in nature.

General:

Figure 1 for Appendix 7-10 presents the nine drainage basins that were evaluated as part of the simulations. These drainages include: Noname Wash (WS1), Little Park Wash (WS 2 through 6), Stinky Spring Wash (WS 7), Lila Canyon (WS 9), and a smaller tributary (WS 8).

The drainages were simulated for the 6-hour and 24-hour rainfall events. This provides an assessment of the drainages response to different types of rainfall events. The 6-hour events are typical of local, isolated high intensity thunderstorms, while the 24-hour events are typical of large, frontal type storms. Rainfall data were obtained from the precipitation frequency data server from the NOAA web site (see Attachment 1)

The simulation was conducted using the Hydroflow program prepared by Intelisolve. This program uses the NRCS unit hydrograph method with selected rainfall distributions to simulate peak flows. It also incorporates channel routing and hydrograph addition to allow multiple watersheds to be simulated and modeled to determine the effect on combined watershed flows.

For the simulation, the watersheds were modeled using a weighted curve number value to cover the entire watershed. This value was determined based on professional judgement using soils and vegetation information from the watershed areas. For the watersheds, the curve number was based on a hydrologic soil group of 'B' due to the sandy soils predominant in the higher elevations and a combination of sage-grass and juniper-grass vegetation with a ground and canopy cover percentage of 40 (see Figure 9.6 from NEH-4 Attached). Hydraulic length and slope values were determined from the topographic maps of the area. Watershed inputs are presented in Table 1.

Channel routing parameters were determined from field observation and from topographic maps of the area. Channel routing inputs are presented in Table 2.

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Simulations were prepared for the 2-, 5-, 10-, 25-, 50-, and 100-year, 6-hour and 24-hour rainfall events for each watershed. The results of these simulations are presented in Table 3. These simulation results present the individual watershed values for watersheds 1, 7, 8, and 9 and the cumulative flows at the junction points within the channel or the total flow for the watershed Little Park Wash. Graphs of the combined hydrographs of each watershed are presented in Attachment 2.

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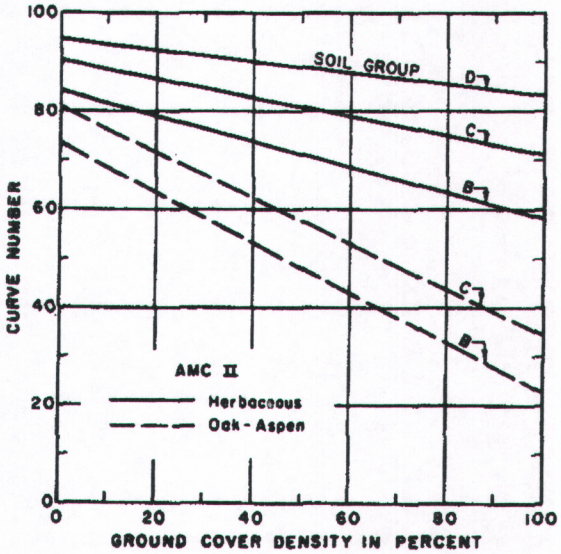

Figure 9.5.--Graph for estimating runoff curve numbers of forest-range complexes in western United States: herbaceous and oak-aspen complexes.

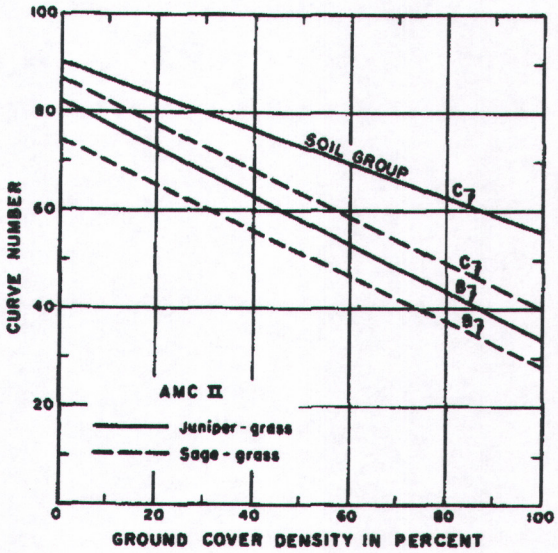

Figure 9.6.--Graph for estimating runoff curve numbers of forest-range complexes in western United States: juniper-grass and sage-grass complexes.

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Table 1

PEAK FLOW SIMULATION WATERSHED INPUTS

Watershed ID	Drainage Area (ac)	Curve Number	Hydraulic Length (ft)	Basin Slope (%)	Time of Concentration (min)
WS1.1	427	65	7290	21.8	50.88
WS1.2	566	65	7520	4.3	118.03
WS7.1	849	65	12880	19.7	84.30
WS8.1	278	65	9670	21.1	64.80
WS9.1	1317	65	13900	20.0	89.00
Little Park 6.1	499	65	7930	20.8	55.70
Little Park 6.2	285	65	6790	19.3	51.10
Little Park 6.3	94	65	2170	4.2	44.20
Little Park 5.1	77	65	2230	44.8	13.70
Little Park 5.2	213	65	4550	13.2	44.80
Little Park 4.1	189	65	3850	31.3	25.40
Little Park 4.2	232	65	5010	10.4	54.60
Little Park 6.4	67	65	2370	4.2	47.00
Little Park 6.5	276	65	6770	17.5	53.50
Little Park 6.6	383	65	5730	3.3	107.50
Little Park 3.1	687	65	7090	24.2	47.20
Little Park 3.2	379	65	4980	4.4	83.30
Little Park 6.7	399	65	5760	2.9	191.30
Little Park 2.1	272	65	7810	22.0	57.80
Little Park 2.2	333	65	7010	4.7	106.20
Little Park 6.8	444	65	6810	2.9	132.1

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Table 2

PEAK FLOW SIMULATION CHANNEL INPUTS

Channel ID	Reach Length (ft)	Mannings n	Side Slope (xH:1V)	Bottom Width (ft)	Channel Slope (%)
WS1 Channel	7520	0.030	2	8	4.3
WS2 Channel	8560	0.030	2	8	4.7
WS6.3 Channel	2170	0.030	2	8	4.2
WS5.2 Channel	4550	0.030	2	8	13.2
WS6.4 Channel	2370	0.030	2	8	4.2
WS4.2 Channel	5010	0.030	2	8	10.4
WS6.6 Channel	5730	0.030	2	8	3.3
WS3.2 Channel	4980	0.030	2	8	4.4
WS6.7 Channel	5760	0.030	2	8	2.9
WS6.8 Channel	6810	0.030	2	8	2.9

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Table 3

PEAK FLOW SIMULATIONS OF UNDISTURBED DRAINAGES
IN THE LILA CANYON MINE AREA

Watershed ID	Return Period	2yr (cfs)	5yr (cfs)	10yr (cfs)	25yr (cfs)	50yr (cfs)	100yr (cfs)
WS1.1	6 hr	0	0	1.39	5.54	9.98	17.18
	24 hr	0.65	3.22	9.31	22.68	39.50	59.77
WS1.2	6 hr	0	0	1.21	6.43	12.77	22.18
	24 hr	0.86	3.82	9.45	20.66	33.99	49.70
WS1 Total	6 hr	0	0	2.37	11.78	22.68	38.79
	24 hr	1.50	6.62	16.96	39.59	67.46	100.70
WS7 Total	6 hr	0	0	2.23	10.43	19.63	33.75
	24 hr	1.29	6.04	15.85	36.15	60.94	90.24
WS8 Total	6 hr	0	0	0.85	3.60	6.59	11.34
	24 hr	0.43	2.09	5.76	13.64	23.46	35.09
WS9 Total	6 hr	0	0	3.46	16.17	30.46	52.36
	24 hr	2.01	9.38	24.59	56.08	94.53	139.99

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Table 3

PEAK FLOW SIMULATIONS OF UNDISTURBED DRAINAGES
IN THE LILA CANYON MINE AREA

Watershed ID	Return Period	2yr (cfs)	5yr (cfs)	10yr (cfs)	25yr (cfs)	50yr (cfs)	100yr (cfs)
Little Park 6.1	6 hr	0	0	1.63	6.48	11.66	20.08
	24 hr	0.76	3.76	10.88	26.5	46.16	69.84
Little Park 6.2	6 hr	0	0	0.93	3.70	6.66	11.47
	24 hr	0.44	2.15	6.21	15.14	26.36	39.89
Little Park 6 Cumulative	6 hr	0	0	2.56	10.18	18.33	31.54
	24 hr	1.20	5.91	17.09	41.63	72.52	109.74
Little Park 6.3	6 hr	0	0	0.32	1.21	2.15	3.70
	24 hr	0.14	0.70	2.17	5.47	9.75	14.92
Little Park 5.1	6 hr	0	0	0.31	1.00	1.73	2.93
	24 hr	0.11	0.59	2.41	7.85	15.16	23.59
Little Park 5.2	6 hr	0	0	0.73	2.75	4.87	8.38
	24 hr	0.32	1.59	4.92	12.40	22.10	33.82
Little Park 5 Cumulative	6 hr	0	0	2.82	11.34	20.41	35.22
	24 hr	1.77	8.54	24.80	61.16	107.32	163.42
Little Park 4.1	6 hr	0	0	0.75	2.58	4.47	7.65
	24 hr	0.29	1.49	5.31	14.72	28.04	43.72
Little Park 4.2	6 hr	0	0	0.76	3.01	5.42	9.33
	24 hr	0.36	1.75	5.06	12.32	21.46	32.47

