

# **Nechako Downstream Allocation Model (N-DAM)**

## **DRAFT Simulation Results**

**November 4, 2004**

Prepared by Dan Bouillon

# **Nechako Downstream Allocation Model (N-DAM) Simulation Results – November 1, 2004-11-02**

Here is the updated model output for your review.

Note there are only 6 scenarios for you to consider. More can be created at any time.

This replaces the previous model output presented on April 23, 2003. The results are fundamentally the same. I have improved the graphics, reorganized the output, and added more information to better compare wet versus dry years, and to assess the fit to sturgeon needs. I have also given each graph a unique letter and provide an explanation for each.

After years of discussion, and model development to better understand flow delivery, it has been determined that there is essentially two options for sharing flow. The first is to establish a 'Fixed Flow Sharing' formula between the river and the reservoir and deliver those shared flows each and every year. The second option was to vary the flow sharing based on a combination of indicators that assess natural variation in precipitation and reservoir level; this is called the 'Variable Flow Sharing Option'.

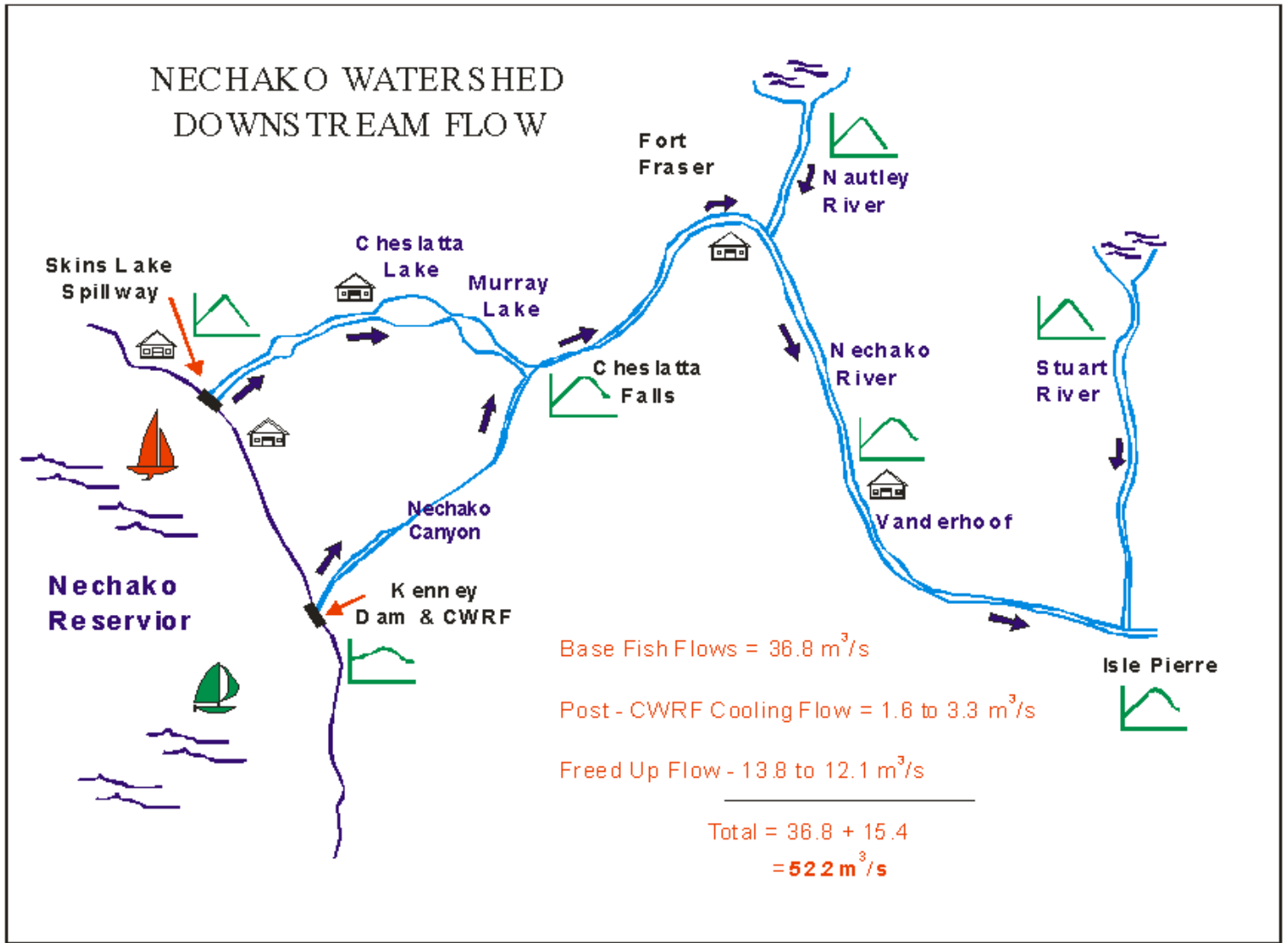
The output provided in this document allows you to consider either option described above. You can choose a fixed sharing value and assume that is what the river and reservoir get each and every year into the future (after a Cold Water Release Facility is built). Or, you can assume that the flow sharing between the reservoir and river will vary each year determined by the measurement of mountain snow pack and reservoir level on May 1<sup>st</sup> of each year. The extreme range in the flow sharing is approximately between 0 cms to the reservoir (12.9 cms to the river at a temperature target of 12 degrees) and 9.5 cms to the reservoir (3.4 cms to the river at a temperature target of 12 degrees). A final range has not been agreed upon. The results of the model simulations presented here will help give you an indication of what to expect at various places along the Nechako River as the flow sharing changes from year to year based on snow pack and reservoir level conditions.

There are an infinite number of possible combinations of model runs that could be produced. The six runs presented here give you a good indication of the full spectrum of outcomes that are possible, given certain assumptions. These assumptions are that the flow through the Skins Lake Spillway will be 15 cms annualized, the Kenney Dam release will be a constant 25 cms, and the temperature release at the cold water release facility will be 12 degrees C during the period July 20 to August 20 of each year. I have provided an additional two model runs to give an indication of how changes in these assumptions can change the model outcomes. In one scenario I assume a 10 degrees C temperature target instead of the 12 degree target. In the other simulation, I assume a constant flow out of the Kenney Dam of 26.4 cms instead of 25 (the former was calculated by Klohen Crippen as an alternative flow delivery for power production at the Kenney Dam. Note that I have assumed that the 15 cms from the SLS is pretty firm (the only possible change might be to the monthly flow delivery schedule that is not considered here).

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Dan Bouillon  
November 4, 2004

Illustration of the Nechako River Watershed indicating water delivery pathway, and the locations where the Nechako Downstream Allocation Model uses and summarizes data.



# Guide to Understanding the Graphs Presented in this Summary

The graphs in the following document are lettered from A to N. Each graph is explained in a brief description below. In addition, there is some terminology that is common to many graphs and these terms are defined below as well.

## Definitions for Some Commonly Used Terminology and Model Messages:

**Naturalized Redistribution =**

**N-DAM Solution =**

**FUF = Freed Up Flow.** The amount of water is that is made available by delivering cooler water during the summer temperature management period (July 20 to August 20) which can be accomplished by building a Cold Water Release Facility. [format, paragraph, Indentation Special, hanging]

**Modelled [results] =**

**Actual =**

**Required =**

**NR =** Nechako River

**M-C =** Murray – Cheslatta system

**SLS =** Skins Lake Spillway

**‘Water is Available’ =**

**‘Adjustment to NFCP Monthly Flows is Required’ =**

**‘Solution is Possible’ =**

## Graph Explanations:

A.

B.

C.

D.

**Table of Contents for N-DAM Simulations - November 01, 2004**  
 (All releases and flows are in cubic metres per second. Temperature is in centigrade.)

- 1) Introduction
- 2) Nechako Downstream Flow Diagram
- 3) Model Results:

SLS Release	KD Release	Temperature Target	Total FUF	FUF to Reservoir	FUF to River	Page # Start
15	25	12	12.9	0	12.9	1
15	25	12	12.9	2	10.9	2
15	25	12	12.9	3.9	9	3
15	25	12	12.9	6	6.9	4
15	25	12	12.9	8	4.9	5
15	25	12	12.9	9.5	3.4	6

For comparison purposes, other values (in red) are modeled as indicated below:

SLS Release	KD Release	Temperature Target	Total FUF	FUF to Reservoir	FUF to River	Page # Start
15	25	10	13.8	3.9	9.9	7
15	26.4	12	12.9	3.9	9.0	8

**Notes:**

The proposed flow sharing model that has evolved out of discussions with the Nechako Watershed Council is called the Variable Flow Sharing Model. It takes the level of the reservoir and the calculated reservoir inflow (based on snow pack) on May 1st of each year to determine the flow sharing formula between the Nechako River and the Nechako Reservoir. The amount of FUF delivered to the river can vary between 3.4 cms and 12.9 cms. The amount of flow that will be held back in the reservoir varies between 0 cms and 9.5 cms.

