Appendix F

Determination of Peak Flow Rates and Floodplain Delineation for Dam Breaches at the Rocky Flats Site

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DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

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DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

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DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

1.0 INTRODUCTION

The study presented in this report was conducted by Wright Water Engineers, Inc. (WWE) to determine peak flow rates and delineate floodplains for a range of storm events at the U.S. Department of Energy (DOE) Rocky Flats Site located in Jefferson County, Colorado. The analysis will be used to support National Environmental Policy Act (NEPA) evaluation and design of planned breaches of Dams A-3, A-4, B-5, C-2 and the Present Landfill (PLF) Dam.

S.M Stoller Corporation (Stoller) is the Legacy Management Support Contractor for DOE at the RFS. This study was conducted for Stoller under Project No. LTS-111-0056-06-003.

DOE has previously completed breaches at seven of the twelve dams at the Rocky Flats Site. Five remaining dams are proposed to be breached in two groups as summarized in Table 1:

Table 1. Future Dam Breach Projects at the Rocky Flats Site

Dam(s)	Schedule
A-3, PLF, C-2	Design in 2010. Construction in 2011.
A-4, B-5	Preliminary design in 2011. Construction in 2015 - 2018.

The locations of the dams listed in Table 1 are shown on Figure 1.

2.0 SCOPE OF WORK

The scope of work addressed by this study involves analyzing stormwater runoff from the four storm events listed in Table 2.

Table 2. Storm Events Analyzed for Peak Flow Analysis

Storm Return Frequency	Duration	Depth
2-year	24-hour	2.2 inches
50-year	24-hour	4.4 inches
100-year	6-hour	3.8 inches
100-year	24-hour	5.0 inches

Notes:

1) Precipitation depths for the 24-hour storm events were derived from NOAA Atlas II, Volume III (Colorado) (NOAA .1973).
2) The precipitation depth for the 100-year, 6-hour event is the same that was used for the Drainage and Flood Control Master Plan for the Rocky Flats Plant (EG&G, 1992), which was derived from the Urban Drainage and Flood Control District Urban Storm Drainage Criteria Manual.

For the storm events listed above, three different dam breach scenarios were evaluated, as summarized in Table 3 and depicted graphically on Figure 2 (at back of report).

Table 3. Dam Conditions Scenarios

Scenario	Dam Breach Conditions	Initial Condition Assumptions
1 (Current Conditions)	Dams A-1, A-2, B-1, B-2, B-3, B-4 and C-1 are all breached. A-3, A-4, B-5, PLF, and C-2 are intact.	Existing breached dams have stop logs in place and are full. All other ponds have outlet works closed and are filled to maximum normal operating range (40% of capacity for A-3, A-4, B-5, and C-2; PLF is filled to 22%).
2	Dams A-1, A-2, B-1, B-2, B-3, B-4 and C-1 are all breached. Dams A-3, PLF, and C-2 are breached. Dams A-4 and B-5 are intact.	Existing breached dams have stop logs in place and are full. Ponds are empty in breached dams A-3, PLF and C-2. Ponds A-4 and B-5 are filled to 40% of capacity.

Scenario	Dam Breach Conditions	Initial Condition Assumptions
3	Dams A-1, A-2, B-1, B-2, B-3, B-4 and C-1 are all breached. Dams A-3, PLF and C-2 are breached. Dams A-4 and B-5 are breached.	Existing breached dams have stop logs in place and are full. Ponds are empty in breached dams A-3, PLF and C-2. Ponds are empty in breached dams A-4 and B-5.

For the four storm events and three dam conditions scenarios described in Table 2 and Table 3, respectively, the following analyses are included in this report:

- Peak flow rate analyses - For each storm event and for each scenario, peak flow rates are calculated at the inlet and outlet of the ponds to be breached (A-3, A-4, B-5, C-2 and PLF). Twelve storm/dam conditions scenarios in total are evaluated.

- Floodplain analysis – For the 100-year, 6-hour event and the 100-year, 24-hour event, floodplain mapping was developed for each scenario. Floodplain mapping was developed for the following areas at the site:

    - A-Series Ponds – From Pond A-2 to the east edge of the Walnut Creek mapping area (east of Indiana Street at the Great Western Reservoir splitter box).

    - B-Series Ponds – From Pond B-4 to the east edge of the Walnut Creek mapping area.

    - PLF Pond – From the PLF pond to the confluence of No Name Gulch and Walnut Creek.

    - C-Series Ponds – From Pond C-1 to the east edge of the Woman Creek mapping area (east of Indiana Street at the junction of inflows to the Woman Creek Reservoir channel).

3.0 BACKGROUND

3.1 Prior Studies

Two prior studies of flood hydrology conducted at RFS were referenced for this study: 1) the *Rocky Flats Plant Drainage and Flood Control Master Plan,* developed by WWE for EG&G in 1992 *(EG&G 1992),* herein referred to as the 1992 study, and 2) the *Determination of Peak Flow, Rocky Flats Environmental Technology Site Dams A-1, A-2, B-1, B-2, B-3, B-4 and C-1*, developed by WWE for Rocky Flats Closure Site Services in 2004 (RFCSS 2004), herein referred to as the 2004 study. These reports are summarized briefly below:

1992 Study - The flood hydrology of the Walnut Creek and Woman Creek drainage catchments, including the portion of the drainages within the RFS, was defined in the 1992 study. This modeling effort was reviewed and adopted by the Site, the Urban Drainage and Flood Control District (UDFCD) and the State of Colorado. The 1992 study included two land-use scenarios: 1) current development (i.e., with the fully developed industrial area at the site), and 2) potential future development. The study did not include a post-closure land-use scenario. Hydrographs for individual basins were calculated using the Colorado Urban Hydrograph Procedure (CUHP) program and routed using the UDSWM2-PC model developed by UDFCD. Flow elevations were determined using HEC-RAS to develop the floodplain delineation for the 100-year, 6-hour storm event. The UDSWM model routing diagram for the 1992 study is included in Appendix A.

2004 Study - The 2004 study was conducted to calculate the estimated peak runoff rates at ponds A-1, A-2, B-1, B-2, B-3, B-4 and C-1 in a post-closure (i.e., “undeveloped”) condition at RFS, and was based on the proposed land configuration of the RFS and the proposed geometry of the dam breaches for those ponds. The 2004 study was not based on the final “as-built” land configuration as it exists in 2010.

Results from the 2004 analysis were used to finalize the designs of the breaches for dams A-1, A-2, B-1, B-2, B-3, and B-4. Similar to the 1992 study, the 2004 study utilized versions of the CUHP and UDSWMM models to calculate peak flow rates and route flows. The 2004 report presents a table of the calibration results for the 2004 CUHP/UDSWMM models calibrated with the results from the 1992 study. The 2004 study did not include floodplain delineation. The UDSWM model routing diagram for the 2004 study is included in Appendix A.

3.2 RFS Dam Breach Geometry

The geometry of the completed and proposed RFS dam breaches is summarized in Table 4.

Table 4. Dam Breach Geometry

Breach Status	Dam	Breach Inlet Elevation	Breach Outlet Elevation	Breach Width (ft)	Breach Side Slopes (H:V)	Stop Log Height (ft)
Completed Breaches	A-1	5823.0	5817.35	10	3:1	3
	A-2	5801.03	5791.85	15.7	3:1	3
	B-1	5878.1	5863.0	10	3:1	3
	B-2	5861.87	5849.2	14.5	3:1	3
	B-3	5846.97	5837.71	16	3:1	3
	B-4	5833.07	5814.93	20.4	3:1	3
	C-1	5813.4	5811.8	6	3:1	3.5
Proposed Breaches	A-3	5777.5	5762.5	17	2:1	N/A
	PLF	5899.0	5888.4	18	2:1	N/A
	C-2	5748.5	5739.0	17	2:1	N/A
	A-4	5733.5	5720.0	20	2:1	N/A
	B-5	5779.5	5756	25	2:1	N/A

Note: N/A indicates not applicable (the proposed breaches will not have stop logs).

3.3 Reference Information

The published standards and references that were used to guide the analysis described in this report include the following:

1. State of Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer. *Rules and Regulations for Dam Safety and Dam Construction*. January 1, 2007.

2. EG&G Rocky Flats, *Rocky Flats Plant Drainage and Flood Control Master Plan.* Prepared for the Department of Energy, Rocky Flats Plant by Wright Water Engineers, Inc. April 1992.

3. NOAA, 1973. Precipitation-Frequency Atlas of the Western United States. Volume III, Colorado. U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

4. Rocky Flats Closure Site Services. *Determination of Peak Flow, Rocky Flats Environmental Technology Site Dams A-1, A-2, B-1, B-2, B-3, B-4 and C-1.* Prepared for the RFCSS by Wright Water Engineers, Inc. December 2004.

5. UDFCD. *CUHP 2005 User Manual. Version 1.3.3.* Urban Drainage and Flood Control District. January 21, 2010.

6. EPA. *Stormwater Managemement Model User's Manual. Version 5.0.* U.S. Environmental Protection Agency. Revised July 2009.

7. S.M. Stoller. A-3, A-4, B-5, C-2, Present Landfill Dam Breaching – NEPA Evaluation. Drawing Sheets 1 – 6. February 12, 2010.

8. S.M. Stoller. A-1, A-2, B-1, B-2, B-3, and B-4 Dam Breaching - As-Constructed. Drawing Sheets 1 – 24. June 23, 2008.

4.0 ANALYSIS PROCEDURE

Three computer models were used for the analyses presented in this report. These include two models for the hydrologic analysis:

1) CUHP 2005, Version 1.3.3.6, which was used to develop hydrographs for each individual catchment, and

2) EPA SWMM, Version 5.0, which was used to route the hydrographs developed in the CUHP. CUHP and SWMM were selected for the analysis to be consistent with the approach used for the 1992 and 2004 studies (see Section 3.1) and to use an approach accepted by UDFCD.

A third model, HEC-RAS Version 4.0, was used to calculate channel hydraulics to determine water surface elevations at various channel cross-sections for the floodplain delineation.

It is noted that the model versions used for this study differ from those used in the prior studies. Version 1.3.3.6 of CUHP was released in January 2010, and Version 5.0 of the EPA SWMM model is different than the UDSWMM model used in 2004. For the floodplain analysis, HEC-RAS is a newer version of the HEC-1 model used for floodplain delineation in the 1992 study. For this study, in addition to using the most current versions of CUHP, SWMM, and HEC-RAS, modifications were made to the sub-catchment boundaries to reflect the most current site topography, to incorporate the “as-built” condition of the completed dam breaches at Dams A-1, A-2, B-1, B-2, B-3, B-4, and C-1, and to reflect the preliminary design of the proposed breaches at Dams A-3, A-4, B-5, C-2 and the PLF Dam.

4.1 CUHP/SWMM Calibration

In order to develop model results for this study that can be reasonably compared with results from the prior hydrologic modeling studies at RFS, the current CUHP model was calibrated to match the results of the CUHP version used in 2004. CUHP input files from 2004 were run in

the current CUHP 1.3.3.6 to generate hydrographs for the individual sub-catchments of the 2004 model. An EPA SWMM 5.0 model was developed to simulate the 2004 UDSWM model used for routing flows. Using the CUHP input files from 2004, output from the new version of the CUHP model for the 100-year, 6-hour storm event was routed into the SWMM model and results were compared with those from 2004. An iterative process was conducted where the CUHP Cp parameter was adjusted and the CUHP flows were routed through SWMM; this process was continued until the routed flows generated from the new CUHP and SWMM models provided a reasonable match with the results from the 2004 study. Results of the calibration for the Walnut Creek and Woman Creek basins are presented in Appendix B. CUHP input values for the Walnut Creek and Woman Creek models are included in Appendix C.

