Appendix C
HSPF Analysis

Parametrix ENGINEERING • PLANNING • ENVIRONMENTAL SCIENCES

TECHNICAL MEMORANDUM

Date:	August 1, 2005
To:	Jenny Gaus, P.E. Senior Surface Water Engineer City of Kirkland Public Works Department
From:	Dave Harms, P.E. and Julie Brandt, P.E.
Subject:	HSPF Analysis of Forbes and Juanita Creeks
cc:	Paul Fendt, P.E., Parametrix Erin Nelson, P.E., Parametrix
Project Number:	558-1802-035 (01/01)
Project Name:	Kirkland Comprehensive Stormwater Plan

INTRODUCTION

A hydrologic analysis has been performed for Juanita and Forbes Creeks as part of the City's Comprehensive Stormwater Plan. The analysis involves development of Hydrologic Simulation Program FORTRAN (HSPF) stormwater models for both basins. HSPF is a continuous simulation model, utilizing actual precipitation and evaporation datasets to generate a hydrologic response from the modeled basins. Characteristics of the simulated hydrologic response are dependent on parameter values assigned to mathematical algorithms simulating the various components of the hydrologic cycle, such as surface ponding, soil infiltration rates and groundwater characteristics.

The models are being utilized to simulate existing and future projected runoff conditions, to quantify potential increases in streamflow, and form the foundation for a strategy of regional versus on-site detention criteria. Assumptions included in the model development and analysis process are listed in the following section.

MODEL ASSUMPTIONS

General

- SeaTac Precipitation data was used in the model, to provide an adequate simulation period for statistical analyses. The precipitation was not factored, consistent with model documentation.
- The predeveloped conditions scenario for Forbes Creek is based on converting all non-forested land use to forested categories.

HSPF Baseline and Regional Detention Analyses

- Land use for model input was processed jointly between the City and King County. County (1995) land use was used for Juanita Creek, since the majority of the basin lies outside of City limits. Since

Juanita Creek is largely "built out," it is assumed that 1995 is representative of current land use conditions in the basin. City (2004) land use was used for Forbes Creek.

- The models were not calibrated to local streamflow data. Calibrated parameter values for Bellevue's Kelsey Creek HSPF model were adopted for Juanita and Forbes Creeks and applied to equivalent soil and ground cover categories.

- Evaporation data is taken from the Puyallup pan evaporation record.

- The future conditions scenario for both basin models included estimated increases in impervious areas. A uniform increase in impervious data was developed by the City, for each subbasin within both basins, based on development and redevelopment potential. Juanita Creek subbasins outside of City limits were not modified.

On-Site Detention

- Each single-parcel site modeled is equal to the average parcel size for the respective zoning category (Single-Family, Multi-Family, and Non-Residential).

- Consistent with Washington State Department of Ecology thresholds for detention facility requirements, each single-parcel site modeled has a minimum of 10,000 square feet (0.23 acres) impervious and/or 32,670 square feet (0.75 acres) of grass.

- Effective impervious area for the redeveloped sites is approximated as:

    - Single-Family Residential: 2600 square feet for each parcel

    - Non-Residential/Commercial: 80 percent of total area

    - Multi-Family Residential: 64.5 percent of total area

- Once the impervious area is calculated, the detention pond land area is subtracted from the remaining pervious area and modeled as impervious.

- Based on the Soil Conservation Service Survey of King County, the Single-Family Residential parcels lie predominantly over Alderwood soils and will be modeled as till. The Multi-Family and Non-Residential parcels lie over a combination of Alderwood soils, Everett soils, and Norma/Snohomish/Tukwila soils and will be modeled as equal parts till, outwash, and saturated.

HSPF BASELINE ANALYSIS

The purpose of the baseline analysis was to determine existing and future stream flow for Juanita and Forbes Creeks, identifying relative changes in flow characteristics for the separate scenarios. A predeveloped conditions scenario also was developed and simulated for Forbes Creek. Results of the analysis indicate larger increases in future stream flows for the Forbes basin than for the Juanita basin. These results are consistent with the more "built out" nature of the Juanita basin, but are also impacted by the lack of potential future impervious area increases outside of City limits. It should be emphasized though that Juanita Creek streamflow from areas within only the City (and therefore not affected by the lack of future County land use data) still showed relatively minor increases in future scenario flow. Table 1 summarizes return period flows for the outlet of both creeks for the modeled scenarios. Locations of

the modeled reaches are identified on Figure 1. Note the very significant increase in Forbes Creek flows between the predeveloped and the existing/future conditions scenarios.

Table 1. Return Period Stream Flows (cfs)

Return Period	Juanita Creek		Forbes Creek		
	Existing	Future	Predeveloped	Existing	Future
2-year	224	228	15.7	144	159
10-year	314	319	38	203	222
25-year	362	367	55	232	253
50-year	398	404	71	254	276
100-year	435	441	90	277	300

Attachment A to this memorandum contains additional results of the baseline analysis. Tables A-1 and A-2 summarize return period flows for all of the reaches modeled in Juanita and Forbes creeks. Several figures illustrating relative changes in stream flow at the outlet to both creeks are included. The figures are organized as follows:

- Figures A-1, A-2 and A-3 characterize changes in flow between the existing and future conditions scenarios, at the outlet to Juanita Creek.
    - Figure A-1 compares existing and future conditions hydrographs for a significant storm.
    - Figure A-2 charts only the difference between the two hydrographs, for the same storm.
    - Figure A-3 charts yearly maximum flows for both scenarios.
- Figures A-4 through A-8 characterize changes in flow between the predeveloped, existing and future conditions scenarios, at the outlet to Forbes Creek.
    - Figure A-4 compares predeveloped, existing and future conditions hydrographs for the same storm as for Juanita Creek.
    - Figure A-5 shows a more detailed hydrograph of the same storm.
    - Figure A-6 charts the difference between the existing and future conditions hydrographs, for the same storm.
    - Figure A-7 charts yearly maximum flows for all three scenarios.
    - Figure A-8 is an existing conditions plot of all nine reaches in the Forbes Creek model. This plot shows essentially simultaneous peak flows at every reach in the Creek, during the selected storm event. This is significant since it illustrates that volume taken out of the peak flow at any reach in the stream (i.e. via a detention facility) will result in a corresponding reduction in peak volume at all downstream reaches.

As a result of the relatively minor projected increases in Juanita Creek streamflow, the remaining HSPF analysis is focused on investigation of regional versus on-site detention for Forbes Creek. The

predeveloped conditions land use scenario was therefore developed for the Forbes basin, to assist in determining regional detention requirements necessary to retrofit runoff back to a predeveloped condition.

ON-SITE VERSUS REGIONAL DETENTION - DISCUSSION

Since the late 1980's many thousands of detention facilities have been constructed in this country in response to implementation of expanded federal, state and local stormwater regulations. Many more will be constructed in response to enactment of NPDES Phase II regulations, which include many small municipalities and construction sites not previously regulated. An important consideration is what the overall, synergistic impact of these detention facilities is on watersheds. Having an understanding of these impacts will assist in defining a strategic approach to detention facility placement. General benefits and limitations of both the regional and on-site approach to detention are summarized below, although the unique characteristics of each watershed should be considered when selecting an approach.

Regional Approach

Advantages:

- Increases ability to provide detention for overall basin runoff.
- Potential to strategically locate facility to address priority runoff/receiving water issues.
- More cost effective for design, construction and maintenance.
- Developers can contribute via latecomer's fees.
- Allows for potential retrofit/control of runoff.
- Potential for development of a City amenity, integrated into pond design.

Disadvantages:

- Upfront cost most likely funded by municipality.
- Space may not be available for a larger regional facility.
- Cost associated with land purchase.
- Potential permitting issues.
- Liability is shifted to the municipality.
- There may be an increase in impacts on conveyance and potential for localized flooding from undetained runoff upstream of regional facilities.

On-Site Approach

Advantages:

- Facility is closer to source, providing more effective control over downstream conveyance capacity issues, localized flooding and stream erosion potential.

- More stringent water quality goals may favor placement of Best Management Practices (integrated into detention facility) closer to the source.
- Cost provided by developer (immediate funding).
- With placement of numerous on-site facilities throughout the watershed, overall peak stream flow reduction (attenuation of peak flows) may be more efficient through enhanced storage effects associated with longer channel reaches.

Disadvantages:

- Numerous facilities require significantly more maintenance.
- Requires developable property (roughly 15%) to be set aside for detention.
- Requires more effort to ensure proper design/construction.
- Downstream facilities may actually increase overall peak flows in stream.
- Retrofitting runoff to predevelopment levels may be less feasible.

Other Factors to Consider

- Weigh the benefits of hydrologic optimization against land use constraints.
- Address coordination of detention and water quality treatment.
- A regional approach to detention could allow for conversion of existing on-site facilities to water quality facilities.
- Potential for re-use as part of overall detention strategy?

FORBES CREEK DETENTION ANALYSIS

Regional Detention

Analysis Approach

After completion of the baseline predeveloped, existing, and future scenarios modeling, an analysis was performed to determine regional detention facility requirements for Forbes Creek. The goal of this analysis was to determine regional volume requirements that will:

- Detain future increases in runoff, from areas tributary to the detention facility, to existing levels. In other words, maintain the status quo.
- Retrofit both existing and future increases in runoff to predeveloped levels, equivalent to forested land cover.

Locations for the potential regional detention facility sites were selected in conjunction with the City, based on the following criteria:

- Ability to control runoff from significant portions of the Forbes Creek basin.
- Availability of land.
- Location with respect to stream deficiencies requiring mitigation.

These criteria resulted in identification of two regional detention facility sites. The first site (RDF1) is located at the "Airshow" parcel. Facility locations, stream reaches and subbasins are identified in Figure 1 and in Attachment A. RDF1 controls flow from subbasins F3, F4 and F5. It is configured as an off-line facility, with all stream flow from just below the ½ of the 2-year return period and higher diverted to the facility. RDF1 is also identified as RDF1x, controlling future flow to existing conditions runoff and RDF1p, controlling future flow to predeveloped conditions runoff. Outflow from RDF1 combines with Reach 4, discharging to Reach 2.

The second site (RDF2) is located adjacent to the west side of I-405, at the end of 120th Avenue. RDF2 controls flow from subbasin F2. It is configured as a flow through facility, since this tributary to Forbes Creek is conveyed entirely via piping in this area. RDF2 is also identified as RDF2x, controlling future flow to existing conditions runoff, and RDF2p, controlling future flow to predeveloped conditions runoff. Outflow from RDF2 also discharges to Reach 2.

Note that one of the reasons these RDF locations were selected was to control excessive peak flows in Reach 2, which experiences erosion/sedimentation problems. Additional locations were identified, but not analyzed, since the detention facility volumes and related downstream benefits determined for RDF1 and 2 provide the information required to determine volume requirements and effectiveness of the regional detention concept.

Model Results

The HSPF model was used to determine the volume requirements and related downstream benefits of both identified facilities. The King County Runoff Time Series (KCRTS) model was used to determine an initial detention facility configuration, for the regional detention scenarios identified above. This process resulted in an initial/approximate detention configuration that was then input to the future conditions HSPF model for identification of facility performance. HSPF simulation results were compared to the target flow duration plot for each scenario, to determine the facility's performance. Further adjustments to the detention facility were made in KCRTS and input directly to HSPF in an iterative manner, until detention discharge resulted in a flow duration plot matching the target requirement. Table 2 summarizes resulting detention volume requirements.

Table 2. Summary of Regional Detention Facility Volume Requirements

	RDF1		RDF2	
Target Flow	Existing (RDF1x)	Predeveloped (RDF1p)	Existing (RDF2x)	Predeveloped (RDF2p)
Detention Volume (ac-ft)	18	660	1.8	300

The table identifies a dramatic increase in volume required to control future runoff to predeveloped conditions, for both regional facility locations. Attachment A contains a number of figures illustrating detention facility performance and also stream flow, with and without the detention facilities.

These figures include flow duration comparison plots of Forbes Creek for the three scenarios (predeveloped, existing and future) modeled. Flow duration plots are created by grouping streamflow for every simulated time-step into incremental flow ranges, then graphing those results based on the percent chance that the given flow range will be exceeded. These figures again highlight the significant increase in flows between the predeveloped and existing/future flows, with the difference increasing for the higher/less frequent flows. Flow duration plots form the basis for the detention sizing criteria. The criteria requires detention of developed conditions runoff, such that the detention discharge flow duration curve generally does not exceed the "target" conditions curve for the range of flows between 1/2 of the 2-year flow, to the 50-year flow. The figures identifying results of the regional analysis are organized as follows:

- Figures numbered A-9, A-10, and A-11 show stream flow hydrographs in Reaches 4, 3, and 2, respectively. The hydrographs compare existing, future and predeveloped flow for a significant storm occurring in February 1996. These hydrographs were produced without the regional detention facilities in place.

- Figure A-12 identifies Reach 4 flow duration curves for existing, future, and predeveloped conditions. It also shows the affects of RDF1x and verifies compliance with the flow duration detention criteria.

- Figures A-13 and A-14 illustrate the effects of RDF1x for Reach 4 and Reach 2, respectively. The figures show that although Reach 4 flow is generally controlled to existing levels, flows in Reach 2 under this scenario are typically not significantly improved.

- Figure A-15 again identifies Reach 4 flow duration curves for existing, future, and predeveloped conditions. It also shows the affects of RDF1p and verifies compliance with the flow duration detention criteria, controlling future flow to predeveloped conditions.

- Figures A-16 and A-17 illustrate the effects of RDF1p for Reach 4 and Reach 2, respectively. Figure A-16 shows that Reach 4 flow is controlled to predeveloped levels. Figure A-17 shows that flow in Reach 2 peaks somewhat higher than predeveloped levels, but is still much lower than future levels.

- Figure A-18 identifies Reach 3 flow duration curves for existing, future, and predeveloped conditions. It also shows the affects of RDF2x and verifies compliance with the flow duration detention criteria.

- Figures A-19 and A-20 illustrate the effects of RDF2x for Reach 3 and Reach 2, respectively. The figures show that although Reach 3 flow is generally controlled to existing levels, only a negligible reduction in flow is achieved in Reach 2 under this scenario. It is expected that this detention facility would have a smaller downstream Impact than RDF1, since it is sized to control flow from a smaller tributary area.

- Figure A-21 again identifies Reach 3 flow duration curves for existing, future, and predeveloped conditions. It also shows the affects of RDF2p and verifies compliance with the flow duration detention criteria, controlling future flow to predeveloped conditions.

- Figures A-22 and A-23 illustrate the effects of RDF1p for Reach 3 and Reach 2, respectively. Figure A-22 shows that Reach 4 flow is actually controlled to somewhat below predeveloped levels, with this detention facility configuration. It should be noted that in this analysis, all detention facility sizes and outlet configurations are planning level estimates. Additional efficiencies in size requirements would likely be gained with additional evaluation. Figure A-23 shows that flow in

Reach 2 peaks significantly higher than predeveloped levels, but is still much lower than future levels. This Figure clearly identifies the impacts on Reach 2, of undetained flow from subbasins F3, F4, and F5.

On-Site Detention

Analysis Approach

The Washington State Department of Ecology's Western Washington Hydrology Model (WWHM2), which is based on HSPF, was used to analyze on-site detention facility volumes through the following approach:

- Detention volumes were calculated for three types of zoning category: (1) Single-Family Residential, (2) Multi-Family Residential, and (3) Non-Residential.
- Land use for model input was calculated from areas located within Forbes Creek Subbasin F5, where a sample of each type of zoning category is located.
- A range of detention volumes was developed by running the model for two different scenarios and calculating the average detention volume required. In the first scenario, the runoff from the total land area of each zoning category within Subbasin F5 is modeled and the resulting detention volume is divided by the number of parcels within that zoning category. In the second modeling scenario, the average land use for a single parcel of each zoning category is derived and the runoff is modeled for each of those "average" parcels.

Additional assumptions used in the analysis are discussed in the Model Assumptions section of this memorandum. Input data is included in the modeling reports contained in Attachment B.

Model Results

The range of detention volumes for each land use zoning category analyzed is presented in Table 3.

Table 3. Summary of On-Site Detention Facility Volume Requirements

Zoning Category	Detention Area per Parcel (acre-feet)	Detention Area per Acre (acre-feet)
Single-Family Residential	0 to 0.072	0 to 0.18
Multi-Family Residential	0.18 to 0.20	0.39 to 0.44
Non-Residential	0.85 to 0.99	0.48 to 0.56

Summary and Conclusions

Results of the regional detention analysis indicate that control of future stream flow to existing levels, as required for the Juanita basin, provides minimal to negligible downstream reduction in peak flow. In contrast, sizing of regional facilities to predeveloped levels, as required for the Forbes basin, provides a significant reduction in downstream flow. However, the volume of these regional facilities is so large that construction is likely not feasible.

Additional analysis of on-site detention in the Forbes basin has been provided for comparison against regional volumes. Also, the discussion of on-site versus regional detention illustrates general advantages

and disadvantages to both approaches. Overall, the level of development that has occurred over many years in the Forbes basin has resulted in a significant increase in peak flows and volume. Based on this change in the Forbes basin, the adoption of a combined/intermediate flow regime may be a more suitable approach to meeting overall goals for the stream without producing detrimentally extreme changes in the stream flow morphology.

In general, while determining an approach to detention, the performance of each type of facility (regional versus on-site) in meeting flow-control requirements must be evaluated against several criteria. Specifically, consideration should be given to factors including capital cost, location, long-term maintenance, land availability, and water-quality treatment capability. Although this HSPF hydrologic analysis resulted in a wide range of detention volume requirements, the results identify information necessary for the City to assist in developing an approach to detention criteria.

Attachment A

HSPF Hydrologic and Detention Analyses Results

Summary Tables and Figures

Table A-1
Summary of HSPF Modeled Flows for Juanita Creek

Reach	Description		Modeled Flows (cfs)[1]	
		Return period	Existing[2]	Future
1	124th to Creek Mouth	2-year	223.9	227.7
		10-year	314.5	319.3
		25-year	361.9	367.1
		50-year	398.2	403.6
		100-year	435.3	440.9
2	Subbasin J2 to Reach 1	2-year	15.5	15.6
		10-year	21.3	21.4
		25-year	24.3	24.4
		50-year	26.5	26.6
		100-year	28.7	28.9
3	129th to Reach 1	2-year	203.2	206.4
		10-year	283.4	287.4
		25-year	324.7	329.1
		50-year	356.0	360.6
		100-year	387.8	392.7
4	Subbasin J9 to Reach 3 (east branch)	2-year	64.2	66.8
		10-year	87.2	90.6
		25-year	98.8	102.4
		50-year	107.5	111.2
		100-year	116.2	120.1
5	Totem Lake to Reach 4 (east branch)	2-year	45.5	46.0
		10-year	61.1	61.8
		25-year	68.6	69.4
		50-year	74.2	75.0
		100-year	79.7	80.6
6	Totem Lake	2-year	11.2	11.2
		10-year	14.2	14.2
		25-year	15.6	15.6
		50-year	16.8	16.8
		100-year	17.9	17.9
7	135th to Reach 3 (Main stem)	2-year	137.6	137.7
		10-year	190.8	190.9
		25-year	219.4	219.6
		50-year	241.6	241.8
		100-year	264.6	264.7
8	Subbasin J6 to Reach 7	2-year	52.8	52.9
		10-year	75.6	75.7
		25-year	87.9	88.1
		50-year	97.6	97.7
		100-year	107.5	107.7
9	Subbasin J5 to Reach 7	2-year	59.5	59.5
		10-year	86.9	86.9
		25-year	102.2	102.2
		50-year	114.2	114.2
		100-year	126.9	126.9

Table A-1
Summary of HSPF Modeled Flows for Juanita Creek

Reach	Description		Modeled Flows (cfs)[1]	
		Return period	Existing[2]	Future
10	Subbasin J4 to Reach 7	2-year	45.7	45.7
		10-year	65.4	65.4
		25-year	76.0	76.1
		50-year	84.3	84.3
		100-year	92.9	92.9

Notes:

[1] The flows summarized in this table are at the downstream end of the reach.

[2] The model was not calibrated to local stream flow.

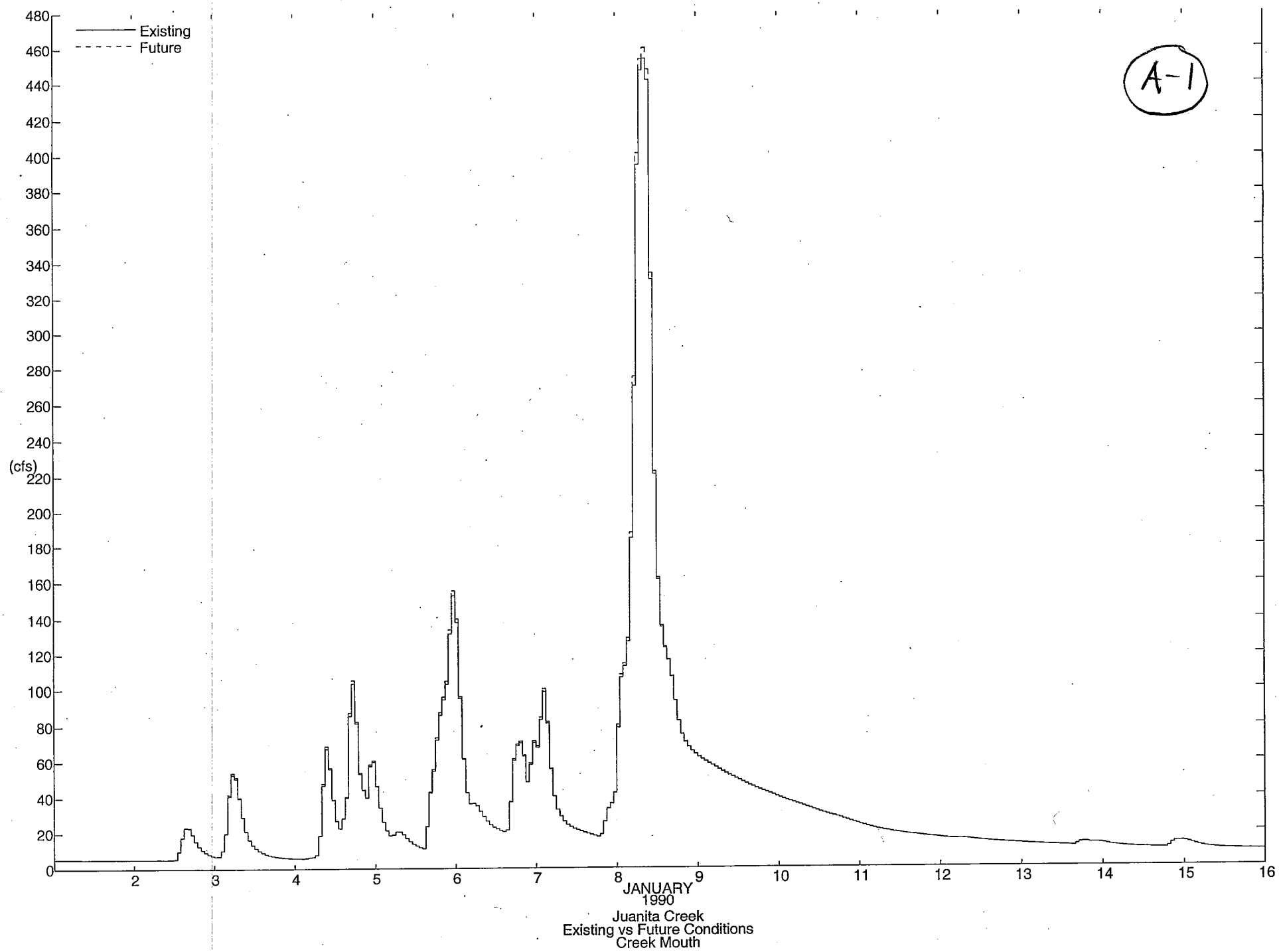
Table A-2
Summary of HSPF Modeled Flows for Forbes Creek

Reach	Description	Return Period	Modeled Flows (cfs)[1] Pre-development	Existing[2]	Future
1	108th to Creek Mouth	2-year	15.7	144.2	159.4
		10-year	38.0	202.6	221.6
		25-year	55.0	232.1	252.8
		50-year	70.8	254.3	276.3
		100-year	89.6	276.8	299.9
2	BNSF Railroad to 108th	2-year	11.6	110.2	122.8
		10-year	27.5	152.9	168.7
		25-year	39.3	174.7	191.7
		50-year	50.0	191.1	208.9
		100-year	62.5	207.7	226.2
3	120th to Reach 2	2-year	2.7	41.5	44.1
		10-year	6.4	58.4	62.0
		25-year	9.0	67.2	71.3
		50-year	11.4	73.9	78.3
		100-year	14.2	80.7	85.5
4	104th to Reach 2	2-year	9.0	77.1	87.8
		10-year	21.8	108.0	121.4
		25-year	31.2	124.2	138.7
		50-year	39.8	136.6	151.8
		100-year	50.0	149.2	165.2
5	Confluence to Reach 4	2-year	5.5	40.9	45.9
		10-year	13.3	55.6	61.7
		25-year	19.0	63.0	69.4
		50-year	24.2	68.6	75.2
		100-year	30.2	74.3	81.0
6	Subbasin F4 to Reach 5	2-year	2.6	28.0	32.4
		10-year	7.0	39.6	45.4
		25-year	10.5	45.7	52.0
		50-year	13.8	50.3	57.0
		100-year	17.9	55.1	62.1
7	Forbes Lake to Reach 5	2-year	2.9	17.0	18.3
		10-year	6.9	21.7	22.7
		25-year	9.8	23.9	24.5
		50-year	12.3	25.4	25.8
		100-year	15.3	26.9	27.0
8	Forbes Lake discharge	2-year	2.9	17.0	18.4
		10-year	6.9	21.7	22.7
		25-year	9.8	23.9	24.5
		50-year	12.3	25.4	25.8
		100-year	15.2	26.9	27.0
9	90th to Forbes Lake	2-year	3.0	46.9	52.5
		10-year	7.9	66.7	74.3
		25-year	11.7	77.1	85.6
		50-year	15.2	85.1	94.3
		100-year	19.3	93.3	103.1

Notes:

[1] The flows summarized in this table are at the downstream end of the reach.