The model runs all assume a temperature target of 12 deg C. A lesser temperature target (10 or 11) would result in more FUF and therefore more water redistributed to the river.

These scenarios were prepared to illustrate the extreme ranges of solutions for flow sharing under the Variable Flow Sharing Model ranging from zero to 9.5 cms to the reservoir. Under the current principles of flow sharing, larger amounts to the reservoir are not possible, as some of the FUF is used to support stable flow through the SLS and stable flow through the Kenney Dam. The example of 3.9 is used instead of 4.0 cms to the reservoir as the outcomes are essentially the same, but the former represents the long term average expected annual amount of FUF held in the reservoir (and therefore a long term average FUF of 9.0 cms to the river).

The scenario with 3.9 cms of Freed Up Flow (FUF) to the reservoir represents the average case based on analysis of last half century of reservoir inflow data, using a proposal of variable FUF hold-back to the reservoir ranging from 0 to 10 cms. It is important to emphasize that this is an average only. The actual FUF retained in the reservoir would vary between 0 to 9.5 cms each year.

The scenario with 10 cms FUF to the reservoir does not work with the average FUF. The reason is that the base releases to the SLS and KD actually use up some of the expected FUF on an annual basis (remember that the required delivery to the river on an annual basis is 36.8 cms but the total of SLS plus KD = 40 cms in these scenarios). There is enough FUF to the river in all the other scenarios to compensate for this because there is at least 3.2 cms to the river to cover these demands. This is a good illustration of one of the tradeoffs of choosing the base flows at the SLS and KD.

Please consider these draft results for discussion purposes.

FUF to Reservoir =	<b>0</b>
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FUF to River =	<b>12.9</b>
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SLS Release =	<b>15</b>
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KD Release =	<b>25</b>
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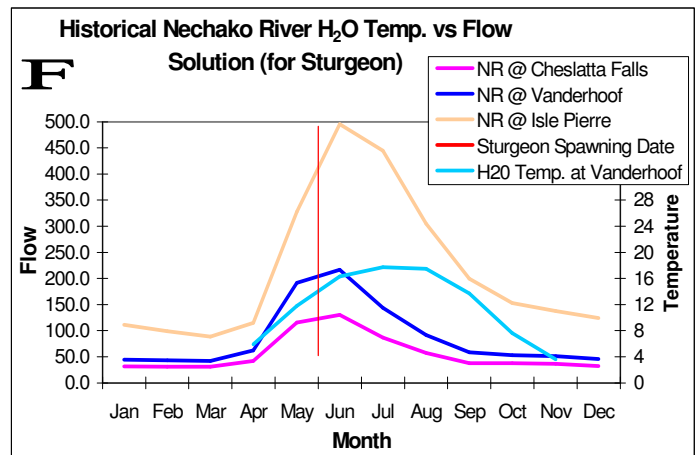
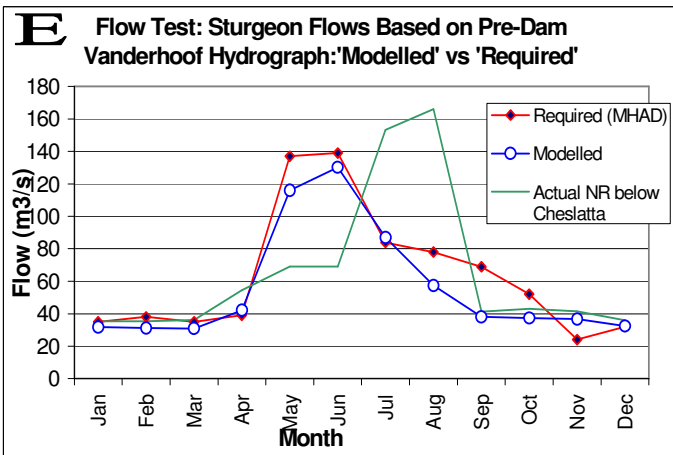
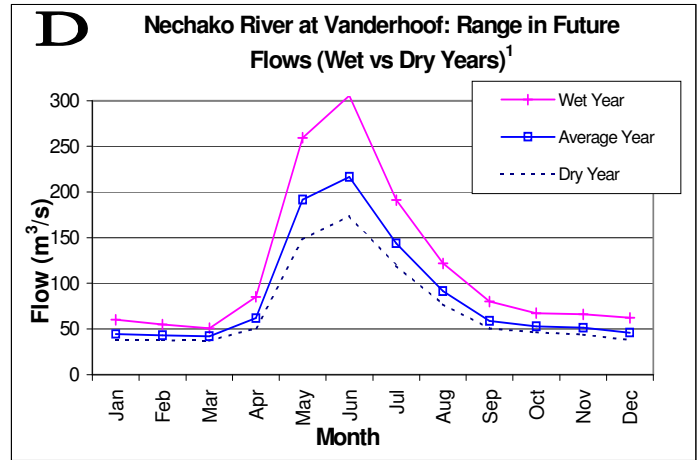
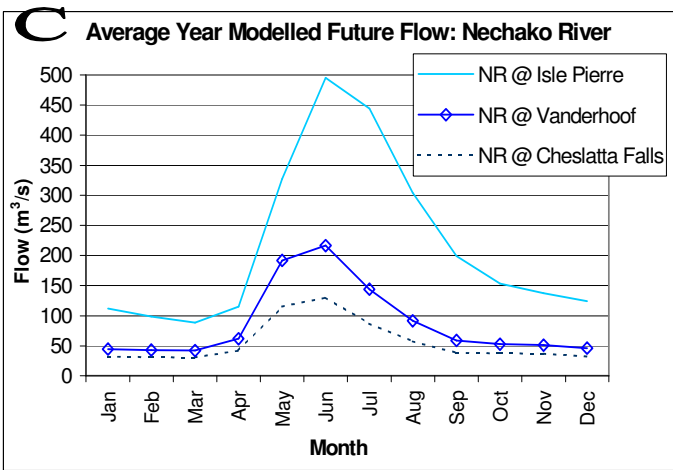
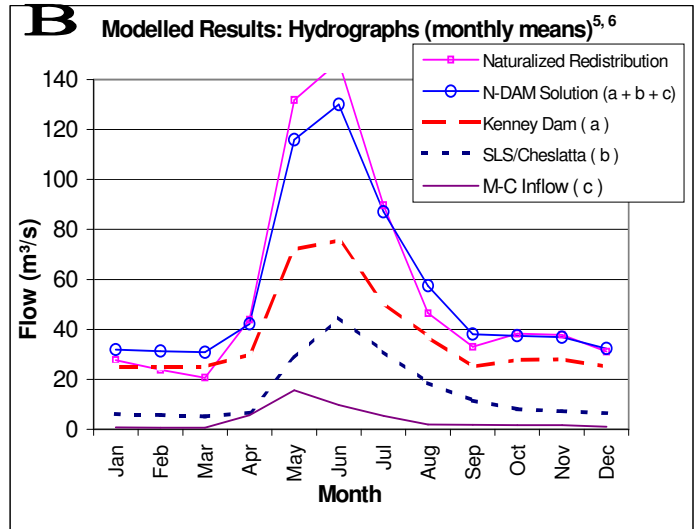
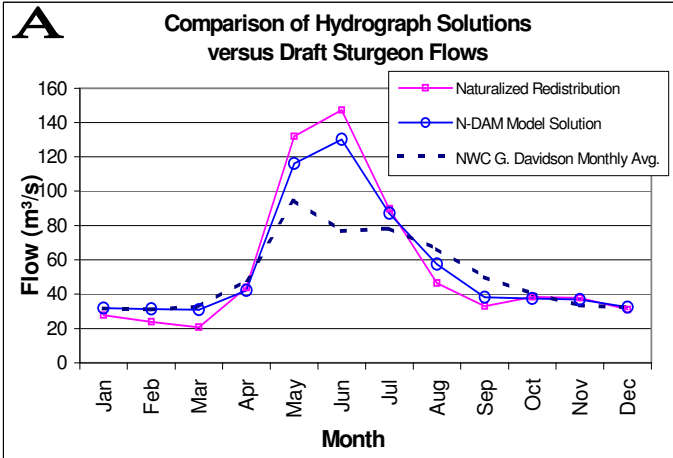
CWRF Temp Target =	<b>12</b>
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Lowest Score = Best Fit:

79	= Test of Fit (Sum of  Modelled - Naturalized Solution )
88%	= Percentage of Monthly Tests Passed
11	= Average Shortfall per Monthly Test Failed (m <sup>3</sup> /s)

\*\*\*WATER IS AVAILABLE\*\*\*  
\*\*\*ADJUSTMENT TO NFCP MONTHLY FLOWS REQUIRED\*\*\*  
\*\*\*SOLUTION IS POSSIBLE\*\*\*

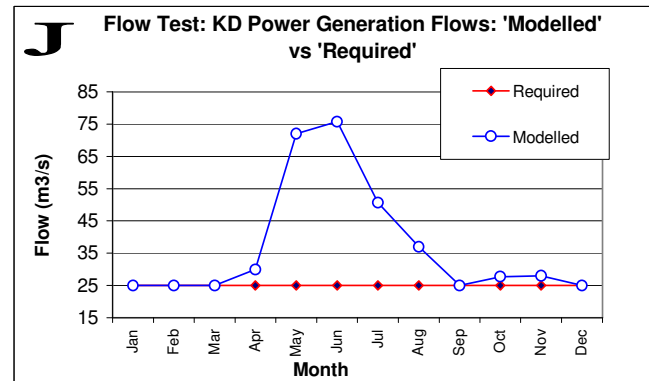
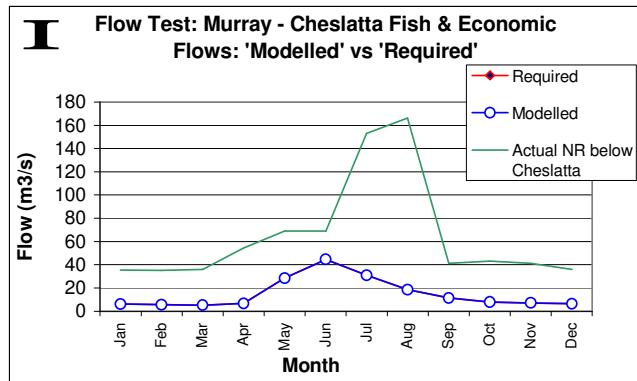
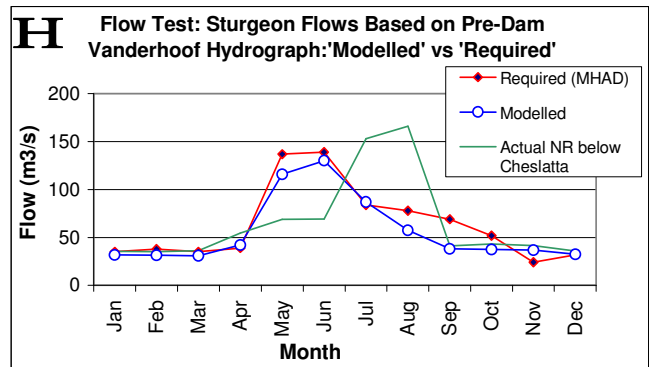
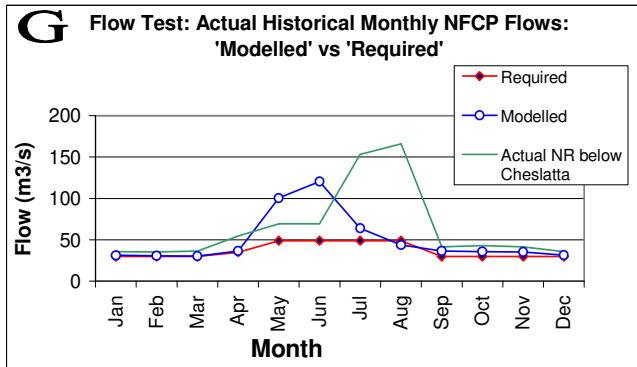
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15	Choose Skins Lake Spillway (SLS) Release Annualized <sup>1</sup>
25	Choose Kenney Dam (KD) Constant Daily Release
12	Choose Temperature Target for Water Release Facility
2.5	Average Cooling Release Annualized (Split 60:40 July:August)
12.9	Average Freed Up Flow (FUF) Available for Redistribution
12.9	Average Flow (FUF) to Redistribute in the Nechako River
0	Choose Average Freed-Up Flow (FUF) to Stay in Reservoir



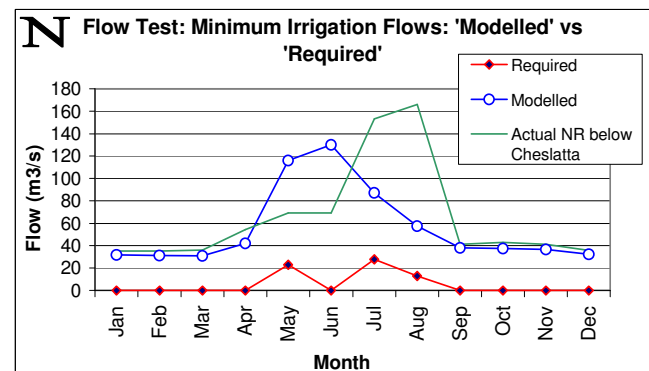
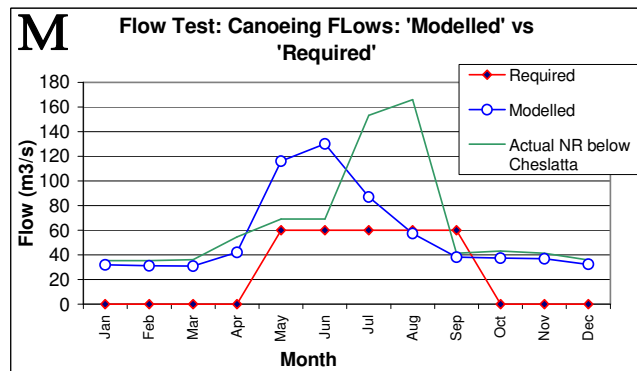
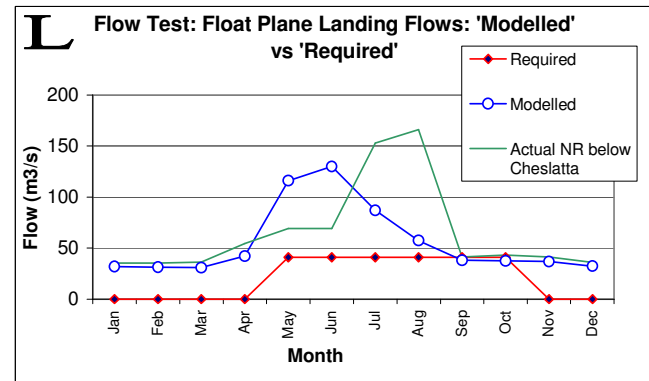
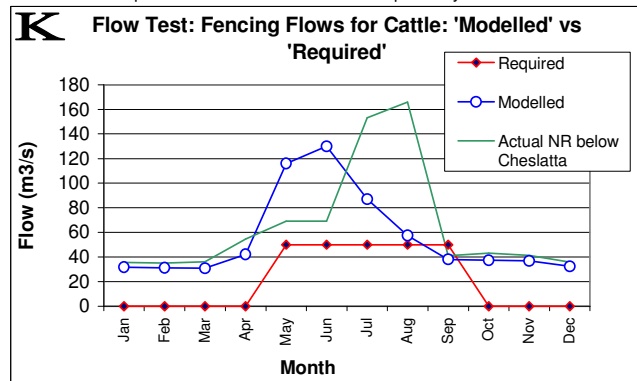
# Summary of Flow Tests to Compare Modelled Output to Needs as Defined by Stakeholders:

FUF to River =	<b>12.9</b>
SLS Release =	<b>15</b>
CWRF Temp Target =	<b>12</b>

FUF to Reservoir =	<b>0</b>
KD Release =	<b>25</b>



Note: Required and Modelled results overlap exactly above.