4.2 Site Topography and Model Development

Site topography based on 2006 aerial survey data, which has been subsequently updated to incorporate more recent localized modifications to the site topography (e.g., inclusion of of dam breaches completed in 2009), was provided by Stoller. Using this updated topography, the following changes were made to the CUHP model:

1. CUHP sub-catchment delineations were re-delineated as needed. Where sub-catchments from the 1992 and 2004 studies were still appropriate, the basin remained the same in the CUHP model and the basin identifier was maintained. For sub-catchments that significantly changed from the 2004 study, a new basin designation was assigned by adding an “A”, “B”, “C”, etc. to the 2004 basin identifier (e.g., sub-catchment “WA6” in Walnut Creek was changed to “WA6A” after it was re-delineated). The new CUHP catchments are shown on Figure 3.

2. CUHP sub-catchment area, length, and length to centroid were recalculated for the newly defined sub-catchments.

3. Other CUHP model variables such as soil infiltration characteristics and surface retention characteristics were changed from the original modeling effort only for those sub-catchments where the original variables did not appear to be consistent with guidance specified by UDFCD.

A new SWMM model was developed to reflect the changes in the site topography and to incorporate the new routing created by the proposed dam breaches. A different SWMM model was created for each of the three scenarios described in Section 2.0. The new SWMM models incorporated the following elements:

1. SWMM element routing was developed using the prior studies as a basis, but with changes to channel lengths made to reflect the new basin delineations developed for the CUHP model.

2. Other channel geometry parameters, such as channel bottom width, side slopes, and roughness coefficients were, where appropriate, adopted from the parameter variables used in the prior studies.

3. The SWMM element numbering was carried over from the 2004 study where possible to facilitate comparison of results from prior studies. However, in cases where the SWMM elements were modified to reflect changes to the CUHP and SWMM models, the SWMM model elements were renumbered in the following manner:

    a. New CUHP sub-catchments were assigned a prefix “7” in the Walnut Creek Basin and an “8” in the Woman Creek basin (e.g., former basin 31, assigned to catchment WA5 in the 2004 model, was designated as basin 731 and assigned to catchment WA5A in the current SWMM model).

    b. New conveyance elements and design points were assigned a 500 series number in the Walnut Creek basin and a 600 series number in the Woman Creek basin. This

is why, for example, there are 400 and 500 series SWMM elements adjacent to one another in the North Walnut Creek basin.

The new SWMM elements are shown on Figure 3, along with the CUHP basin designations. The SWMM model routing is shown on Figure 4 (Note: Figure 4 reflects the SWMM routing for Scenario 3; SWMM routing for Scenarios 1 and 2 is the same as Scenario 3 except for the absence of breaches that are specific to each scenario).

4.3 Storm Events

As described in Section 2.0, in accordance with the scope of work for the project, the model analysis for this study is conducted for the 100-year, 6-hour duration storm event and the 2-year, 50-year, and 100-year, 24-hour duration storm events. Prior hydrology studies at RFS included analyses of the 100-year, 6-hour event. Therefore, for this study, the 100-year, 6-hour event included the same precipitation depth (3.8 inches) and distribution, based on UDFCD methodology, as was used by past studies.

Since there were no 24-hour storm events analyzed in the prior RFS studies, storm event depths for the 24-hour storms in the current study were obtained from the NOAA Atlas II, Volume III (Colorado) (NOAA 1973). To facilitate comparisons between the 6-hour event and the 24-hour events, the UDFCD distribution for the 6-hour event was applied to the 24-hour storm depths (i.e., each time step for the 6-hour event was multiplied by 4 to create a 24-hour storm distribution, with values interpolated to generate 5-minute precipitation depths). These distributions were used in the CUHP model to generate peak hydrographs for each sub-catchment for each storm event analyzed; the CUHP output for each storm was then used as input for the SWMM models for each dam breach scenario.

4.4 Modeling Assumptions

As presented in Table 3, the assumptions regarding the conditions of the ponds are as follows:

- The existing breached dams (A-1, A-2, B-1, B-2, B-3, B-4 and C-1) remain in their current form for all scenarios. The associated ponds are filled to the top of the stop log structures at the beginning of each scenario.

- Dams A-3 and C-2 are filled to 40 percent (their normal maximum operating condition) and the outlet works are closed at the beginning of Scenario 1. Similarly, the PLF dam is filled to 22 percent (the level of the outlet works) and the outlet works closed at the beginning of Scenario 1. In Scenarios 2 and 3, where these three dams are breached, their initial pond condition is empty.

- Dams A-4 and B-5 are filled to 40 percent (their normal maximum operating condition) at the beginning of Scenarios 1 and 2 and the outlet works are closed. In Scenario 3, where these two dams are breached, their initial pond condition is empty.

These assumptions were defined by Stoller as representative conditions to consider as a starting point for the modeled dam breach scenarios.

5.0 RESULTS

5.1 Peak Flow Rates

The peak flow rates at each of the dams proposed to be breached, for each of the storm events and for each of the different scenarios, are presented in Table 5 through Table 9.

Table 5. Calculated Peak Flow Rates at Dam A-3

Scenario	Storm Event	Storm Event Depth (in)	A-3 Pond Peak Inflow (cfs)	A-3 Breach Peak Flow (cfs)	A-3 Spillway Peak Flow (cfs)
Scenario 1	2-yr, 24-hr	2.2	3	N/A – not breached	0
A-Series Ponds:	50-yr, 24-hr	4.4	257	N/A – not breached	26
Breached: A-1 and A-2	100-yr, 24-hr	5.0	366	N/A – not breached	92
Not Breached: A-3, and A-4	100-yr, 6-hr	3.8	527	N/A – not breached	158
Scenario 2	2-yr, 24-hr	2.2	3	0	N/A
A-Series Ponds:	50-yr, 24-hr	4.4	257	242	N/A
Breached: A-1 through A-3	100-yr, 24-hr	5.0	366	342	N/A
Not Breached: A-4	100-yr, 6-hr	3.8	527	493	N/A
Scenario 3	2-yr, 24-hr	2.2	3	0	N/A
A-Series Ponds:	50-yr, 24-hr	4.4	257	242	N/A
Breached: A-1 through A-4	100-yr, 24-hr	5.0	366	342	N/A
Not Breached: None	100-yr, 6-hr	3.8	527	493	N/A

Notes: For Pond A-3, the Scenario 2 peak flow values are the same as in Scenario 3 because the breach conditions of A-3 and the upstream A-Series ponds are the same in both Scenarios. N/A indicates not applicable.

Table 6. Calculated Peak Flow Rates at Dam A-4

Scenario	Storm Event	Storm Event Depth (in)	A-4 Pond Peak Inflow (cfs)	A-4 Breach Peak Flow (cfs)	A-4 Spillway Peak Flow (cfs)
Scenario 1	2-yr, 24-hr	2.2	4	N/A – not breached	0
A-Series Ponds:	50-yr, 24-hr	4.4	35	N/A – not breached	0
Breached: A-1 and A-2	100-yr, 24-hr	5.0	94	N/A – not breached	0
Not Breached: A-3, and A-4	100-yr, 6-hr	3.8	161	N/A – not breached	0
Scenario 2	2-yr, 24-hr	2.2	4	N/A – not breached	0
A-Series Ponds:	50-yr, 24-hr	4.4	255	N/A – not breached	0
Breached: A-1 through A-3	100-yr, 24-hr	5.0	363	N/A – not breached	0
Not Breached: A-4	100-yr, 6-hr	3.8	525	N/A – not breached	0
Scenario 3	2-yr, 24-hr	2.2	4	1	N/A
A-Series Ponds:	50-yr, 24-hr	4.4	255	250	N/A
Breached: A-1 through A-4	100-yr, 24-hr	5.0	363	355	N/A
Not Breached: None	100-yr, 6-hr	3.8	525	511	N/A

Note: N/A indicates not applicable.

Table 7. Calculated Peak Flow Rates at Dam B-5

Scenario	Storm Event	Storm Event Depth (in)	B-5 Pond Peak Inflow (cfs)	B-5 Breach Peak Flow (cfs)	B-5 Spillway Peak Flow (cfs)
Scenario 1	2-yr, 24-hr	2.2	3	N/A – not breached	0
B-Series Ponds:	50-yr, 24-hr	4.4	153	N/A – not breached	0
Breached: B-1 through B-4	100-yr, 24-hr	5.0	224	N/A – not breached	0
Not Breached: B-5	100-yr, 6-hr	3.8	373	N/A – not breached	0
Scenario 2	2-yr, 24-hr	2.2	3	N/A – not breached	0
B-Series Ponds:	50-yr, 24-hr	4.4	153	N/A – not breached	0
Breached: B-1 through B-4	100-yr, 24-hr	5.0	224	N/A – not breached	0
Not Breached: B-5	100-yr, 6-hr	3.8	373	N/A – not breached	0
Scenario 3	2-yr, 24-hr	2.2	3	0	N/A
B-Series Ponds:	50-yr, 24-hr	4.4	153	151	N/A
Breached: B-1 through B-5	100-yr, 24-hr	5.0	224	220	N/A
Not Breached: None	100-yr, 6-hr	3.8	373	360	N/A

Note: N/A indicates not applicable.

Table 8. Calculated Peak Flow Rates at PLF Dam

Scenario	Storm Event	Storm Event Depth (in)	PLF Dam Peak Inflow (cfs)	PLF Dam Breach Peak Flow (cfs)	PLF Dam Spillway Peak Flow (cfs)
Scenario 1	2-yr, 24-hr	2.2	1	N/A – not breached	0
PLF Pond Drainage:	50-yr, 24-hr	4.4	15	N/A – not breached	0
Breached: None	100-yr, 24-hr	5.0	19	N/A – not breached	0
Not Breached: PLF Pond Dam	100-yr, 6-hr	3.8	26	N/A – not breached	0
Scenario 2	2-yr, 24-hr	2.2	1	0	N/A
PLF Pond Drainage:	50-yr, 24-hr	4.4	15	15	N/A
Breached: PLF Pond Dam	100-yr, 24-hr	5.0	19	19	N/A
Not Breached: None	100-yr, 6-hr	3.8	26	26	N/A
Scenario 3	2-yr, 24-hr	2.2	1	0	N/A
PLF Pond Drainage:	50-yr, 24-hr	4.4	15	15	N/A
Breached: PLF Pond Dam	100-yr, 24-hr	5.0	19	19	N/A
Not Breached: None	100-yr, 6-hr	3.8	26	26	N/A

Notes: For the PLF Dam, the Scenario 2 peak flow values are the same as in Scenario 3 because the breach conditions of the PLF Dam and the upstream conditions are the same in both Scenarios. N/A indicates not applicable.

Table 9. Calculated Peak Flow Rates at Dam C-2

Scenario	Storm Event	Storm Event Depth (in)	Dam C-2 Inflow (cfs)	Dam C-2 Breach Peak Flow (cfs)	Dam C-2 Spillway Peak Flow (cfs)
Scenario 1	2-yr, 24-hr	2.2	6	N/A – not breached	0
Woman Creek Drainage:	50-yr, 24-hr	4.4	146	N/A – not breached	0
Breached: C-1	100-yr, 24-hr	5.0	190	N/A – not breached	0
Not Breached: C-2	100-yr, 6-hr	3.8	277	N/A – not breached	0
Scenario 2	2-yr, 24-hr	2.2	6	4	N/A
Woman Creek Drainage:	50-yr, 24-hr	4.4	146	141	N/A
Breached: C-1 and C-2	100-yr, 24-hr	5.0	190	184	N/A
Not Breached: None	100-yr, 6-hr	3.8	277	266	N/A
Scenario 3	2-yr, 24-hr	2.2	6	4	N/A
Woman Creek Drainage:	50-yr, 24-hr	4.4	146	141	N/A
Breached: C-1 and C-2	100-yr, 24-hr	5.0	190	184	N/A
Not Breached: None	100-yr, 6-hr	3.8	277	266	N/A

Note: For the C-2 Dam, the Scenario 2 peak flow values are the same as in Scenario 3 because the breach conditions of the C-2 Dam and C-1 upstream are the same in both Scenarios. N/A indicates not applicable.