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Table 3

PEAK FLOW SIMULATIONS OF UNDISTURBED DRAINAGES
IN THE LILA CANYON MINE AREA

Watershed ID	Return Period	2yr (cfs)	5yr (cfs)	10yr (cfs)	25yr (cfs)	50yr (cfs)	100yr (cfs)
Little Park 6.4	6 hr	0	0	0.23	0.86	1.53	2.64
	24 hr	0.10	0.50	1.55	3.90	6.95	10.64
Little Park 6.5	6 hr	0	0	0.90	3.58	6.45	11.10
	24 hr	0.42	2.08	6.02	14.66	25.53	38.63
Little Park 4 Cumulative	6 hr	0	0	6.17	24.81	44.74	77.12
	24 hr	2.93	14.01	40.73	101.08	178.91	269.04
Little Park 6.6	6 hr	0	0	0.87	4.44	8.64	14.92
	24 hr	0.58	2.60	6.58	14.58	24.18	35.52
Little Park 3.1	6 hr	0	0	2.35	8.86	15.72	27.03
	24 hr	1.03	5.13	15.87	40.00	71.27	109.07
Little Park 3.2	6 hr	0	0	1.00	4.65	8.76	15.07
	24 hr	0.58	2.70	7.08	16.14	27.20	40.29
Little Park 3 Cumulative	6 hr	0	0	9.73	42.29	77.65	133.01
	24 hr	5.08	23.46	65.66	162.22	284.24	430.10
Little Park 6.7	6 hr	0	0	0.76	4.53	9.00	15.63
	24 hr	0.60	2.69	6.66	14.57	23.96	35.04
Little Park 2.1	6 hr	0	0	0	1.84	4.30	7.79
	24 hr	0.17	0.81	2.54	7.96	14.23	24.90
Little Park 2.2	6 hr	0	0	0.64	3.68	7.15	12.35
	24 hr	0.48	2.16	5.45	12.07	20.02	29.40

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Table 3

PEAK FLOW SIMULATIONS OF UNDISTURBED DRAINAGES
IN THE LILA CANYON MINE AREA

Watershed ID	Return Period	2yr (cfs)	5yr (cfs)	10yr (cfs)	25yr (cfs)	50yr (cfs)	100yr (cfs)
Little Park 2 Cumulative	6 hr	0	0	11.07	54.40	100.57	168.92
	24 hr	6.59	29.31	80.68	192.12	329.11	493.91
Little Park Total	6 hr	0	0	11.56	58.64	110.02	183.99
	24 hr	7.24	31.45	84.30	199.12	340.37	508.74

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ATTACHMENT 1

PRECIPITATION DATA

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POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 39.43 N 110.35 W 6397 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003
Extracted: Tue Nov 22 2005

Confidence Limits | Seasonality | Location Maps | Other Info. | GIS data | Maps | Help | Docs | U.S. Map

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.15	0.23	0.29	0.39	0.49	0.58	0.66	0.83	1.03	1.36	1.62	1.91	2.21	2.50	3.19	3.79	4.59	5.38
5	0.22	0.33	0.41	0.55	0.68	0.78	0.85	1.04	1.27	1.66	1.98	2.33	2.71	3.07	3.93	4.63	5.61	6.59
10	0.27	0.41	0.51	0.69	0.85	0.96	1.03	1.22	1.49	1.91	2.27	2.68	3.11	3.52	4.52	5.28	6.40	7.50
25	0.36	0.54	0.67	0.91	1.12	1.25	1.31	1.49	1.77	2.23	2.66	3.15	3.67	4.11	5.29	6.12	7.42	8.69
50	0.44	0.67	0.82	1.11	1.37	1.51	1.57	1.72	2.01	2.48	2.96	3.51	4.09	4.57	5.89	6.75	8.18	9.56
100	0.53	0.81	1.00	1.35	1.67	1.83	1.88	2.00	2.26	2.74	3.27	3.89	4.53	5.02	6.49	7.38	8.93	10.43
200	0.65	0.98	1.22	1.64	2.03	2.21	2.26	2.37	2.58	3.00	3.58	4.27	4.97	5.49	7.09	7.99	9.67	11.27
500	0.83	1.26	1.56	2.10	2.60	2.82	2.88	2.99	3.19	3.34	4.00	4.78	5.57	6.10	7.88	8.79	10.64	12.35
1000	1.00	1.52	1.88	2.54	3.14	3.39	3.46	3.56	3.76	3.79	4.32	5.16	6.02	6.56	8.48	9.39	11.36	13.15

Text version of table

* These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.

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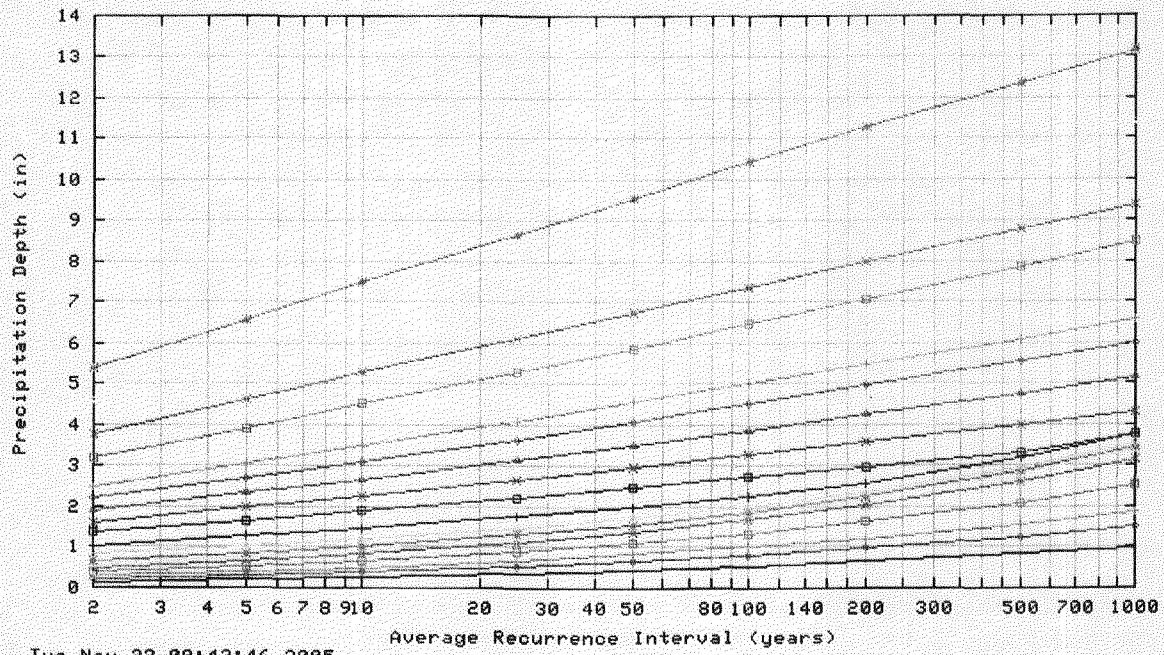
Partial duration based Point Precipitation Frequency Estimates Version: 3
39.43 N 110.35 W 6397 ft



Tue Nov 22 08:43:46 2005

Duration			
5-min		48-hr	30-day
10-min	3-hr	4-day	
15-min		7-day	60-day
30-min	12-hr	10-day	
60-min	24-hr	20-day	