FUF to Reservoir =	<b>2</b>
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FUF to River =	<b>10.9</b>
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SLS Release =	<b>15</b>
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KD Release =	<b>25</b>
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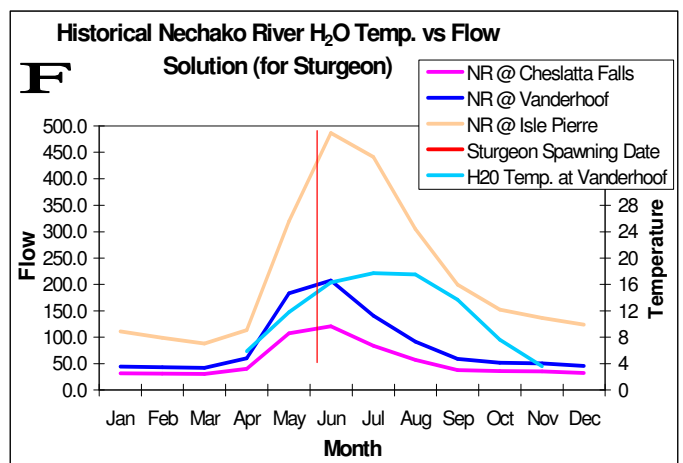
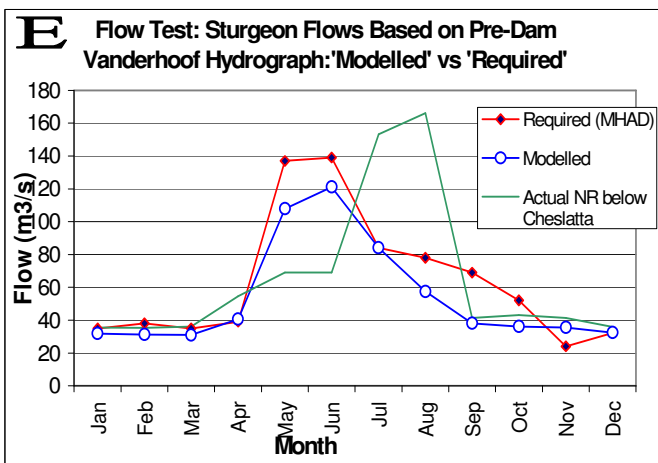
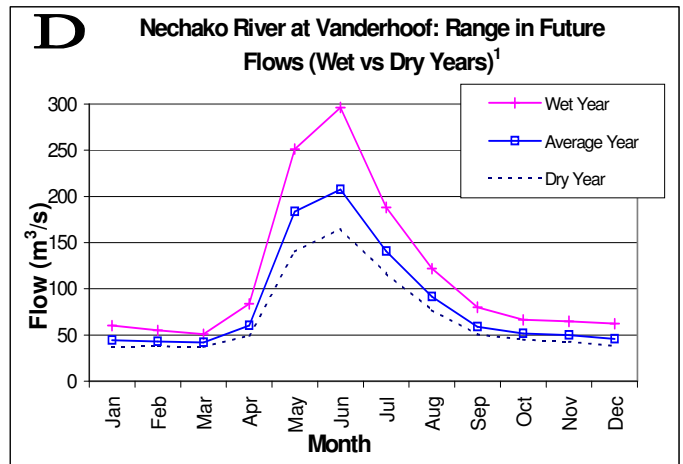
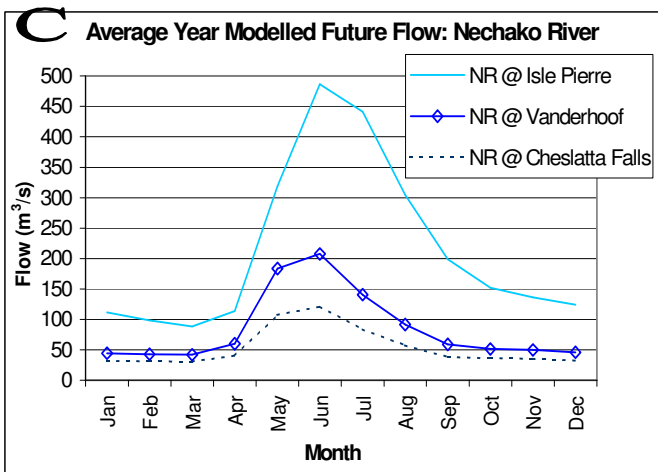
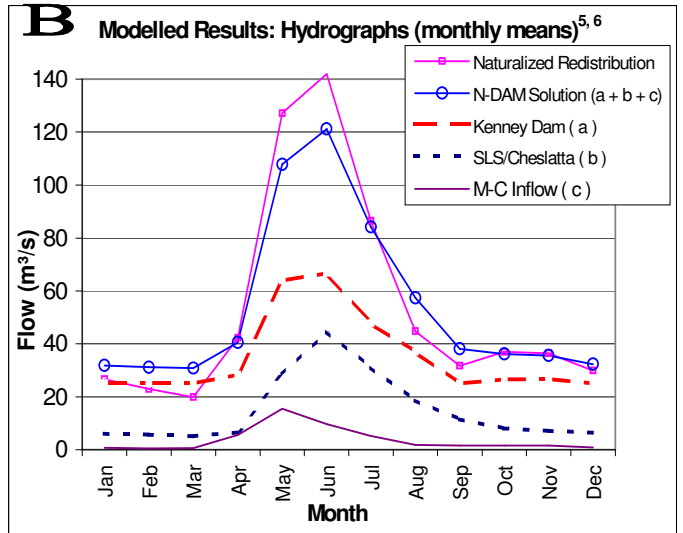
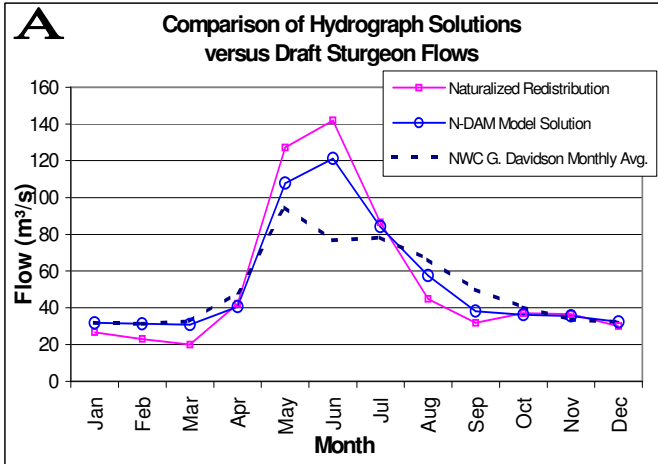
CWRF Temp Target =	<b>12</b>
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Lowest Score = Best Fit:

92	= Test of Fit ( $\sum  Modelled - Naturalized Solution $ )
88%	= Percentage of Monthly Tests Passed
12	= Average Shortfall per Monthly Test Failed ( $m^3/s$ )

\*\*\*WATER IS AVAILABLE\*\*\*  
 \*\*\*ADJUSTMENT TO NFCP MONTHLY FLOWS REQUIRED\*\*\*  
 \*\*\*SOLUTION IS POSSIBLE\*\*\*

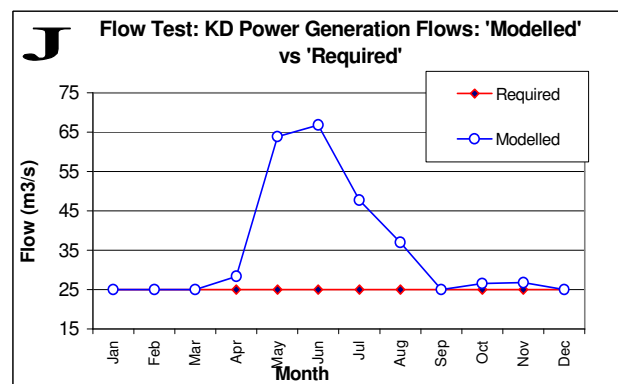
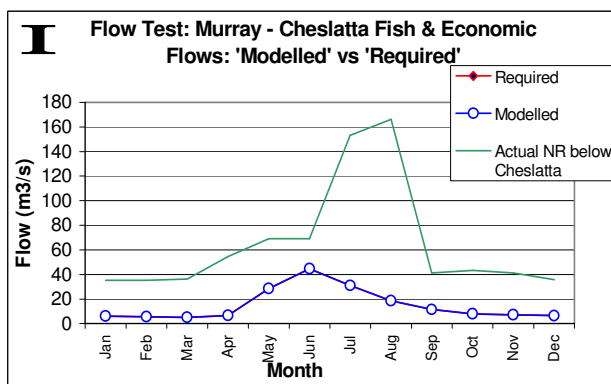
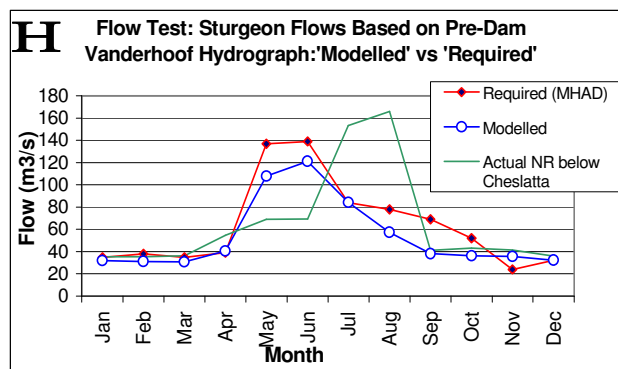
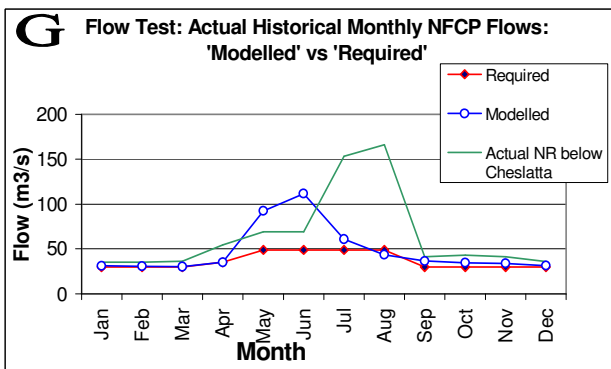
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15	Choose Skins Lake Spillway (SLS) Release Annualized <sup>1</sup>
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2	Choose Average Freed-Up Flow (FUF) to Stay in Reservoir