[2] The model was not calibrated to local stream flow.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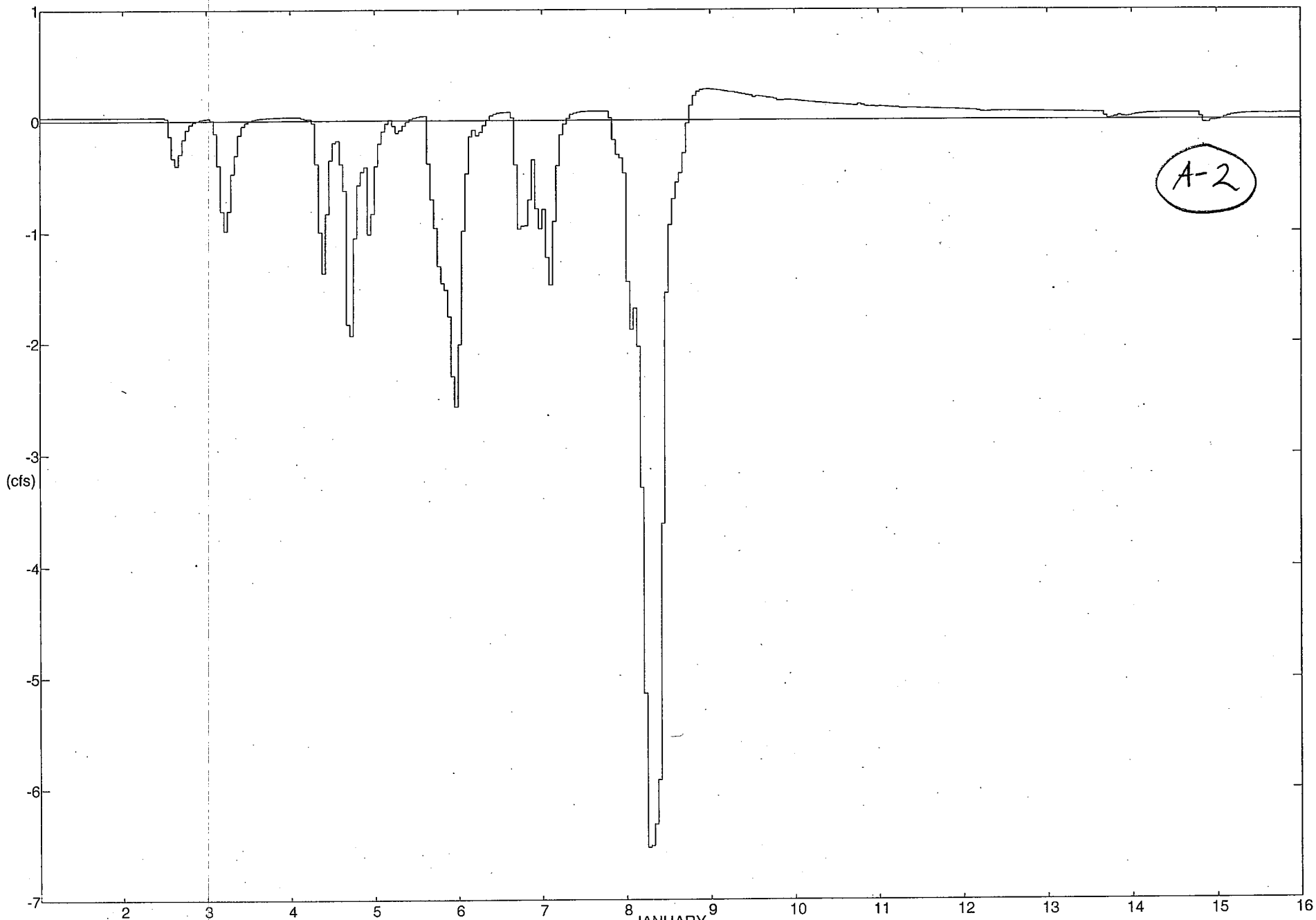
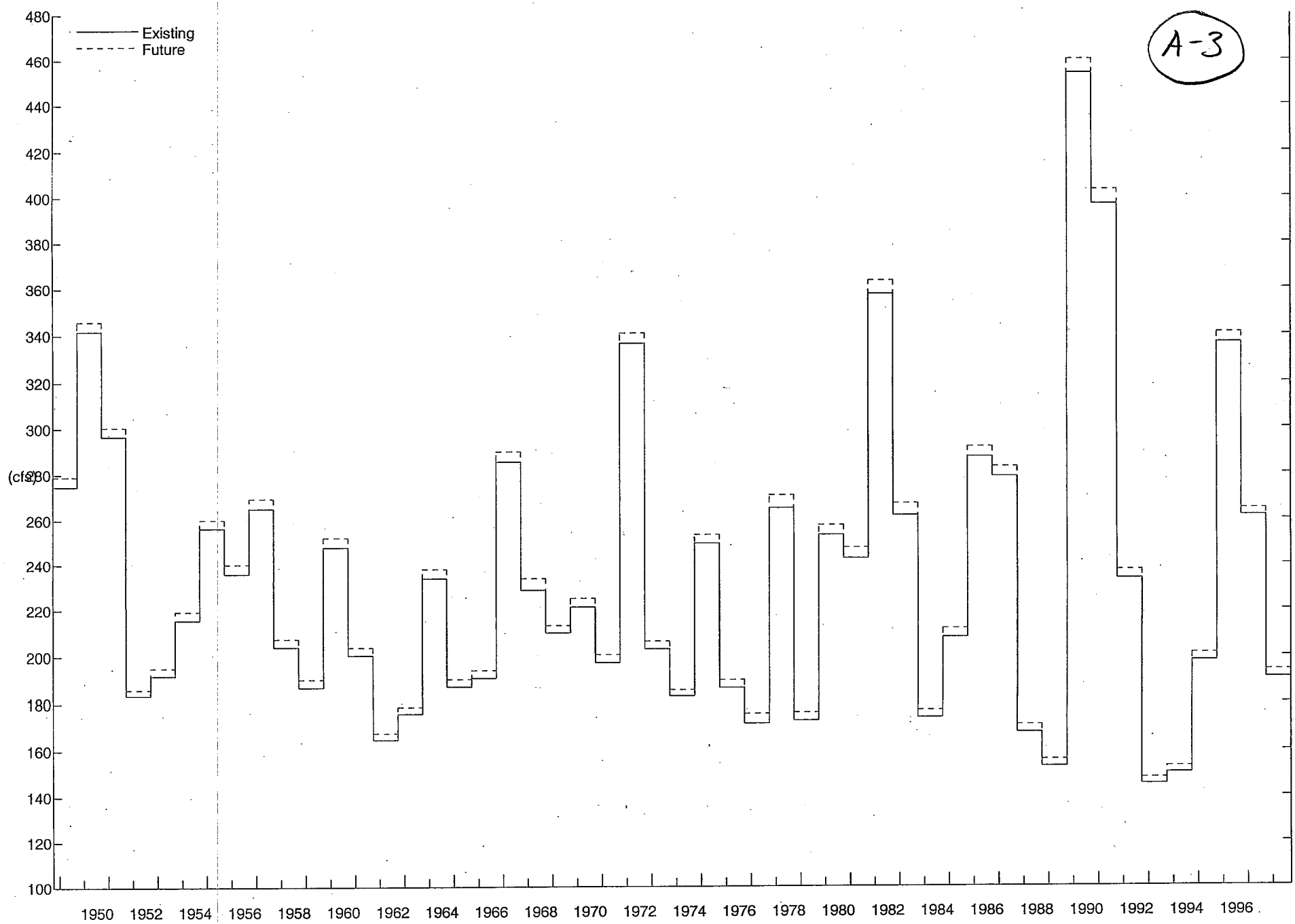
Juanita Creek
Existing vs Future Conditions
Creek Mouth

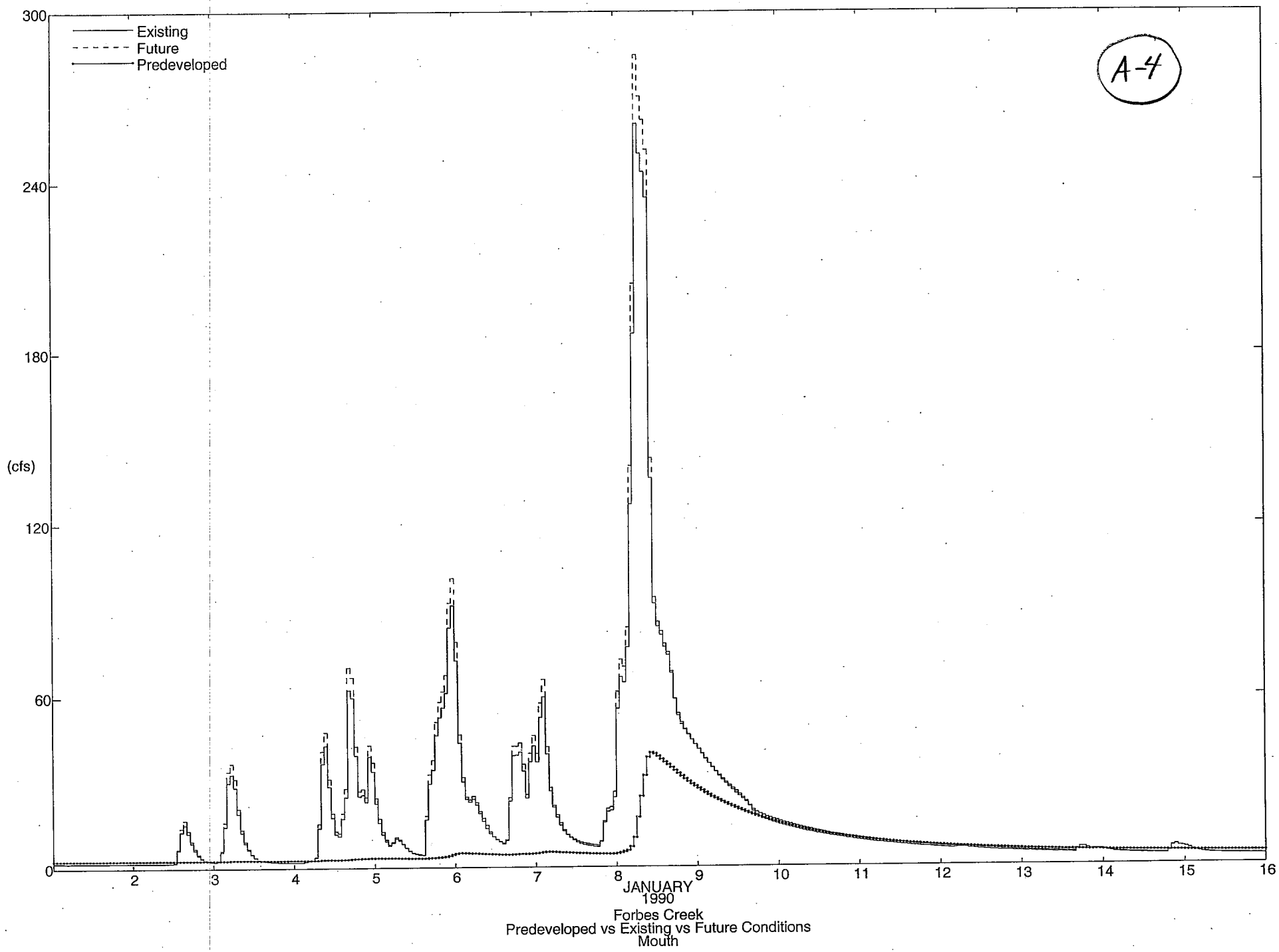
A-1



Juanita Creek
Residual Time Series Plot (Existing - Future)
Creek Mouth



Juanita Creek
Yearly Maximum Flow
Creek Mouth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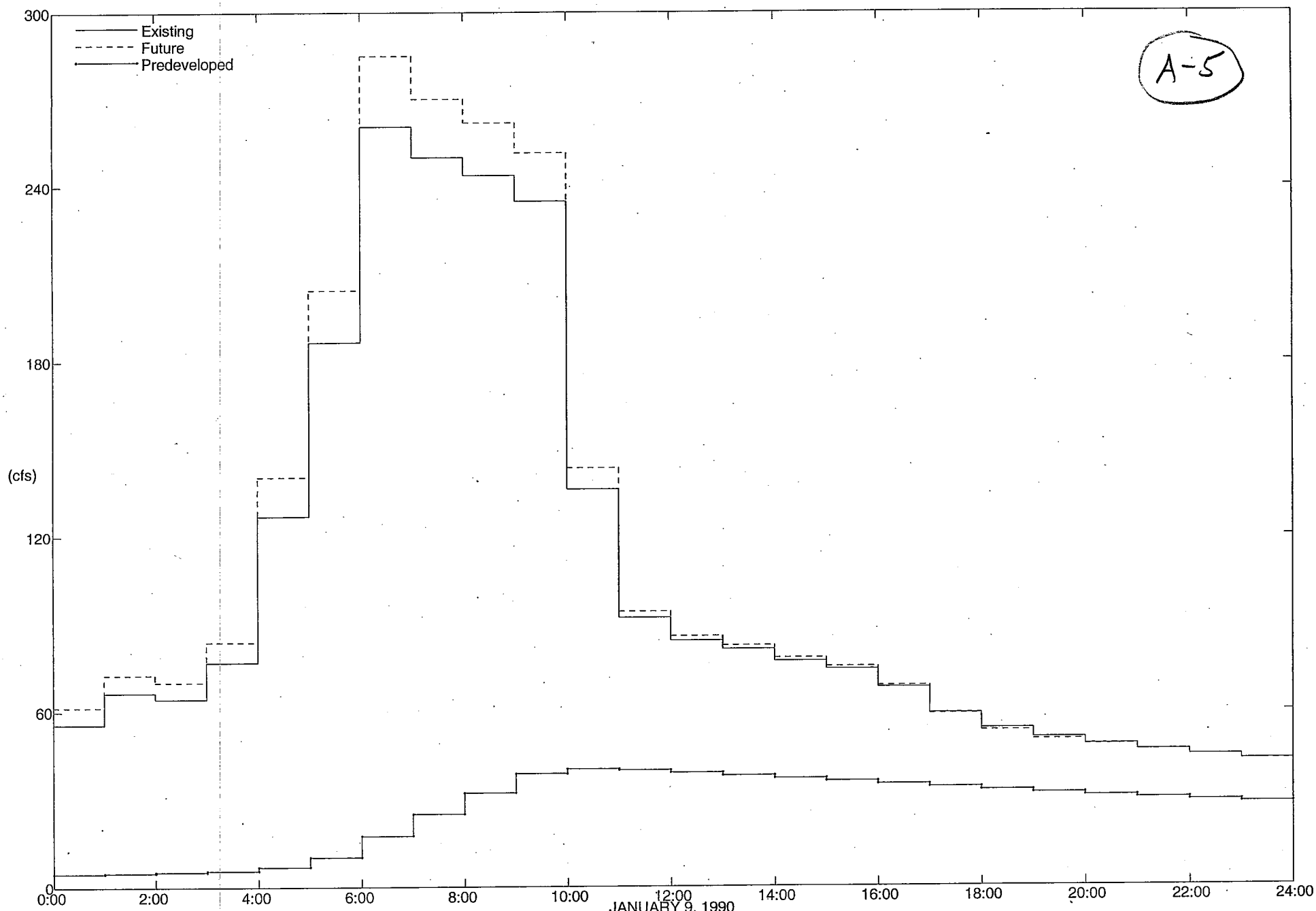
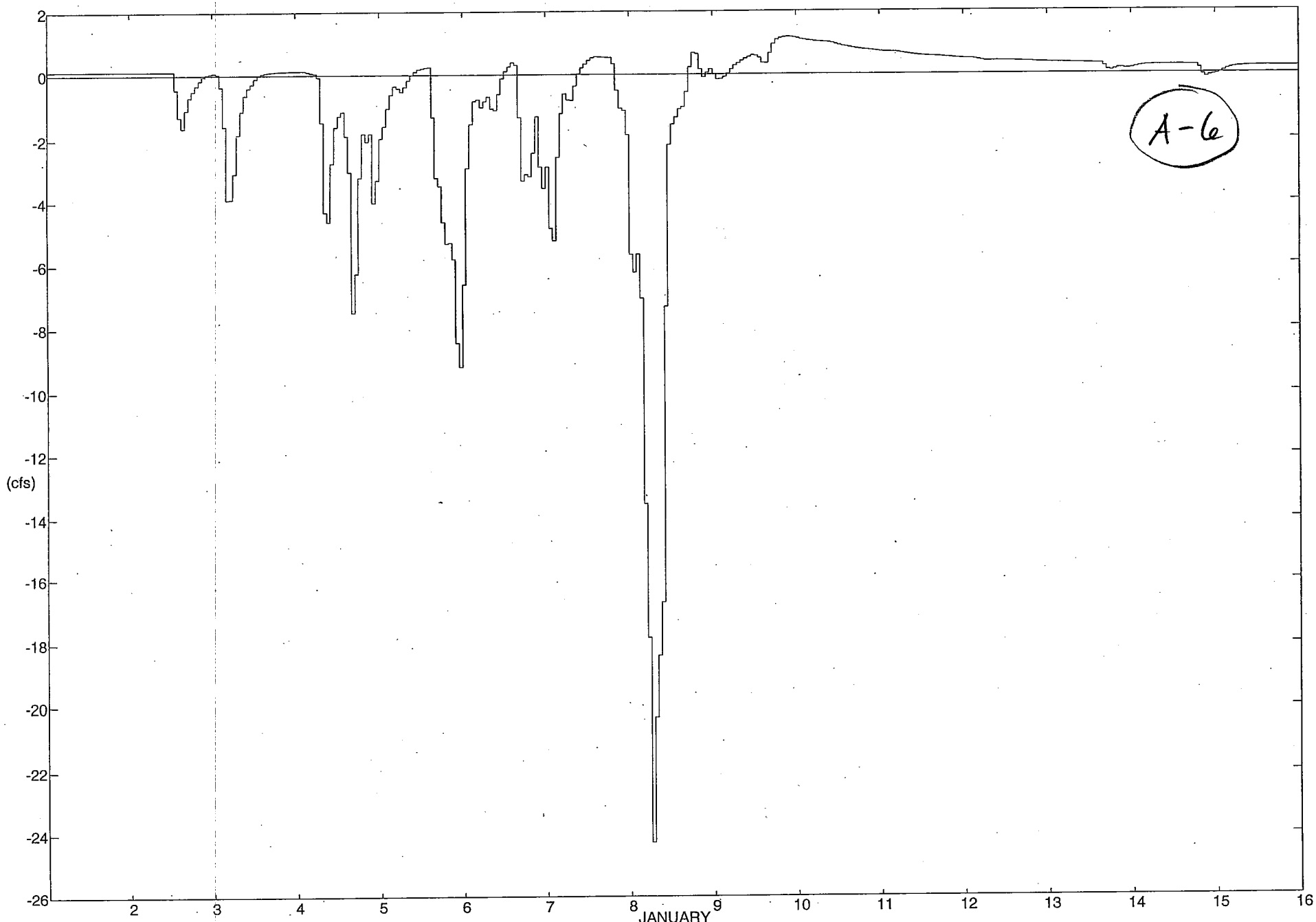
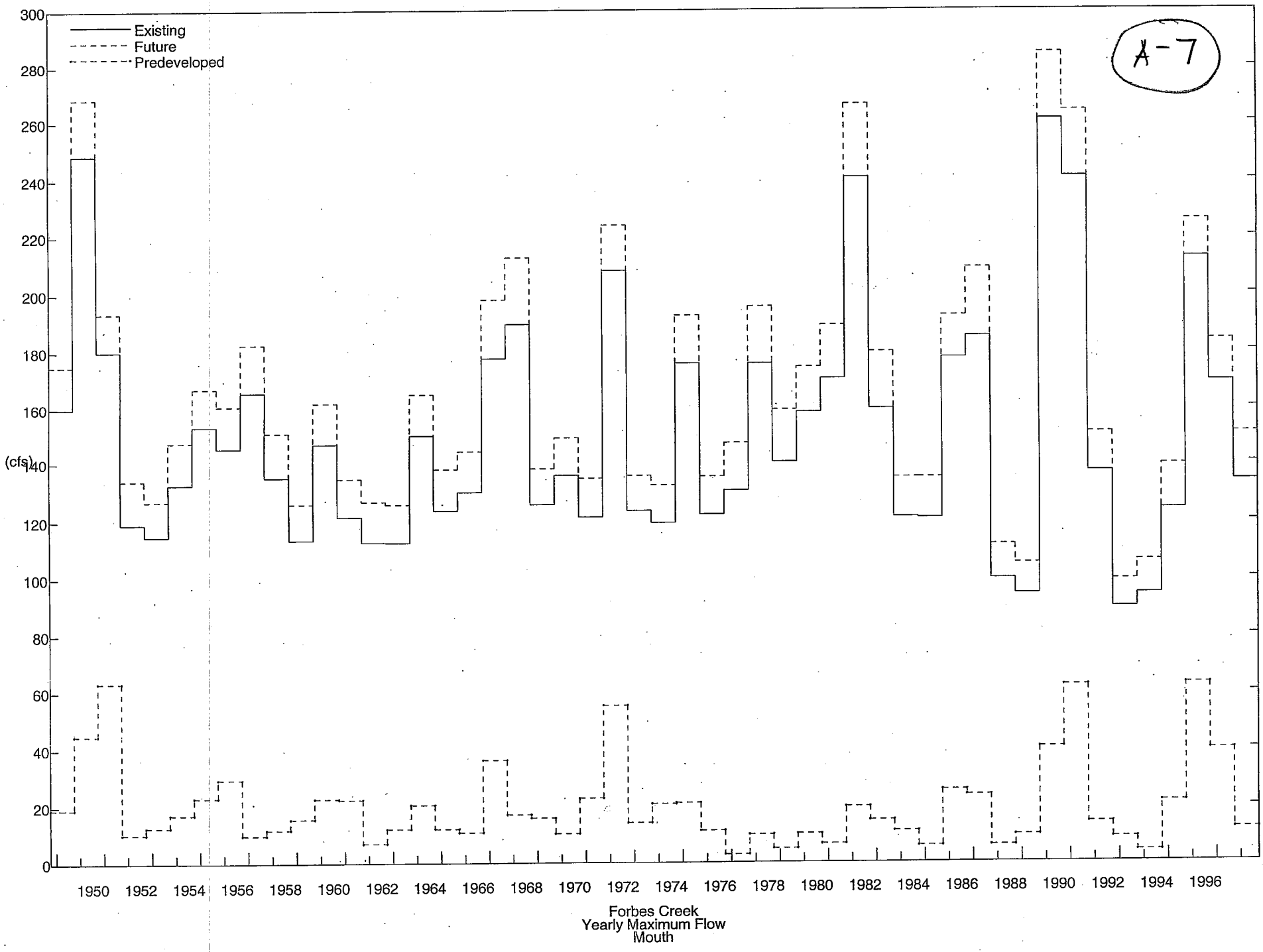
Forbes Creek
Predeveloped vs Existing vs Future Conditions
Mouth