Table 10. Calculated Peak Flow Rates at Walnut and Woman Creeks at Indiana Street

Scenario	Storm Event	Storm Event Depth (in)	Walnut Creek and Indiana Street Peak Flow (cfs)	Woman Creek and Indiana Street Peak Flow (cfs)
Scenario 1	2-yr, 24-hr	2.2	3	30
	50-yr, 24-hr	4.4	446	605
	100-yr, 24-hr	5.0	627	961
	100-yr, 6-hr	3.8	905	1443
Scenario 2	2-yr, 24-hr	2.2	3	30
	50-yr, 24-hr	4.4	454	644
	100-yr, 24-hr	5.0	636	1019
	100-yr, 6-hr	3.8	918	1533
Scenario 3	2-yr, 24-hr	2.2	3	30
	50-yr, 24-hr	4.4	758	644
	100-yr, 24-hr	5.0	1034	1019
	100-yr, 6-hr	3.8	1530	1533

(Note: Results are for flow estimates on the east side of Indiana Street at the study boundaries. Results for Scenarios 2 and 3 for Woman Creek are the same because the pond breach conditions in the Woman Creek basin are the same for each of those scenarios)

A listing of peak flow rates at all SWMM model nodes, for all scenarios, is provided in Appendix D.

5.2 Floodplain Delineation

The floodplain delineation mapping is organized as listed in Table 11.

Table 11. Floodplain Mapping

Drainage Basin	Storm Event	Scenario	Figure Number
Walnut Creek	100-Year, 6-Hour	1	5a
		2	5b
		3	5c
	100-Year, 24-Hour	1	5d
		2	5e
		3	5f
Woman Creek	100-Year, 6-Hour	1	6a
		2	6b
	100-Year, 24-Hour	1	6c
		2	6d

Model output from HEC-RAS, with water surface elevations at cross-sections throughout the study area, is provided in Appendix E.

Key findings of the peak flow analysis and floodplain delineation for the different scenarios analyzed are summarized below:

<u>Walnut Creek Basin:</u>

- The spillway for the A-3 dam has flow in Scenario 1 (current conditions scenario) during the 50-year, 24-hour storm (26 cfs), the 100-year, 24-hour storm (92 cfs) and the 100-year, 6-hour storm (158 cfs). In Scenarios 2 and 3, the A-3 dam is breached and hence the spillway does not flow in either of those scenarios for any of the storms analyzed.

- The spillway for the A-4 dam does not flow in any of the scenario/storm event combinations analyzed.

- The spillway for the B-5 dam does not flow in any of the scenario/storm event combinations analyzed.

- The roadway at Walnut Creek and Indiana Street is overtopped by flow from Walnut Creek in one scenario analyzed. During the 100-year, 6-hour storm event, in Scenario 3, Walnut Creek overtops Indiana Street. The maximum estimated depth of flow over the Indiana Street crown is approximately 1.2 feet for that storm event/dam breach scenario.

- The floodplain extent upstream of the dams at Ponds A-3, A-4, B-5 and the PLF Pond is largest in Scenario 1 because the dams are intact and the pool elevations are raised. However, downstream from these ponds, the floodplain extent is widest in Scenario 3, because all the dams have been breached and the peak flows are higher. At Walnut Creek and Indiana Street, where the floodplain broadens because of the constriction as flows pass through the 12-foot diameter corrugated metal pipe (CMP) under the road, the floodplain cross-section width for the 100-year 6-hour storm is approximately 690 feet in Scenario 1 versus 850 feet in Scenario 3.

<u>Woman Creek Basin:</u>

- The spillway for the C-2 dam does not flow in any of the scenario/storm event combinations analyzed.

- The roadway at Woman Creek and Indiana Street is overtopped by flow from Woman Creek during three storm events: 1) 100-year, 6-hour event, 2) 100-year, 24-hour event, and 2) 50-year, 24-hour event. For each of these events, Indiana Street is overtopped by Woman Creek for both Scenario 1 (dam C-2 not breached) and Scenario 2 (dam C-2 breached). For the events analyzed where Woman Creek overtops Indiana Street, the

maximum estimated depth of flow over the roadway crown ranges from approximately 0.7 feet for the 50-year, 24-hour event (for Scenario 1) up to approximately 2.0 feet for the 100-year, 6-hour event (for Scenario 2). (Note: The boundaries of the Woman Creek flow over Indiana Street are approximate based on the available survey data in that area. Also note that Scenario 2 is the same as Scenario 3 in the Woman Creek basin because dam C-2 is breached in both scenarios). The flow conveyance structures underneath Indiana Street at Woman Creek include: 1) an elliptical CMP, 44 inches tall by 72 inches wide, located on the main Woman Creek channel, 2) a 3-foot diameter CMP, located approximately 340 feet north of the main Woman Creek channel, and 3) a 12-foot diameter CMP with vertical concrete sidewalls and gravel bottom, located north of and adjacent to the 3-foot CMP.

- The floodplain extent upstream from the dam at Pond C-2 is largest in Scenario 1 because the dam is intact and the C-2 pool elevation is raised from the inflow from the South Interceptor Ditch (note that this area is not within the main Woman Creek channel, which is routed around Pond C-2). Downstream from Pond C-2, the Woman Creek floodplain extent is only slightly larger in Scenario 2, because the dam has been breached and the peak flows are higher. The flow from Woman Creek which is routed around C-2 in both scenarios represents the majority of the flow downstream from Pond C-2. Consequently, the effect of the C-2 dam breach is relatively minor in terms of floodplain extent; in both scenarios, the total cross-section width of the Woman Creek floodplain at Indiana Street, from the north side of the north channel to the south side of the main channel, is approximately 1100 feet.