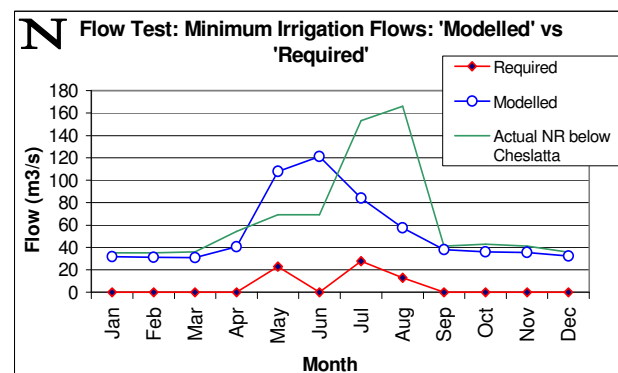
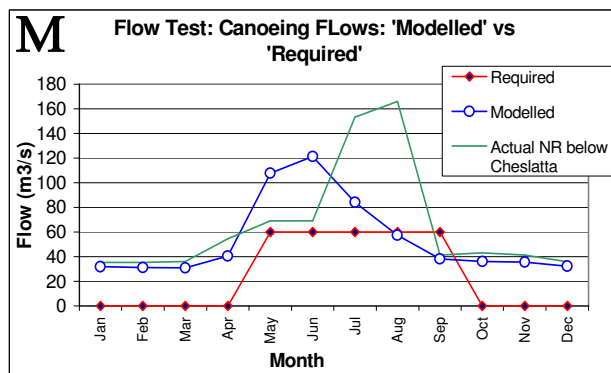
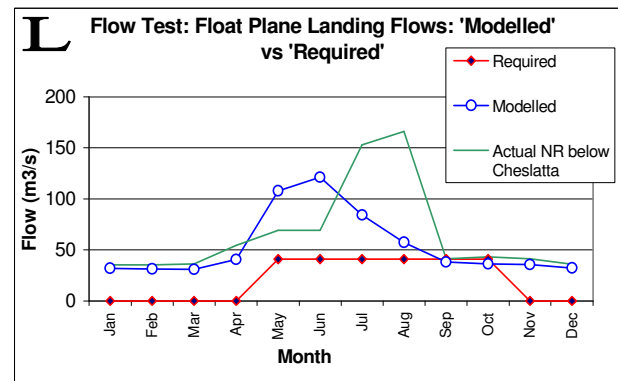
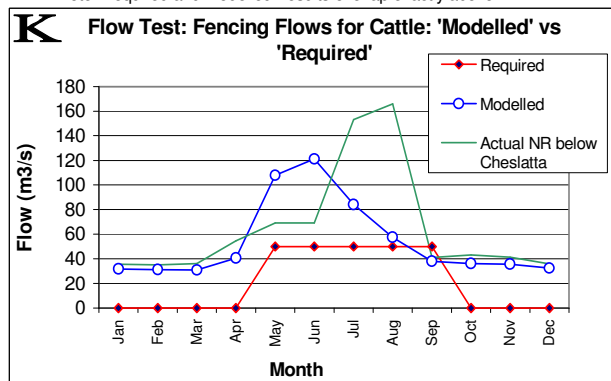
# Summary of Flow Tests to Compare Modelled Output to Needs as Defined by Stakeholders:

FUF to River =	<b>10.9</b>
SLS Release =	<b>15</b>
CWRF Temp Target =	<b>12</b>

FUF to Reservoir =	<b>2</b>
KD Release =	<b>25</b>



Note: Required and Modelled results overlap exactly above.



FUF to Reservoir =	<b>3.9</b>
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FUF to River =	<b>9</b>
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SLS Release =	<b>15</b>
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KD Release =	<b>25</b>
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CWRF Temp Target =	<b>12</b>
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**Lowest Score = Best Fit:**

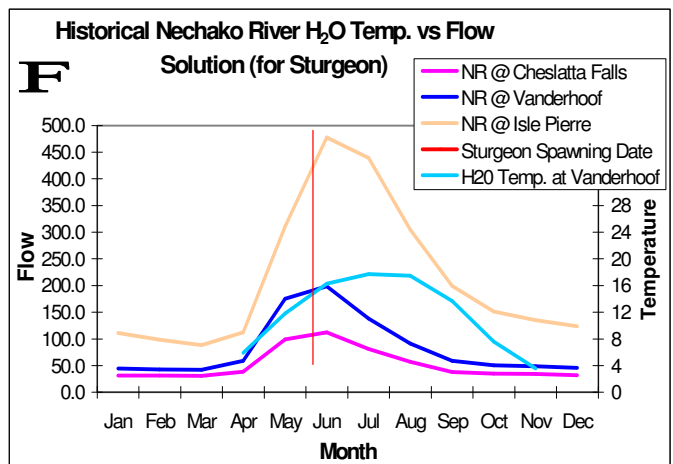
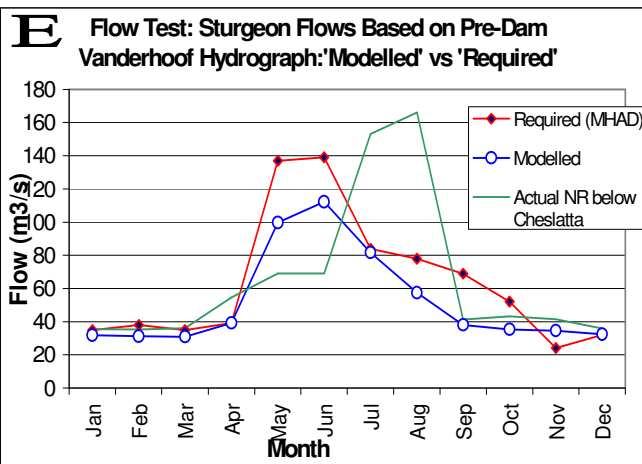
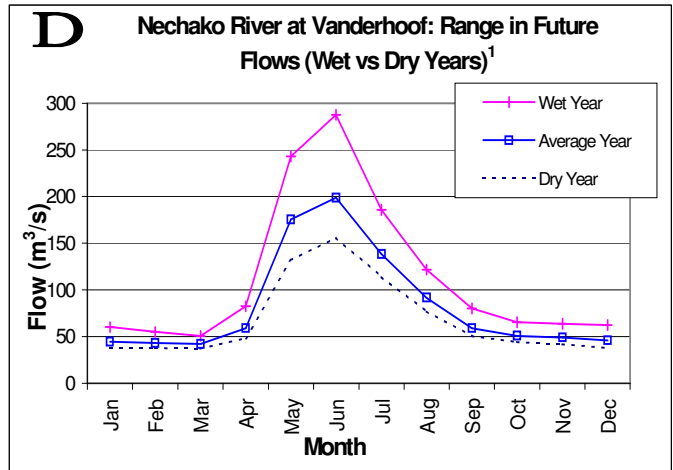
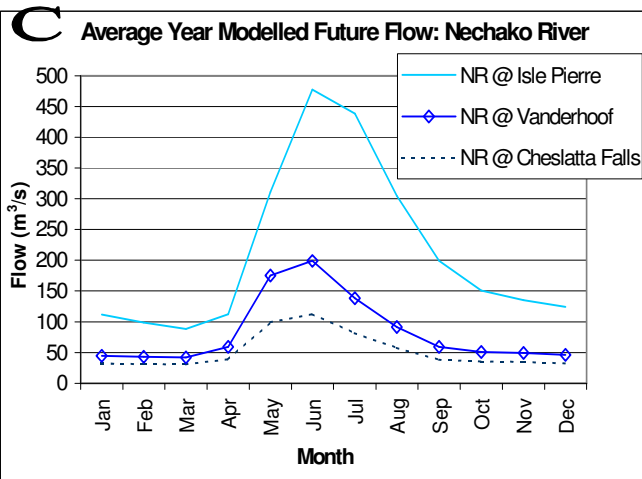
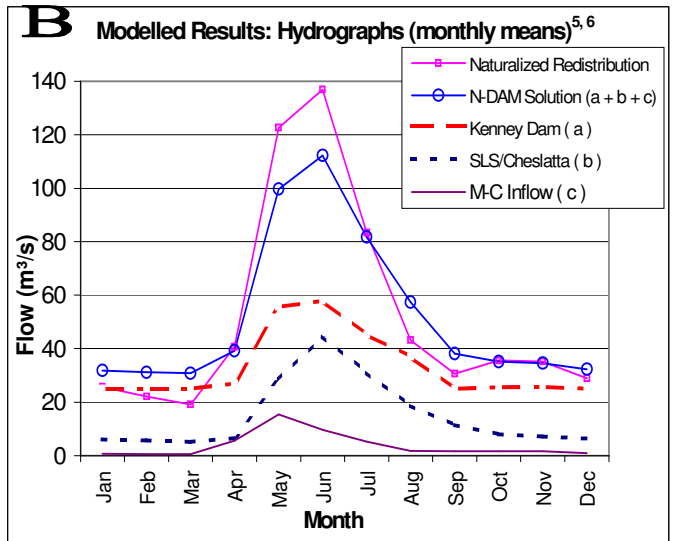
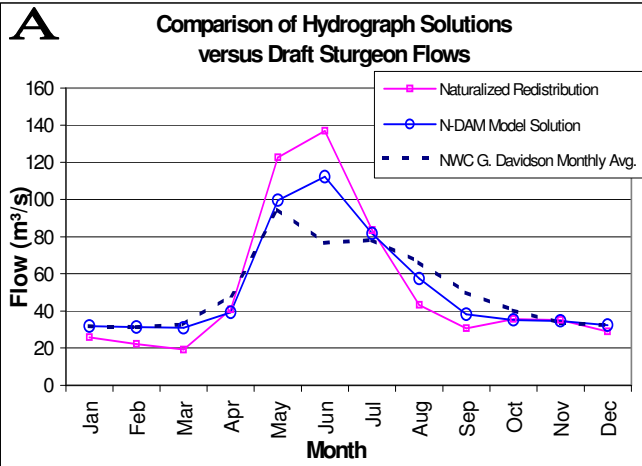
<b>104</b>	<b>= Test of Fit (Sum<sup>q</sup> Modelled - Naturalized Solution )</b>
<b>86%</b>	<b>= Percentage of Monthly Tests Passed</b>
<b>12</b>	<b>= Average Shortfall per Monthly Test Failed (m<sup>3</sup>/s)</b>