Forbes Creek
Predeveloped vs Existing vs Future Conditions
Mouth



Forbes Creek
Residual Time Series Plot (Existing - Future)
Mouth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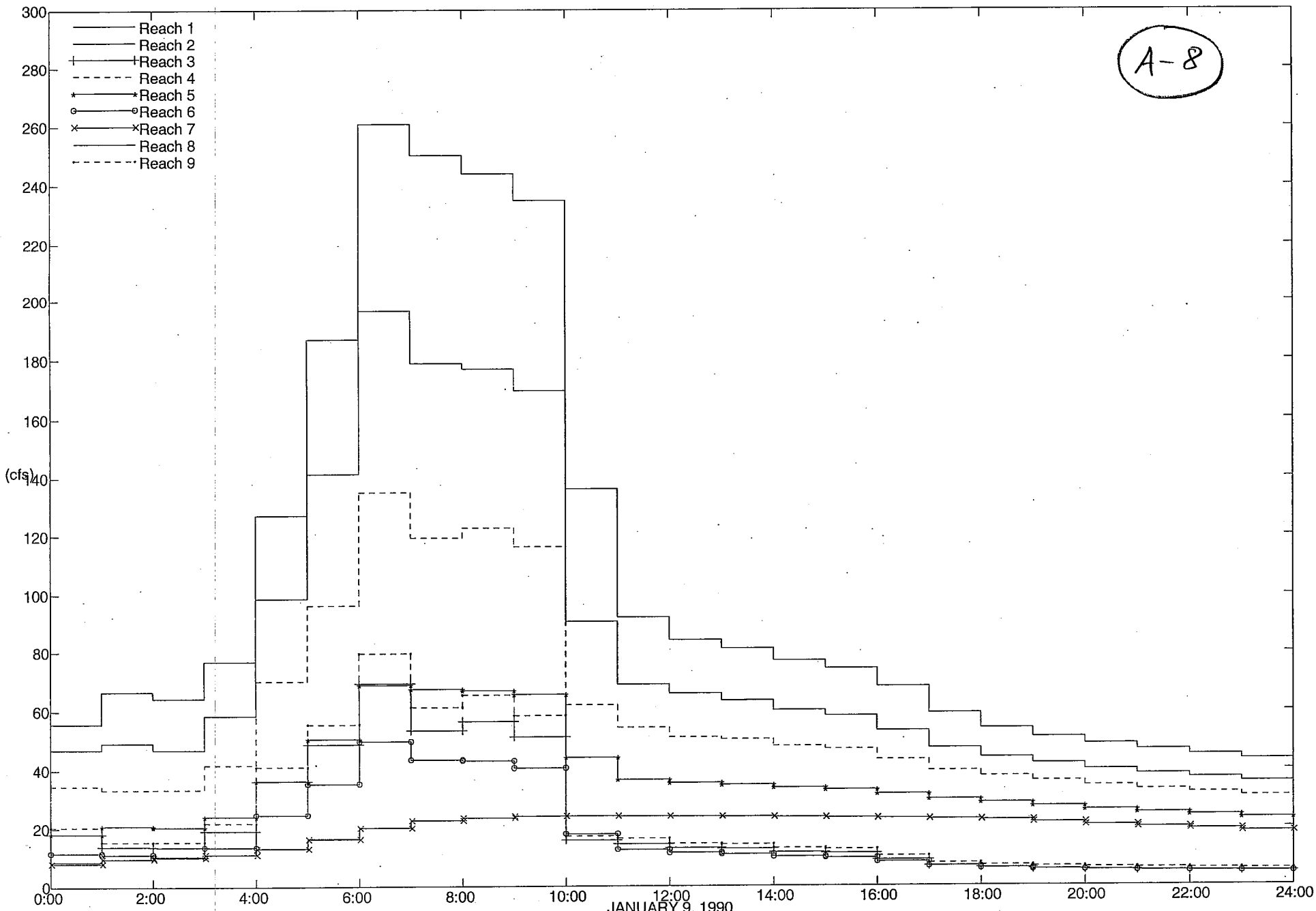
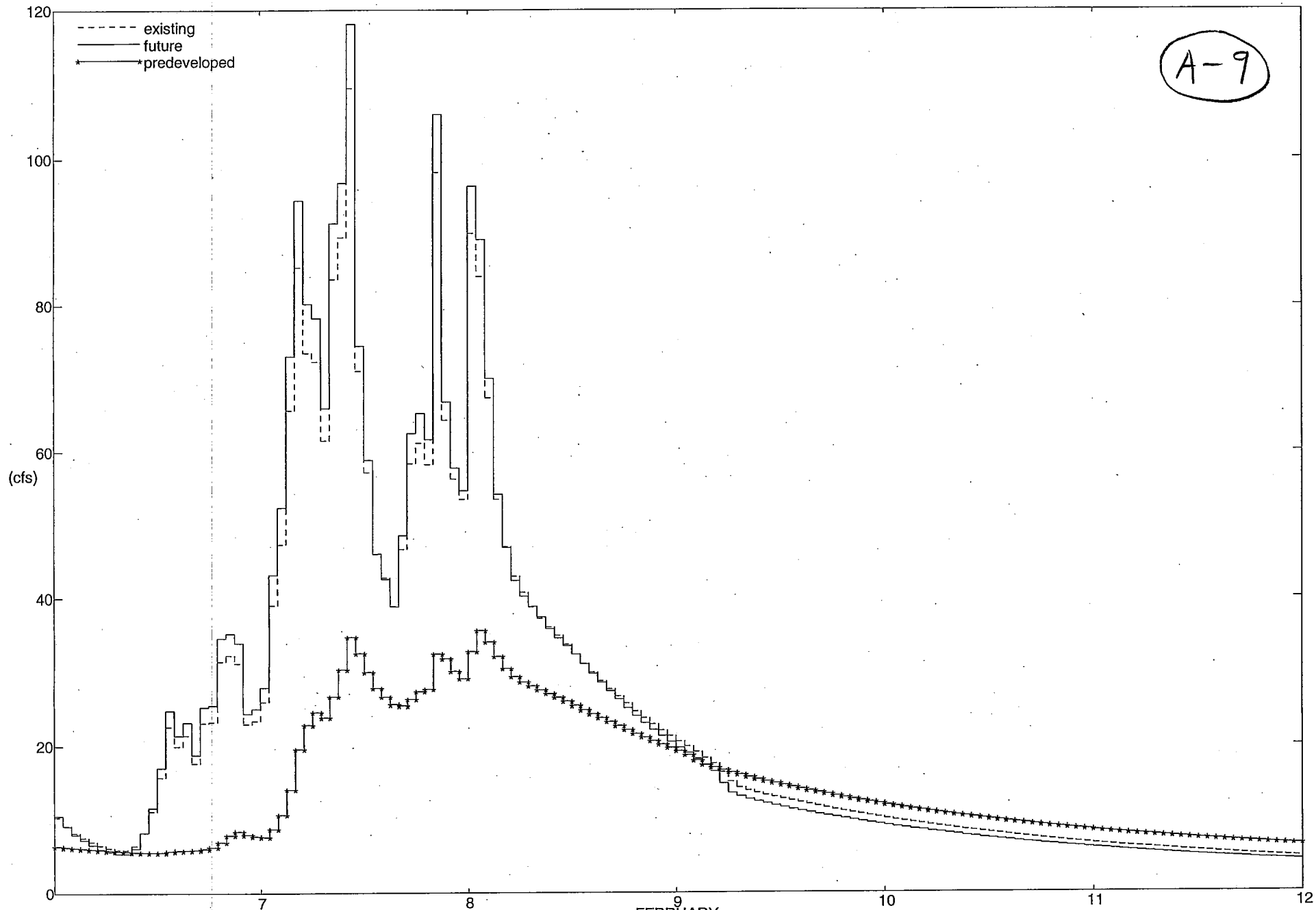
1980
1982
1984
1986
1988
1990
1992
1994
1996
Forbes Creek
Yearly Maximum Flow
Mouth

A-7

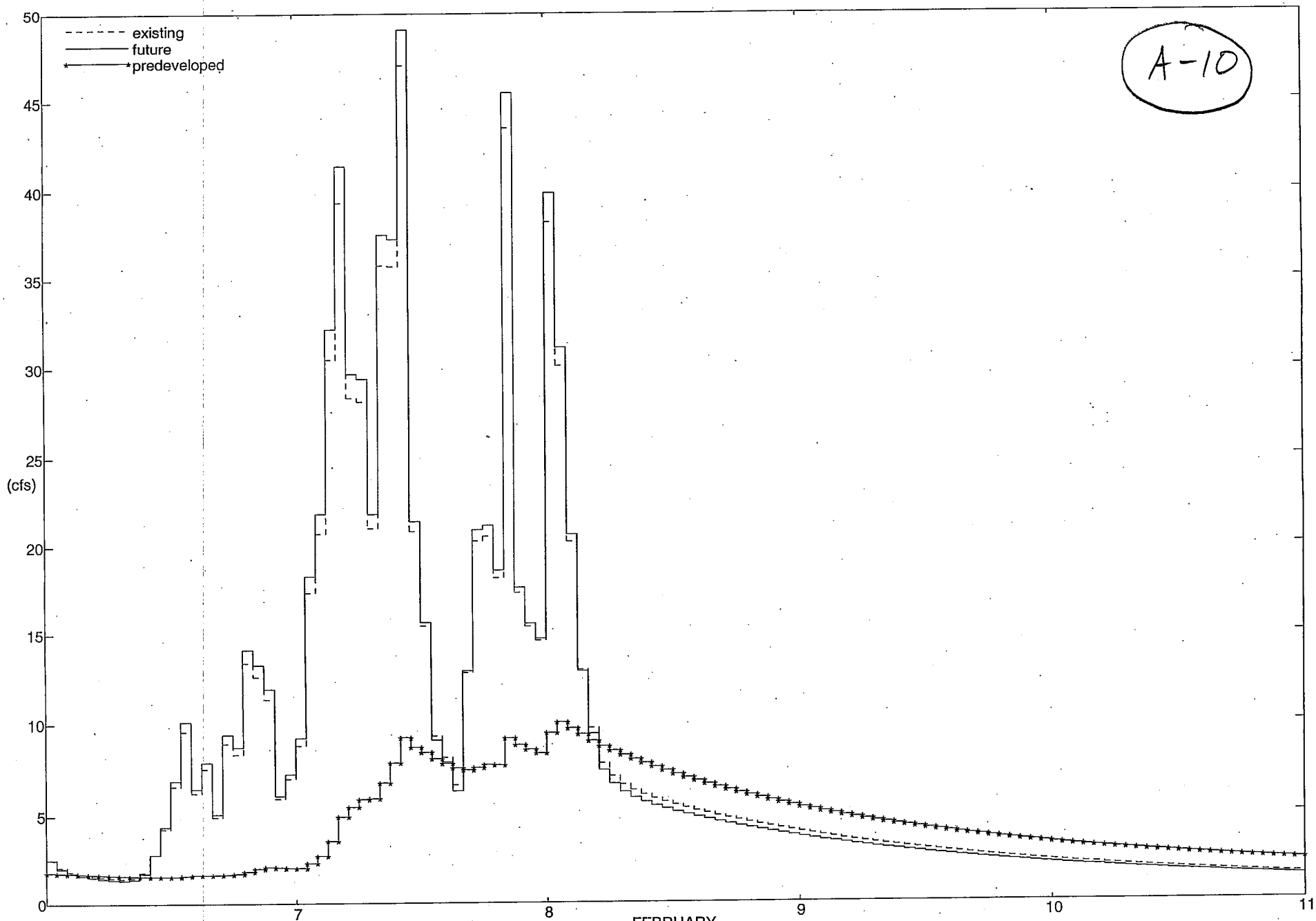


Forbes Creek
Predeveloped vs Existing vs Future Conditions
Mouth



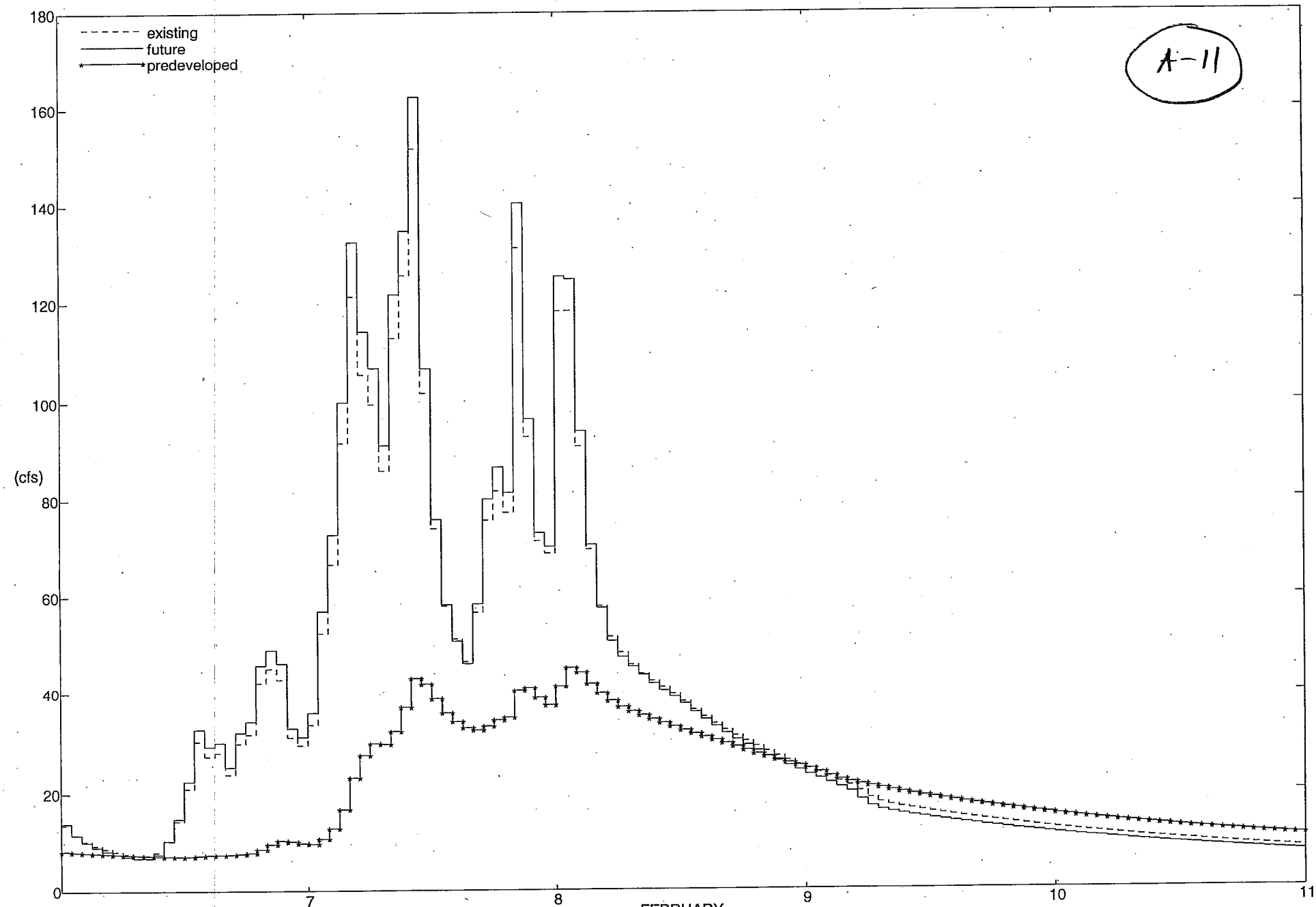
Forbes Creek
Comparison of Analysis Scenarios
Reach 4

A-9



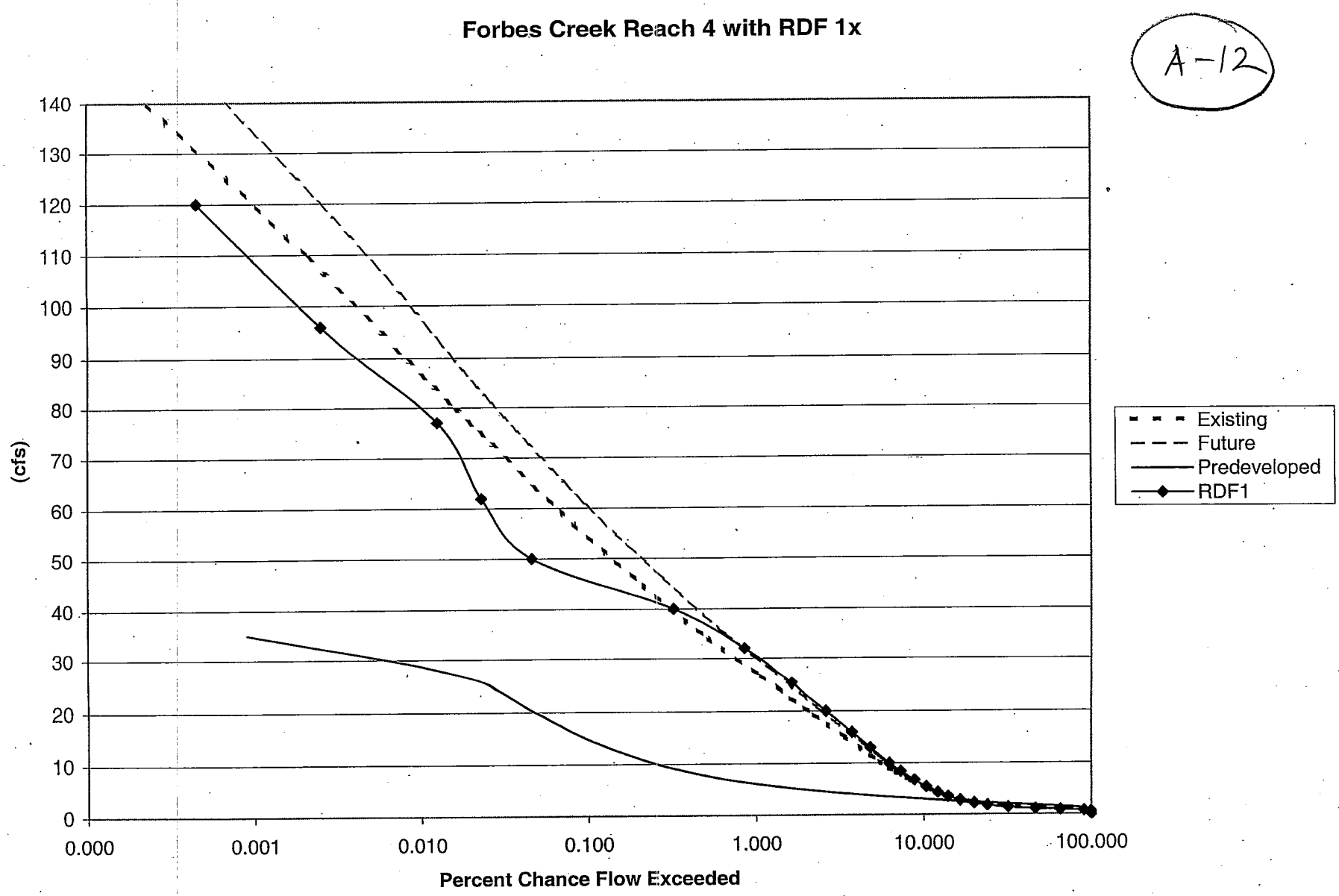
A-10

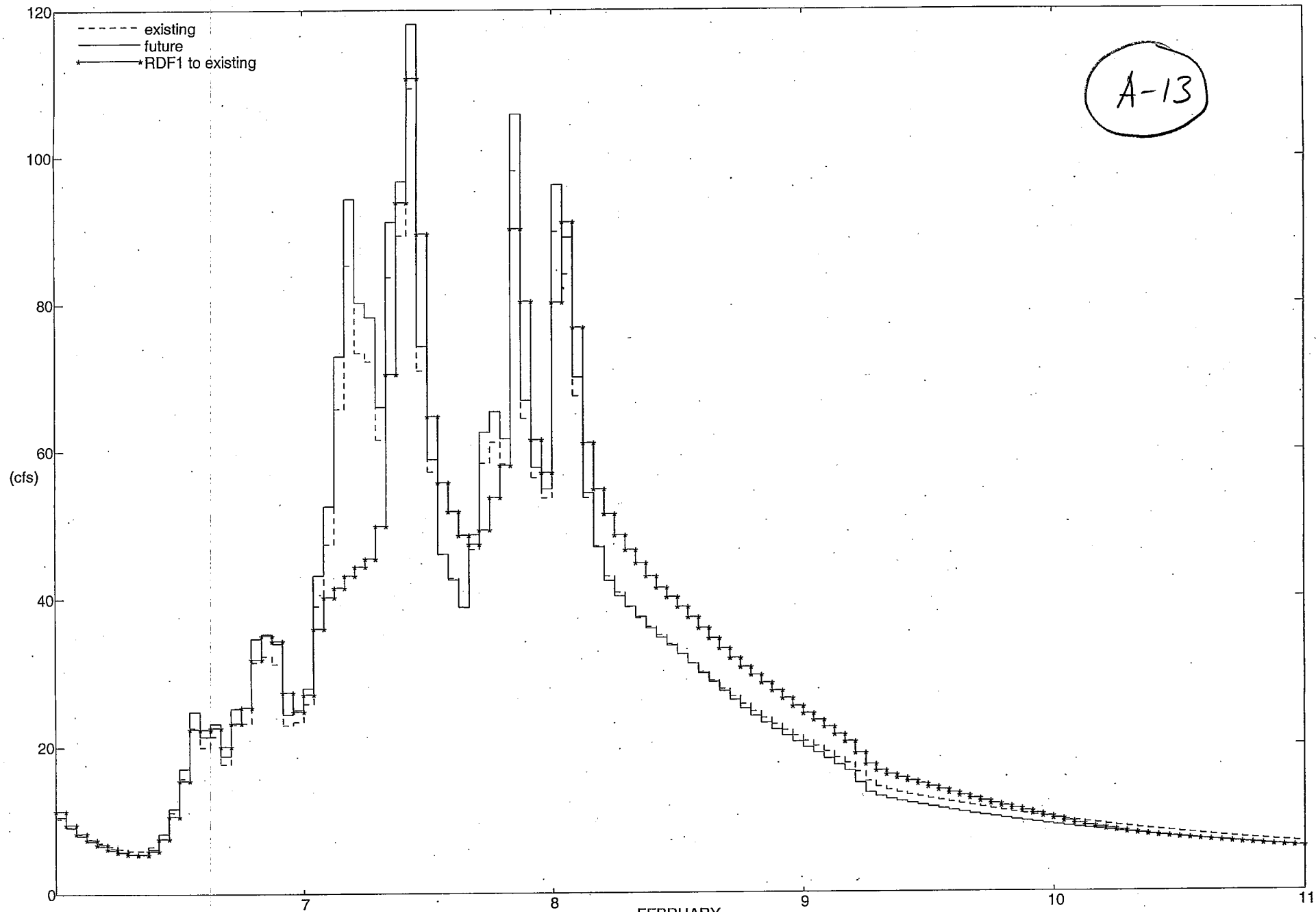
FEBRUARY
1996
Forbes Creek
Comparison of Analysis Scenarios
Reach 3



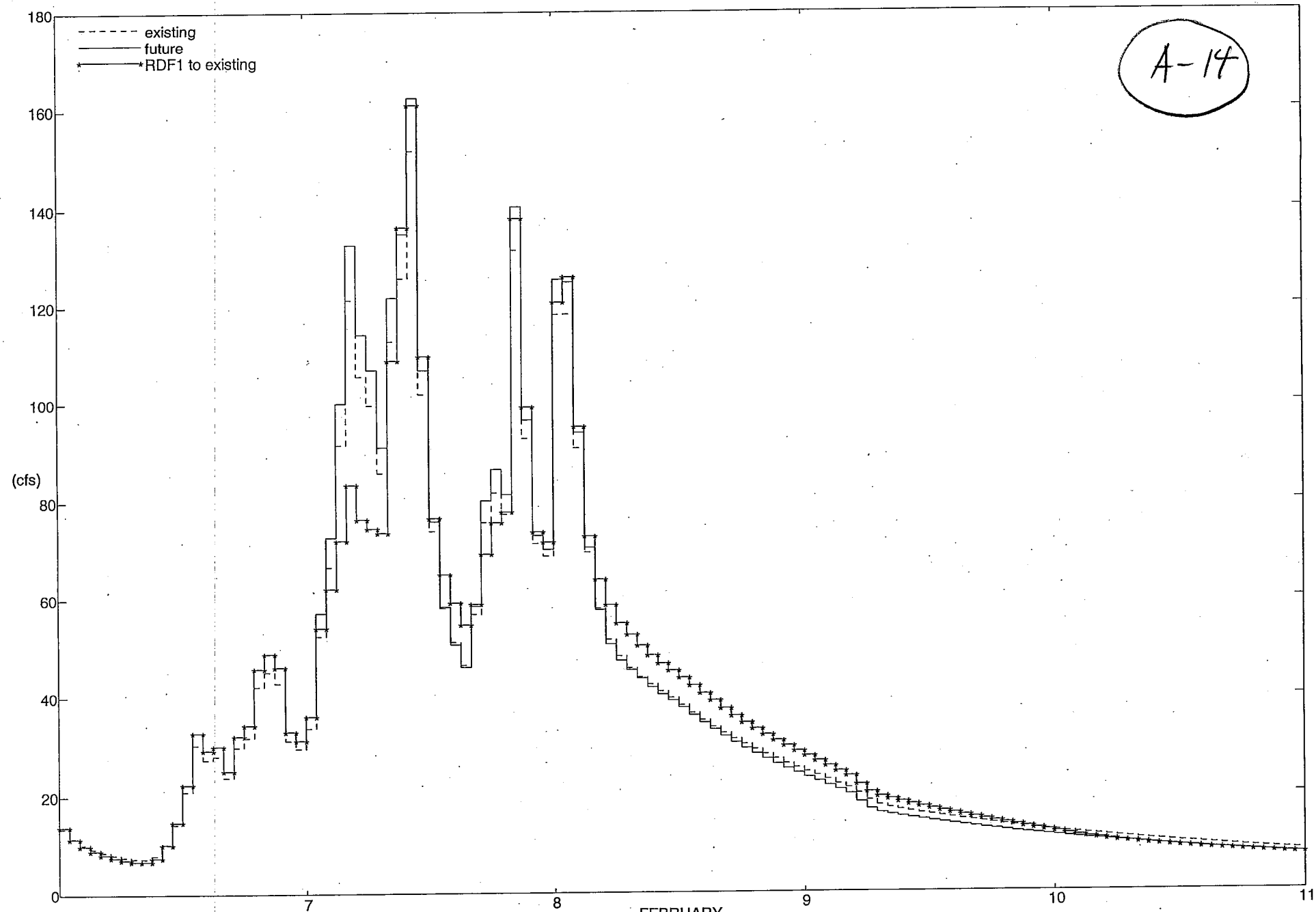
FEBRUARY
1996
Forbes Creek
Comparison of Analysis Results
Reach 2