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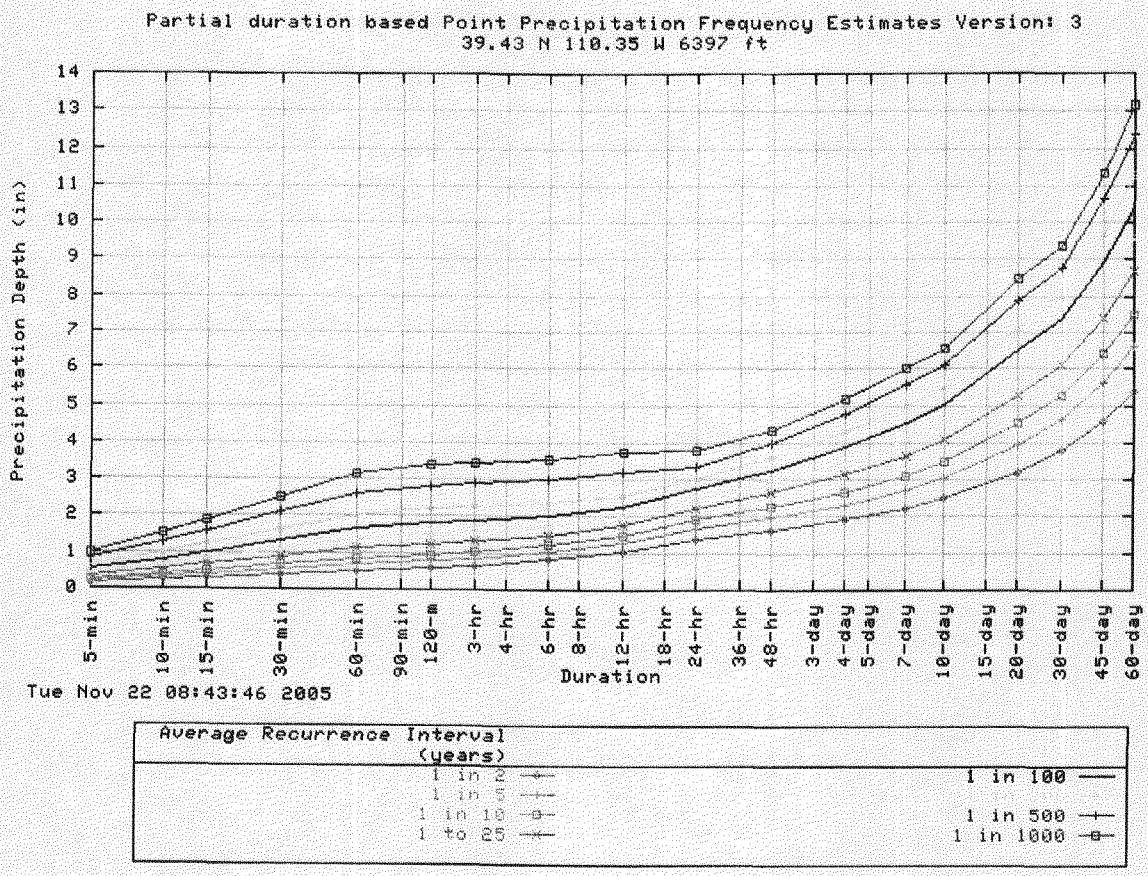

Confidence Limits -

*** Upper bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.18	0.28	0.35	0.47	0.58	0.67	0.75	0.94	1.16	1.49	1.77	2.09	2.43	2.73	3.47	4.12	4.99	5.83
5	0.26	0.39	0.48	0.65	0.80	0.90	0.97	1.17	1.43	1.82	2.16	2.55	2.98	3.34	4.27	5.02	6.08	7.12
10	0.32	0.48	0.60	0.81	1.00	1.11	1.18	1.38	1.66	2.08	2.46	2.92	3.42	3.82	4.90	5.71	6.92	8.11
25	0.42	0.64	0.80	1.07	1.33	1.45	1.51	1.71	2.00	2.45	2.89	3.42	4.01	4.46	5.74	6.61	8.02	9.38
50	0.52	0.79	0.98	1.32	1.63	1.77	1.82	1.99	2.28	2.74	3.21	3.82	4.49	4.96	6.39	7.32	8.85	10.35
100	0.63	0.96	1.20	1.61	1.99	2.15	2.21	2.35	2.62	3.04	3.56	4.24	4.97	5.48	7.06	8.02	9.67	11.32
200	0.78	1.18	1.47	1.97	2.44	2.63	2.69	2.82	3.04	3.35	3.91	4.66	5.46	5.99	7.74	8.71	10.49	12.28
500	1.02	1.55	1.92	2.58	3.19	3.44	3.52	3.62	3.83	3.87	4.40	5.24	6.17	6.68	8.67	9.63	11.58	13.55
1000	1.25	1.90	2.36	3.18	3.93	4.21	4.29	4.38	4.60	4.65	4.79	5.71	6.70	7.23	9.37	10.34	12.43	14.49

* The **upper** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.

** These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

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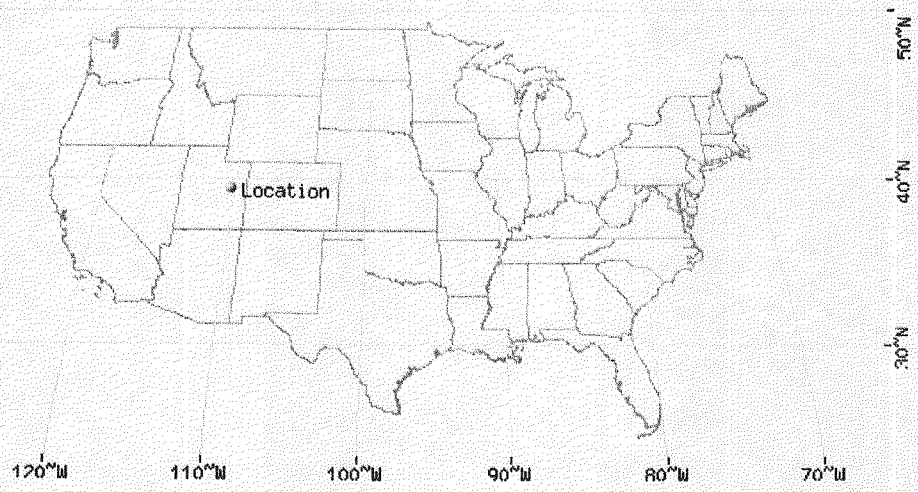
*** Lower bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.14	0.21	0.26	0.34	0.42	0.51	0.58	0.74	0.93	1.26	1.49	1.77	2.02	2.31	2.95	3.52	4.25	4.99
5	0.19	0.28	0.35	0.47	0.58	0.68	0.75	0.92	1.14	1.53	1.82	2.15	2.49	2.82	3.63	4.29	5.19	6.09
10	0.23	0.35	0.43	0.59	0.72	0.83	0.90	1.08	1.32	1.75	2.08	2.46	2.83	3.21	4.16	4.87	5.88	6.91
25	0.30	0.45	0.56	0.76	0.94	1.05	1.12	1.30	1.56	2.05	2.42	2.86	3.31	3.72	4.85	5.62	6.77	7.95
50	0.35	0.54	0.67	0.90	1.12	1.25	1.31	1.48	1.75	2.27	2.67	3.16	3.66	4.10	5.36	6.16	7.43	8.70
100	0.42	0.64	0.80	1.07	1.33	1.47	1.54	1.70	1.95	2.49	2.93	3.47	4.01	4.46	5.86	6.68	8.05	9.43
200	0.49	0.75	0.93	1.26	1.56	1.72	1.80	1.97	2.19	2.71	3.17	3.76	4.34	4.83	6.34	7.18	8.65	10.11
500	0.60	0.92	1.14	1.53	1.90	2.09	2.21	2.41	2.66	3.00	3.49	4.13	4.78	5.27	6.95	7.81	9.39	10.96
1000	0.70	1.06	1.32	1.78	2.20	2.41	2.55	2.80	3.08	3.22	3.72	4.40	5.08	5.59	7.39	8.25	9.93	11.55

* The **lower** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **less** than.
** These precipitation frequency estimates are based on a partial duration maxima series. **ARI** is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

Maps -



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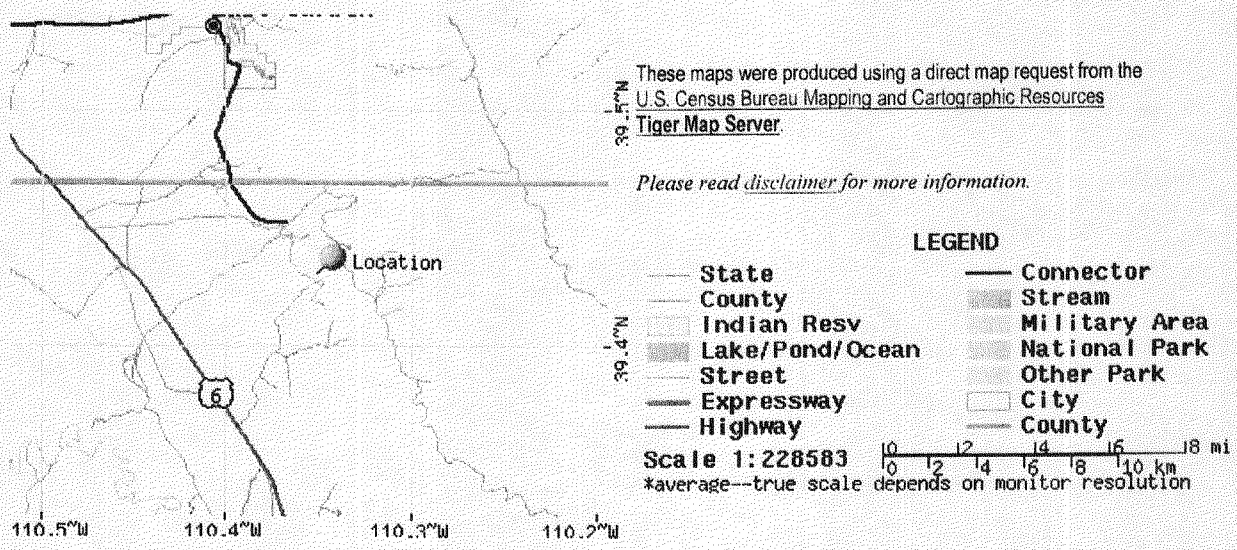

Other Maps/Photographs -

View USGS digital orthophoto quadrangle (DOQ) covering this location from TerraServer; **USGS Aerial Photograph** may also be available
from this site. A DOQ is a computer-generated image of an aerial photograph in which image displacement caused by terrain relief and camera tilts has been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. Visit the USGS for more information.