Plot Date/Time: 03/31/2010, 09:00:36 AM; Z:\PROJECT FILES\07\071-091\071-091.010\CAD-GIS\CAD\RF SITE MAP 1.DWG-FIGURE 1

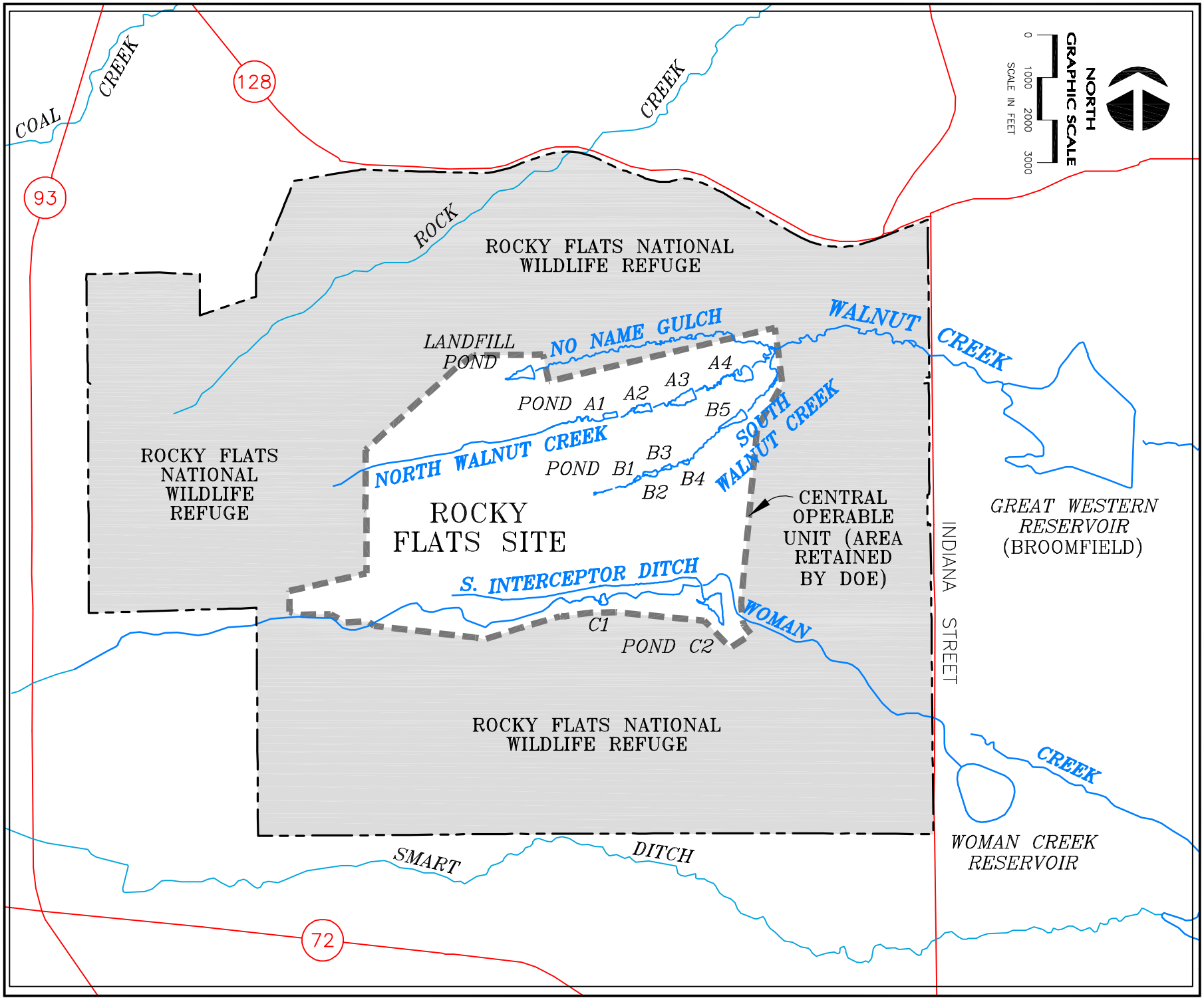

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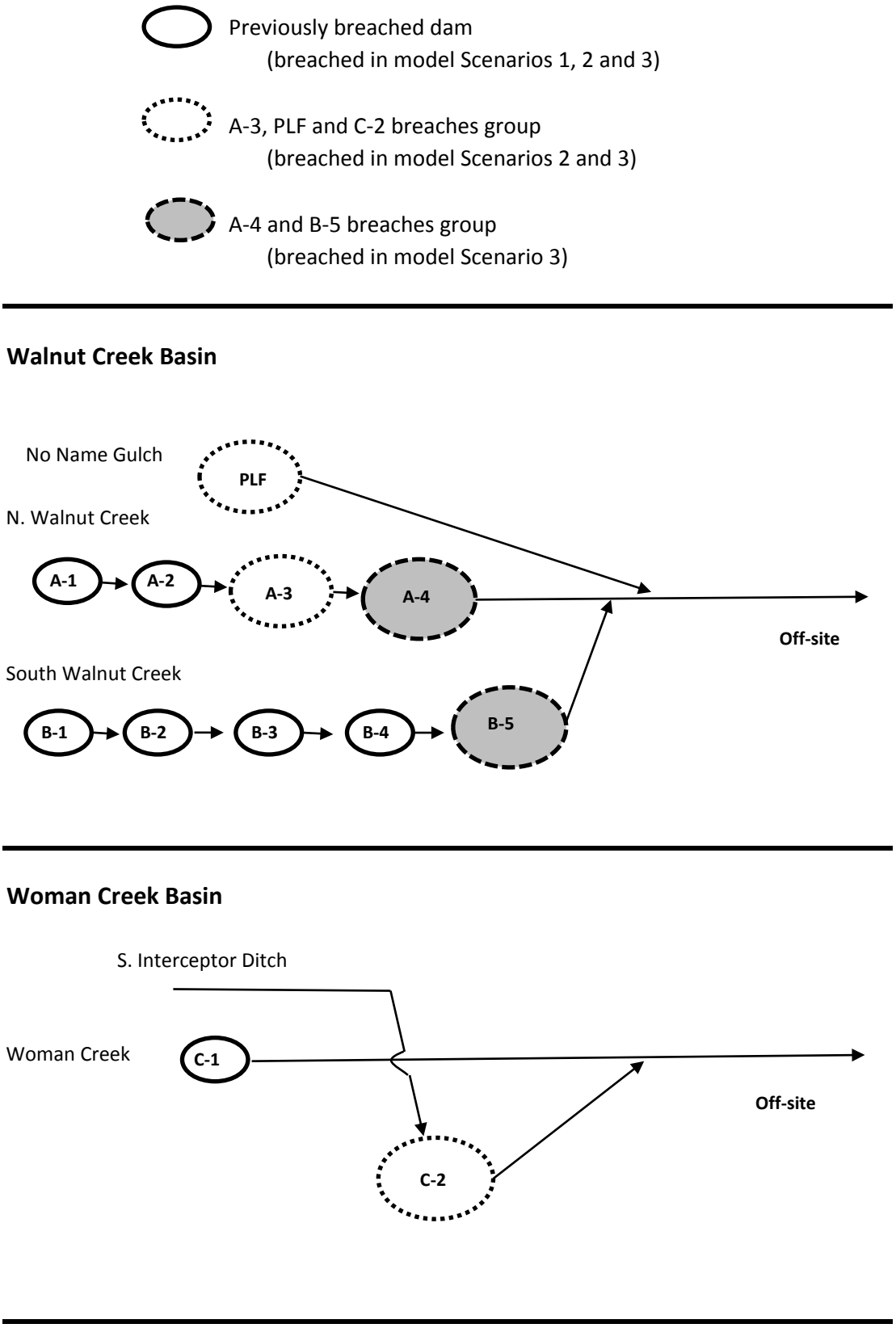
FIGURE 1

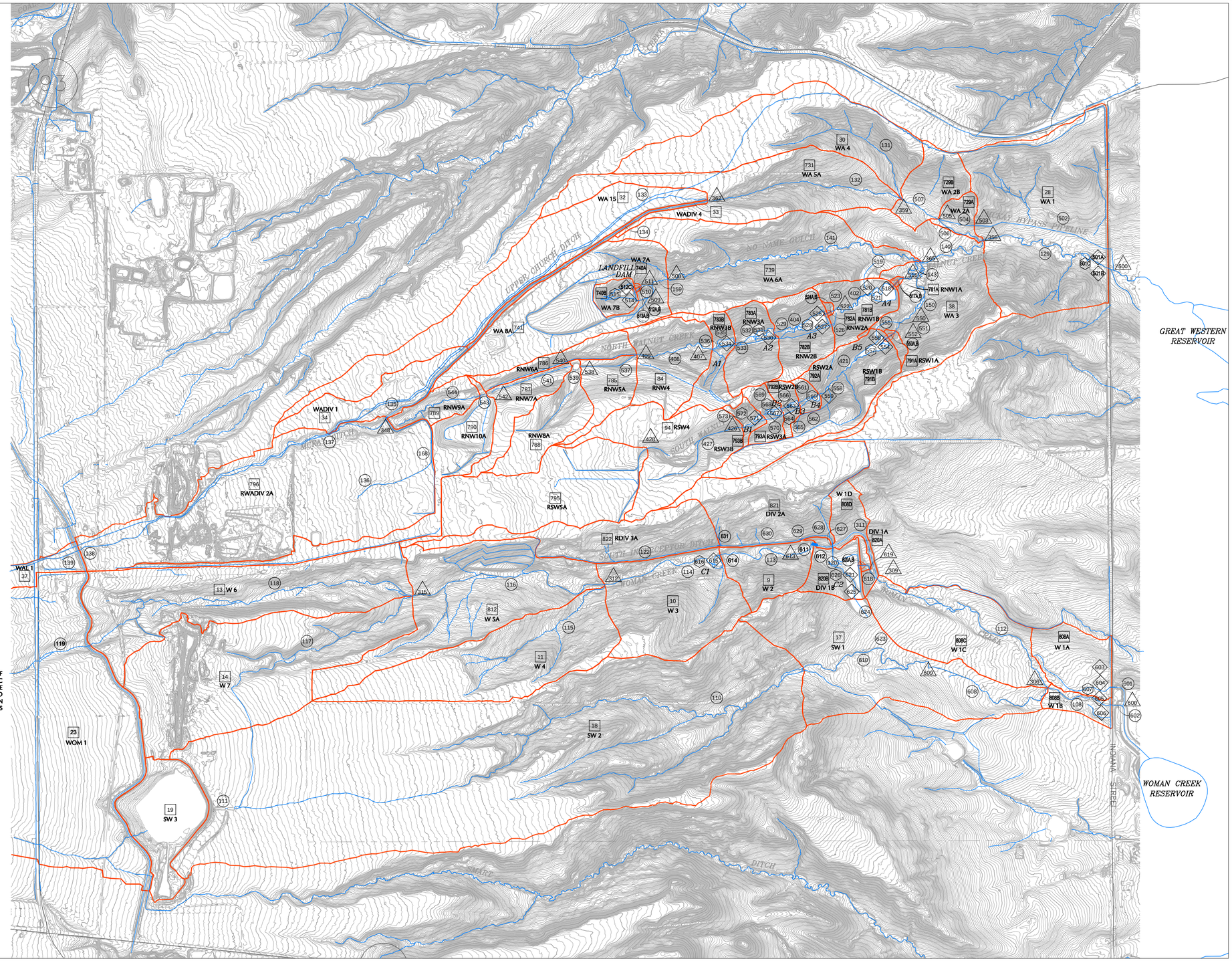
ROCKY FLATS SITE MAP

Figure 2. Schematic Diagram of Dam Breach Scenarios – Walnut and Woman Creek Basins



LEGEND

- BASIN BOUNDARY
- LAKE, STREAM
- CONTOUR–10' INTERVAL
- CONTOUR–2' INTERVAL
- ROADS, OTHER FEATURES
- WADIV 1 789 — BASIN DESIGNATION (CUHP, SWMM)
- 348 — DESIGN POINT
- 515 — POND
- 514 — POND OUTLET
- 168 — CHANNEL OR CULVERT(S)



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DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

CUHP BASIN DELINEATION AND SWMM MODEL ELEMENTS

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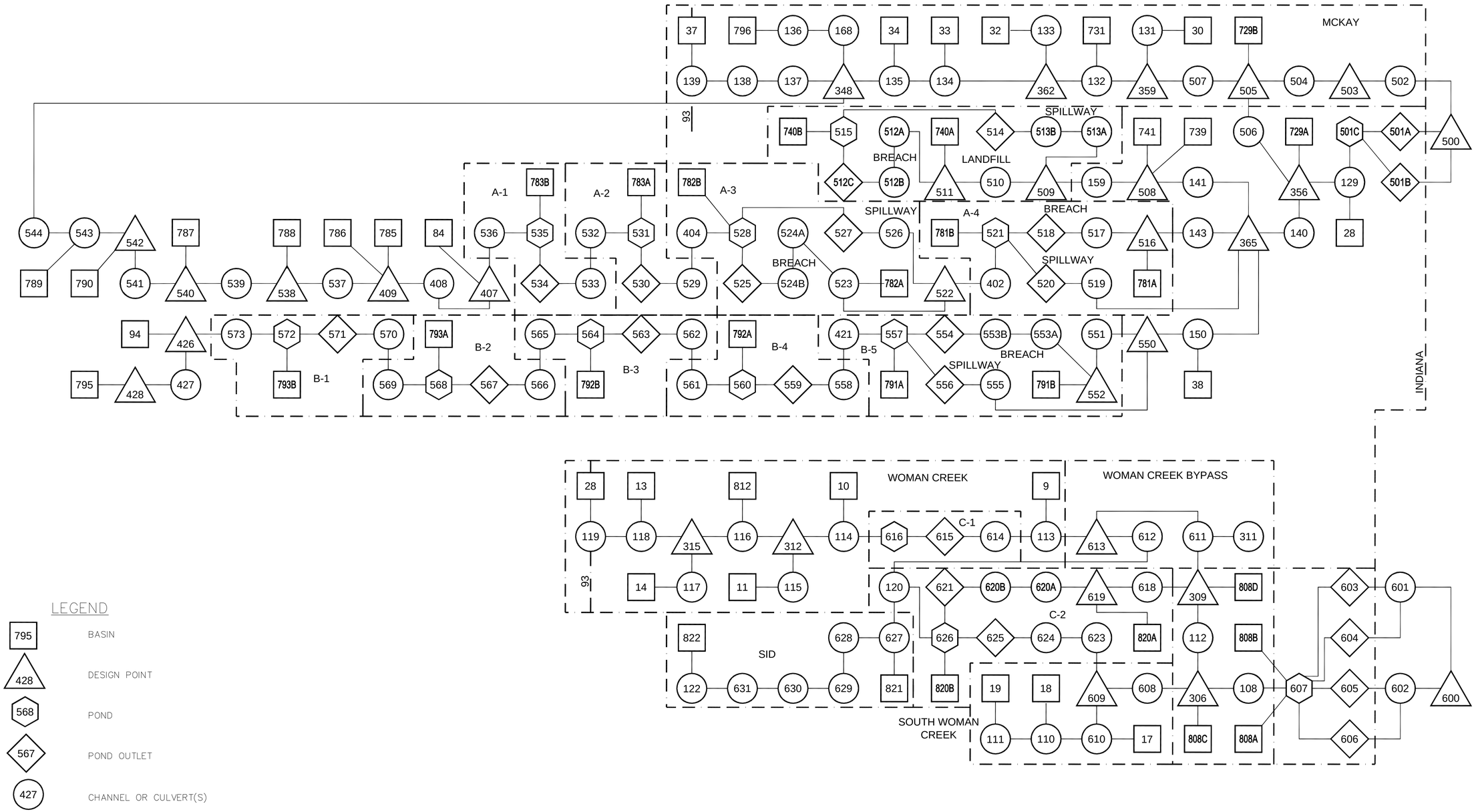

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DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