A-12


Forbes Creek Reach 4 with RDF 1x
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
(cfs)
0.000
0.001
0.010
0.100
1.000
10.000
100.000
Percent Chance Flow Exceeded
Existing
Future
Predeveloped
RDF1

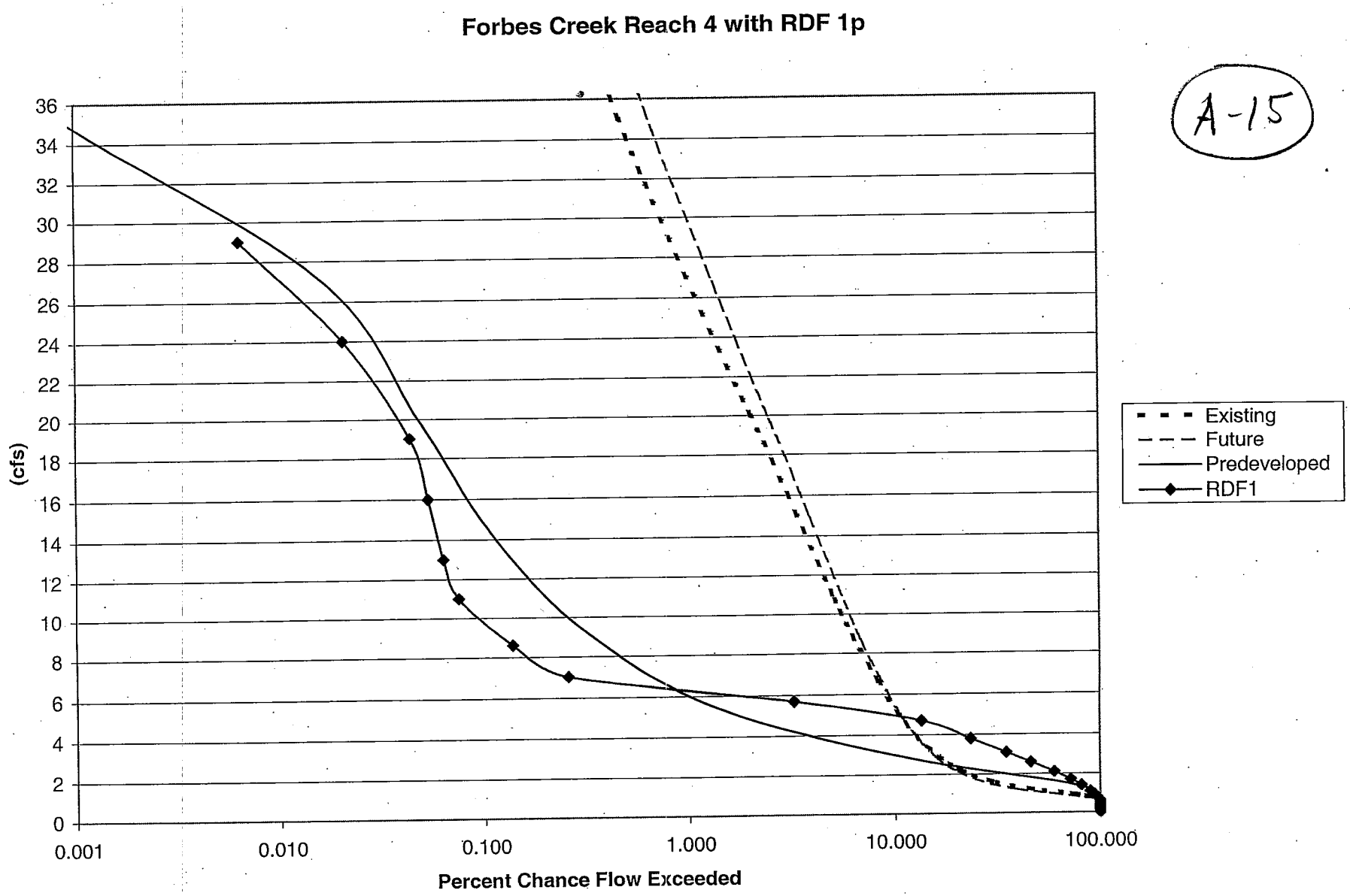


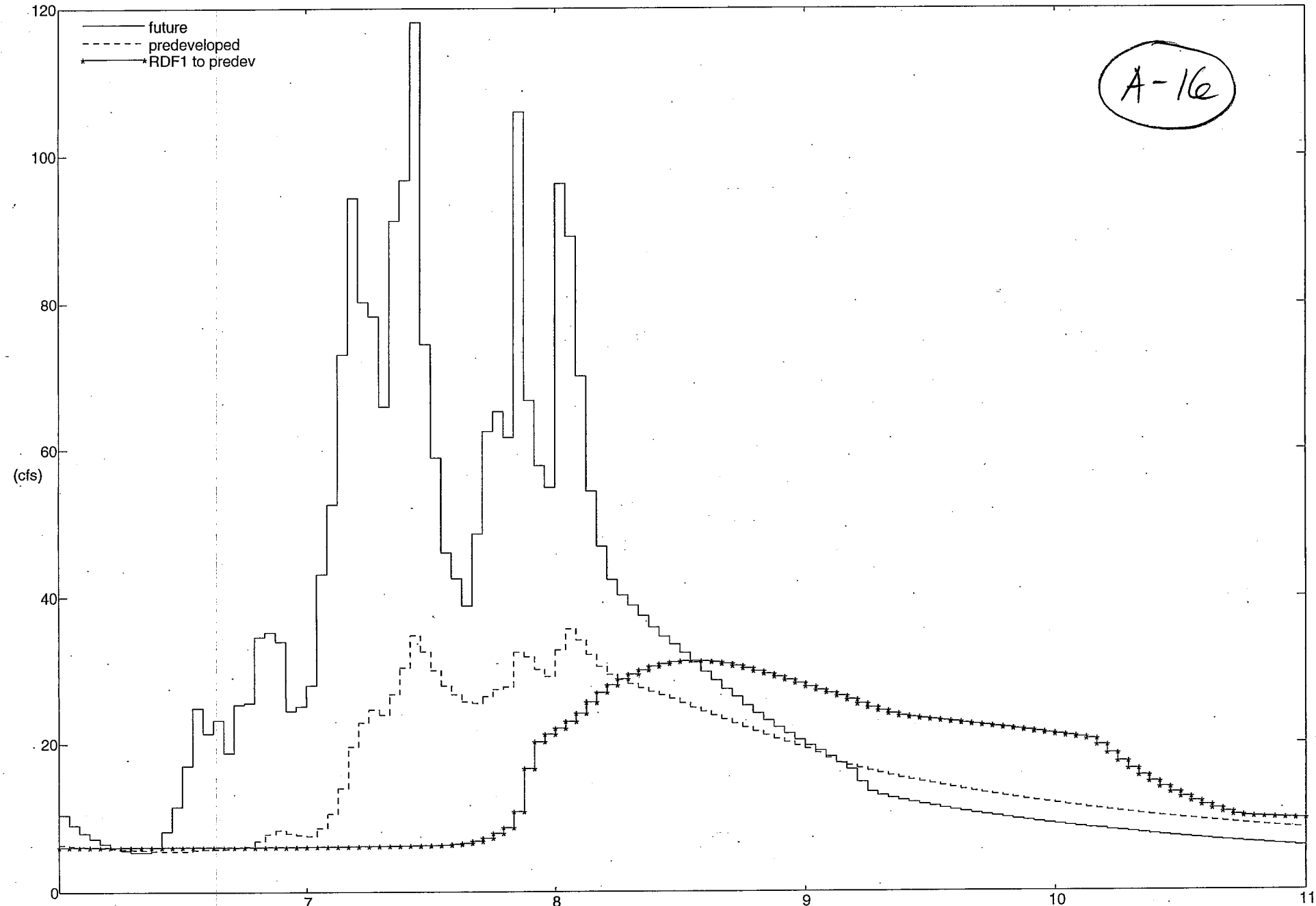
FEBRUARY
1996
Forbes Creek
Comparison of Analysis Scenarios
Reach 4



A-14

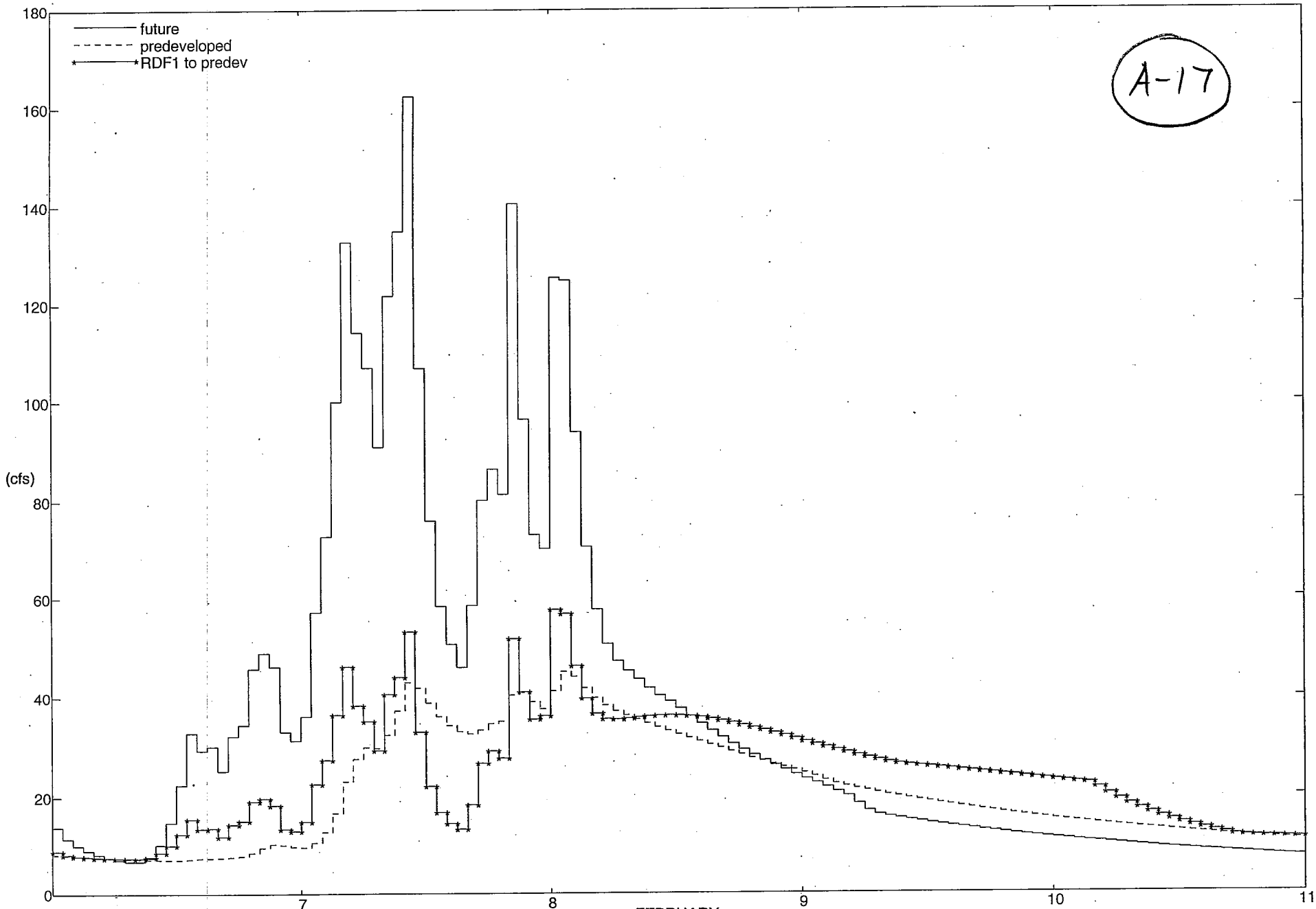
FEBRUARY
1996
Forbes Creek
Comparison of Analysis Scenarios
Reach 2


Forbes Creek Reach 4 with RDF 1p
A-15
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
(cfs)
0.001
0.010
0.100
1.000
10.000
100.000
Percent Chance Flow Exceeded
Existing
Future
Predeveloped
RDF1



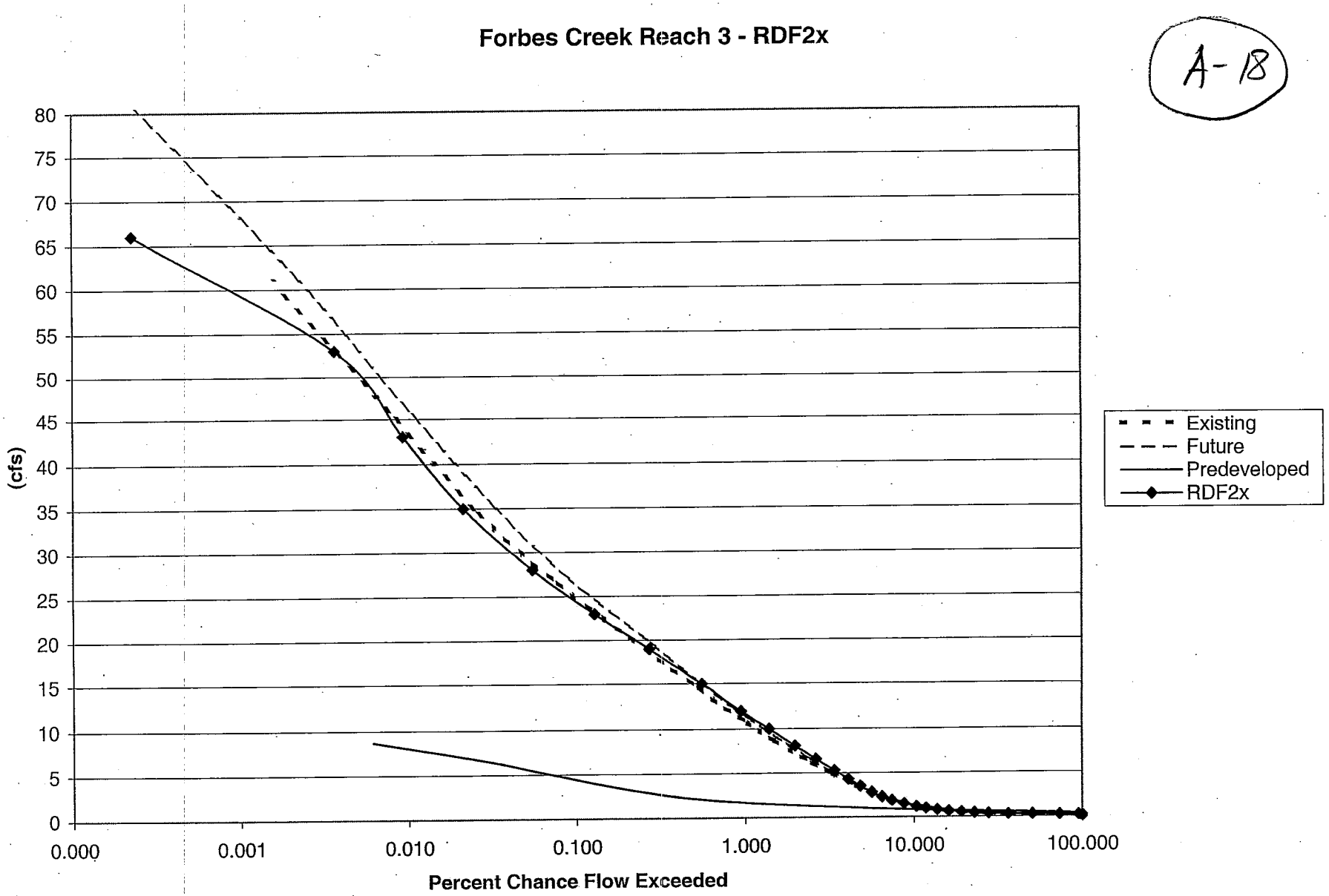
A-16

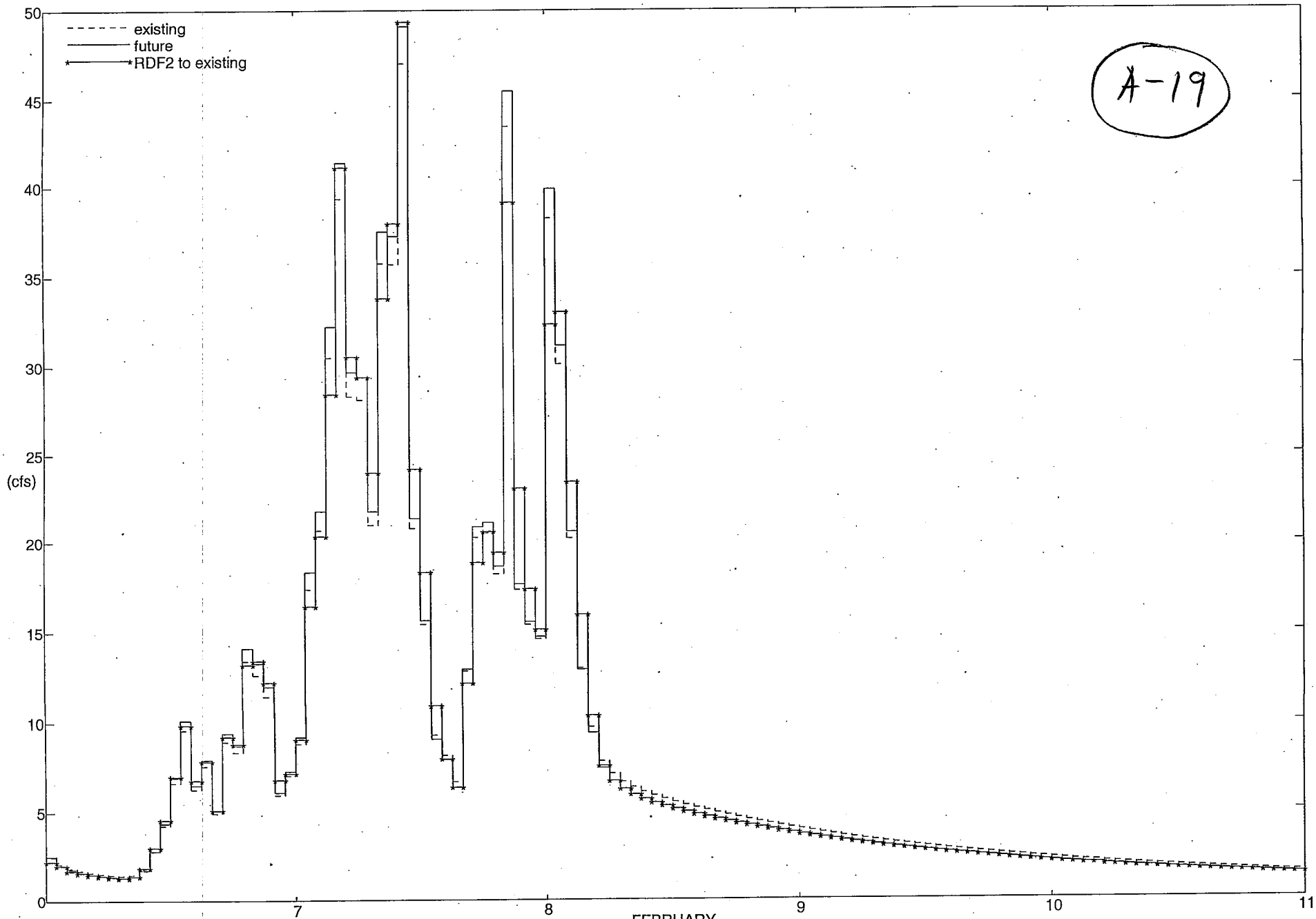
FEBRUARY
1996
Forbes Creek
Comparison of Analysis Results
Reach 4



FEBRUARY
1996
Forbes Creek
Comparison of Analysis Results
Reach 2

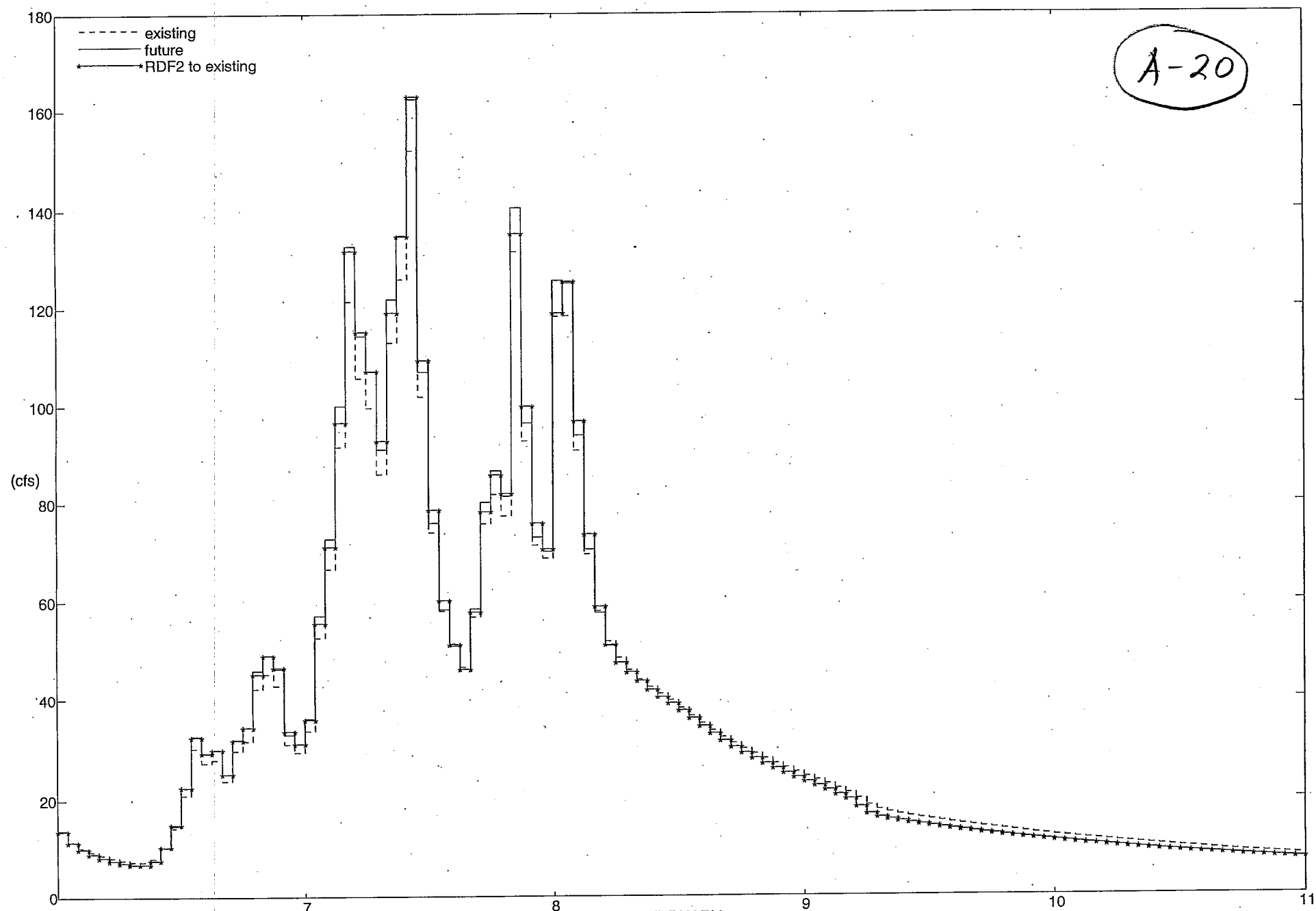
A-18


Forbes Creek Reach 3 - RDF2x
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
(cfs)
0.000
0.001
0.010
0.100
1.000
10.000
100.000
Percent Chance Flow Exceeded
Existing
Future
Predeveloped
RDF2x