Watershed/Stream Flow Information -

Find the Watershed for this location using the U.S. Environmental Protection Agency's site.

Climate Data Sources -

Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information
about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study,
please refer to our documentation.

Using the **National Climatic Data Center's (NCDC)** station search engine, locate other climate stations within: +/-30 minutes ...OR... +/-1 degree of this location (39.43/-110.35). Digital ASCII data can be obtained directly from **NCDC**.

Find Natural Resources Conservation Service (NRCS) SNOTEL (SNOwpack TELemetry) stations by visiting the **Western Regional Climate Center's state-specific SNOTEL station maps**.

Hydrometeorological Design Studies Center
DOC/NOAA/National Weather Service
1325 East-West Highway
Silver Spring, MD 20910
(301) 713-1669
Questions?: HDSC.Questions@noaa.gov

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ATTACHMENT 2

SIMULATION HYDROGRAPHS

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6-HOUR SIMULATION RESULTS

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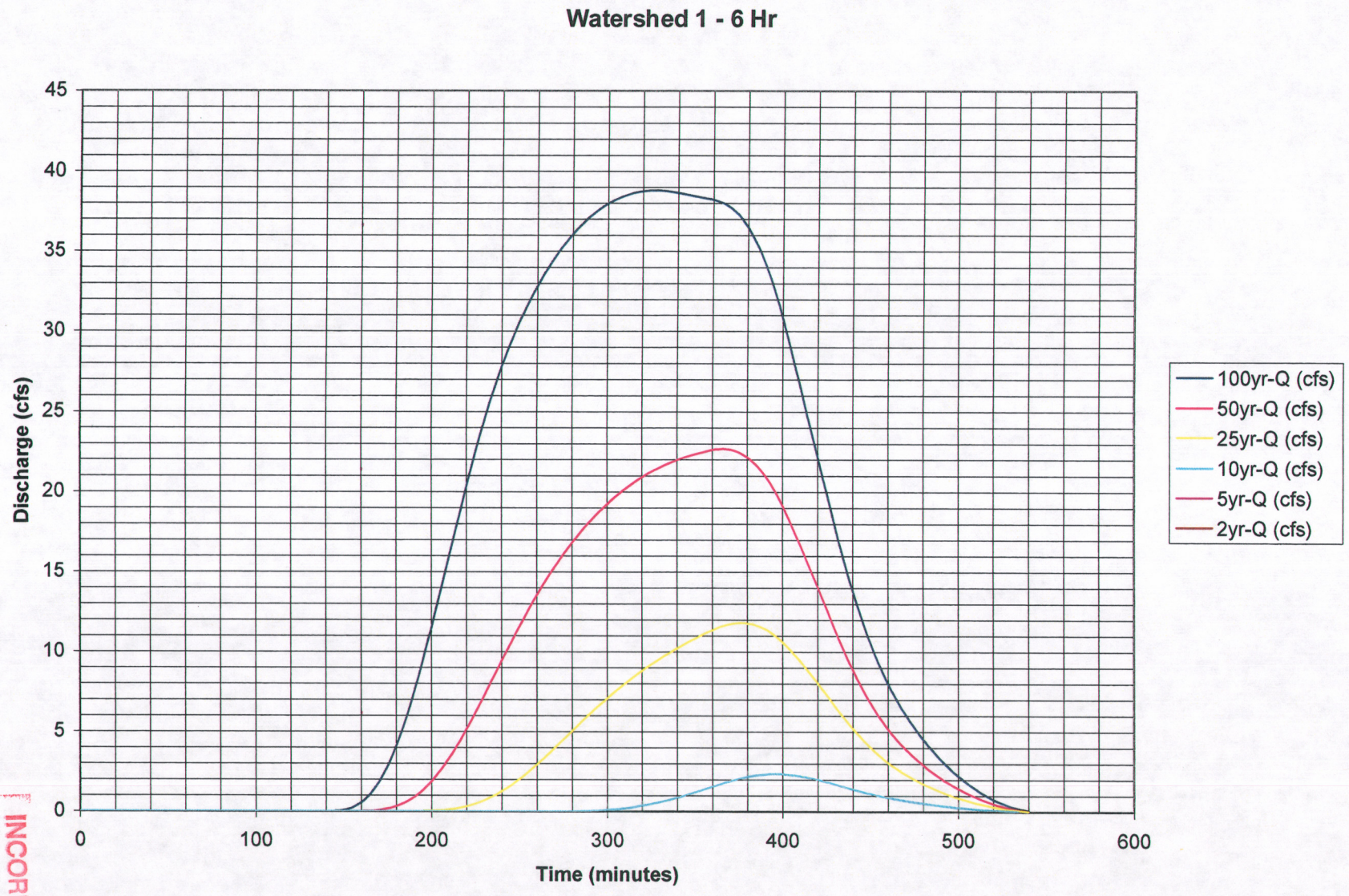

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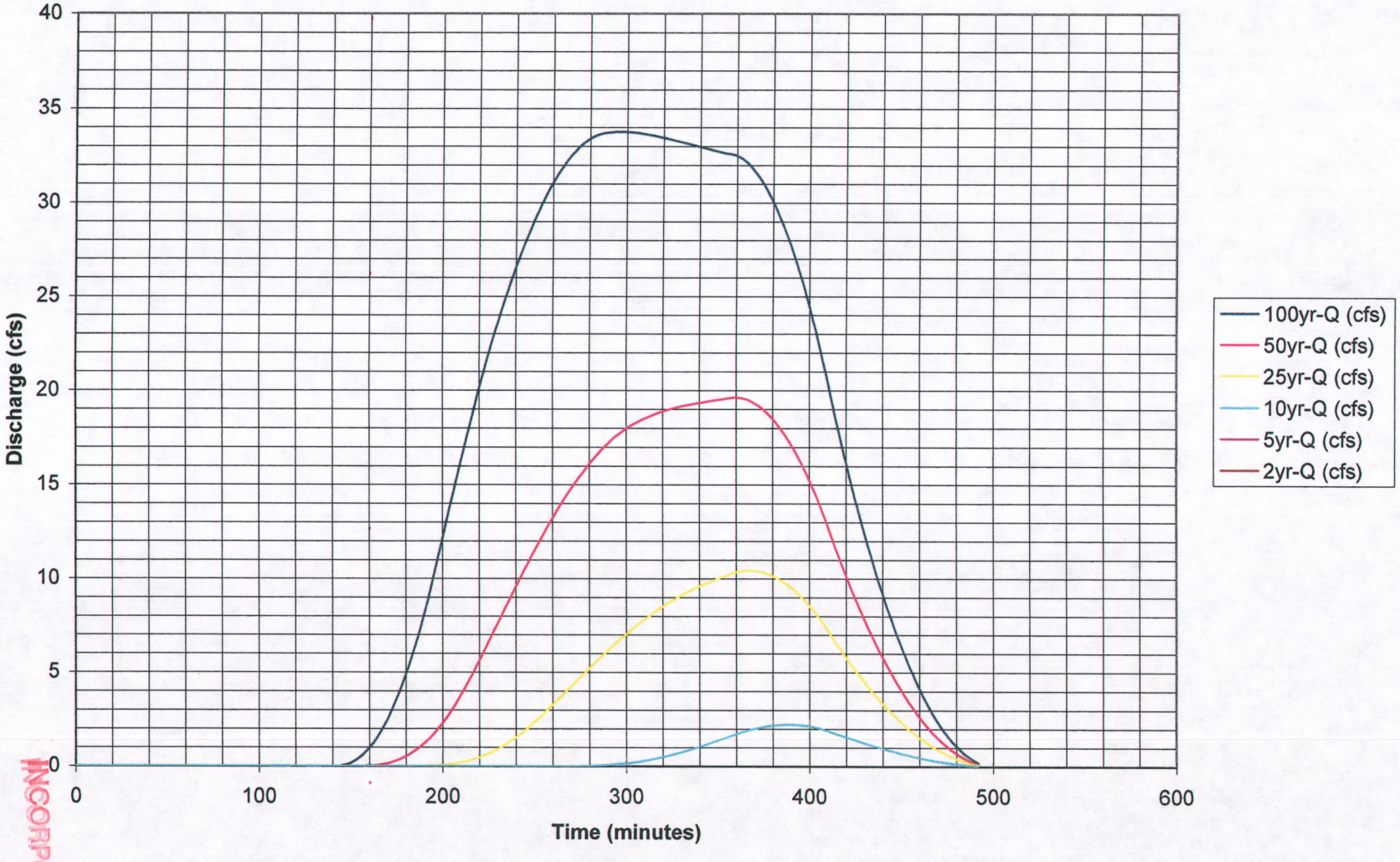
Watershed 7 - 6Hr