SWMM MODEL ROUTING DIAGRAM

JOB NO. 071-091.010
REVISION NO. 0
SHEET NO. 4

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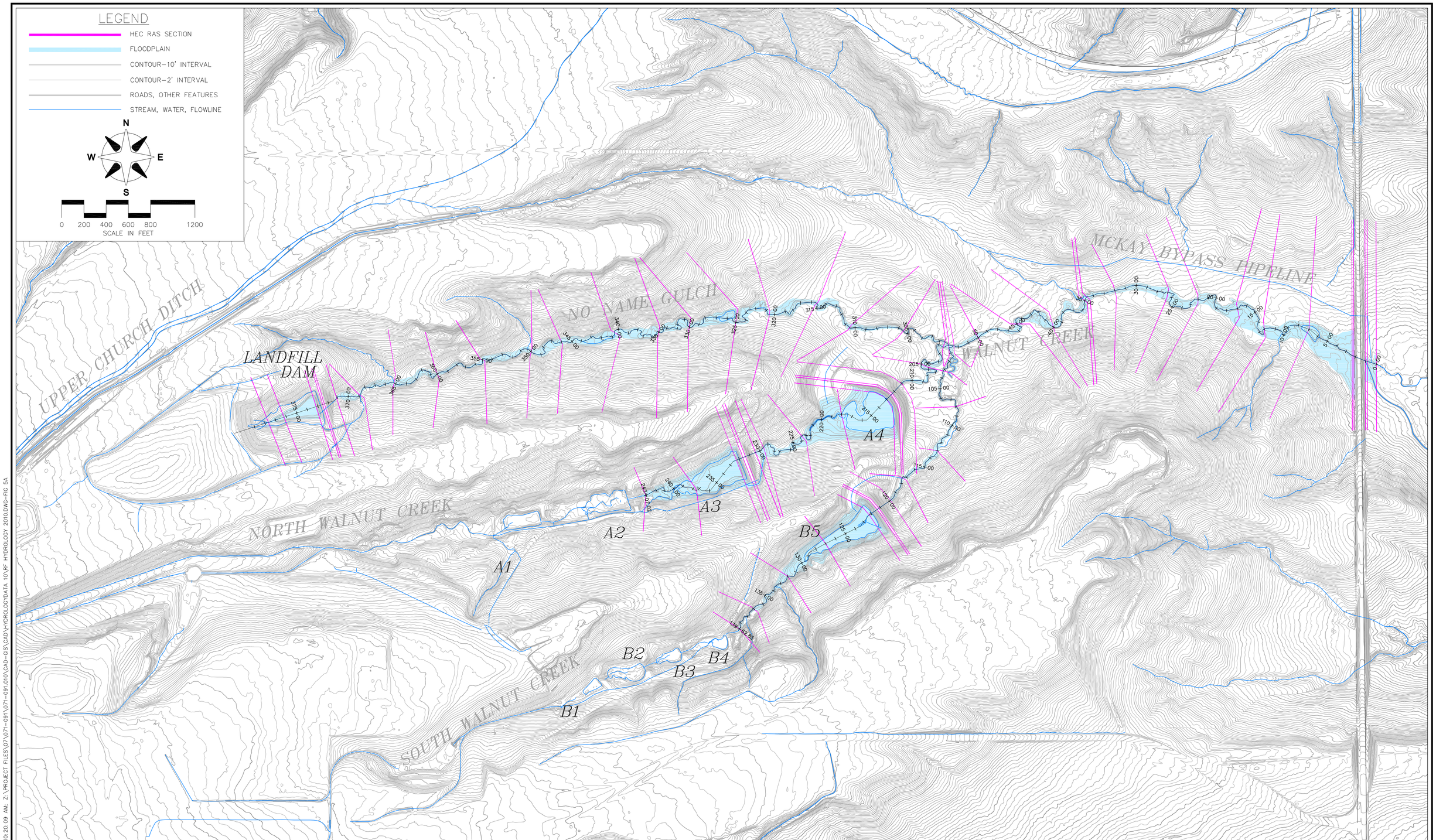

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DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

FLOODPLAIN DELINEATION
WALNUT CREEK, SCENARIO 1
100-YEAR, 6 HOUR STORM EVENT

JOB NO. 071-091.010
REVISION NO. 0
SHEET NO. 5a

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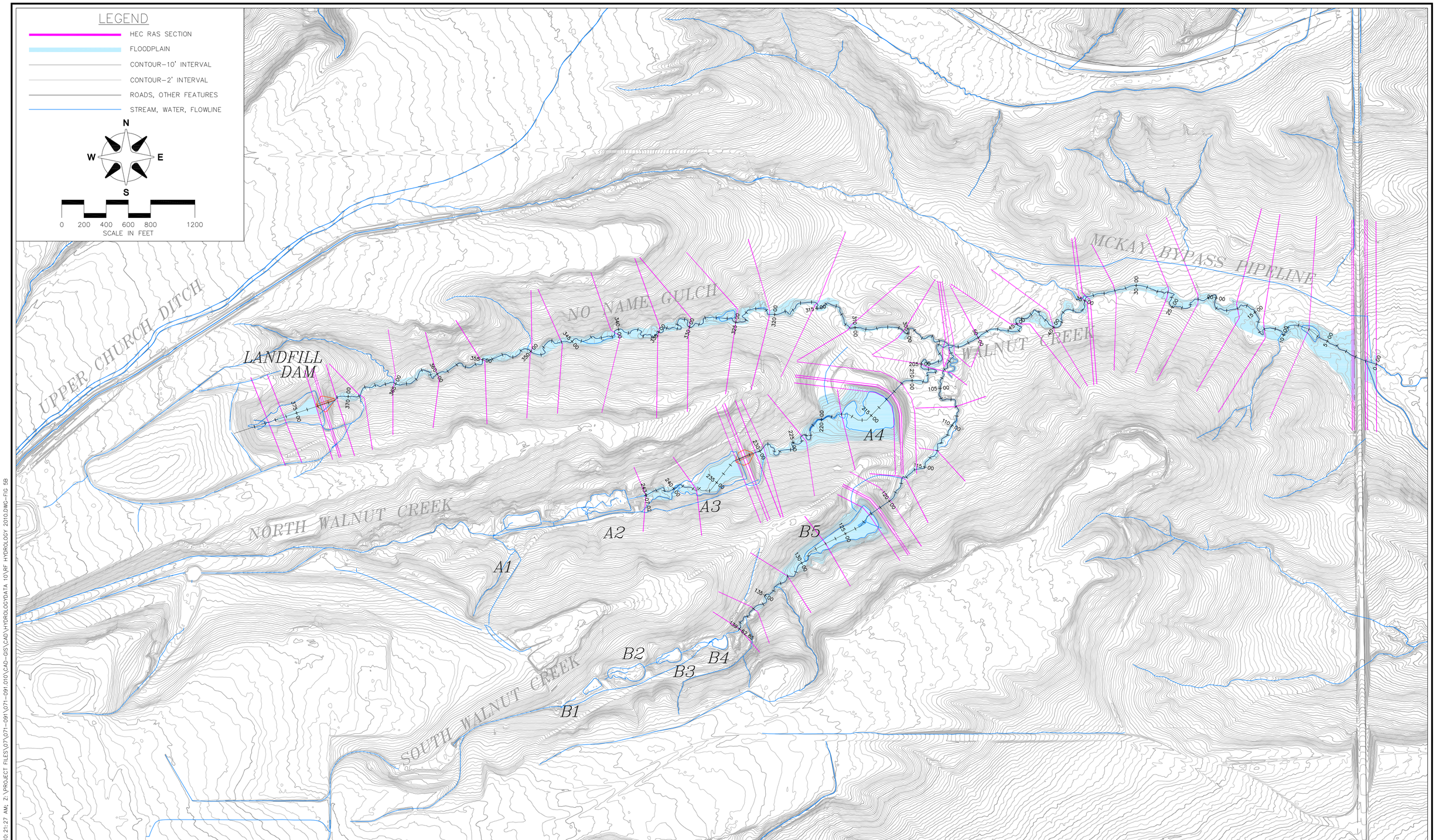

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FILE	RF Hydrology 2010.dwg	

DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

FLOODPLAIN DELINEATION
WALNUT CREEK, SCENARIO 2
100-YEAR, 6 HOUR STORM EVENT

JOB NO. 071–091.010
REVISION NO. 0
SHEET NO. 5b

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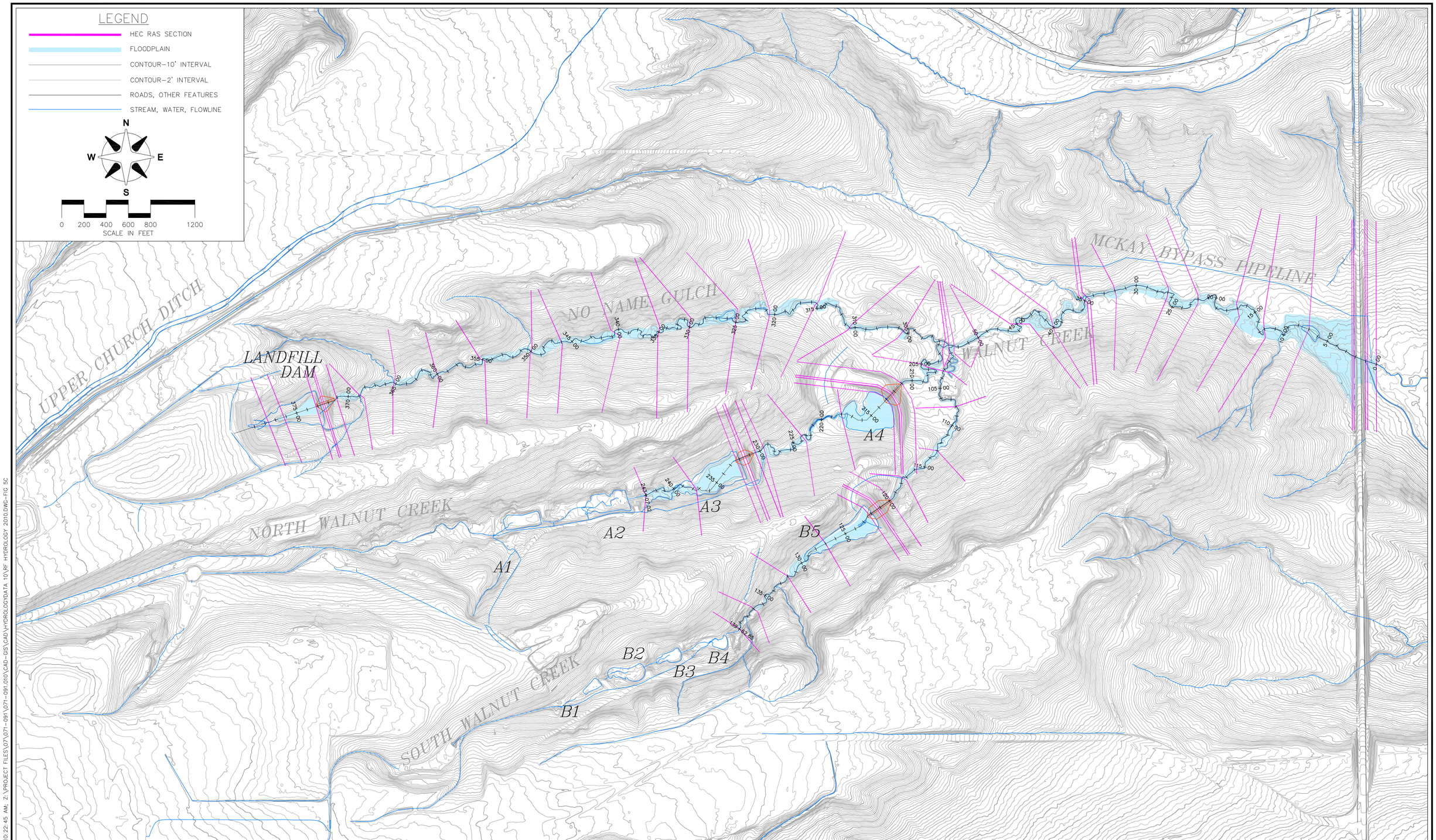

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DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