**\*\*\*WATER IS AVAILABLE\*\*\***

**\*\*\*ADJUSTMENT TO NFCP MONTHLY FLOWS REQUIRED\*\*\***

**\*\*\*SOLUTION IS POSSIBLE\*\*\***

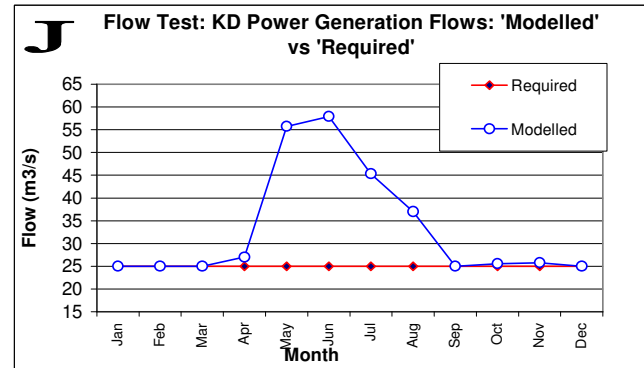
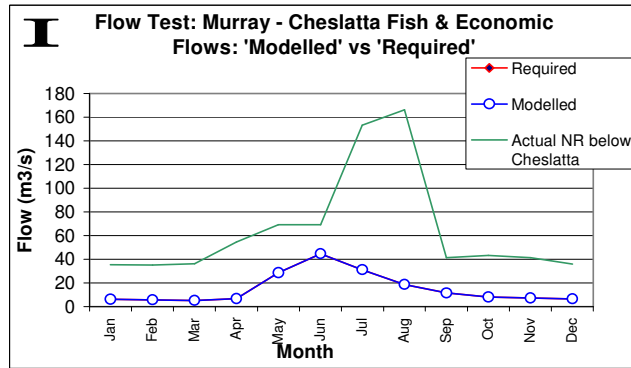
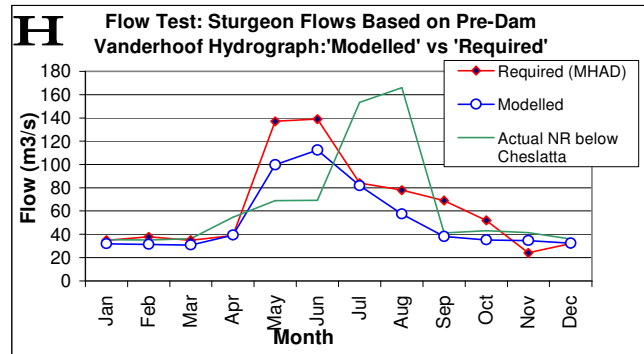
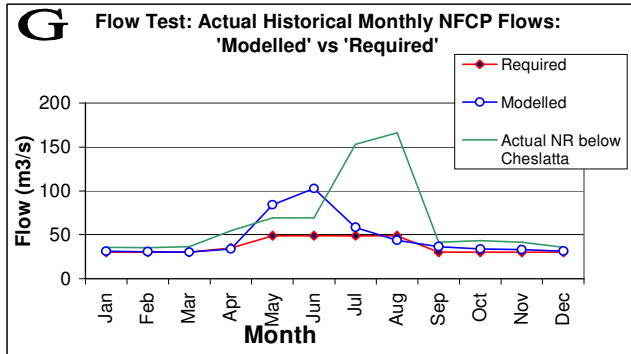
Parameter Choices From 'Model & Results' Work Sheet	
<b>15</b>	Choose Skins Lake Spillway (SLS) Release Annualized <sup>1</sup>
<b>25</b>	Choose Kenney Dam (KD) Constant Daily Release
<b>12</b>	Choose Temperature Target for Water Release Facility
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<b>12.9</b>	Average Freed Up Flow (FUF) Available for Redistribution
<b>9</b>	Average Flow (FUF) to Redistribute in the Nechako River
<b>3.9</b>	Choose Average Freed-Up Flow (FUF) to Stay in Reservoir



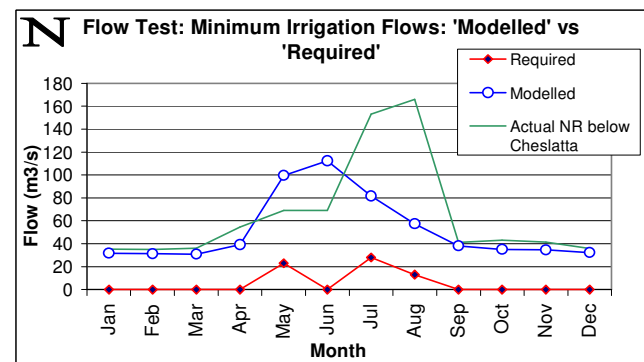
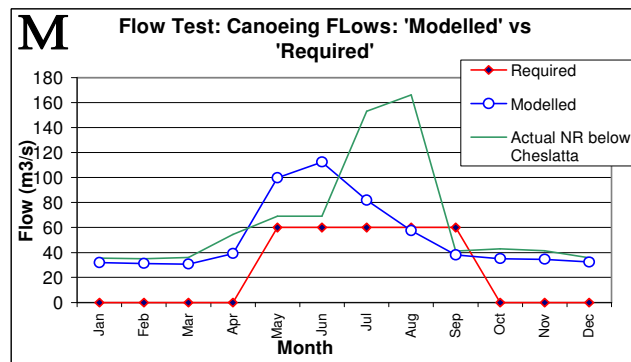
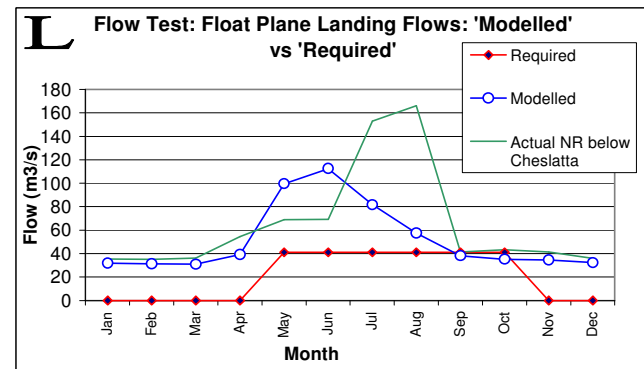
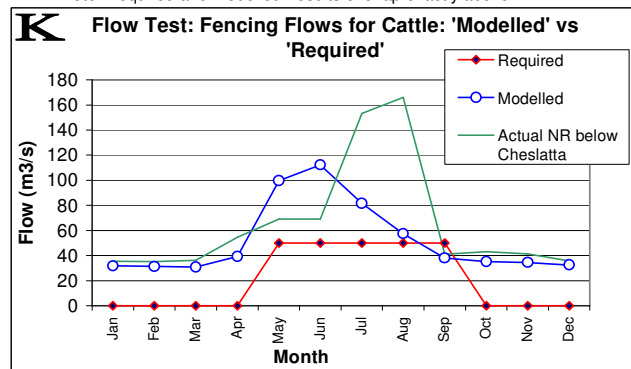
# Summary of Flow Tests to Compare Modelled Output to Needs as Defined by Stakeholders:

FUF to River =	<b>9</b>
SLS Release =	<b>15</b>
CWRP Temp Target =	<b>12</b>

FUF to Reservoir =	<b>3.9</b>
KD Release =	<b>25</b>



Note: Required and Modelled results overlap exactly above.



FUF to Reservoir =	<b>6</b>
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FUF to River =	<b>6.9</b>
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SLS Release =	<b>15</b>
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KD Release =	<b>25</b>
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CWRF Temp Target =	<b>12</b>
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Parameter Choices From 'Model & Results' Work Sheet	
15	Choose Skins Lake Spillway (SLS) Release Annualized <sup>1</sup>
25	Choose Kenney Dam (KD) Constant Daily Release
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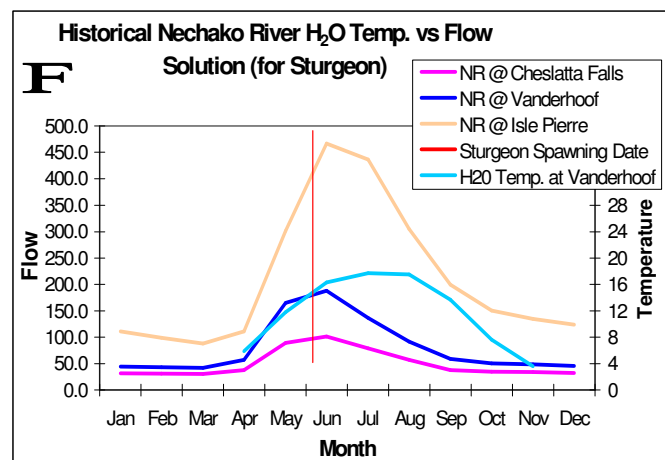
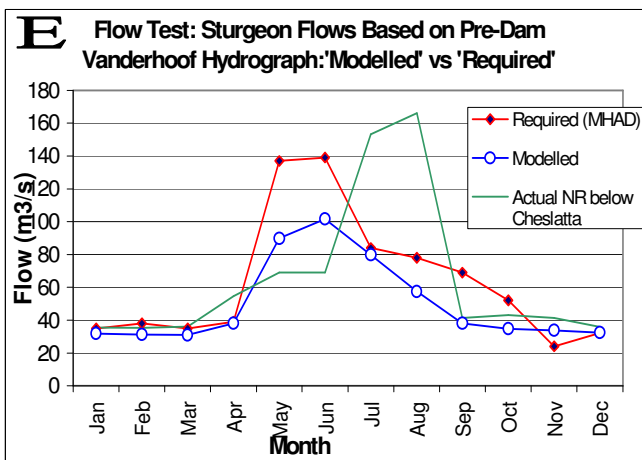
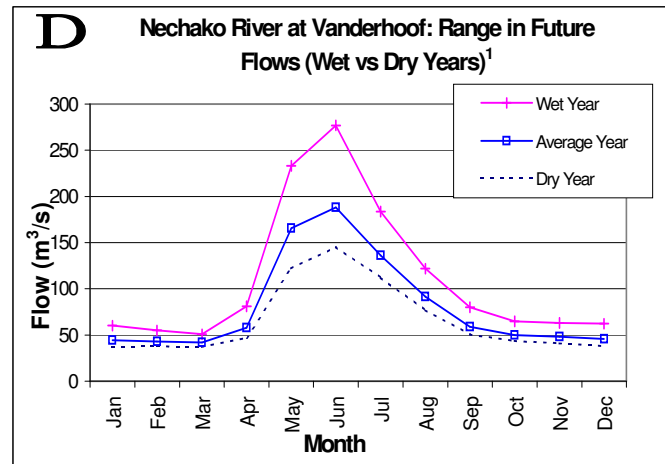
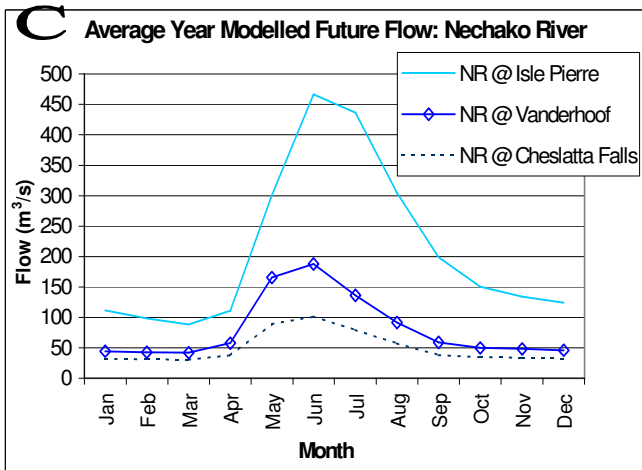
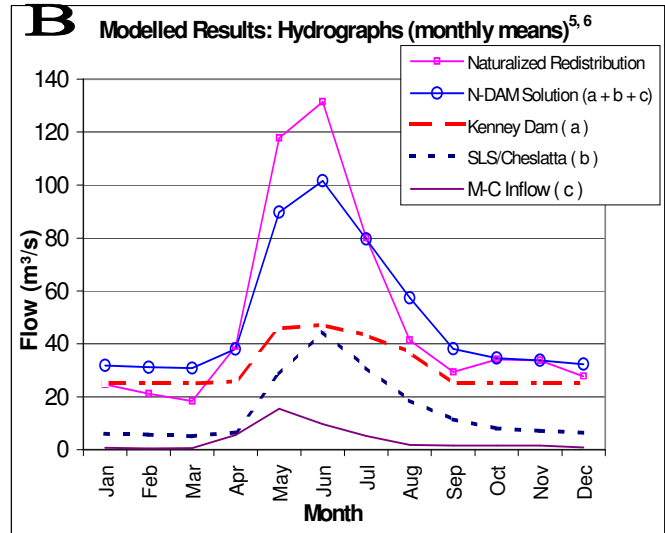
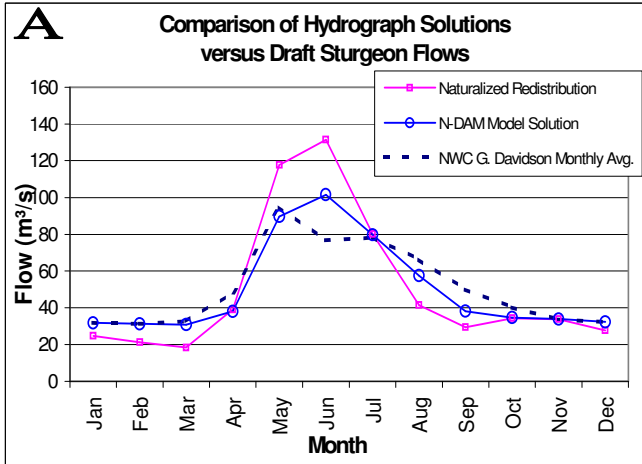
**Lowest Score = Best Fit:**

119	= Test of Fit (Sum <sup>d</sup>  Modelled - Naturalized Solution )
85%	= Percentage of Monthly Tests Passed
13	= Average Shortfall per Monthly Test Failed (m <sup>3</sup> /s)