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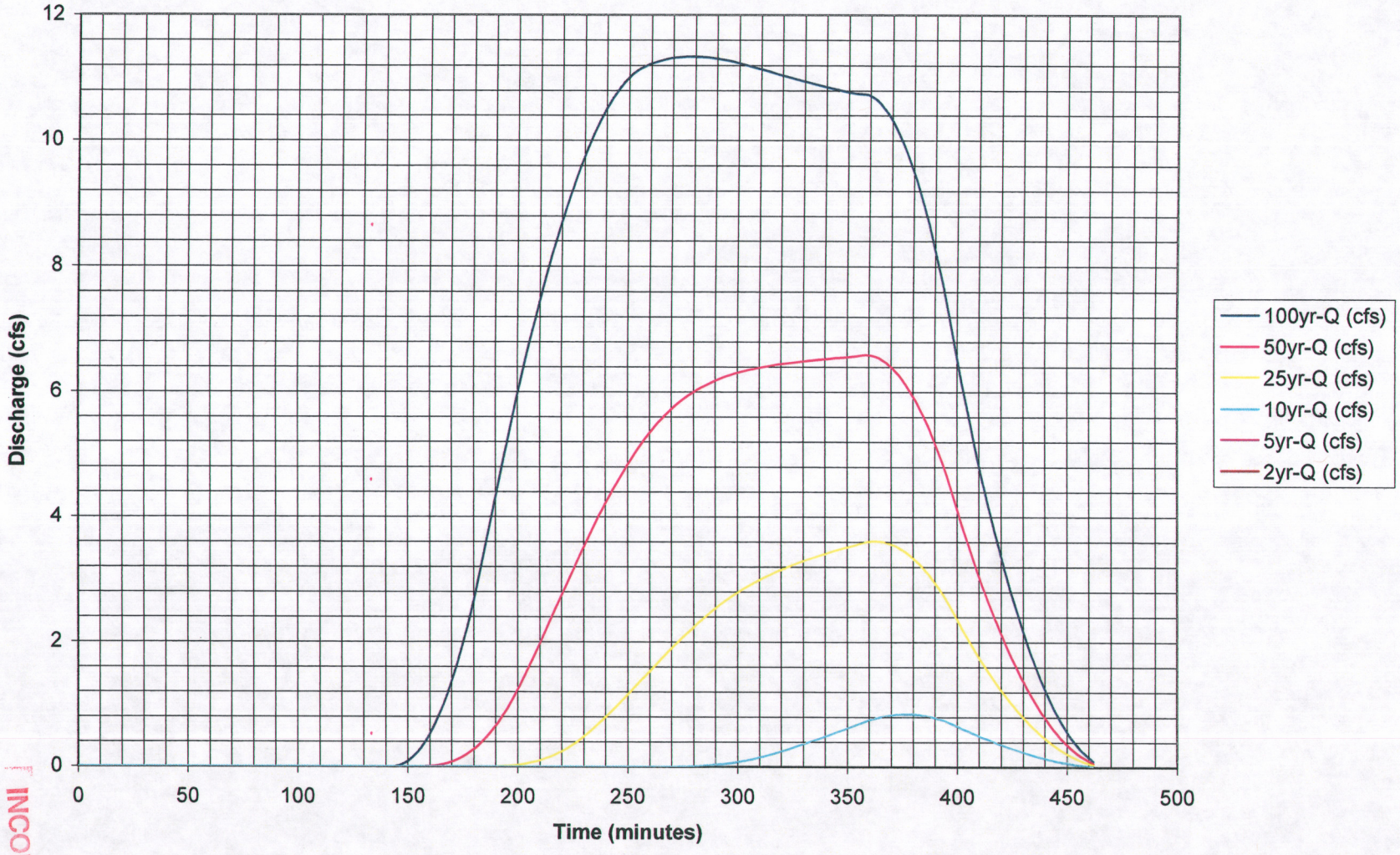
Watershed 8 - 6Hr



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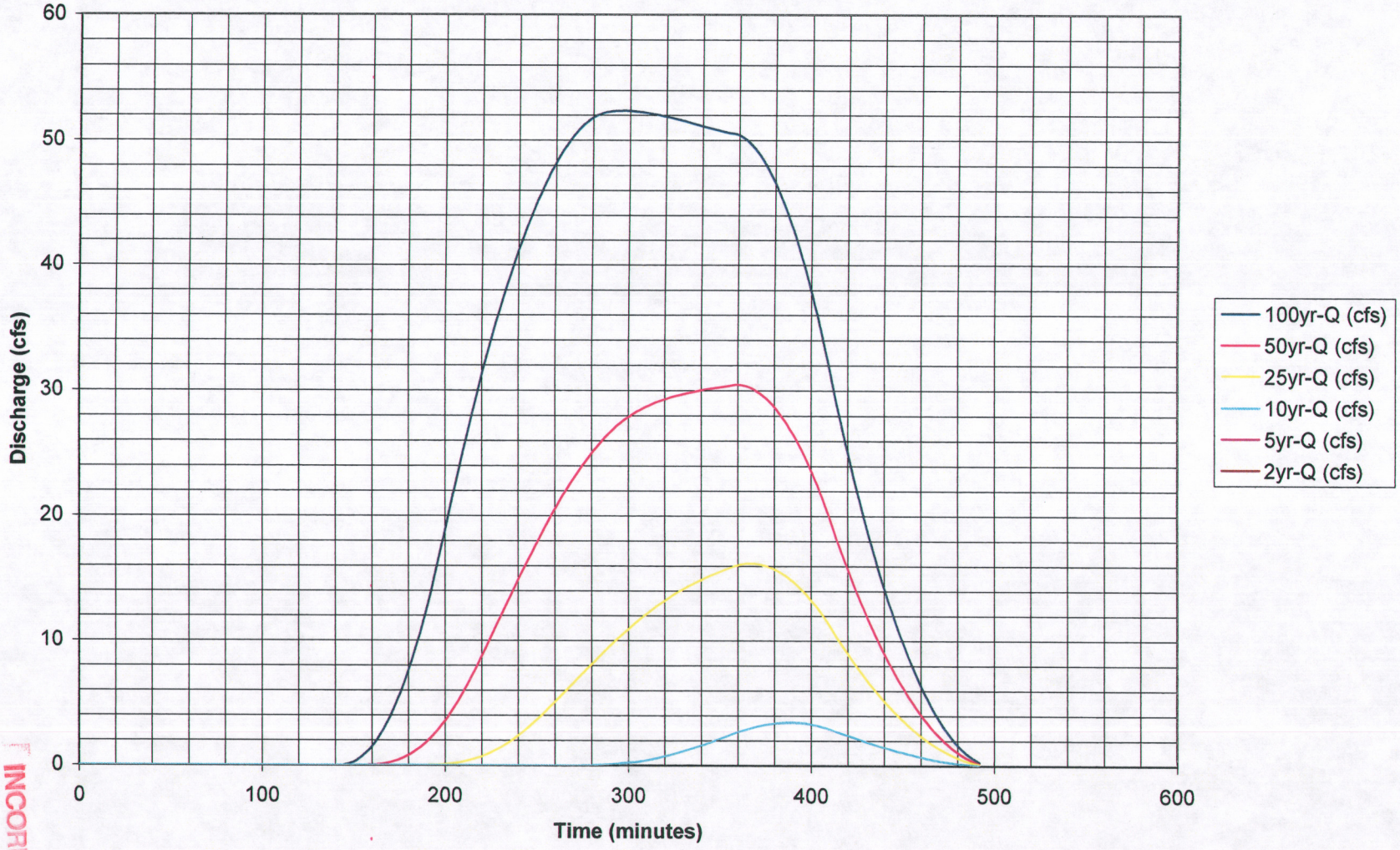
Watershed 9 - 6Hr