FLOODPLAIN DELINEATION
WALNUT CREEK, SCENARIO 3
100-YEAR, 6 HOUR STORM EVENT

JOB NO. 071-091.010
REVISION NO. 0
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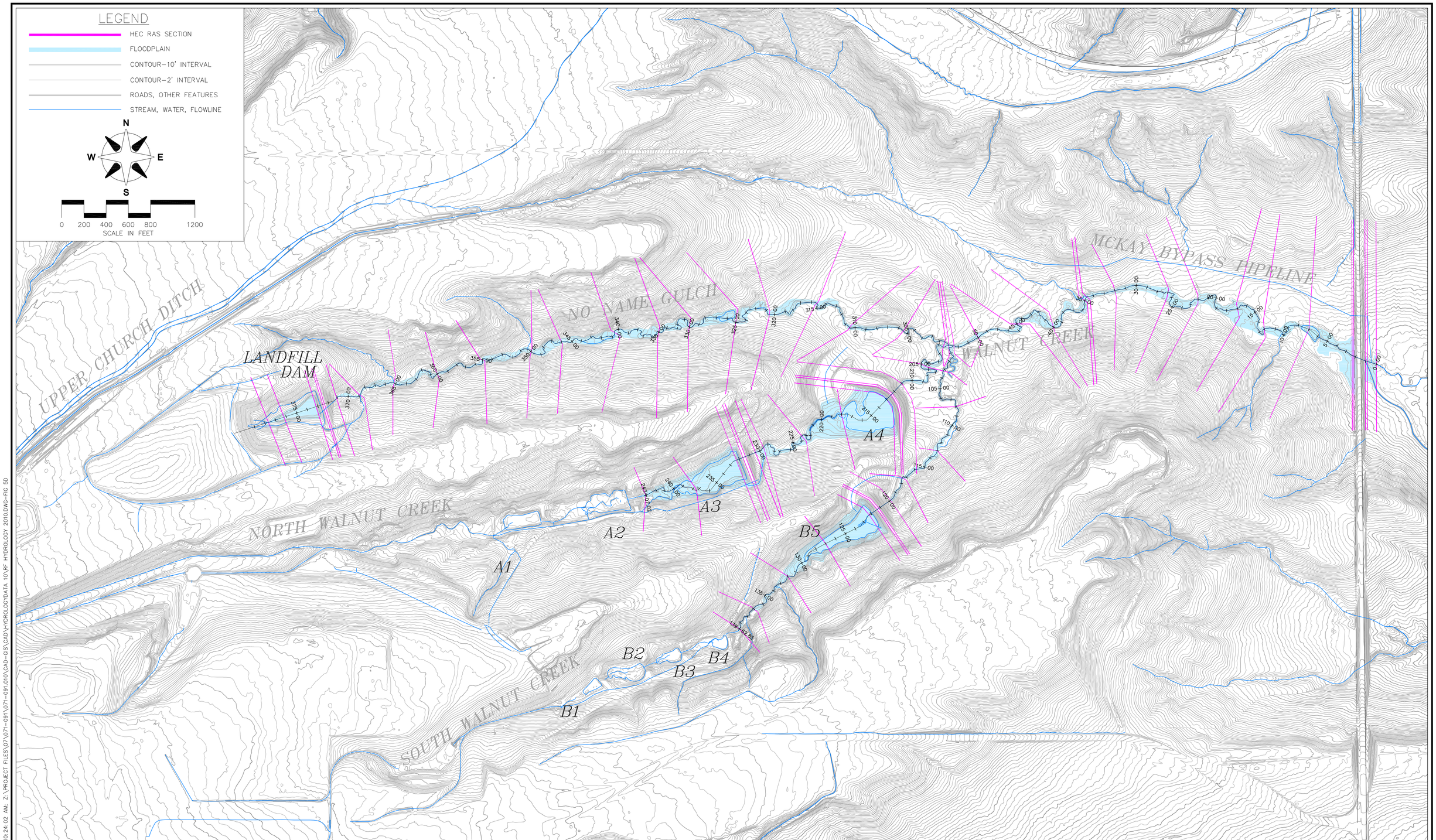

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DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

FLOODPLAIN DELINEATION
WALNUT CREEK, SCENARIO 1
100-YEAR, 24 HOUR STORM EVENT

JOB NO. 071–091.010
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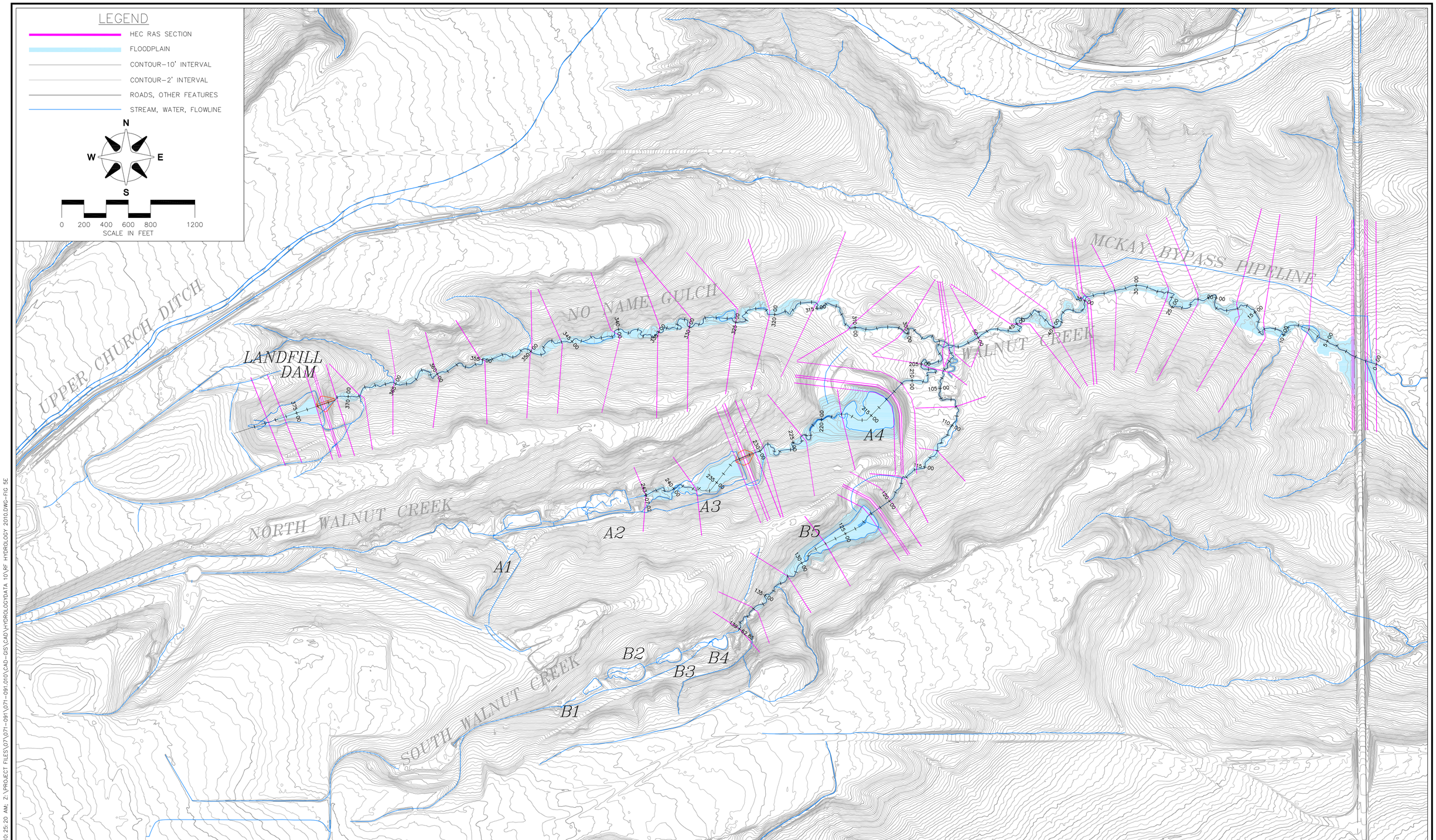

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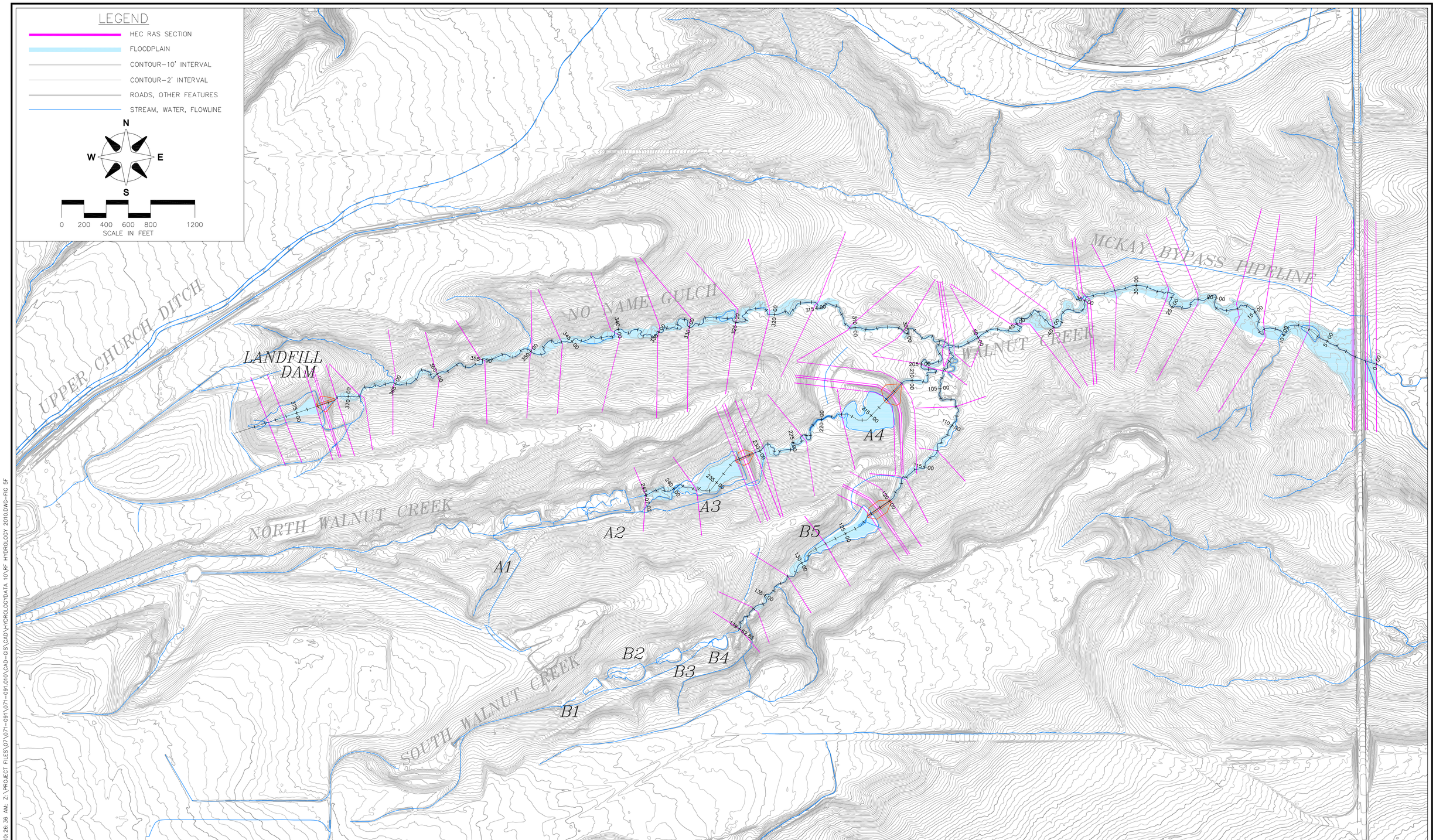
DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