A-19

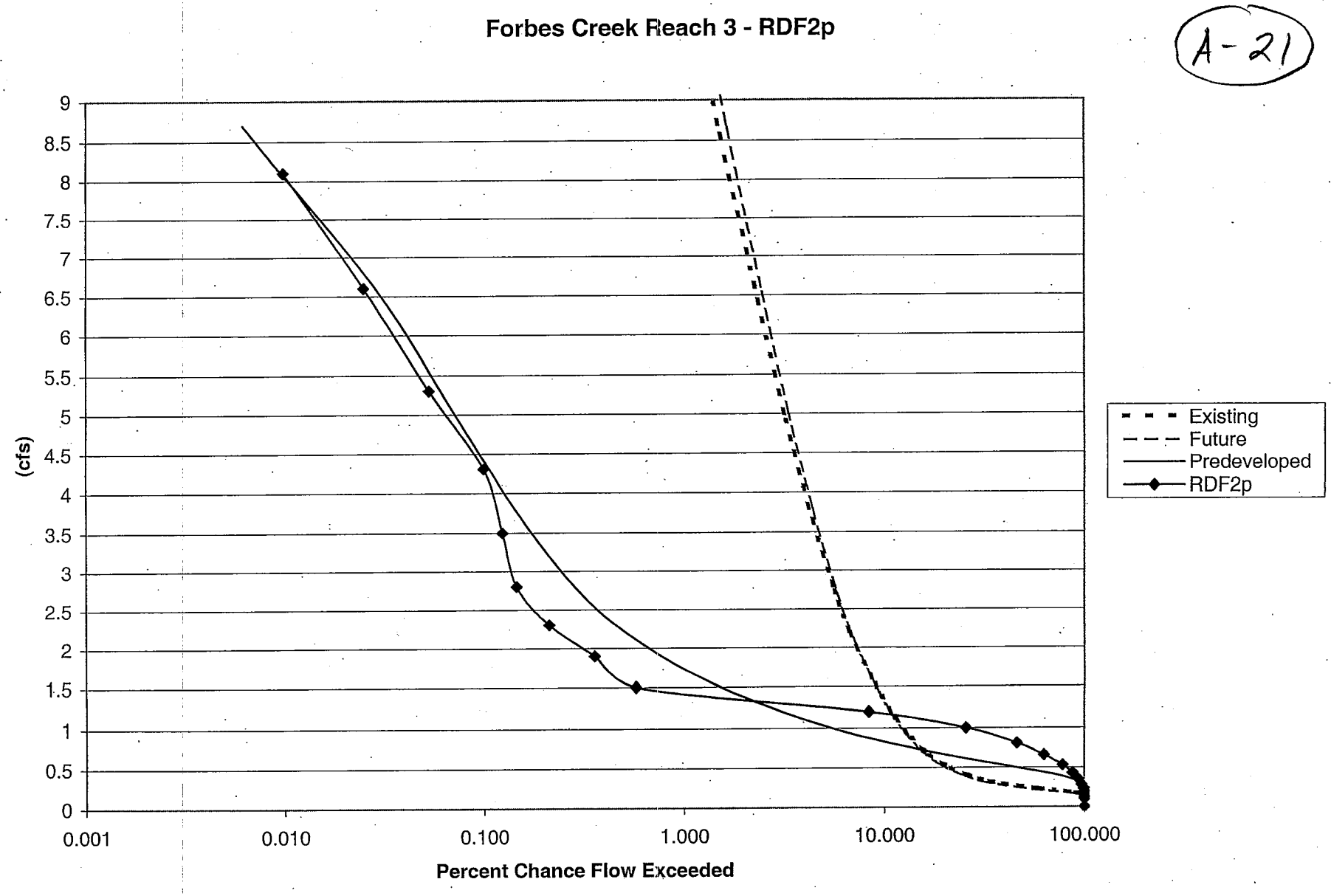
FEBRUARY
1996
Forbes Creek
Comparison of Analysis Scenarios
Reach 3

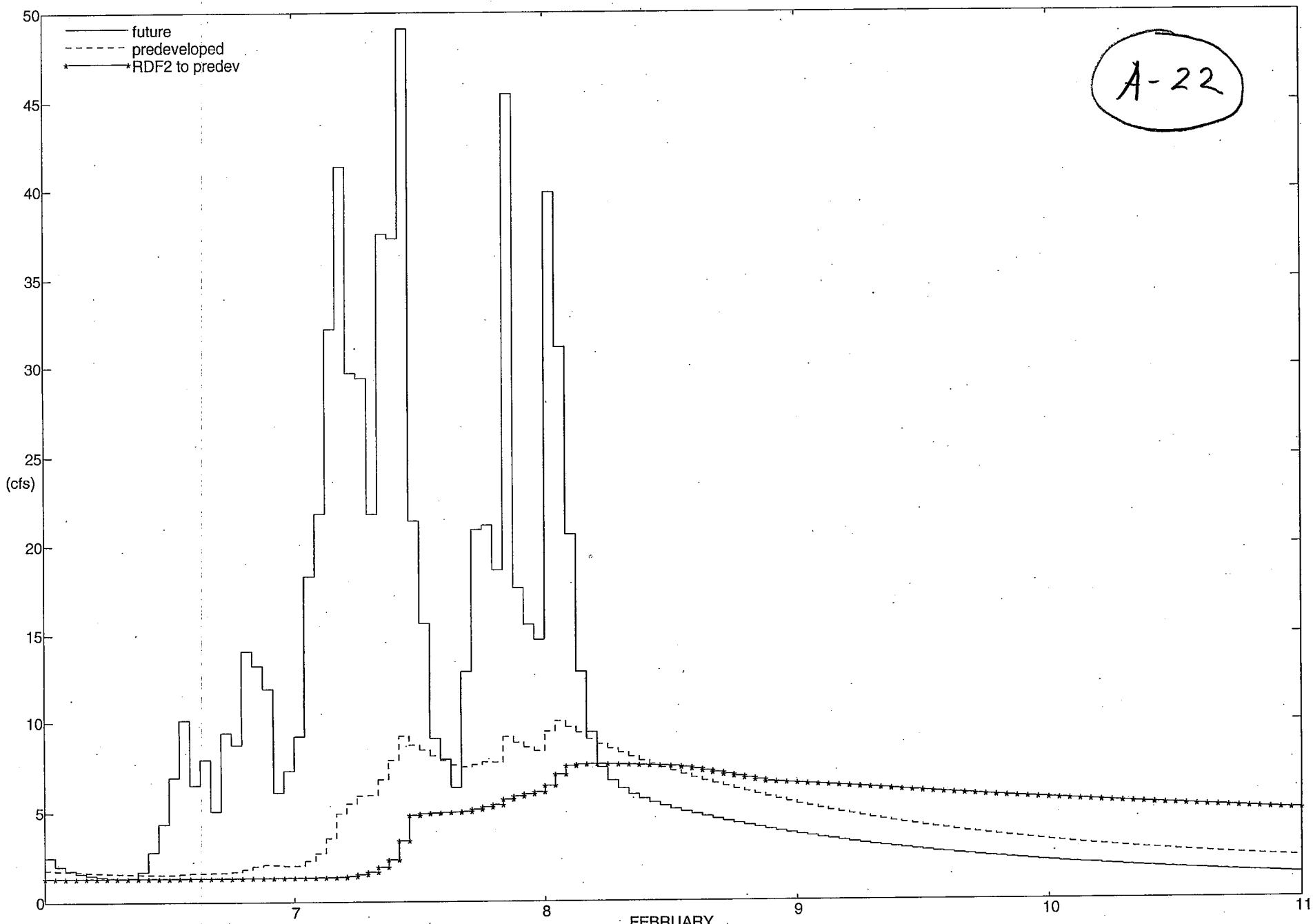


A-20

FEBRUARY
1996
Forbes Creek
Comparison of Analysis Scenarios
Reach 2

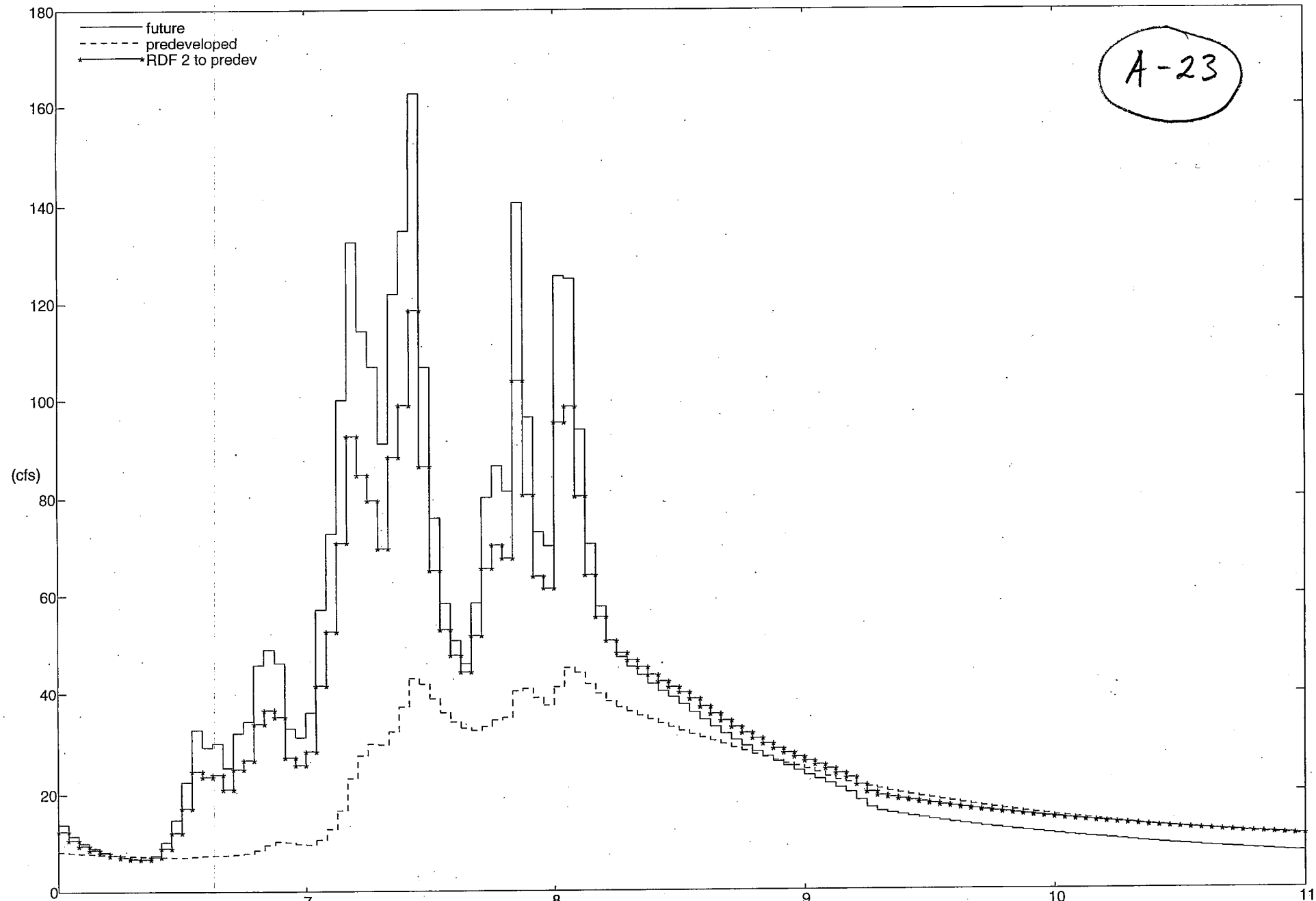
A-21


Forbes Creek Reach 3 - RDF2p
(cfs)
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.001
0.010
0.100
1.000
10.000
100.000
Percent Chance Flow Exceeded
Existing
Future
Predeveloped
RDF2p



A-22

FEBRUARY
1996
Forbes Creek
Comparison of Analysis Scenarios
Reach 3

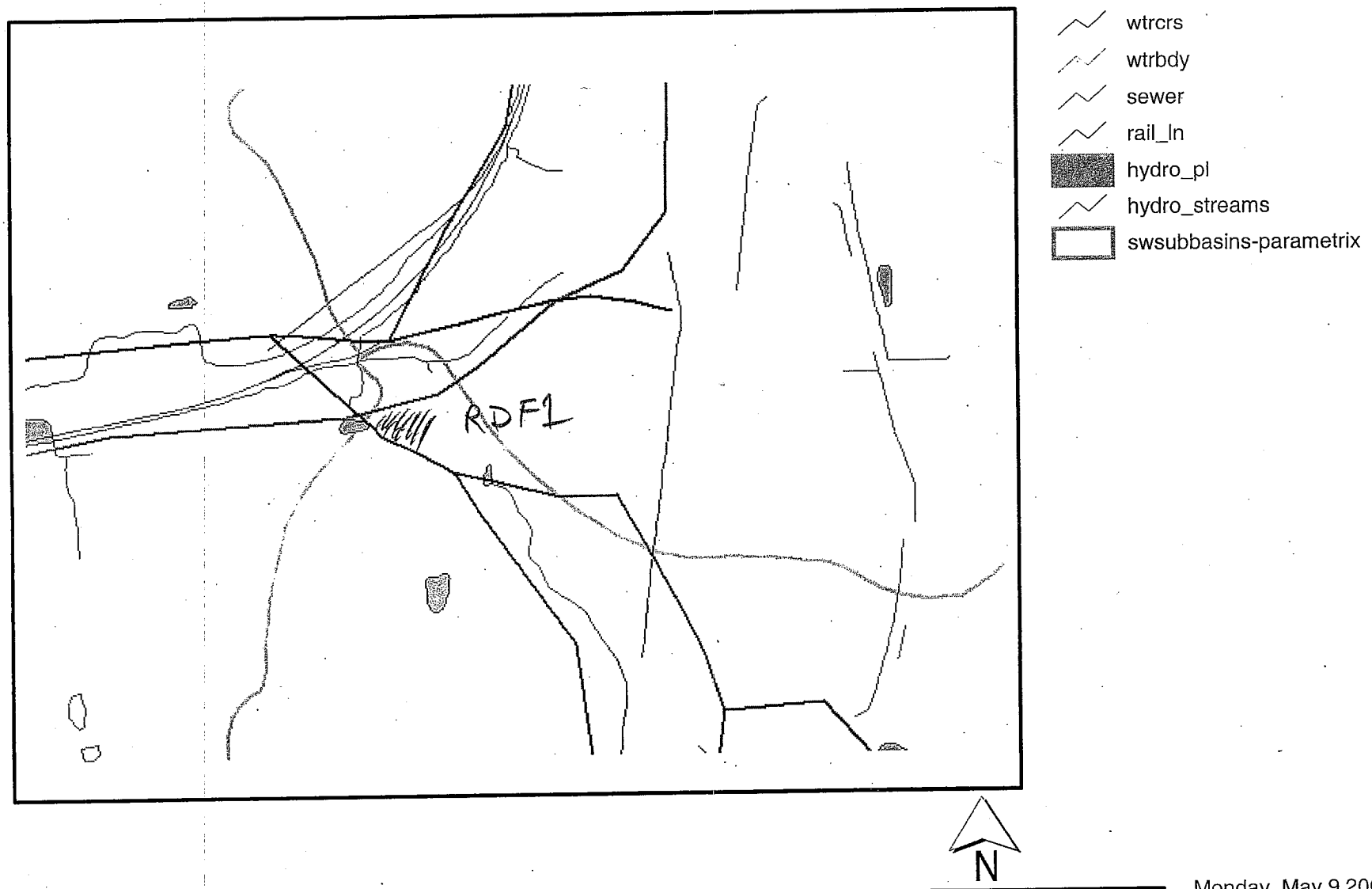


Forbes Creek
Comparison of Analysis Scenarios
Reach 2

A-23

ESRI ArcExplorer 2.0

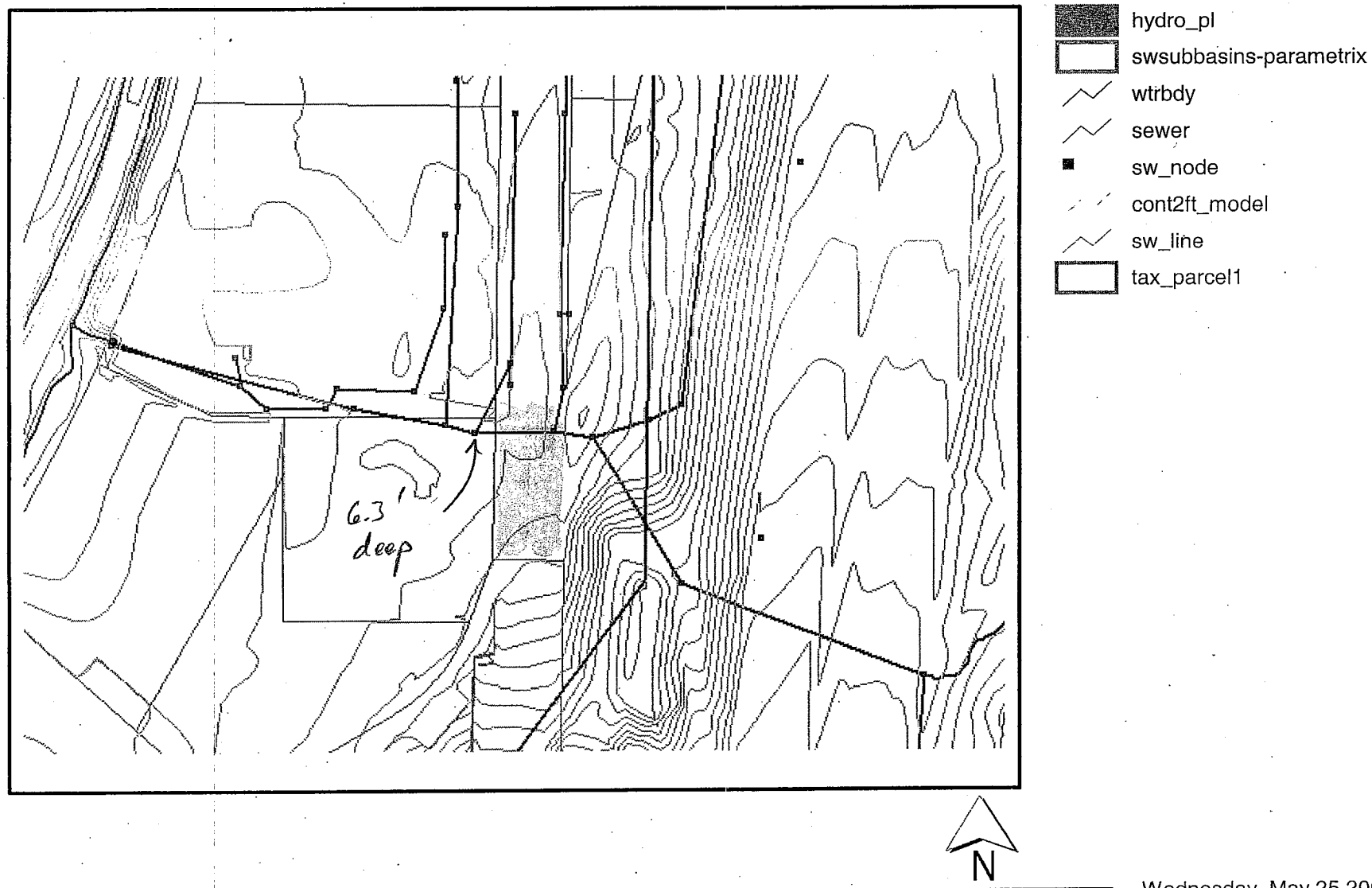
regional facility site "Airshow" Parcel



Monday, May 9 2005

ESRI ArcExplorer 2.0

120th Ave Regional Detention Location



Wednesday, May 25 2005

Attachment B

On-Site Detention Analysis for Forbes Creek Subbasin F5

WWHM Model Results

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: F5 Single-Family Total Area
Site Address:
City :
Report Date : 07/08/2005
Gage : Seatac
Data Start : 1948
Data End : 1998
Precip Scale: 1.00

PREDEVELOPED LAND USE

Basin : Forbes Creek Subbasin F5
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	36.0931

DEVELOPED LAND USE
Basin : Basin 1
Flows To : Pond 1
GroundWater: No

Land Use	Acres
TILL GRASS:	29.7212
IMPERVIOUS:	6.3719

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Point of Compliance
Pond Rain / Evap is not activated.
Dimensions
Depth: 7ft.
Bottom Length: 199.25ft.
Bottom Width : 199.25ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 6.516 acre-ft.
Discharge Structure

Riser Height: 6 ft.
Riser Diameter: 18 in.
NotchType : Rectangular
Notch Width : 0.214 ft.
Notch Height: 2.625 ft.
Orifice 1 Diameter: 3.084 in. **Elevation:** 0 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.911	0.000	0.000	0.000
0.078	0.916	0.071	0.070	0.000
0.156	0.920	0.142	0.099	0.000
0.233	0.924	0.214	0.121	0.000
0.311	0.929	0.286	0.139	0.000
0.389	0.933	0.359	0.156	0.000
0.467	0.937	0.431	0.171	0.000
0.544	0.942	0.504	0.184	0.000
0.622	0.946	0.578	0.197	0.000
0.700	0.950	0.652	0.209	0.000
0.778	0.955	0.726	0.220	0.000
0.856	0.959	0.800	0.231	0.000
0.933	0.963	0.875	0.241	0.000
1.011	0.968	0.950	0.251	0.000
1.089	0.972	1.025	0.261	0.000
1.167	0.977	1.101	0.270	0.000
1.244	0.981	1.177	0.279	0.000
1.322	0.985	1.254	0.287	0.000
1.400	0.990	1.331	0.296	0.000
1.478	0.994	1.408	0.304	0.000
1.556	0.999	1.485	0.312	0.000
1.633	1.003	1.563	0.319	0.000
1.711	1.008	1.641	0.327	0.000
1.789	1.012	1.720	0.334	0.000
1.867	1.017	1.799	0.341	0.000
1.944	1.021	1.878	0.348	0.000
2.022	1.026	1.958	0.355	0.000
2.100	1.030	2.038	0.362	0.000
2.178	1.035	2.118	0.369	0.000
2.256	1.039	2.199	0.375	0.000
2.333	1.044	2.280	0.382	0.000
2.411	1.049	2.361	0.388	0.000
2.489	1.053	2.443	0.394	0.000
2.567	1.058	2.525	0.400	0.000
2.644	1.062	2.607	0.406	0.000
2.722	1.067	2.690	0.412	0.000
2.800	1.072	2.773	0.418	0.000
2.878	1.076	2.857	0.424	0.000
2.956	1.081	2.941	0.429	0.000
3.033	1.086	3.025	0.435	0.000
3.111	1.090	3.109	0.441	0.000
3.189	1.095	3.194	0.446	0.000
3.267	1.100	3.280	0.451	0.000
3.344	1.104	3.365	0.457	0.000
3.422	1.109	3.451	0.469	0.000
3.500	1.114	3.538	0.498	0.000
3.578	1.118	3.625	0.535	0.000
3.656	1.123	3.712	0.577	0.000

3.733	1.128	3.799	0.624	0.000
3.811	1.133	3.887	0.675	0.000
3.889	1.137	3.976	0.728	0.000
3.967	1.142	4.064	0.783	0.000
4.044	1.147	4.153	0.840	0.000
4.122	1.152	4.243	0.899	0.000
4.200	1.157	4.332	0.958	0.000
4.278	1.161	4.423	1.018	0.000
4.356	1.166	4.513	1.078	0.000
4.433	1.171	4.604	1.147	0.000
4.511	1.176	4.695	1.221	0.000
4.589	1.181	4.787	1.298	0.000
4.667	1.186	4.879	1.377	0.000
4.744	1.190	4.971	1.458	0.000
4.822	1.195	5.064	1.542	0.000
4.900	1.200	5.157	1.627	0.000
4.978	1.205	5.251	1.715	0.000
5.056	1.210	5.345	1.804	0.000
5.133	1.215	5.439	1.896	0.000
5.211	1.220	5.534	1.989	0.000
5.289	1.225	5.629	2.085	0.000
5.367	1.230	5.724	2.182	0.000
5.444	1.235	5.820	2.281	0.000
5.522	1.240	5.916	2.382	0.000
5.600	1.245	6.013	2.484	0.000
5.678	1.250	6.110	2.589	0.000
5.756	1.255	6.207	2.695	0.000
5.833	1.260	6.305	2.802	0.000
5.911	1.265	6.403	2.911	0.000
5.989	1.270	6.502	3.022	0.000
6.067	1.275	6.601	3.293	0.000
6.144	1.280	6.700	3.847	0.000
6.222	1.285	6.800	4.580	0.000
6.300	1.290	6.900	5.454	0.000
6.378	1.295	7.001	6.449	0.000
6.456	1.300	7.101	7.553	0.000
6.533	1.305	7.203	8.755	0.000
6.611	1.310	7.304	10.05	0.000
6.689	1.316	7.407	11.42	0.000
6.767	1.321	7.509	12.88	0.000
6.844	1.326	7.612	14.42	0.000
6.922	1.331	7.715	16.02	0.000
7.000	1.336	7.819	17.70	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	**Flow(cfs)**
2 year	0.92294
5 year	1.439444
10 year	1.720565
25 year	2.006965
50 year	2.177305
100 year	2.317432

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	0.617118
5 year	1.019148
10 year	1.354262
25 year	1.865524
50 year	2.316352
100 year	2.832534