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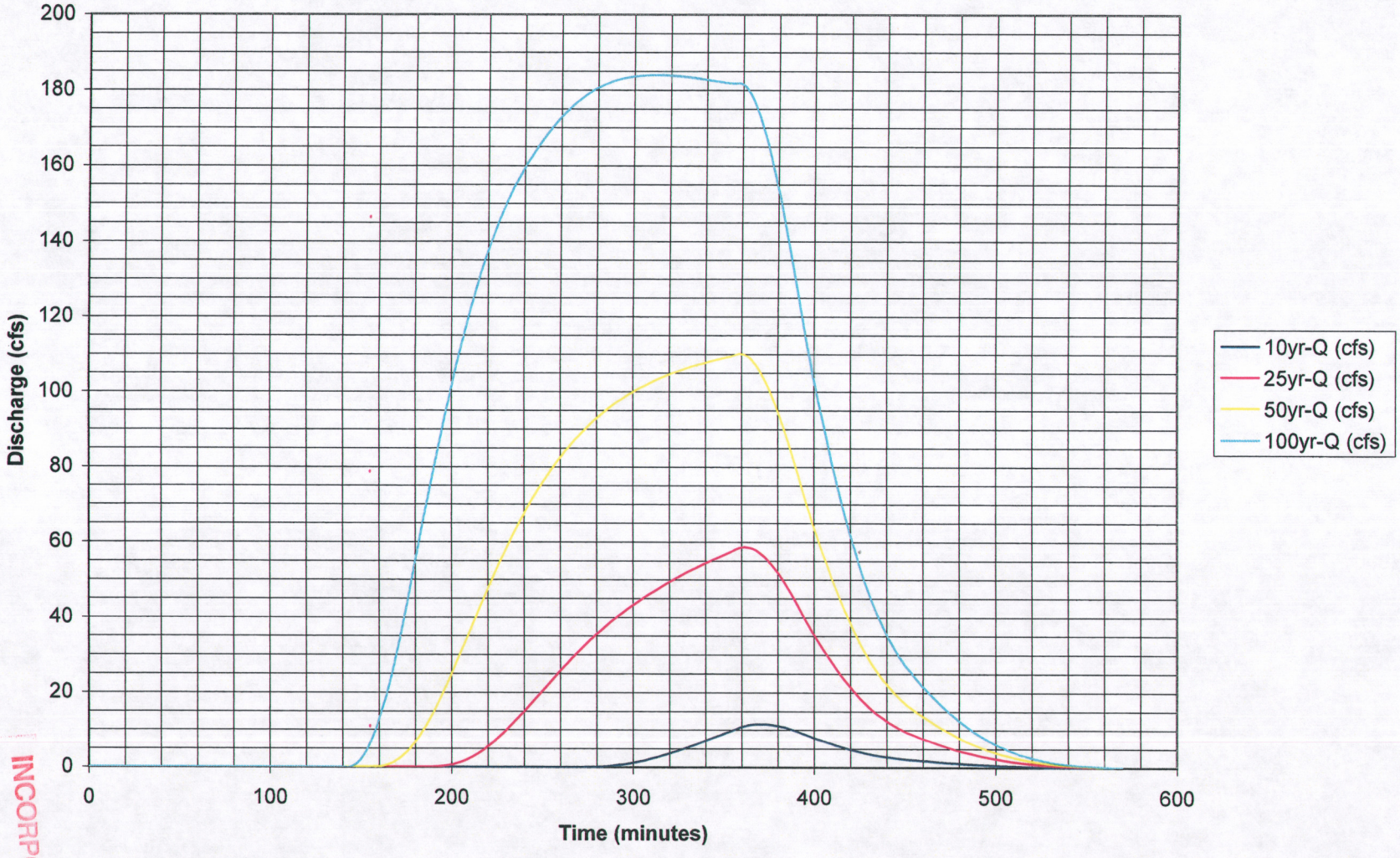
Watershed 6 - 6hr



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24-HOUR SIMULATION RESULTS

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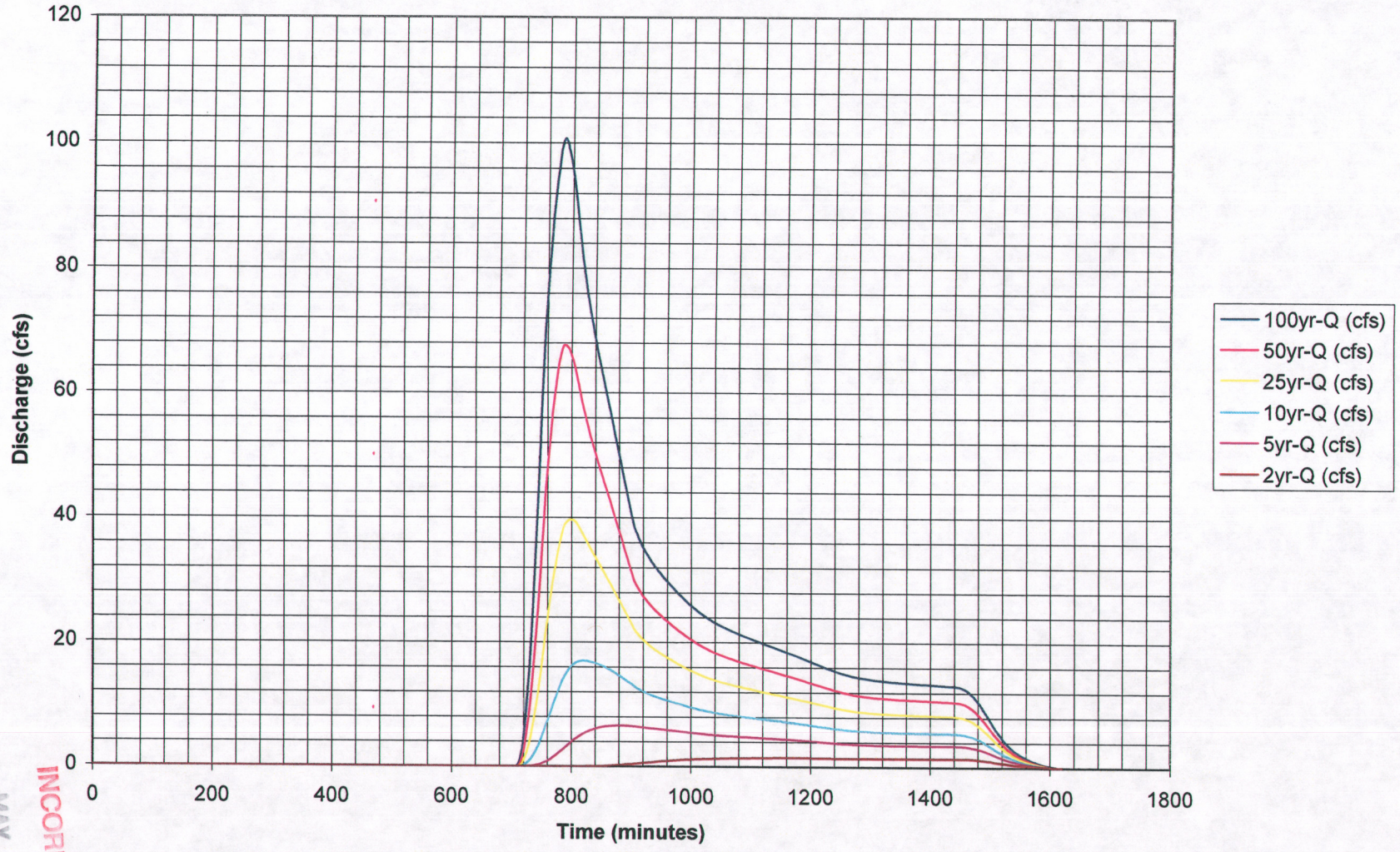
Watershed 1 - 24 Hr