FLOODPLAIN DELINEATION
WALNUT CREEK, SCENARIO 2
100-YEAR, 24 HOUR STORM EVENT

JOB NO. 071-091.010

REVISION NO. 0

SHEET NO. 5e



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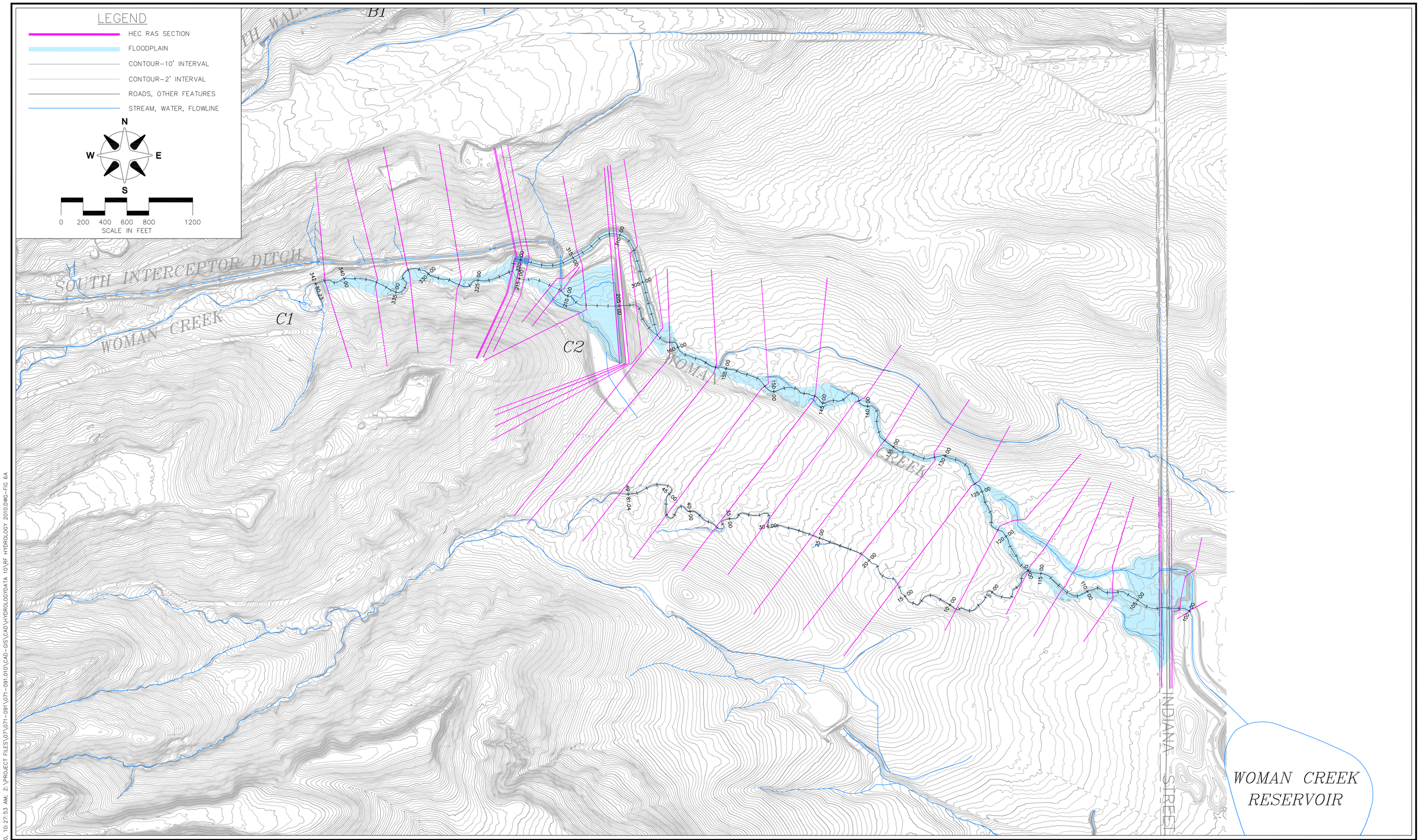
DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

FLOODPLAIN DELINEATION
WALNUT CREEK, SCENARIO 3
100-YEAR, 24 HOUR STORM EVENT

JOB NO. 071-091.010

REVISION NO. 0

SHEET NO. 5f



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DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

FLOODPLAIN DELINEATION
WOMAN CREEK, SCENARIO 1
100-YEAR, 6 HOUR STORM EVENT

JOB NO. 071-091.010
REVISION NO. 0
SHEET NO. 6a

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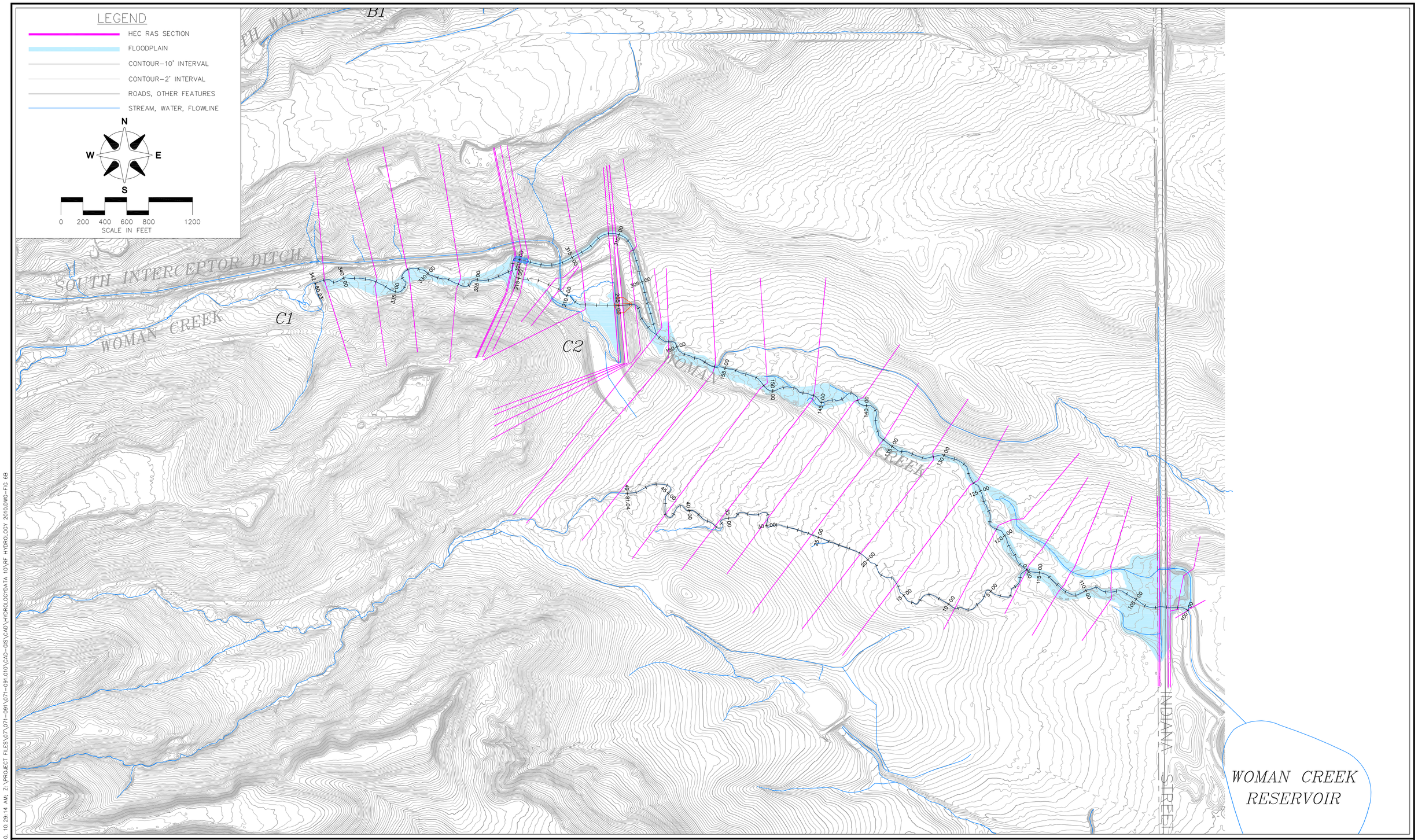

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DETAIL	DKW	03/31/10
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APPROVAL		
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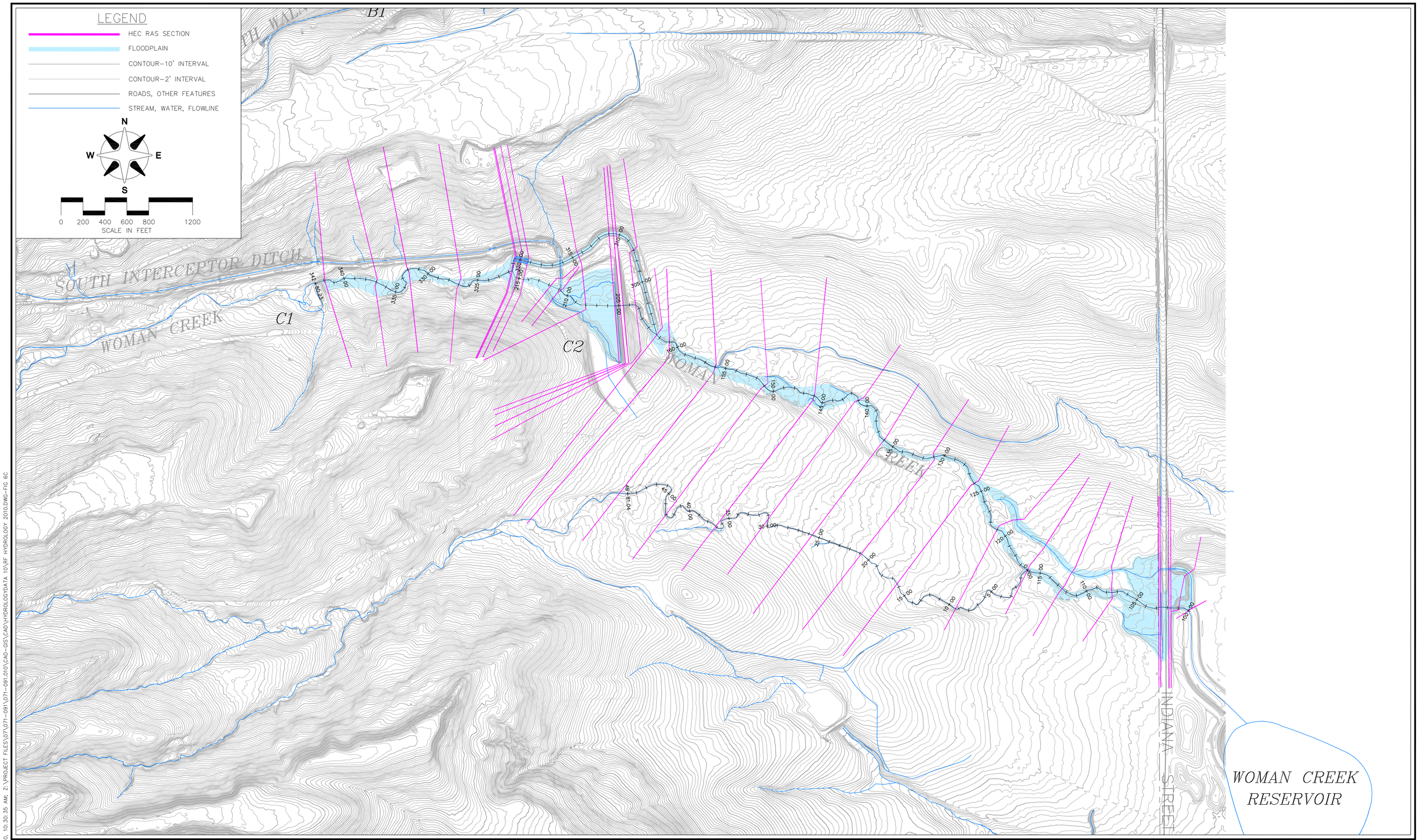
FILE	RF Hydrology 2010.dwg	

DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

FLOODPLAIN DELINEATION WOMAN CREEK, SCENARIO 2 100-YEAR, 6 HOUR STORM EVENT

JOB NO. 071-091.010
REVISION NO. 0
SHEET NO. 6b

Plot Date/Time: 04/01/2010, 10:29:14 AM; Z:\PROJECT FILES\07\071-091\071-091.010\CAD-GIS\CAD\HYDROLOGY\DATA 10\RF HYDROLOGY 2010.DWG-FIG 6B



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DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

FLOODPLAIN DELINEATION WOMAN CREEK, SCENARIO 1 100-YEAR, 24 HOUR STORM EVENT

JOB NO. 071-091.010
REVISION NO. 0
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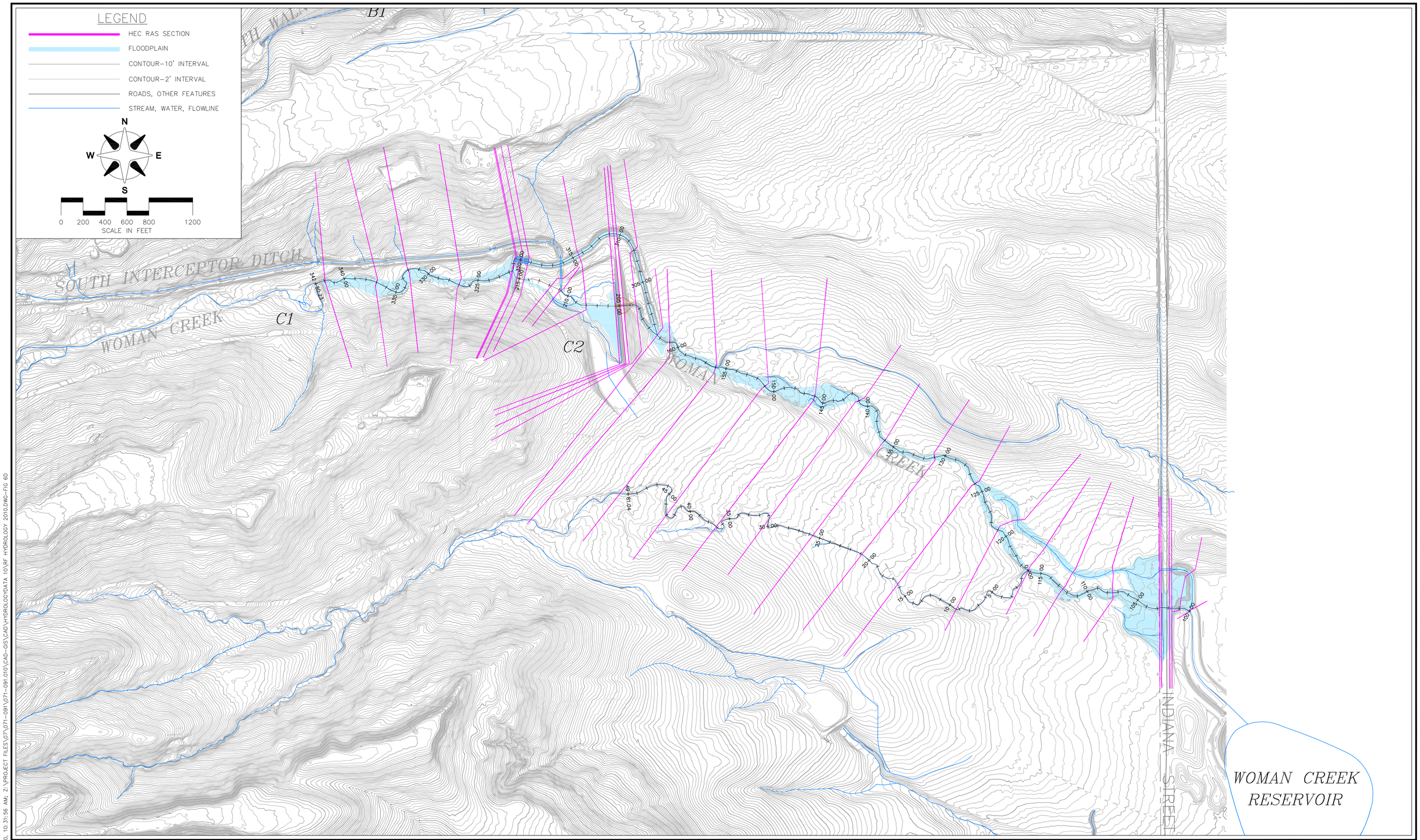

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FILE	RF Hydrology 2010.dwg	

DETERMINATION OF PEAK FLOW RATES AND FLOODPLAIN DELINEATION FOR DAM BREACHES AT THE ROCKY FLATS SITE

FLOODPLAIN DELINEATION
WOMAN CREEK, SCENARIO 2
100-YEAR, 24 HOUR STORM EVENT

JOB NO. 071-091.010
REVISION NO. 0
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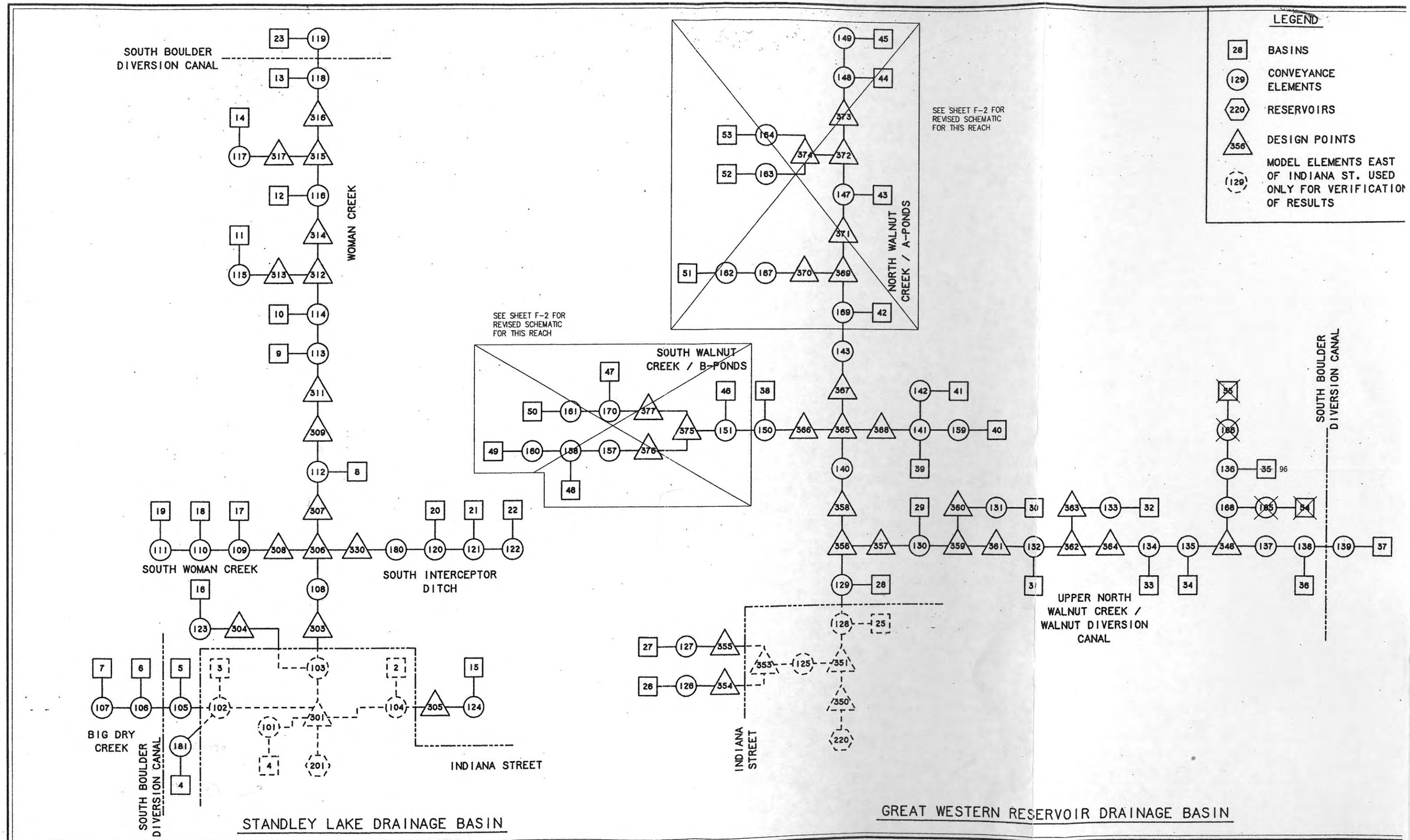

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SCALE	N.T.S.	
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ROCKY FLATS DAM BREACH

ORIGINAL UDSWMM MODEL SCHEMATIC WITH REVISED AREAS MARKED

JOB NO. 901-004.890

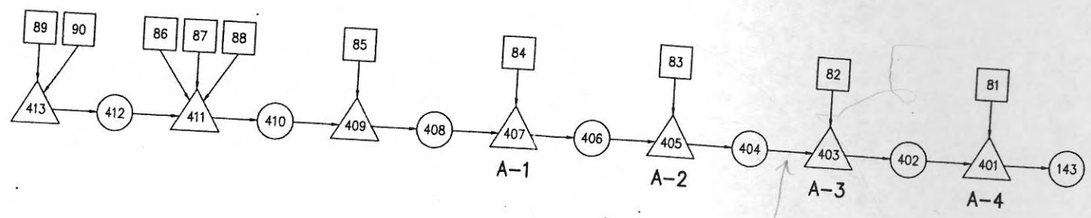
REVISION NO. -

SHEET NO. F-1

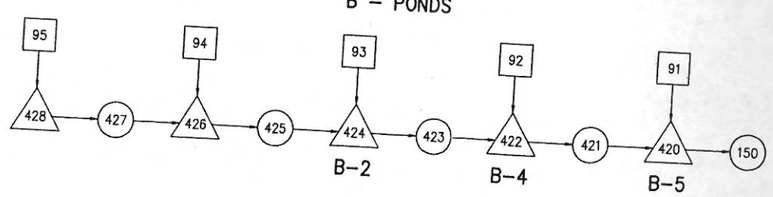
LEGEND

- 81 — BASINS
- 143 — CONVEYANCE ELEMENTS
- 401 — DESIGN POINTS

NORTH WALNUT / A – PONDS



SOUTH WALNUT / B – PONDS



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SCALE	N.T.S.	
FILE RF-Drainage Plan.dwg		

ROCKY FLATS DAM BREACH

REVISED PORTIONS OF UDSWMM MODEL SCHEMATIC

JOB NO. 901-004.890

REVISION NO. -

SHEET NO. F-2

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