Yearly Peaks for Predeveloped and Developed-Mitigated

Year	Predeveloped	Developed
1949	1.071	0.409
1950	2.070	0.886
1951	2.280	2.143
1952	0.706	0.367
1953	0.541	0.435
1954	0.793	0.577
1955	1.397	0.579
1956	1.196	1.025
1957	0.903	0.500
1958	0.982	0.684
1959	0.812	0.419
1960	1.422	1.637
1961	0.823	0.741
1962	0.480	0.330
1963	0.648	0.539
1964	0.812	0.472
1965	0.605	0.892
1966	0.621	0.434
1967	1.399	0.634
1968	0.827	0.440
1969	0.818	0.437
1970	0.647	0.452
1971	0.590	0.550
1972	1.691	1.341
1973	0.737	0.800
1974	0.795	0.631
1975	1.215	0.455
1976	0.749	0.557
1977	0.074	0.246
1978	0.653	0.688
1979	0.379	0.334
1980	1.098	1.451
1981	0.580	0.461
1982	1.111	1.133
1983	1.007	0.632
1984	0.641	0.381
1985	0.347	0.343
1986	1.753	1.020
1987	1.483	1.278
1988	0.537	0.379
1989	0.340	0.338
1990	2.400	1.903
1991	2.095	1.563
1992	0.692	0.729

1993	0.773	0.396
1994	0.195	0.306
1995	1.099	0.766
1996	2.151	2.157
1997	1.977	1.863
1998	0.401	0.367

Ranked Yearly Peaks for Predeveloped and Developed-Mitigated

Rank	Predeveloped	Developed
1	2.2803	2.1427
2	2.1510	1.9034
3	2.0952	1.8626
4	2.0700	1.6372
5	1.9765	1.5633
6	1.7532	1.4507
7	1.6914	1.3410
8	1.4833	1.2784
9	1.4221	1.1326
10	1.3994	1.0247
11	1.3974	1.0200
12	1.2150	0.8924
13	1.1958	0.8856
14	1.1109	0.8002
15	1.0990	0.7659
16	1.0983	0.7407
17	1.0712	0.7289
18	1.0072	0.6876
19	0.9821	0.6841
20	0.9026	0.6338
21	0.8274	0.6319
22	0.8232	0.6307
23	0.8185	0.5793
24	0.8118	0.5774
25	0.8115	0.5568
26	0.7953	0.5505
27	0.7927	0.5390
28	0.7731	0.5004
29	0.7488	0.4718
30	0.7370	0.4605
31	0.7057	0.4554
32	0.6921	0.4518
33	0.6529	0.4401
34	0.6484	0.4367
35	0.6470	0.4349
36	0.6411	0.4344
37	0.6212	0.4187
38	0.6049	0.4089
39	0.5897	0.3961
40	0.5803	0.3809
41	0.5405	0.3789
42	0.5369	0.3673
43	0.4805	0.3671
44	0.4015	0.3425
45	0.3790	0.3385
46	0.3469	0.3340
47	0.3398	0.3299

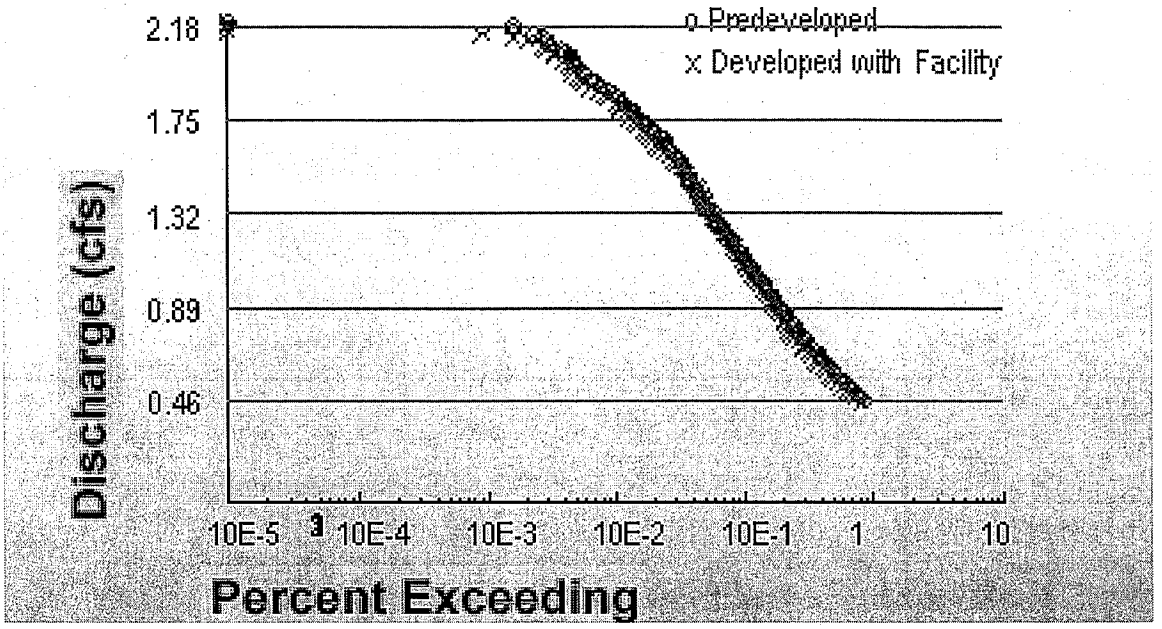
48	0.1953	0.3055
49	0.0741	0.2460

1/2 2 year to 50 year

Flow(CFS)	Predev	Final	Percentage	Pass/Fail
0.4615	3783	3611	95.0	Pass
0.4788	3500	3218	91.0	Pass
0.4961	3243	2975	91.0	Pass
0.5135	3041	2777	91.0	Pass
0.5308	2844	2574	90.0	Pass
0.5481	2633	2376	90.0	Pass
0.5655	2454	2192	89.0	Pass
0.5828	2283	2024	88.0	Pass
0.6001	2129	1905	89.0	Pass
0.6175	2001	1788	89.0	Pass
0.6348	1887	1665	88.0	Pass
0.6521	1774	1575	88.0	Pass
0.6695	1679	1481	88.0	Pass
0.6868	1585	1382	87.0	Pass
0.7041	1490	1292	86.0	Pass
0.7214	1399	1233	88.0	Pass
0.7388	1319	1164	88.0	Pass
0.7561	1238	1099	88.0	Pass
0.7734	1188	1042	87.0	Pass
0.7908	1115	991	88.0	Pass
0.8081	1056	945	89.0	Pass
0.8254	1004	921	91.0	Pass
0.8428	954	892	93.0	Pass
0.8601	902	856	94.0	Pass
0.8774	861	825	95.0	Pass
0.8948	819	788	96.0	Pass
0.9121	774	758	97.0	Pass
0.9294	738	733	99.0	Pass
0.9468	712	699	98.0	Pass
0.9641	669	661	98.0	Pass
0.9814	643	630	97.0	Pass
0.9988	617	603	97.0	Pass
1.0161	586	572	97.0	Pass
1.0334	566	537	94.0	Pass
1.0507	534	507	94.0	Pass
1.0681	508	482	94.0	Pass
1.0854	474	466	98.0	Pass
1.1027	454	450	99.0	Pass
1.1201	432	432	100.0	Pass
1.1374	418	403	96.0	Pass
1.1547	391	392	100.0	Pass
1.1721	371	376	101.0	Pass
1.1894	354	362	102.0	Pass
1.2067	342	342	100.0	Pass
1.2241	322	326	101.0	Pass
1.2414	305	309	101.0	Pass
1.2587	282	297	105.0	Pass
1.2761	273	280	102.0	Pass
1.2934	260	266	102.0	Pass
1.3107	245	259	105.0	Pass
1.3281	232	251	108.0	Pass

1.3454	223	234	104.0	Pass
1.3627	212	228	107.0	Pass
1.3800	206	222	107.0	Pass
1.3974	197	213	108.0	Pass
1.4147	189	207	109.0	Pass
1.4320	182	197	108.0	Pass
1.4494	174	187	107.0	Pass
1.4667	168	176	104.0	Pass
1.4840	159	168	105.0	Pass
1.5014	155	163	105.0	Pass
1.5187	151	155	102.0	Pass
1.5360	145	148	102.0	Pass
1.5534	143	137	95.0	Pass
1.5707	135	125	92.0	Pass
1.5880	127	117	92.0	Pass
1.6054	120	110	91.0	Pass
1.6227	113	98	86.0	Pass
1.6400	109	90	82.0	Pass
1.6574	107	85	79.0	Pass
1.6747	96	83	86.0	Pass
1.6920	89	78	87.0	Pass
1.7094	84	74	88.0	Pass
1.7267	75	68	90.0	Pass
1.7440	72	63	87.0	Pass
1.7613	63	58	92.0	Pass
1.7787	61	55	90.0	Pass
1.7960	58	49	84.0	Pass
1.8133	52	48	92.0	Pass
1.8307	49	45	91.0	Pass
1.8480	47	40	85.0	Pass
1.8653	43	37	86.0	Pass
1.8827	39	33	84.0	Pass
1.9000	34	29	85.0	Pass
1.9173	31	25	80.0	Pass
1.9347	29	24	82.0	Pass
1.9520	26	23	88.0	Pass
1.9693	25	21	84.0	Pass
1.9867	23	21	91.0	Pass
2.0040	21	19	90.0	Pass
2.0213	21	18	85.0	Pass
2.0387	20	15	75.0	Pass
2.0560	18	15	83.0	Pass
2.0733	17	13	76.0	Pass
2.0906	14	12	85.0	Pass
2.1080	13	9	69.0	Pass
2.1253	12	7	58.0	Pass
2.1426	10	4	40.0	Pass
2.1600	7	0	.0	Pass
2.1773	7	0	.0	Pass

Water Quality BMP Flow and Volume.
On-line facility volume: 0 acre-feet
On-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**
Off-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**



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WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: F5 Multi-Family Total Area
Site Address:
City :
Report Date : 07/08/2005
Gage : Seatac
Data Start : 1948
Data End : 1998
Precip Scale: 1.00

PREDEVELOPED LAND USE

Basin : Forbes Creek Subbasin F5
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	4.1694
OUTWASH FOREST:	4.1694
SATURATED FOREST:	4.1694

DEVELOPED LAND USE
Basin : Forbes Creek Subbasin F5
Flows To : Pond 1
GroundWater: No

Land Use	Acres
TILL GRASS:	1.1468
OUTWASH GRASS:	1.1468
SATURATED GRASS:	1.1468
IMPERVIOUS:	9.0678

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Point of Compliance
Pond Rain / Evap is not activated.
Dimensions
Depth: 7ft.
Bottom Length: 170.69ft.
Bottom Width : 170.69ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1

Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 4.919 acre-ft.
Discharge Structure
Riser Height: 6 ft.
Riser Diameter: 18 in.
NotchType : Rectangular
Notch Width : 0.120 ft.
Notch Height: 1.477 ft.
Orifice 1 Diameter: 1.528 in. **Elevation:** 0 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.669	0.000	0.000	0.000
0.078	0.673	0.052	0.017	0.000
0.156	0.676	0.105	0.024	0.000
0.233	0.680	0.157	0.030	0.000
0.311	0.684	0.210	0.034	0.000
0.389	0.687	0.264	0.038	0.000
0.467	0.691	0.317	0.042	0.000
0.544	0.695	0.371	0.045	0.000
0.622	0.698	0.425	0.048	0.000
0.700	0.702	0.480	0.051	0.000
0.778	0.706	0.535	0.054	0.000
0.856	0.710	0.590	0.057	0.000
0.933	0.713	0.645	0.059	0.000
1.011	0.717	0.701	0.062	0.000
1.089	0.721	0.757	0.064	0.000
1.167	0.725	0.813	0.066	0.000
1.244	0.729	0.869	0.068	0.000
1.322	0.732	0.926	0.071	0.000
1.400	0.736	0.983	0.073	0.000
1.478	0.740	1.041	0.075	0.000
1.556	0.744	1.098	0.076	0.000
1.633	0.748	1.156	0.078	0.000
1.711	0.752	1.215	0.080	0.000
1.789	0.756	1.273	0.082	0.000
1.867	0.760	1.332	0.084	0.000
1.944	0.763	1.391	0.086	0.000
2.022	0.767	1.451	0.087	0.000
2.100	0.771	1.511	0.089	0.000
2.178	0.775	1.571	0.090	0.000
2.256	0.779	1.631	0.092	0.000
2.333	0.783	1.692	0.094	0.000
2.411	0.787	1.753	0.095	0.000
2.489	0.791	1.815	0.097	0.000
2.567	0.795	1.876	0.098	0.000
2.644	0.799	1.938	0.100	0.000
2.722	0.803	2.001	0.101	0.000
2.800	0.807	2.063	0.103	0.000
2.878	0.811	2.126	0.104	0.000
2.956	0.815	2.189	0.105	0.000
3.033	0.819	2.253	0.107	0.000
3.111	0.823	2.317	0.108	0.000
3.189	0.827	2.381	0.110	0.000
3.267	0.831	2.445	0.111	0.000
3.344	0.835	2.510	0.112	0.000

3.422	0.839	2.575	0.113	0.000
3.500	0.844	2.641	0.115	0.000
3.578	0.848	2.707	0.116	0.000
3.656	0.852	2.773	0.117	0.000
3.733	0.856	2.839	0.118	0.000
3.811	0.860	2.906	0.120	0.000
3.889	0.864	2.973	0.121	0.000
3.967	0.868	3.040	0.122	0.000
4.044	0.873	3.108	0.123	0.000
4.122	0.877	3.176	0.125	0.000
4.200	0.881	3.244	0.126	0.000
4.278	0.885	3.313	0.127	0.000
4.356	0.889	3.382	0.128	0.000
4.433	0.894	3.451	0.129	0.000
4.511	0.898	3.521	0.130	0.000
4.589	0.902	3.591	0.138	0.000
4.667	0.906	3.661	0.154	0.000
4.744	0.911	3.732	0.173	0.000
4.822	0.915	3.803	0.196	0.000
4.900	0.919	3.874	0.221	0.000
4.978	0.923	3.946	0.248	0.000
5.056	0.928	4.018	0.276	0.000
5.133	0.932	4.090	0.306	0.000
5.211	0.936	4.163	0.337	0.000
5.289	0.941	4.236	0.368	0.000
5.367	0.945	4.309	0.399	0.000
5.444	0.949	4.383	0.431	0.000
5.522	0.954	4.457	0.463	0.000
5.600	0.958	4.531	0.502	0.000
5.678	0.962	4.606	0.543	0.000
5.756	0.967	4.681	0.584	0.000
5.833	0.971	4.756	0.627	0.000
5.911	0.976	4.832	0.672	0.000
5.989	0.980	4.908	0.717	0.000
6.067	0.985	4.985	0.976	0.000
6.144	0.989	5.061	1.528	0.000
6.222	0.993	5.138	2.257	0.000
6.300	0.998	5.216	3.128	0.000
6.378	1.002	5.294	4.120	0.000
6.456	1.007	5.372	5.221	0.000
6.533	1.011	5.450	6.420	0.000
6.611	1.016	5.529	7.710	0.000
6.689	1.020	5.608	9.085	0.000
6.767	1.025	5.688	10.54	0.000
6.844	1.029	5.768	12.07	0.000
6.922	1.034	5.848	13.67	0.000
7.000	1.038	5.928	15.34	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	**Flow(cfs)**
2 year	0.262578
5 year	0.505618

10 year	0.691079
25 year	0.943421
50 year	1.140079
100 year	1.341413

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	0.143472
5 year	0.241995
10 year	0.331047
25 year	0.477218
50 year	0.615216
100 year	0.782566

Yearly Peaks for Predeveloped and Developed-Mitigated

Year	Predeveloped	Developed
1949	0.245	0.107
1950	0.857	0.130
1951	0.835	0.882
1952	0.233	0.098
1953	0.129	0.205
1954	0.371	0.118
1955	0.679	0.110
1956	0.554	0.443
1957	0.188	0.115
1958	0.367	0.120
1959	0.304	0.117
1960	0.517	0.237
1961	0.368	0.130
1962	0.058	0.098
1963	0.195	0.122
1964	0.366	0.162
1965	0.344	0.172
1966	0.153	0.120
1967	0.670	0.130
1968	0.175	0.114
1969	0.416	0.119
1970	0.172	0.124
1971	0.282	0.116
1972	0.819	0.601
1973	0.339	0.201
1974	0.289	0.122
1975	0.420	0.111
1976	0.319	0.116
1977	0.051	0.096
1978	0.085	0.123
1979	0.123	0.089
1980	0.129	0.437
1981	0.144	0.117
1982	0.416	0.158
1983	0.209	0.119
1984	0.302	0.105
1985	0.085	0.101
1986	0.222	0.120
1987	0.436	0.183
1988	0.064	0.110

1989	0.079	0.105
1990	0.434	0.220
1991	0.875	0.430
1992	0.101	0.121
1993	0.095	0.094
1994	0.025	0.089
1995	0.349	0.131
1996	0.892	0.650
1997	0.630	0.589
1998	0.191	0.108

Ranked Yearly Peaks for Predeveloped and Developed-Mitigated

Rank	Predeveloped	Developed
1	0.8752	0.6502
2	0.8575	0.6010
3	0.8351	0.5886
4	0.8187	0.4432
5	0.6788	0.4374
6	0.6700	0.4303
7	0.6301	0.2365
8	0.5538	0.2203
9	0.5169	0.2049
10	0.4361	0.2007
11	0.4344	0.1830
12	0.4203	0.1723
13	0.4157	0.1617
14	0.4156	0.1579
15	0.3706	0.1310
16	0.3677	0.1301
17	0.3674	0.1299
18	0.3658	0.1298
19	0.3493	0.1244
20	0.3438	0.1234
21	0.3386	0.1224
22	0.3193	0.1221
23	0.3038	0.1207
24	0.3021	0.1202
25	0.2888	0.1196
26	0.2823	0.1195
27	0.2447	0.1195
28	0.2334	0.1191
29	0.2216	0.1178
30	0.2090	0.1171
31	0.1946	0.1170
32	0.1906	0.1162
33	0.1882	0.1158
34	0.1745	0.1150
35	0.1722	0.1141
36	0.1531	0.1113
37	0.1444	0.1104
38	0.1293	0.1098
39	0.1288	0.1078
40	0.1225	0.1073
41	0.1014	0.1049
42	0.0947	0.1048
43	0.0849	0.1010

44	0.0848	0.0982
45	0.0792	0.0982
46	0.0636	0.0962
47	0.0578	0.0939
48	0.0509	0.0894
49	0.0246	0.0891

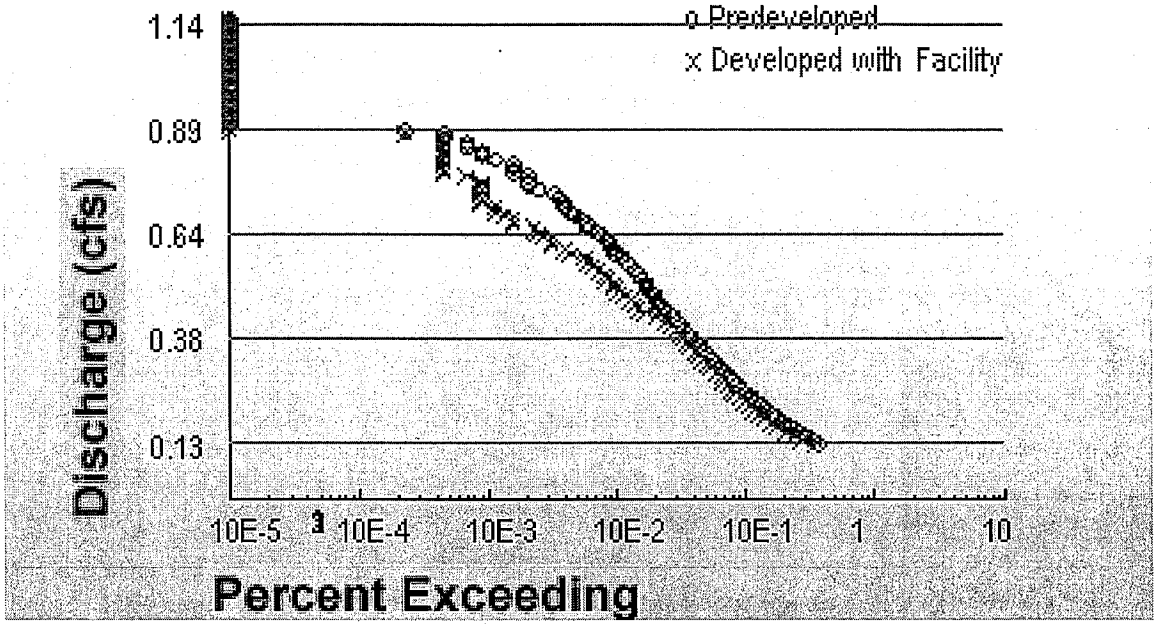
1/2 2 year to 50 year

Flow(CFS)	Predev	Final	Percentage	Pass/Fail
0.1313	1632	1586	97.0	Pass
0.1415	1443	1227	85.0	Pass
0.1517	1281	1046	81.0	Pass
0.1619	1118	908	81.0	Pass
0.1720	986	788	79.0	Pass
0.1822	869	695	79.0	Pass
0.1924	780	621	79.0	Pass
0.2026	717	566	78.0	Pass
0.2128	656	522	79.0	Pass
0.2230	599	482	80.0	Pass
0.2332	534	440	82.0	Pass
0.2434	488	408	83.0	Pass
0.2536	442	374	84.0	Pass
0.2638	410	355	86.0	Pass
0.2739	382	329	86.0	Pass
0.2841	358	306	85.0	Pass
0.2943	327	291	88.0	Pass
0.3045	303	266	87.0	Pass
0.3147	282	245	86.0	Pass
0.3249	257	229	89.0	Pass
0.3351	243	209	86.0	Pass
0.3453	229	191	83.0	Pass
0.3555	215	181	84.0	Pass
0.3657	197	168	85.0	Pass
0.3758	183	159	86.0	Pass
0.3860	169	150	88.0	Pass
0.3962	158	140	88.0	Pass
0.4064	147	128	87.0	Pass
0.4166	139	117	84.0	Pass
0.4268	131	106	80.0	Pass
0.4370	123	90	73.0	Pass
0.4472	112	75	66.0	Pass
0.4574	105	66	62.0	Pass
0.4676	93	63	67.0	Pass
0.4777	91	58	63.0	Pass
0.4879	89	52	58.0	Pass
0.4981	81	47	58.0	Pass
0.5083	76	44	57.0	Pass
0.5185	75	43	57.0	Pass
0.5287	69	38	55.0	Pass
0.5389	66	37	56.0	Pass
0.5491	62	33	53.0	Pass
0.5593	57	30	52.0	Pass
0.5695	53	27	50.0	Pass
0.5796	49	26	53.0	Pass
0.5898	43	20	46.0	Pass
0.6000	42	18	42.0	Pass

0.6102	40	14	35.0	Pass
0.6204	38	14	36.0	Pass
0.6306	35	12	34.0	Pass
0.6408	32	11	34.0	Pass
0.6510	27	10	37.0	Pass
0.6612	27	7	25.0	Pass
0.6713	24	7	29.0	Pass
0.6815	21	6	28.0	Pass
0.6917	19	5	26.0	Pass
0.7019	18	5	27.0	Pass
0.7121	17	4	23.0	Pass
0.7223	16	4	25.0	Pass
0.7325	15	4	26.0	Pass
0.7427	11	4	36.0	Pass
0.7529	9	4	44.0	Pass
0.7631	9	4	44.0	Pass
0.7732	9	3	33.0	Pass
0.7834	7	2	28.0	Pass
0.7936	7	2	28.0	Pass
0.8038	7	2	28.0	Pass
0.8140	5	2	40.0	Pass
0.8242	4	2	50.0	Pass
0.8344	4	2	50.0	Pass
0.8446	3	2	66.0	Pass
0.8548	3	2	66.0	Pass
0.8650	2	2	100.0	Pass
0.8751	2	1	50.0	Pass
0.8853	1	0	.0	Pass
0.8955	0	0	.0	Pass
0.9057	0	0	.0	Pass
0.9159	0	0	.0	Pass
0.9261	0	0	.0	Pass
0.9363	0	0	.0	Pass
0.9465	0	0	.0	Pass
0.9567	0	0	.0	Pass
0.9669	0	0	.0	Pass
0.9770	0	0	.0	Pass
0.9872	0	0	.0	Pass
0.9974	0	0	.0	Pass
1.0076	0	0	.0	Pass
1.0178	0	0	.0	Pass
1.0280	0	0	.0	Pass
1.0382	0	0	.0	Pass
1.0484	0	0	.0	Pass
1.0586	0	0	.0	Pass
1.0688	0	0	.0	Pass
1.0789	0	0	.0	Pass
1.0891	0	0	.0	Pass
1.0993	0	0	.0	Pass
1.1095	0	0	.0	Pass
1.1197	0	0	.0	Pass
1.1299	0	0	.0	Pass
1.1401	0	0	.0	Pass

Water Quality BMP Flow and Volume.
On-line facility volume: 0 acre-feet
On-line facility target flow: 0 **cfs.**

Adjusted for 15 min: 0 cfs.
Off-line facility target flow: 0 cfs.
Adjusted for 15 min: 0 cfs.