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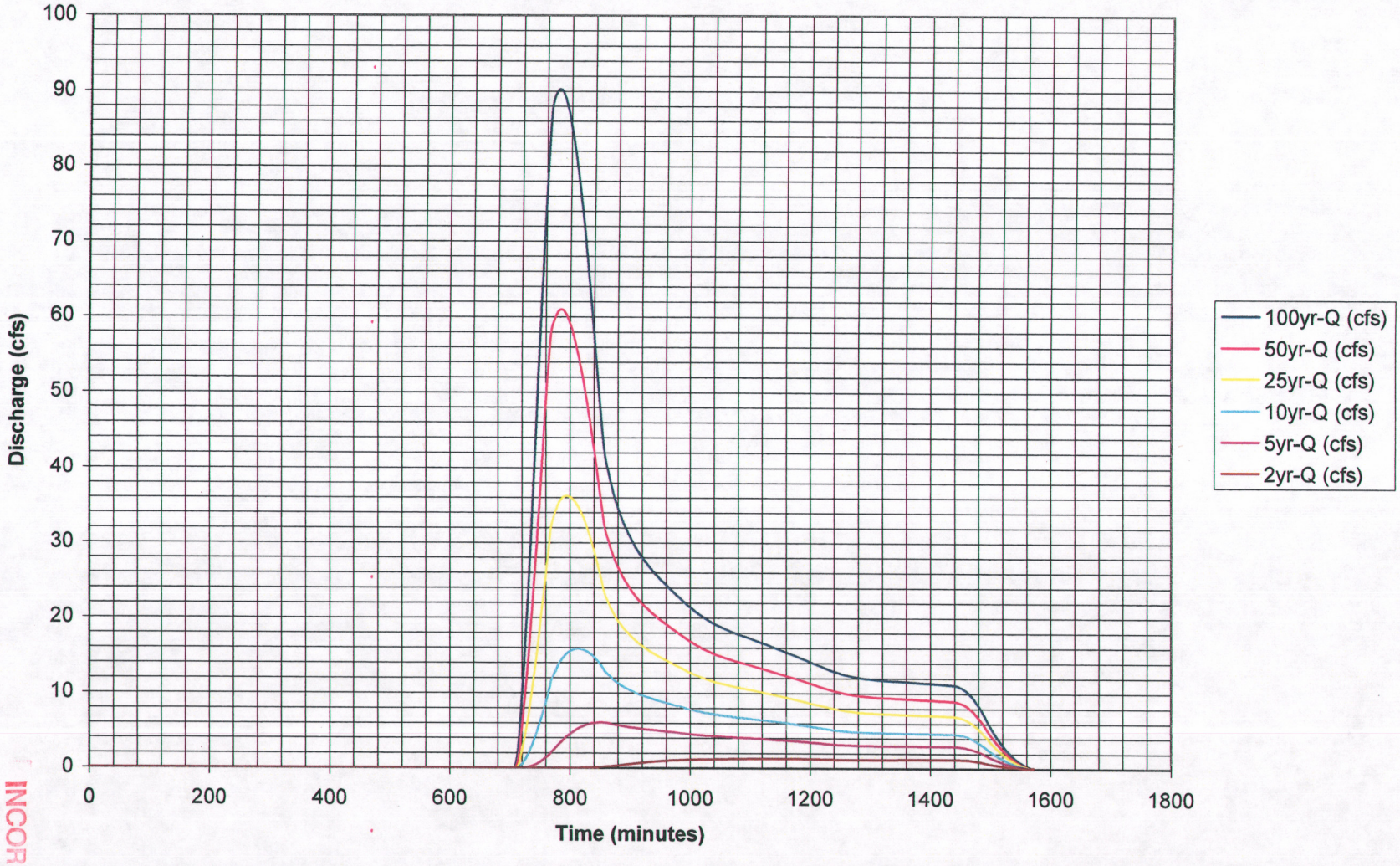
Watershed 7 - 24 Hr



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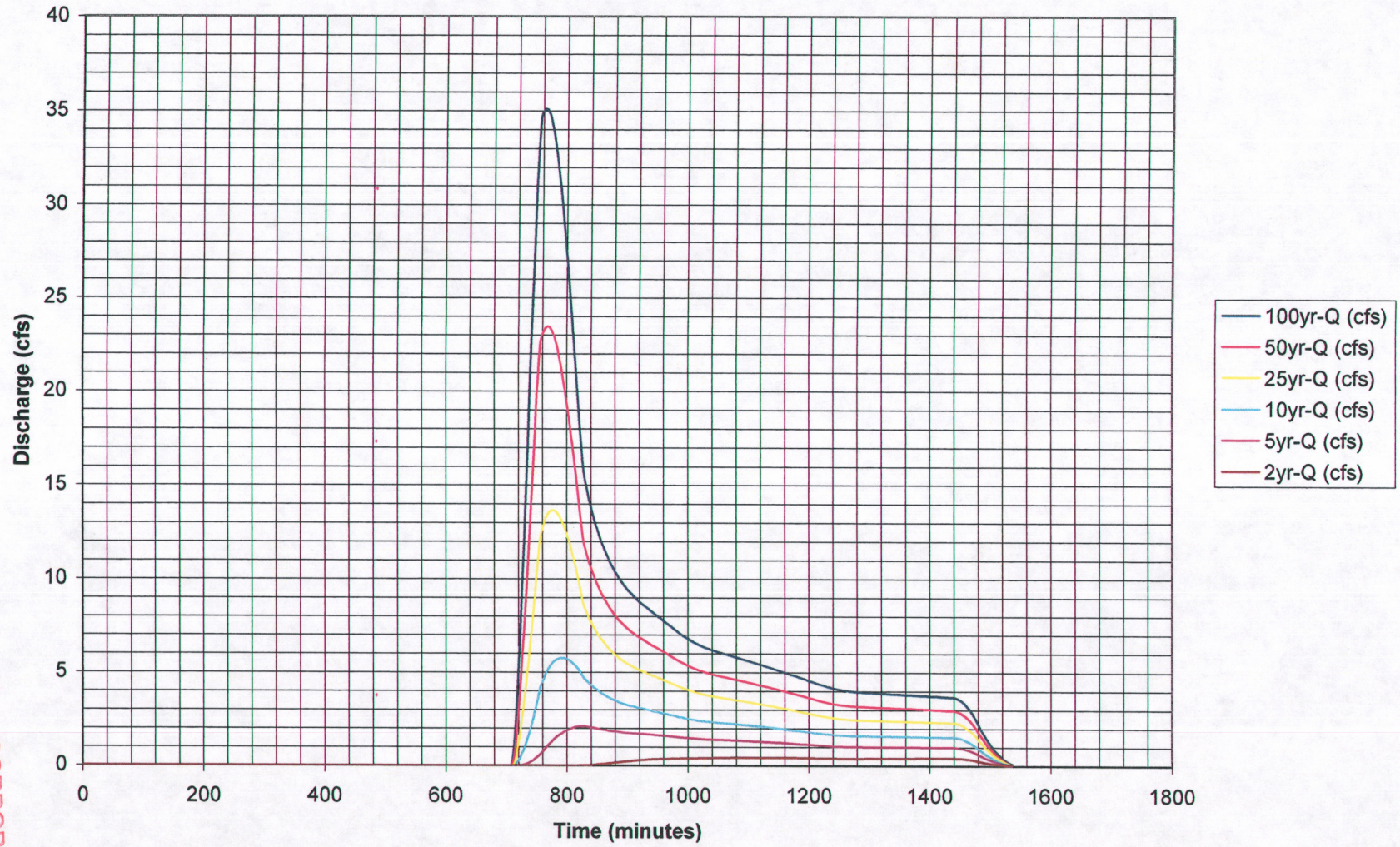
Watershed 8 - 24 Hr



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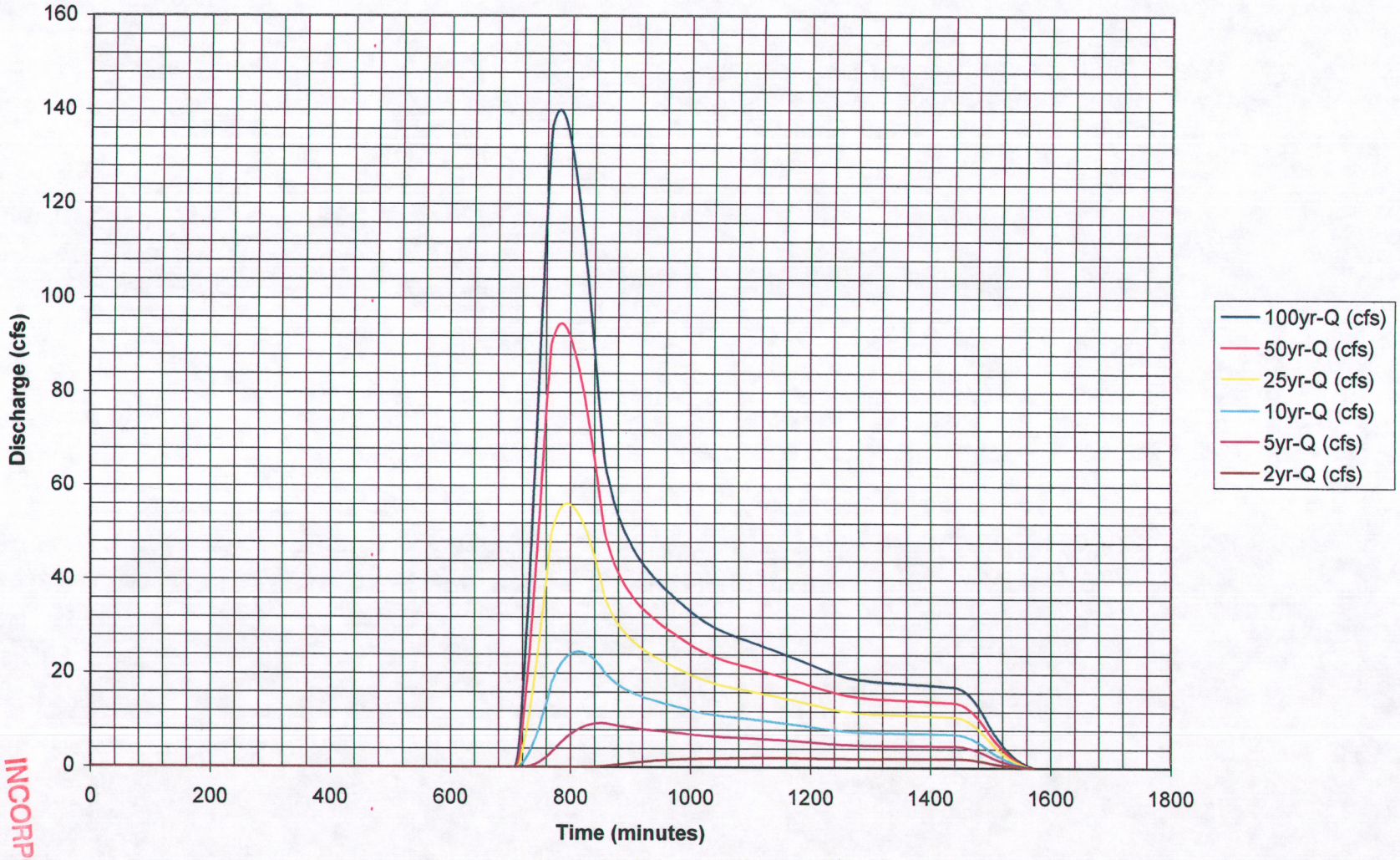
Watershed 9 - 24 Hr



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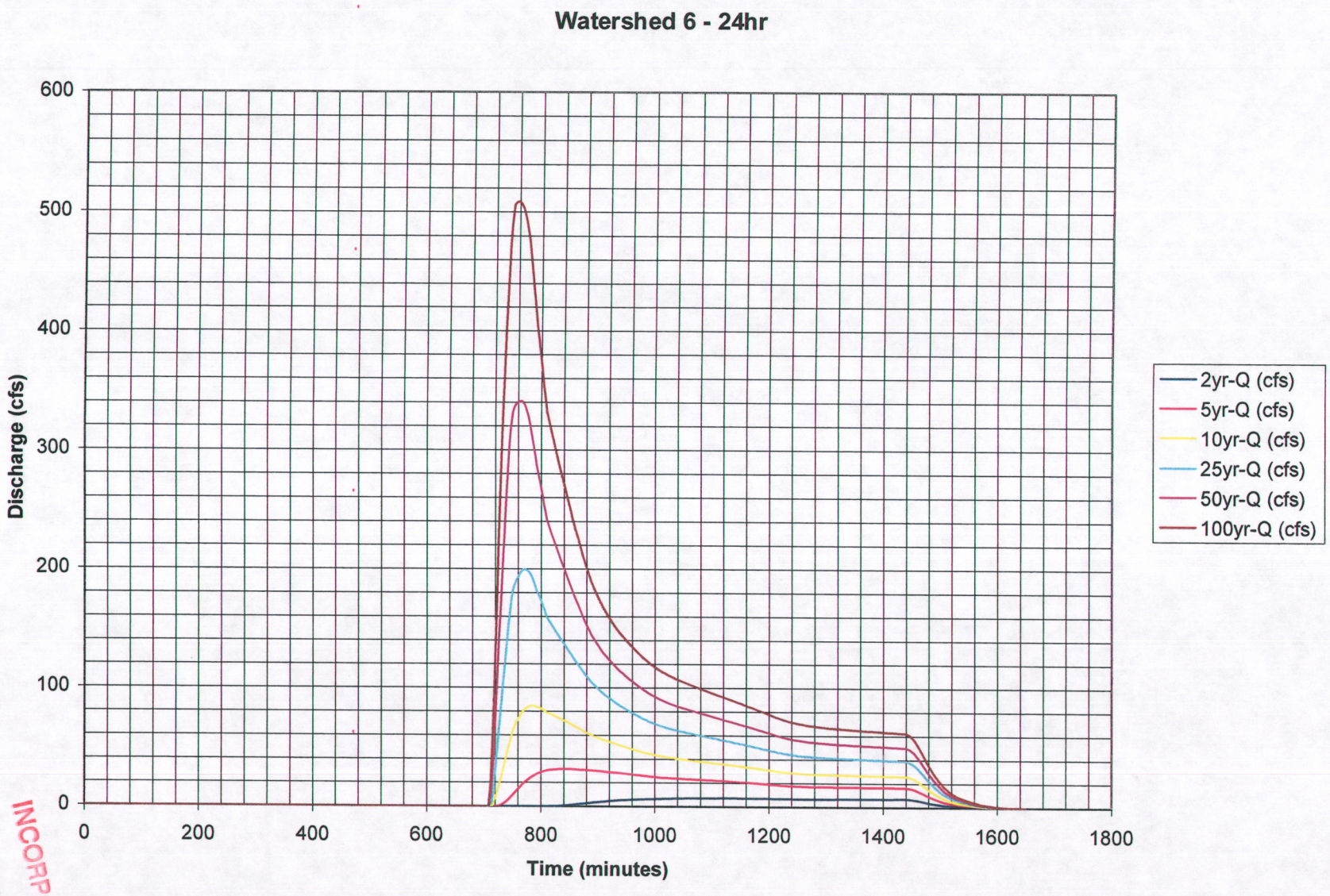

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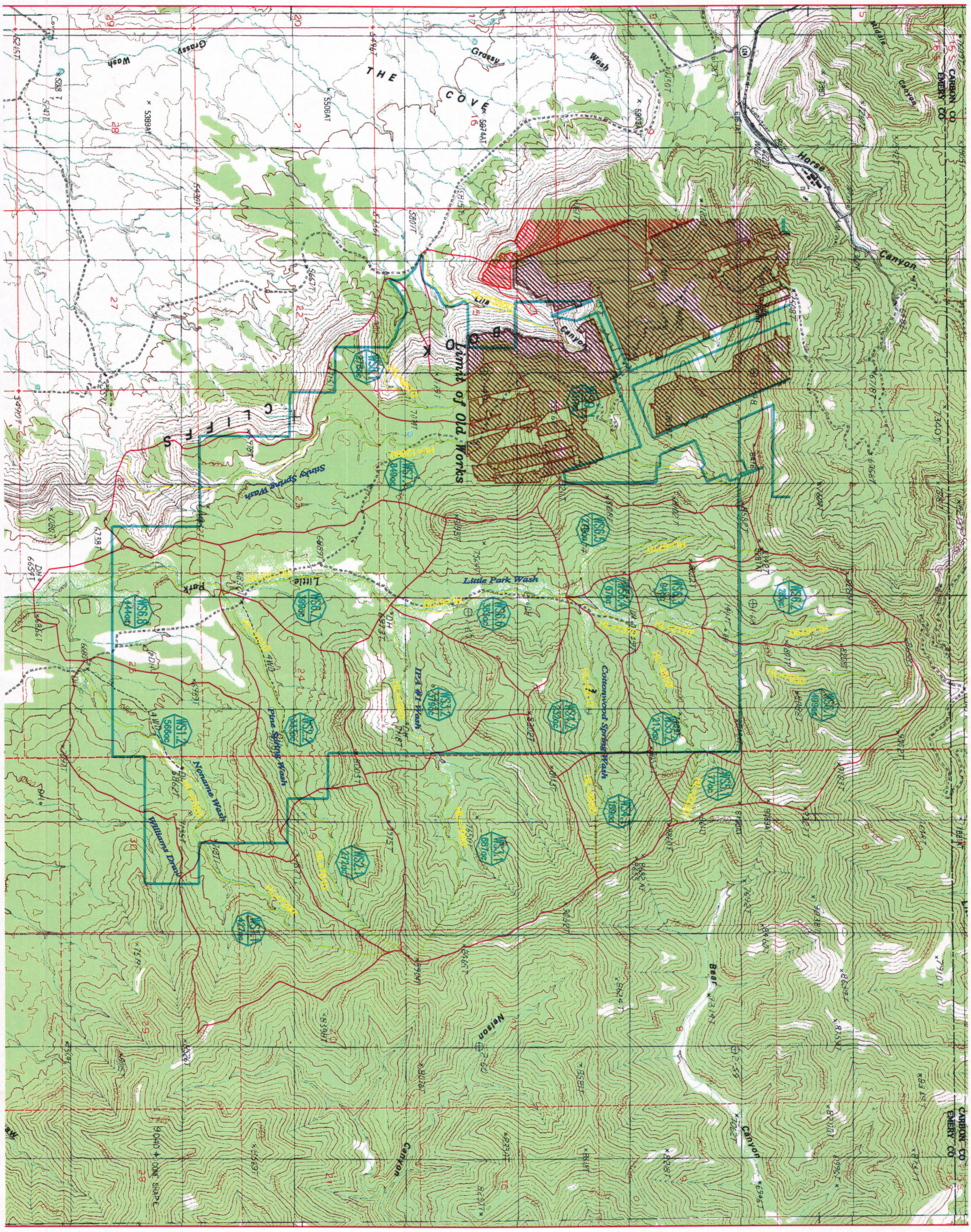

Scale: 1"=3000'

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HD	FIGURE 1. DRAINAGE LOCATIONS AND AREAS AND AREAS FOR LILA EXPANSION	UTAHAMERICAN ENGERGY INC. PRICE, UTAH	LILA EXPANSION LILA CANYON