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WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: F5 Non-Residential Total Area
Site Address:
City :
Report Date : 07/08/2005
Gage : Seatac
Data Start : 1948
Data End : 1998
Precip Scale: 1.00

PREDEVELOPED LAND USE

Basin : Forbes Creek Subbasin F5
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	4.1384
OUTWASH FOREST:	4.1384
SATURATED FOREST:	4.1384

DEVELOPED LAND USE
Basin : Forbes Creek Subbasin F5
Flows To : Pond 1
GroundWater: No

Land Use	Acres
TILL GRASS:	0.4944
OUTWASH GRASS:	0.4944
SATURATED GRASS:	0.4944
IMPERVIOUS:	10.932

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Point of Compliance
Pond Rain / Evap is not activated.
Dimensions
Depth: 7ft.
Bottom Length: 205.74ft.
Bottom Width : 205.74ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1

Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 6.910 acre-ft.
Discharge Structure
Riser Height: 6 ft.
Riser Diameter: 18 in.
NotchType : Rectangular
Notch Width : 0.130 ft.
Notch Height: 1.267 ft.
Orifice 1 Diameter: 1.51 in. **Elevation:** 0 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.972	0.000	0.000	0.000
0.078	0.976	0.076	0.017	0.000
0.156	0.981	0.152	0.024	0.000
0.233	0.985	0.228	0.029	0.000
0.311	0.989	0.305	0.033	0.000
0.389	0.994	0.382	0.037	0.000
0.467	0.998	0.460	0.041	0.000
0.544	1.003	0.538	0.044	0.000
0.622	1.007	0.616	0.047	0.000
0.700	1.012	0.694	0.050	0.000
0.778	1.016	0.773	0.053	0.000
0.856	1.021	0.852	0.055	0.000
0.933	1.025	0.932	0.058	0.000
1.011	1.030	1.012	0.060	0.000
1.089	1.034	1.092	0.062	0.000
1.167	1.039	1.173	0.065	0.000
1.244	1.044	1.254	0.067	0.000
1.322	1.048	1.335	0.069	0.000
1.400	1.053	1.417	0.071	0.000
1.478	1.057	1.499	0.073	0.000
1.556	1.062	1.581	0.075	0.000
1.633	1.067	1.664	0.077	0.000
1.711	1.071	1.747	0.078	0.000
1.789	1.076	1.831	0.080	0.000
1.867	1.080	1.914	0.082	0.000
1.944	1.085	1.999	0.084	0.000
2.022	1.090	2.083	0.085	0.000
2.100	1.094	2.168	0.087	0.000
2.178	1.099	2.253	0.088	0.000
2.256	1.104	2.339	0.090	0.000
2.333	1.108	2.425	0.091	0.000
2.411	1.113	2.512	0.093	0.000
2.489	1.118	2.598	0.094	0.000
2.567	1.123	2.685	0.096	0.000
2.644	1.127	2.773	0.097	0.000
2.722	1.132	2.861	0.099	0.000
2.800	1.137	2.949	0.100	0.000
2.878	1.142	3.038	0.102	0.000
2.956	1.146	3.127	0.103	0.000
3.033	1.151	3.216	0.104	0.000
3.111	1.156	3.306	0.106	0.000
3.189	1.161	3.396	0.107	0.000
3.267	1.166	3.486	0.108	0.000
3.344	1.171	3.577	0.110	0.000

3.422	1.175	3.668	0.111	0.000
3.500	1.180	3.760	0.112	0.000
3.578	1.185	3.852	0.113	0.000
3.656	1.190	3.944	0.114	0.000
3.733	1.195	4.037	0.116	0.000
3.811	1.200	4.130	0.117	0.000
3.889	1.205	4.224	0.118	0.000
3.967	1.210	4.318	0.119	0.000
4.044	1.214	4.412	0.120	0.000
4.122	1.219	4.507	0.122	0.000
4.200	1.224	4.602	0.123	0.000
4.278	1.229	4.697	0.124	0.000
4.356	1.234	4.793	0.125	0.000
4.433	1.239	4.889	0.126	0.000
4.511	1.244	4.986	0.127	0.000
4.589	1.249	5.083	0.128	0.000
4.667	1.254	5.180	0.129	0.000
4.744	1.259	5.278	0.131	0.000
4.822	1.264	5.376	0.143	0.000
4.900	1.269	5.474	0.161	0.000
4.978	1.274	5.573	0.183	0.000
5.056	1.279	5.673	0.209	0.000
5.133	1.284	5.772	0.236	0.000
5.211	1.290	5.872	0.266	0.000
5.289	1.295	5.973	0.297	0.000
5.367	1.300	6.074	0.329	0.000
5.444	1.305	6.175	0.362	0.000
5.522	1.310	6.277	0.396	0.000
5.600	1.315	6.379	0.430	0.000
5.678	1.320	6.481	0.465	0.000
5.756	1.325	6.584	0.502	0.000
5.833	1.330	6.687	0.544	0.000
5.911	1.336	6.791	0.588	0.000
5.989	1.341	6.895	0.634	0.000
6.067	1.346	7.000	0.893	0.000
6.144	1.351	7.105	1.444	0.000
6.222	1.356	7.210	2.173	0.000
6.300	1.362	7.316	3.044	0.000
6.378	1.367	7.422	4.037	0.000
6.456	1.372	7.528	5.138	0.000
6.533	1.377	7.635	6.337	0.000
6.611	1.383	7.742	7.627	0.000
6.689	1.388	7.850	9.001	0.000
6.767	1.393	7.958	10.46	0.000
6.844	1.398	8.067	11.99	0.000
6.922	1.404	8.176	13.59	0.000
7.000	1.409	8.285	15.26	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	**Flow(cfs)**
2 year	0.260689
5 year	0.50198

10 year	0.686107
25 year	0.936634
50 year	1.131877
100 year	1.331763

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	0.130654
5 year	0.213974
10 year	0.289149
25 year	0.412492
50 year	0.529008
100 year	0.670468

Yearly Peaks for Predeveloped and Developed-Mitigated

Year	Predeveloped	Developed
1949	0.243	0.102
1950	0.851	0.130
1951	0.829	0.880
1952	0.232	0.093
1953	0.128	0.223
1954	0.368	0.119
1955	0.674	0.107
1956	0.550	0.454
1957	0.187	0.110
1958	0.365	0.116
1959	0.302	0.120
1960	0.513	0.134
1961	0.365	0.129
1962	0.057	0.095
1963	0.193	0.118
1964	0.363	0.131
1965	0.341	0.125
1966	0.152	0.118
1967	0.665	0.145
1968	0.173	0.109
1969	0.413	0.116
1970	0.171	0.120
1971	0.280	0.112
1972	0.813	0.484
1973	0.336	0.127
1974	0.287	0.123
1975	0.417	0.112
1976	0.317	0.115
1977	0.051	0.089
1978	0.084	0.119
1979	0.122	0.083
1980	0.128	0.319
1981	0.143	0.114
1982	0.413	0.125
1983	0.208	0.120
1984	0.300	0.105
1985	0.084	0.097
1986	0.220	0.111
1987	0.433	0.129
1988	0.063	0.106

1989	0.079	0.106
1990	0.431	0.127
1991	0.869	0.347
1992	0.101	0.113
1993	0.094	0.087
1994	0.024	0.087
1995	0.347	0.127
1996	0.886	0.609
1997	0.626	0.484
1998	0.189	0.106

Ranked Yearly Peaks for Predeveloped and Developed-Mitigated

Rank	Predeveloped	Developed
1	0.8689	0.6092
2	0.8513	0.4838
3	0.8291	0.4837
4	0.8128	0.4538
5	0.6739	0.3469
6	0.6652	0.3187
7	0.6256	0.2228
8	0.5498	0.1446
9	0.5132	0.1345
10	0.4330	0.1305
11	0.4312	0.1303
12	0.4173	0.1293
13	0.4127	0.1287
14	0.4126	0.1275
15	0.3680	0.1274
16	0.3650	0.1271
17	0.3648	0.1254
18	0.3632	0.1246
19	0.3468	0.1232
20	0.3413	0.1202
21	0.3361	0.1199
22	0.3170	0.1198
23	0.3016	0.1193
24	0.2999	0.1192
25	0.2868	0.1184
26	0.2803	0.1183
27	0.2429	0.1162
28	0.2317	0.1160
29	0.2200	0.1147
30	0.2075	0.1136
31	0.1932	0.1126
32	0.1892	0.1119
33	0.1868	0.1115
34	0.1733	0.1113
35	0.1710	0.1098
36	0.1520	0.1094
37	0.1434	0.1072
38	0.1283	0.1064
39	0.1279	0.1061
40	0.1216	0.1061
41	0.1007	0.1047
42	0.0940	0.1020
43	0.0843	0.0970

44	0.0842	0.0954
45	0.0786	0.0930
46	0.0631	0.0887
47	0.0574	0.0870
48	0.0505	0.0868
49	0.0244	0.0827

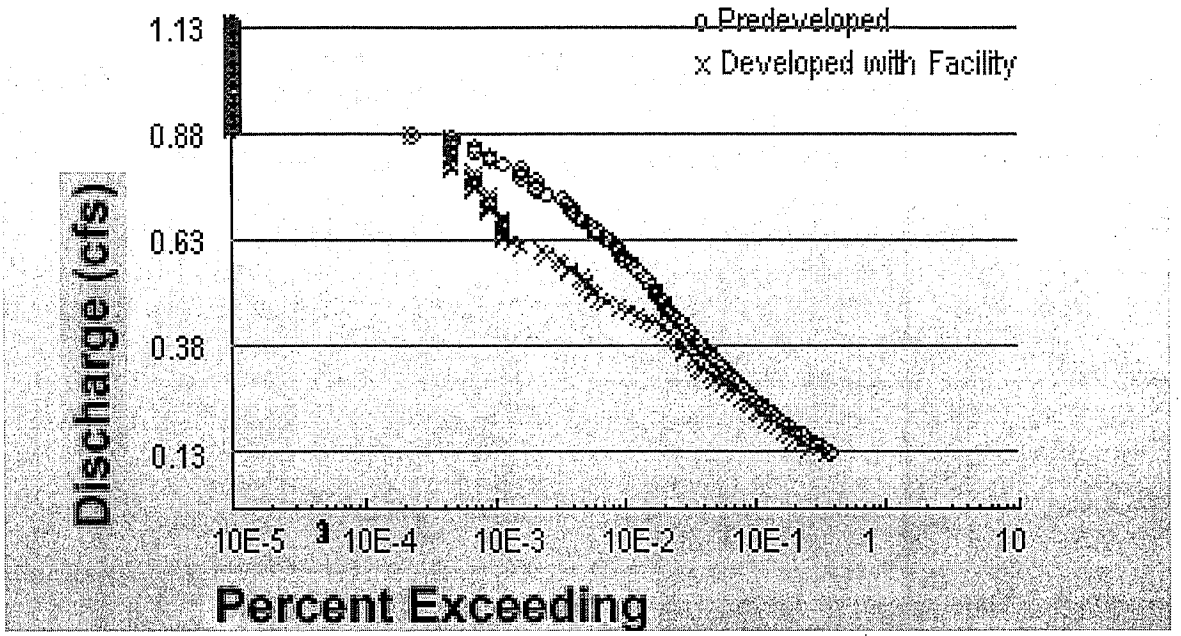
1/2 2 year to 50 year

Flow(CFS)	Predev	Final	Percentage	Pass/Fail
0.1303	1634	1524	93.0	Pass
0.1405	1442	1136	78.0	Pass
0.1506	1281	977	76.0	Pass
0.1607	1117	875	78.0	Pass
0.1708	996	808	81.0	Pass
0.1809	875	740	84.0	Pass
0.1910	779	672	86.0	Pass
0.2012	712	607	85.0	Pass
0.2113	655	538	82.0	Pass
0.2214	596	489	82.0	Pass
0.2315	534	450	84.0	Pass
0.2416	490	415	84.0	Pass
0.2517	442	385	87.0	Pass
0.2619	410	355	86.0	Pass
0.2720	382	319	83.0	Pass
0.2821	358	281	78.0	Pass
0.2922	327	253	77.0	Pass
0.3023	303	216	71.0	Pass
0.3124	282	200	70.0	Pass
0.3226	257	178	69.0	Pass
0.3327	243	168	69.0	Pass
0.3428	229	157	68.0	Pass
0.3529	216	145	67.0	Pass
0.3630	197	130	65.0	Pass
0.3731	179	124	69.0	Pass
0.3833	170	118	69.0	Pass
0.3934	158	112	70.0	Pass
0.4035	147	104	70.0	Pass
0.4136	139	95	68.0	Pass
0.4237	131	86	65.0	Pass
0.4338	122	76	62.0	Pass
0.4440	113	67	59.0	Pass
0.4541	104	56	53.0	Pass
0.4642	93	48	51.0	Pass
0.4743	91	41	45.0	Pass
0.4844	88	32	36.0	Pass
0.4945	81	29	35.0	Pass
0.5047	76	26	34.0	Pass
0.5148	75	25	33.0	Pass
0.5249	69	23	33.0	Pass
0.5350	65	22	33.0	Pass
0.5451	62	21	33.0	Pass
0.5552	57	17	29.0	Pass
0.5654	53	17	32.0	Pass
0.5755	49	15	30.0	Pass
0.5856	43	14	32.0	Pass
0.5957	42	11	26.0	Pass

0.6058	40	10	25.0	Pass
0.6159	39	7	17.0	Pass
0.6261	34	6	17.0	Pass
0.6362	32	5	15.0	Pass
0.6463	27	5	18.0	Pass
0.6564	27	5	18.0	Pass
0.6665	24	5	20.0	Pass
0.6766	21	5	23.0	Pass
0.6868	19	5	26.0	Pass
0.6969	18	4	22.0	Pass
0.7070	17	4	23.0	Pass
0.7171	16	4	25.0	Pass
0.7272	15	4	26.0	Pass
0.7373	11	4	36.0	Pass
0.7475	9	3	33.0	Pass
0.7576	9	3	33.0	Pass
0.7677	9	3	33.0	Pass
0.7778	7	3	42.0	Pass
0.7879	7	3	42.0	Pass
0.7980	7	2	28.0	Pass
0.8081	5	2	40.0	Pass
0.8183	4	2	50.0	Pass
0.8284	4	2	50.0	Pass
0.8385	3	2	66.0	Pass
0.8486	3	2	66.0	Pass
0.8587	2	2	100.0	Pass
0.8688	2	2	100.0	Pass
0.8790	1	1	100.0	Pass
0.8891	0	0	100.0	Pass
0.8992	0	0	.0	Pass
0.9093	0	0	.0	Pass
0.9194	0	0	.0	Pass
0.9295	0	0	.0	Pass
0.9397	0	0	.0	Pass
0.9498	0	0	.0	Pass
0.9599	0	0	.0	Pass
0.9700	0	0	.0	Pass
0.9801	0	0	.0	Pass
0.9902	0	0	.0	Pass
1.0004	0	0	.0	Pass
1.0105	0	0	.0	Pass
1.0206	0	0	.0	Pass
1.0307	0	0	.0	Pass
1.0408	0	0	.0	Pass
1.0509	0	0	.0	Pass
1.0611	0	0	.0	Pass
1.0712	0	0	.0	Pass
1.0813	0	0	.0	Pass
1.0914	0	0	.0	Pass
1.1015	0	0	.0	Pass
1.1116	0	0	.0	Pass
1.1218	0	0	.0	Pass
1.1319	0	0	.0	Pass

Water Quality BMP Flow and Volume.
On-line facility volume: 0 acre-feet
On-line facility target flow: 0 cfs.

Adjusted for 15 min: 0 cfs.
Off-line facility target flow: 0 cfs.
Adjusted for 15 min: 0 cfs.



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WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: F5 Multi-Family Single Parcel
Site Address:
City :
Report Date : 07/08/2005
Gage : Seatac
Data Start : 1948
Data End : 1998
Precip Scale: 1.00

PREDEVELOPED LAND USE

Basin : Forbes Creek Subbasin F5
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	0.1489
OUTWASH FOREST:	0.1489
SATURATED FOREST:	0.1489

DEVELOPED LAND USE
Basin : Forbes Creek Subbasin F5
Flows To : Pond 1
GroundWater: No

Land Use	Acres
TILL GRASS:	0.0462
OUTWASH GRASS:	0.0462
SATURATED GRASS:	0.0462
IMPERVIOUS:	0.3081

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Point of Compliance
Pond Rain / Evap is not activated.
Dimensions
Depth: 7ft.
Bottom Length: 18.14ft.
Bottom Width : 18.14ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1

Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 0.195 acre-ft.
Discharge Structure
Riser Height: 6 ft.
Riser Diameter: 18 in.
NotchType : Rectangular
Notch Width : 0.000 ft.
Notch Height: 0.000 ft.
Orifice 1 Diameter: 0.27 in. **Elevation:** 0 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.008	0.000	0.000	0.000
0.078	0.008	0.001	0.001	0.000
0.156	0.008	0.001	0.001	0.000
0.233	0.009	0.002	0.001	0.000
0.311	0.009	0.003	0.001	0.000
0.389	0.010	0.003	0.001	0.000
0.467	0.010	0.004	0.001	0.000
0.544	0.011	0.005	0.001	0.000
0.622	0.011	0.006	0.002	0.000
0.700	0.011	0.007	0.002	0.000
0.778	0.012	0.008	0.002	0.000
0.856	0.012	0.008	0.002	0.000
0.933	0.013	0.009	0.002	0.000
1.011	0.013	0.010	0.002	0.000
1.089	0.014	0.012	0.002	0.000
1.167	0.015	0.013	0.002	0.000
1.244	0.015	0.014	0.002	0.000
1.322	0.016	0.015	0.002	0.000
1.400	0.016	0.016	0.002	0.000
1.478	0.017	0.018	0.002	0.000
1.556	0.017	0.019	0.002	0.000
1.633	0.018	0.020	0.002	0.000
1.711	0.019	0.022	0.003	0.000
1.789	0.019	0.023	0.003	0.000
1.867	0.020	0.025	0.003	0.000
1.944	0.020	0.026	0.003	0.000
2.022	0.021	0.028	0.003	0.000
2.100	0.022	0.029	0.003	0.000
2.178	0.022	0.031	0.003	0.000
2.256	0.023	0.033	0.003	0.000
2.333	0.024	0.035	0.003	0.000
2.411	0.024	0.037	0.003	0.000
2.489	0.025	0.039	0.003	0.000
2.567	0.026	0.041	0.003	0.000
2.644	0.027	0.043	0.003	0.000
2.722	0.027	0.045	0.003	0.000
2.800	0.028	0.047	0.003	0.000
2.878	0.029	0.049	0.003	0.000
2.956	0.030	0.051	0.003	0.000
3.033	0.030	0.054	0.003	0.000
3.111	0.031	0.056	0.003	0.000
3.189	0.032	0.058	0.003	0.000
3.267	0.033	0.061	0.003	0.000
3.344	0.034	0.064	0.004	0.000

3.422	0.034	0.066	0.004	0.000
3.500	0.035	0.069	0.004	0.000
3.578	0.036	0.072	0.004	0.000
3.656	0.037	0.074	0.004	0.000
3.733	0.038	0.077	0.004	0.000
3.811	0.039	0.080	0.004	0.000
3.889	0.039	0.083	0.004	0.000
3.967	0.040	0.086	0.004	0.000
4.044	0.041	0.090	0.004	0.000
4.122	0.042	0.093	0.004	0.000
4.200	0.043	0.096	0.004	0.000
4.278	0.044	0.100	0.004	0.000
4.356	0.045	0.103	0.004	0.000
4.433	0.046	0.107	0.004	0.000
4.511	0.047	0.110	0.004	0.000
4.589	0.048	0.114	0.004	0.000
4.667	0.049	0.118	0.004	0.000
4.744	0.050	0.122	0.004	0.000
4.822	0.051	0.125	0.004	0.000
4.900	0.052	0.129	0.004	0.000
4.978	0.053	0.133	0.004	0.000
5.056	0.054	0.138	0.004	0.000
5.133	0.055	0.142	0.004	0.000
5.211	0.056	0.146	0.004	0.000
5.289	0.057	0.151	0.004	0.000
5.367	0.058	0.155	0.004	0.000
5.444	0.059	0.160	0.004	0.000
5.522	0.060	0.164	0.004	0.000
5.600	0.061	0.169	0.005	0.000
5.678	0.063	0.174	0.005	0.000
5.756	0.064	0.179	0.005	0.000
5.833	0.065	0.184	0.005	0.000
5.911	0.066	0.189	0.005	0.000
5.989	0.067	0.194	0.005	0.000
6.067	0.068	0.199	0.256	0.000
6.144	0.069	0.205	0.807	0.000
6.222	0.071	0.210	1.535	0.000
6.300	0.072	0.216	2.405	0.000
6.378	0.073	0.221	3.397	0.000
6.456	0.074	0.227	4.497	0.000
6.533	0.075	0.233	5.695	0.000
6.611	0.077	0.239	6.984	0.000
6.689	0.078	0.245	8.358	0.000
6.767	0.079	0.251	9.812	0.000
6.844	0.080	0.257	11.34	0.000
6.922	0.082	0.263	12.94	0.000
7.000	0.083	0.270	14.61	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	**Flow(cfs)**
2 year	0.009445
5 year	0.018188

10 year	0.024859
25 year	0.033936
50 year	0.04101
100 year	0.048252

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	0.004112
5 year	0.00584
10 year	0.007151
25 year	0.00901
50 year	0.010549
100 year	0.012226

Yearly Peaks for Predeveloped and Developed-Mitigated

Year	Predeveloped	Developed
1949	0.009	0.004
1950	0.031	0.004
1951	0.030	0.032
1952	0.008	0.003
1953	0.005	0.004
1954	0.013	0.004
1955	0.024	0.004
1956	0.020	0.022
1957	0.007	0.004
1958	0.013	0.004
1959	0.011	0.004
1960	0.019	0.004
1961	0.013	0.004
1962	0.002	0.003
1963	0.007	0.004
1964	0.013	0.004
1965	0.012	0.004
1966	0.006	0.004
1967	0.024	0.004
1968	0.006	0.004
1969	0.015	0.004
1970	0.006	0.004
1971	0.010	0.004
1972	0.029	0.005
1973	0.012	0.004
1974	0.010	0.004
1975	0.015	0.004
1976	0.011	0.004
1977	0.002	0.003
1978	0.003	0.004
1979	0.004	0.003
1980	0.005	0.005
1981	0.005	0.004
1982	0.015	0.004
1983	0.008	0.004
1984	0.011	0.004
1985	0.003	0.004
1986	0.008	0.004
1987	0.016	0.004
1988	0.002	0.004

1989	0.003	0.004
1990	0.016	0.004
1991	0.031	0.004
1992	0.004	0.004
1993	0.003	0.003
1994	0.001	0.003
1995	0.013	0.004
1996	0.032	0.005
1997	0.023	0.006
1998	0.007	0.004

Ranked Yearly Peaks for Predeveloped and Developed-Mitigated

Rank	Predeveloped	Developed
1	0.0315	0.0222
2	0.0308	0.0058
3	0.0300	0.0046
4	0.0294	0.0046
5	0.0244	0.0046
6	0.0241	0.0044
7	0.0227	0.0044
8	0.0199	0.0043
9	0.0186	0.0043
10	0.0157	0.0043
11	0.0156	0.0042
12	0.0151	0.0042
13	0.0150	0.0042
14	0.0149	0.0042
15	0.0133	0.0042
16	0.0132	0.0042
17	0.0132	0.0041
18	0.0132	0.0041
19	0.0126	0.0041
20	0.0124	0.0040
21	0.0122	0.0040
22	0.0115	0.0040
23	0.0109	0.0040
24	0.0109	0.0039
25	0.0104	0.0039
26	0.0102	0.0039
27	0.0088	0.0039
28	0.0084	0.0039
29	0.0080	0.0039
30	0.0075	0.0039
31	0.0070	0.0039
32	0.0069	0.0039
33	0.0068	0.0038
34	0.0063	0.0038
35	0.0062	0.0038
36	0.0055	0.0037
37	0.0052	0.0037
38	0.0046	0.0037
39	0.0046	0.0037
40	0.0044	0.0036
41	0.0036	0.0036
42	0.0034	0.0036
43	0.0031	0.0035

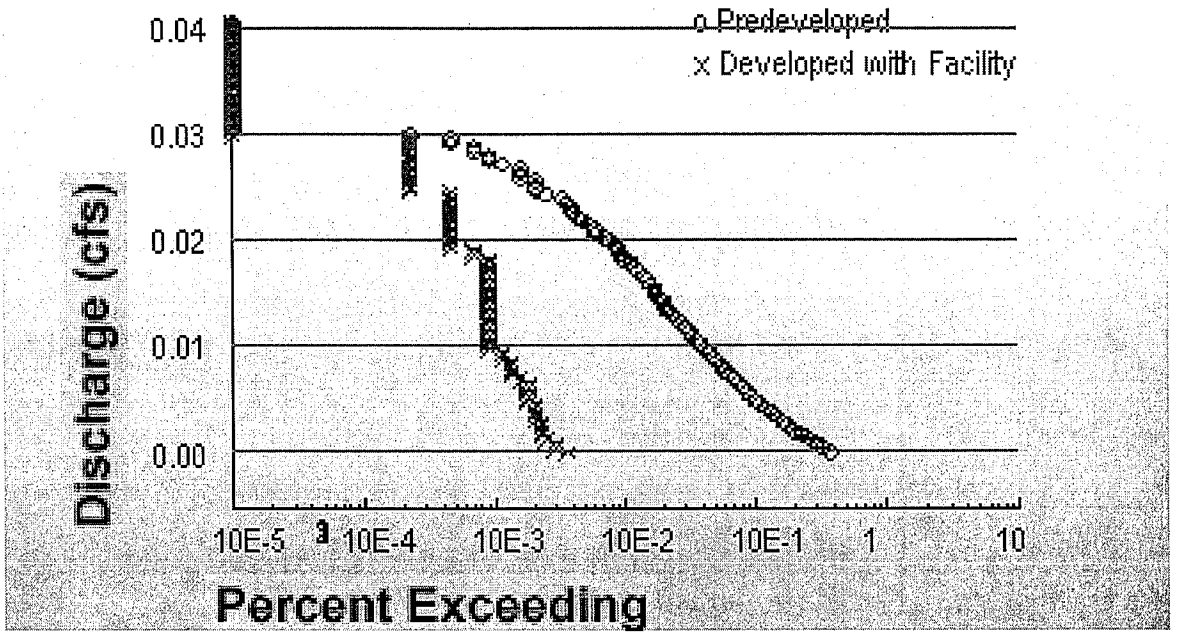
44	0.0030	0.0034
45	0.0028	0.0034
46	0.0023	0.0034
47	0.0021	0.0034
48	0.0018	0.0032
49	0.0009	0.0032

1/2 2 year to 50 year

Flow(CFS)	Predev	Final	Percentage	Pass/Fail
0.0047	1632	16	.0	Pass
0.0051	1436	13	.0	Pass
0.0055	1272	13	1.0	Pass
0.0058	1106	11	.0	Pass
0.0062	986	10	1.0	Pass
0.0066	868	10	1.0	Pass
0.0069	778	10	1.0	Pass
0.0073	712	10	1.0	Pass
0.0077	654	9	1.0	Pass
0.0080	592	9	1.0	Pass
0.0084	533	9	1.0	Pass
0.0088	485	9	1.0	Pass
0.0091	441	8	1.0	Pass
0.0095	407	8	1.0	Pass
0.0099	381	8	2.0	Pass
0.0102	357	8	2.0	Pass
0.0106	327	8	2.0	Pass
0.0110	302	7	2.0	Pass
0.0113	281	6	2.0	Pass
0.0117	256	6	2.0	Pass
0.0121	243	6	2.0	Pass
0.0124	229	6	2.0	Pass
0.0128	215	5	2.0	Pass
0.0132	197	5	2.0	Pass
0.0135	180	4	2.0	Pass
0.0139	170	4	2.0	Pass
0.0143	158	4	2.0	Pass
0.0146	147	4	2.0	Pass
0.0150	139	4	2.0	Pass
0.0154	130	4	3.0	Pass
0.0157	121	4	3.0	Pass
0.0161	112	4	3.0	Pass
0.0165	104	4	3.0	Pass
0.0168	93	4	4.0	Pass
0.0172	91	4	4.0	Pass
0.0176	88	4	4.0	Pass
0.0179	81	4	4.0	Pass
0.0183	76	4	5.0	Pass
0.0187	75	4	5.0	Pass
0.0190	69	4	5.0	Pass
0.0194	65	4	6.0	Pass
0.0198	62	4	6.0	Pass
0.0201	57	4	7.0	Pass
0.0205	53	4	7.0	Pass
0.0209	49	4	8.0	Pass
0.0212	43	4	9.0	Pass
0.0216	42	3	7.0	Pass

0.0219	40	3	7.0	Pass
0.0223	38	2	5.0	Pass
0.0227	34	2	5.0	Pass
0.0230	32	2	6.0	Pass
0.0234	27	2	7.0	Pass
0.0238	27	2	7.0	Pass
0.0241	24	2	8.0	Pass
0.0245	21	2	9.0	Pass
0.0249	19	2	10.0	Pass
0.0252	18	2	11.0	Pass
0.0256	17	2	11.0	Pass
0.0260	16	2	12.0	Pass
0.0263	15	2	13.0	Pass
0.0267	11	2	18.0	Pass
0.0271	9	1	11.0	Pass
0.0274	9	1	11.0	Pass
0.0278	9	1	11.0	Pass
0.0282	7	1	14.0	Pass
0.0285	7	1	14.0	Pass
0.0289	7	1	14.0	Pass
0.0293	5	1	20.0	Pass
0.0296	4	1	25.0	Pass
0.0300	4	1	25.0	Pass
0.0304	3	1	33.0	Pass
0.0307	3	1	33.0	Pass
0.0311	2	1	50.0	Pass
0.0315	2	1	50.0	Pass
0.0318	1	0	.0	Pass
0.0322	0	0	.0	Pass
0.0326	0	0	.0	Pass
0.0329	0	0	.0	Pass
0.0333	0	0	.0	Pass
0.0337	0	0	.0	Pass
0.0340	0	0	.0	Pass
0.0344	0	0	.0	Pass
0.0348	0	0	.0	Pass
0.0351	0	0	.0	Pass
0.0355	0	0	.0	Pass
0.0359	0	0	.0	Pass
0.0362	0	0	.0	Pass
0.0366	0	0	.0	Pass
0.0370	0	0	.0	Pass
0.0373	0	0	.0	Pass
0.0377	0	0	.0	Pass
0.0381	0	0	.0	Pass
0.0384	0	0	.0	Pass
0.0388	0	0	.0	Pass
0.0392	0	0	.0	Pass
0.0395	0	0	.0	Pass
0.0399	0	0	.0	Pass
0.0403	0	0	.0	Pass
0.0406	0	0	.0	Pass
0.0410	0	0	.0	Pass

Water Quality BMP Flow and Volume.
On-line facility volume: 0 acre-feet
On-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**
Off-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**



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WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: F5 Non-Residential Single Parcel
Site Address:
City :
Report Date : 07/08/2005
Gage : Seatac
Data Start : 1948
Data End : 1998
Precip Scale: 1.00

PREDEVELOPED LAND USE

Basin : Forbes Creek Subbasin F5
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	0.5912
OUTWASH FOREST:	0.5912
SATURATED FOREST:	0.5912

DEVELOPED LAND USE
Basin : Forbes Creek Subbasin F5
Flows To : Pond 1
GroundWater: No

Land Use	Acres
TILL GRASS:	0.1116
OUTWASH GRASS:	0.1116
SATURATED GRASS:	0.1116
IMPERVIOUS:	1.4388

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Point of Compliance
Pond Rain / Evap is not activated.
Dimensions
Depth: 7ft.
Bottom Length: 59.84ft.
Bottom Width : 59.84ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1

Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 0.849 acre-ft.
Discharge Structure
Riser Height: 6 ft.
Riser Diameter: 18 in.
NotchType : Rectangular
Notch Width : 0.011 ft.
Notch Height: 1.119 ft.
Orifice 1 Diameter: 0.565 in. **Elevation:** 0 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.082	0.000	0.000	0.000
0.078	0.083	0.006	0.002	0.000
0.156	0.085	0.013	0.003	0.000
0.233	0.086	0.020	0.004	0.000
0.311	0.087	0.026	0.005	0.000
0.389	0.089	0.033	0.005	0.000
0.467	0.090	0.040	0.006	0.000
0.544	0.091	0.047	0.006	0.000
0.622	0.093	0.054	0.007	0.000
0.700	0.094	0.062	0.007	0.000
0.778	0.096	0.069	0.007	0.000
0.856	0.097	0.077	0.008	0.000
0.933	0.098	0.084	0.008	0.000
1.011	0.100	0.092	0.008	0.000
1.089	0.101	0.100	0.009	0.000
1.167	0.103	0.108	0.009	0.000
1.244	0.104	0.116	0.009	0.000
1.322	0.105	0.124	0.010	0.000
1.400	0.107	0.132	0.010	0.000
1.478	0.108	0.140	0.010	0.000
1.556	0.110	0.149	0.010	0.000
1.633	0.111	0.157	0.011	0.000
1.711	0.113	0.166	0.011	0.000
1.789	0.114	0.175	0.011	0.000
1.867	0.116	0.184	0.011	0.000
1.944	0.117	0.193	0.012	0.000
2.022	0.119	0.202	0.012	0.000
2.100	0.120	0.212	0.012	0.000
2.178	0.122	0.221	0.012	0.000
2.256	0.124	0.231	0.013	0.000
2.333	0.125	0.240	0.013	0.000
2.411	0.127	0.250	0.013	0.000
2.489	0.128	0.260	0.013	0.000
2.567	0.130	0.270	0.013	0.000
2.644	0.132	0.280	0.014	0.000
2.722	0.133	0.290	0.014	0.000
2.800	0.135	0.301	0.014	0.000
2.878	0.136	0.311	0.014	0.000
2.956	0.138	0.322	0.014	0.000
3.033	0.140	0.333	0.015	0.000
3.111	0.141	0.344	0.015	0.000
3.189	0.143	0.355	0.015	0.000
3.267	0.145	0.366	0.015	0.000
3.344	0.147	0.377	0.015	0.000

3.422	0.148	0.389	0.016	0.000
3.500	0.150	0.400	0.016	0.000
3.578	0.152	0.412	0.016	0.000
3.656	0.154	0.424	0.016	0.000
3.733	0.155	0.436	0.016	0.000
3.811	0.157	0.448	0.016	0.000
3.889	0.159	0.461	0.017	0.000
3.967	0.161	0.473	0.017	0.000
4.044	0.162	0.486	0.017	0.000
4.122	0.164	0.498	0.017	0.000
4.200	0.166	0.511	0.017	0.000
4.278	0.168	0.524	0.017	0.000
4.356	0.170	0.537	0.017	0.000
4.433	0.172	0.550	0.018	0.000
4.511	0.173	0.564	0.018	0.000
4.589	0.175	0.577	0.018	0.000
4.667	0.177	0.591	0.018	0.000
4.744	0.179	0.605	0.018	0.000
4.822	0.181	0.619	0.018	0.000
4.900	0.183	0.633	0.019	0.000
4.978	0.185	0.647	0.020	0.000
5.056	0.187	0.662	0.021	0.000
5.133	0.189	0.676	0.023	0.000
5.211	0.191	0.691	0.026	0.000
5.289	0.193	0.706	0.028	0.000
5.367	0.194	0.721	0.031	0.000
5.444	0.196	0.736	0.033	0.000
5.522	0.198	0.752	0.036	0.000
5.600	0.200	0.767	0.039	0.000
5.678	0.202	0.783	0.042	0.000
5.756	0.204	0.799	0.045	0.000
5.833	0.206	0.815	0.048	0.000
5.911	0.209	0.831	0.051	0.000
5.989	0.211	0.847	0.055	0.000
6.067	0.213	0.864	0.307	0.000
6.144	0.215	0.880	0.857	0.000
6.222	0.217	0.897	1.586	0.000
6.300	0.219	0.914	2.456	0.000
6.378	0.221	0.931	3.448	0.000
6.456	0.223	0.948	4.548	0.000
6.533	0.225	0.966	5.746	0.000
6.611	0.227	0.983	7.035	0.000
6.689	0.229	1.001	8.409	0.000
6.767	0.232	1.019	9.863	0.000
6.844	0.234	1.037	11.39	0.000
6.922	0.236	1.055	12.99	0.000
7.000	0.238	1.074	14.67	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	**Flow(cfs)**
2 year	0.037151
5 year	0.071538

10 year	0.097779
25 year	0.133482
50 year	0.161306
100 year	0.189792

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	0.018206
5 year	0.02702
10 year	0.034384
25 year	0.045693
50 year	0.055762
100 year	0.067408

Yearly Peaks for Predeveloped and Developed-Mitigated

Year	Predeveloped	Developed
1949	0.035	0.015
1950	0.121	0.018
1951	0.118	0.120
1952	0.033	0.014
1953	0.018	0.025
1954	0.052	0.017
1955	0.096	0.016
1956	0.078	0.048
1957	0.027	0.016
1958	0.052	0.017
1959	0.043	0.017
1960	0.073	0.019
1961	0.052	0.018
1962	0.008	0.014
1963	0.028	0.017
1964	0.052	0.018
1965	0.049	0.018
1966	0.022	0.017
1967	0.095	0.018
1968	0.025	0.016
1969	0.059	0.017
1970	0.024	0.017
1971	0.040	0.016
1972	0.116	0.045
1973	0.048	0.018
1974	0.041	0.017
1975	0.059	0.016
1976	0.045	0.016
1977	0.007	0.014
1978	0.012	0.017
1979	0.017	0.013
1980	0.018	0.037
1981	0.020	0.016
1982	0.059	0.018
1983	0.030	0.017
1984	0.043	0.015
1985	0.012	0.015
1986	0.031	0.017
1987	0.062	0.018
1988	0.009	0.016

1989	0.011	0.015
1990	0.061	0.018
1991	0.124	0.034
1992	0.014	0.017
1993	0.013	0.013
1994	0.003	0.013
1995	0.049	0.018
1996	0.126	0.051
1997	0.089	0.050
1998	0.027	0.015

Ranked Yearly Peaks for Predeveloped and Developed-Mitigated

Rank	Predeveloped	Developed
1	0.1238	0.0514
2	0.1213	0.0502
3	0.1182	0.0479
4	0.1158	0.0455
5	0.0960	0.0371
6	0.0948	0.0342
7	0.0892	0.0249
8	0.0784	0.0189
9	0.0731	0.0185
10	0.0617	0.0185
11	0.0615	0.0184
12	0.0595	0.0184
13	0.0588	0.0182
14	0.0588	0.0182
15	0.0524	0.0181
16	0.0520	0.0181
17	0.0520	0.0181
18	0.0518	0.0180
19	0.0494	0.0173
20	0.0486	0.0173
21	0.0479	0.0171
22	0.0452	0.0171
23	0.0430	0.0169
24	0.0427	0.0168
25	0.0409	0.0167
26	0.0399	0.0167
27	0.0346	0.0167
28	0.0330	0.0166
29	0.0313	0.0166
30	0.0296	0.0165
31	0.0275	0.0163
32	0.0270	0.0163
33	0.0266	0.0162
34	0.0247	0.0161
35	0.0244	0.0160
36	0.0217	0.0158
37	0.0204	0.0157
38	0.0183	0.0156
39	0.0182	0.0153
40	0.0173	0.0153
41	0.0144	0.0151
42	0.0134	0.0151
43	0.0120	0.0145

44	0.0120	0.0141
45	0.0112	0.0140
46	0.0090	0.0138
47	0.0082	0.0135
48	0.0072	0.0131
49	0.0035	0.0128

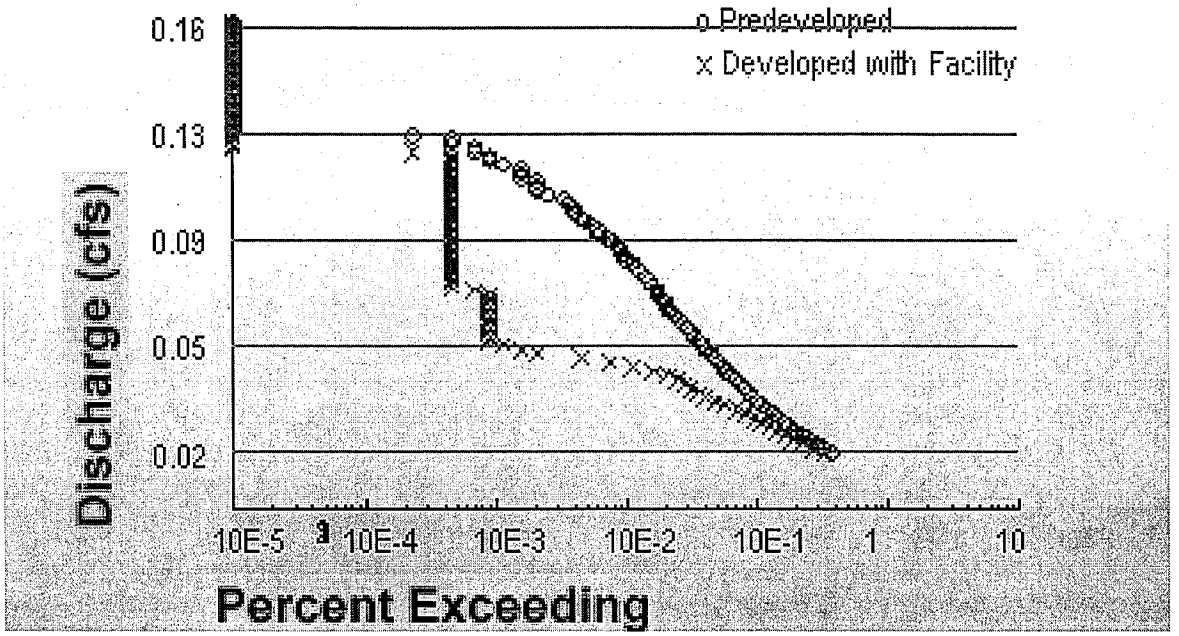
1/2 2 year to 50 year

Flow(CFS)	Predev	Final	Percentage	Pass/Fail
0.0186	1632	1467	89.0	Pass
0.0200	1437	1177	81.0	Pass
0.0215	1272	986	77.0	Pass
0.0229	1106	843	76.0	Pass
0.0243	986	722	73.0	Pass
0.0258	869	626	72.0	Pass
0.0272	779	557	71.0	Pass
0.0287	712	485	68.0	Pass
0.0301	654	429	65.0	Pass
0.0316	592	363	61.0	Pass
0.0330	533	307	57.0	Pass
0.0344	485	253	52.0	Pass
0.0359	441	214	48.0	Pass
0.0373	407	179	43.0	Pass
0.0388	381	159	41.0	Pass
0.0402	357	142	39.0	Pass
0.0416	327	127	38.0	Pass
0.0431	302	110	36.0	Pass
0.0445	281	93	33.0	Pass
0.0460	256	72	28.0	Pass
0.0474	243	49	20.0	Pass
0.0489	228	33	14.0	Pass
0.0503	214	20	9.0	Pass
0.0517	197	9	4.0	Pass
0.0532	178	7	3.0	Pass
0.0546	169	5	2.0	Pass
0.0561	158	4	2.0	Pass
0.0575	146	4	2.0	Pass
0.0589	138	4	2.0	Pass
0.0604	130	4	3.0	Pass
0.0618	121	4	3.0	Pass
0.0633	112	4	3.0	Pass
0.0647	104	4	3.0	Pass
0.0662	93	4	4.0	Pass
0.0676	91	4	4.0	Pass
0.0690	88	4	4.0	Pass
0.0705	81	4	4.0	Pass
0.0719	76	4	5.0	Pass
0.0734	75	3	4.0	Pass
0.0748	69	2	2.0	Pass
0.0762	65	2	3.0	Pass
0.0777	62	2	3.0	Pass
0.0791	57	2	3.0	Pass
0.0806	53	2	3.0	Pass
0.0820	49	2	4.0	Pass
0.0835	43	2	4.0	Pass
0.0849	42	2	4.0	Pass

0.0863	40	2	5.0	Pass
0.0878	38	2	5.0	Pass
0.0892	34	2	5.0	Pass
0.0907	32	2	6.0	Pass
0.0921	27	2	7.0	Pass
0.0935	27	2	7.0	Pass
0.0950	24	2	8.0	Pass
0.0964	21	2	9.0	Pass
0.0979	19	2	10.0	Pass
0.0993	18	2	11.0	Pass
0.1008	17	2	11.0	Pass
0.1022	16	2	12.0	Pass
0.1036	15	2	13.0	Pass
0.1051	11	2	18.0	Pass
0.1065	9	2	22.0	Pass
0.1080	9	2	22.0	Pass
0.1094	9	2	22.0	Pass
0.1108	7	2	28.0	Pass
0.1123	7	2	28.0	Pass
0.1137	7	2	28.0	Pass
0.1152	5	2	40.0	Pass
0.1166	4	2	50.0	Pass
0.1181	4	2	50.0	Pass
0.1195	3	1	33.0	Pass
0.1209	3	0	.0	Pass
0.1224	2	0	.0	Pass
0.1238	2	0	.0	Pass
0.1253	1	0	.0	Pass
0.1267	0	0	.0	Pass
0.1281	0	0	.0	Pass
0.1296	0	0	.0	Pass
0.1310	0	0	.0	Pass
0.1325	0	0	.0	Pass
0.1339	0	0	.0	Pass
0.1354	0	0	.0	Pass
0.1368	0	0	.0	Pass
0.1382	0	0	.0	Pass
0.1397	0	0	.0	Pass
0.1411	0	0	.0	Pass
0.1426	0	0	.0	Pass
0.1440	0	0	.0	Pass
0.1454	0	0	.0	Pass
0.1469	0	0	.0	Pass
0.1483	0	0	.0	Pass
0.1498	0	0	.0	Pass
0.1512	0	0	.0	Pass
0.1527	0	0	.0	Pass
0.1541	0	0	.0	Pass
0.1555	0	0	.0	Pass
0.1570	0	0	.0	Pass
0.1584	0	0	.0	Pass
0.1599	0	0	.0	Pass
0.1613	0	0	.0	Pass

Water Quality BMP Flow and Volume.
On-line facility volume: 0 acre-feet
On-line facility target flow: 0 **cfs.**

Adjusted for 15 min: 0 cfs.
Off-line facility target flow: 0 cfs.
Adjusted for 15 min: 0 cfs.



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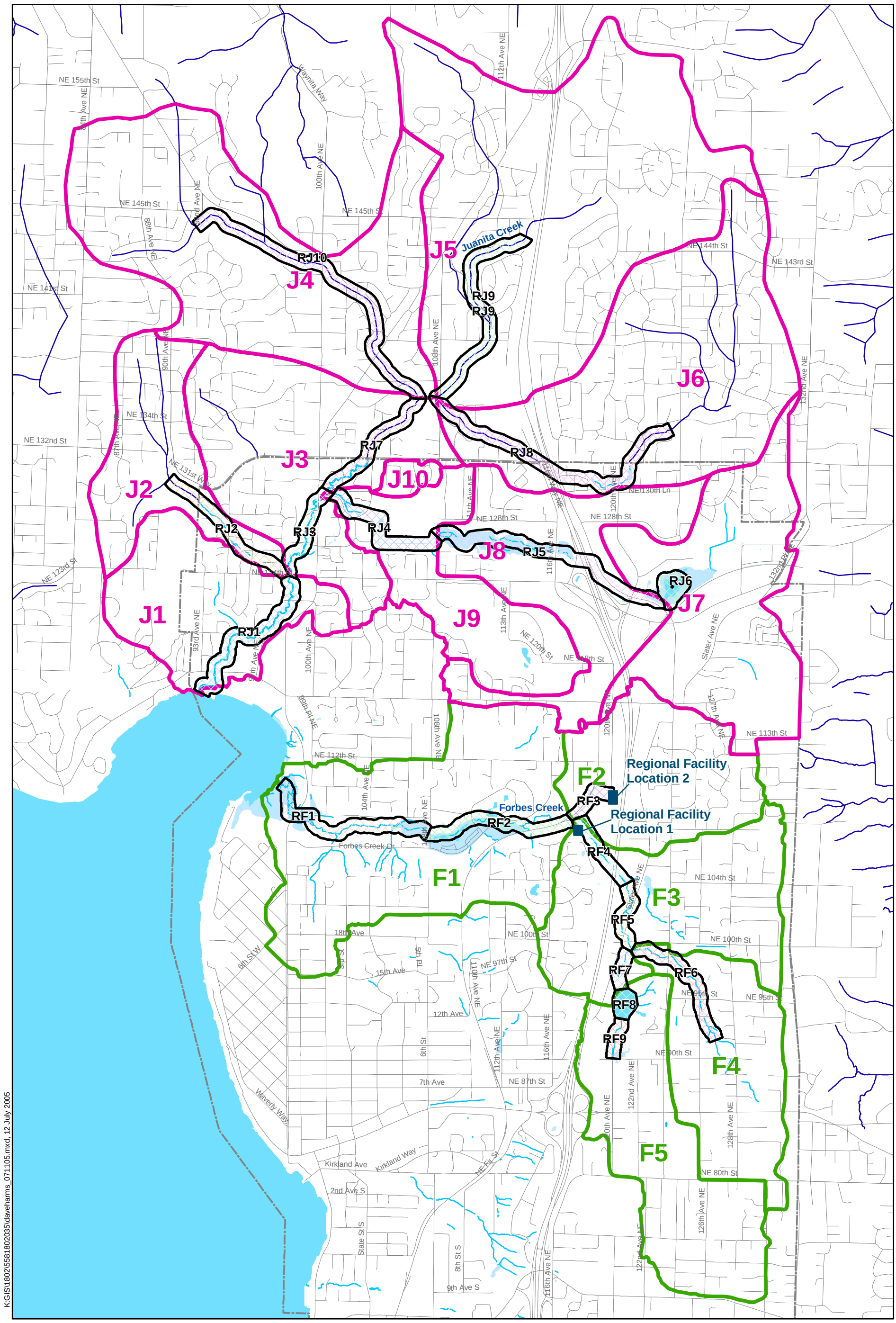

Feet
0 1,000 2,000
1 inch equals 2,000 feet

KC Street
KC Watercourse
Street Centerline
Stream
City Limit
Lake
Forbes Creek Subbasin
Juanita Creek Subbasin

Figure 1
Juanita Creek and
Forbes Creek Subbasins
City of Kirkland
Stormwater Management Plan