\*\*\*WATER IS AVAILABLE\*\*\*

\*\*\*ADJUSTMENT TO NFCP MONTHLY FLOWS REQUIRED\*\*\*

\*\*\*SOLUTION IS POSSIBLE\*\*\*

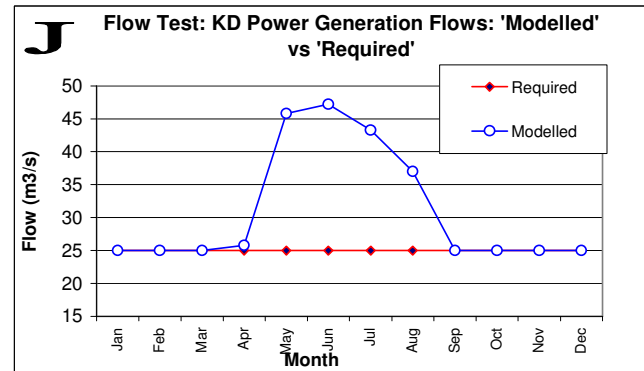
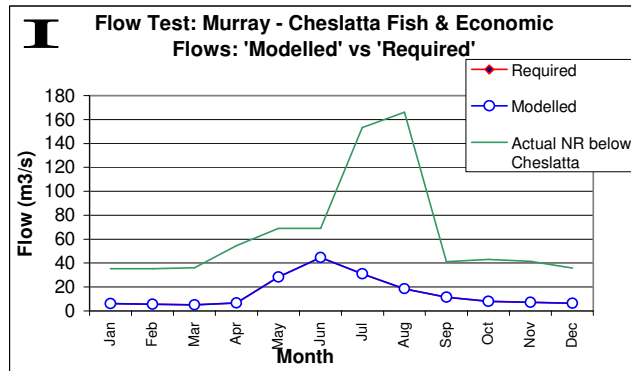
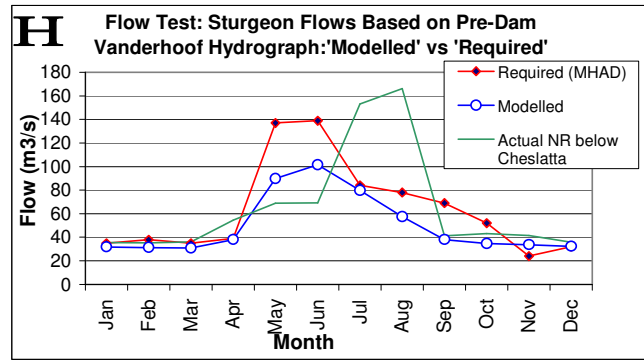
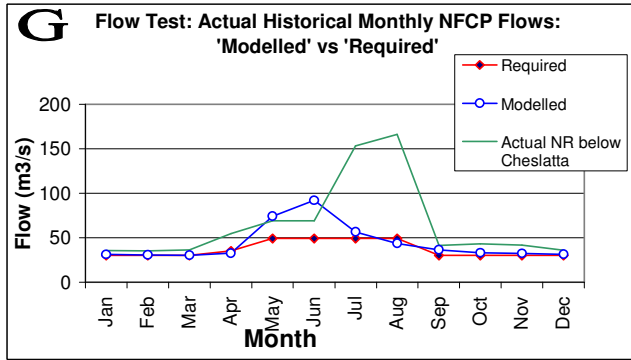




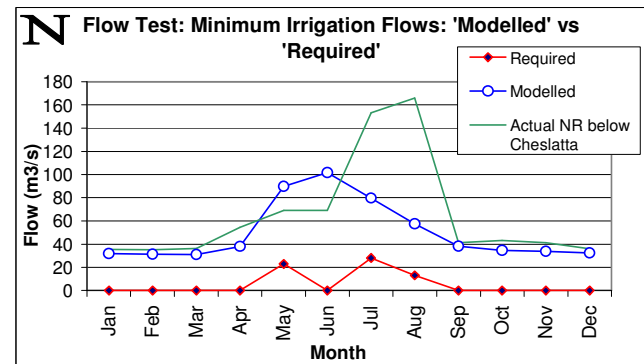
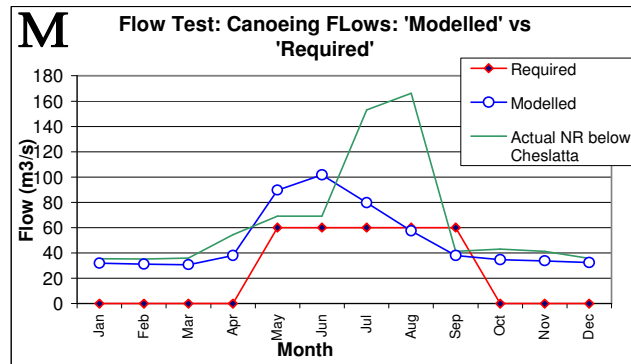
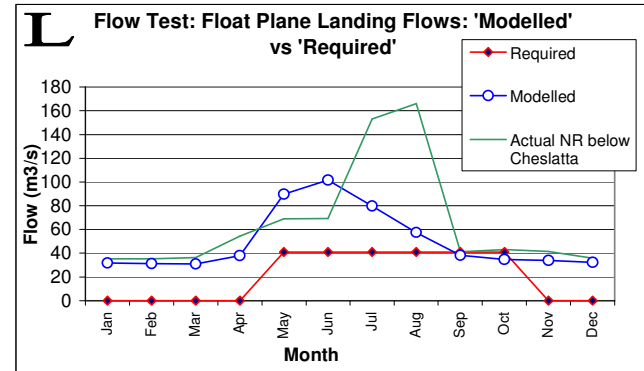
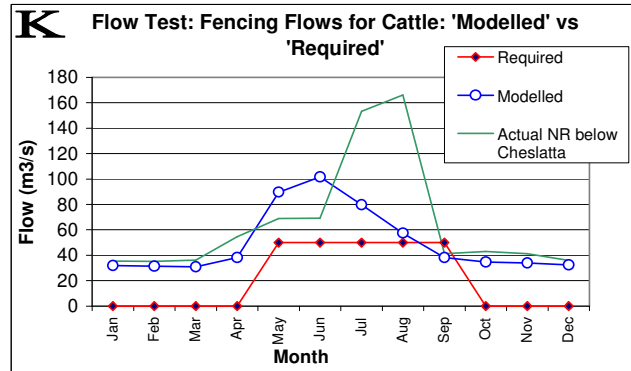
# Summary of Flow Tests to Compare Modelled Output to Needs as Defined by Stakeholders:

FUF to River =	<b>6.9</b>
SLS Release =	<b>15</b>
CWRF Temp Target =	<b>12</b>

FUF to Reservoir =	<b>6</b>
KD Release =	<b>25</b>



Note: Required and Modelled results overlap exactly above.



FUF to Reservoir =	<b>8</b>
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FUF to River =	<b>4.9</b>
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SLS Release =	<b>15</b>
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KD Release =	<b>25</b>
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CWRF Temp Target =	<b>12</b>
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Lowest Score = Best Fit:

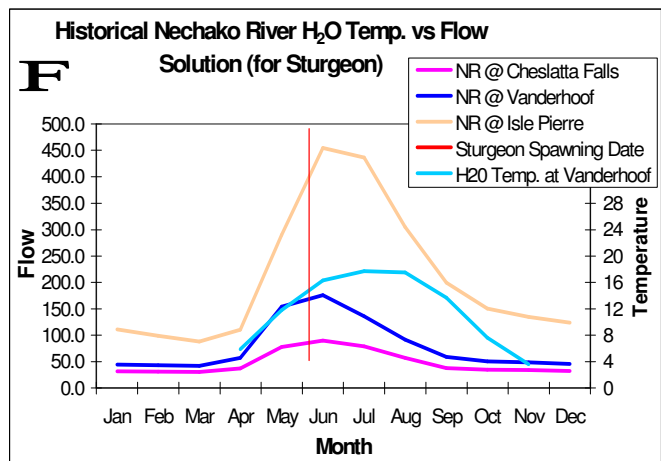
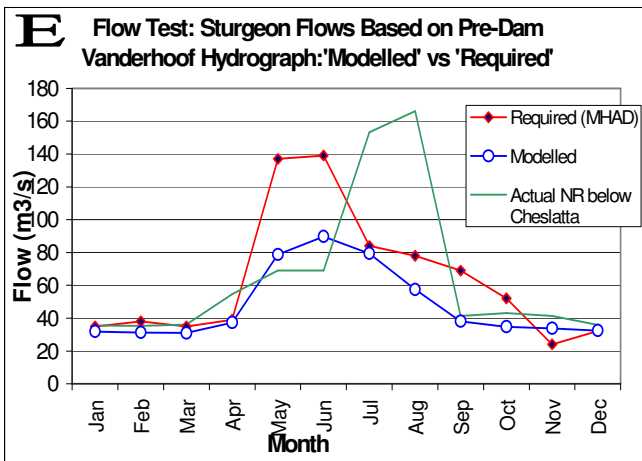
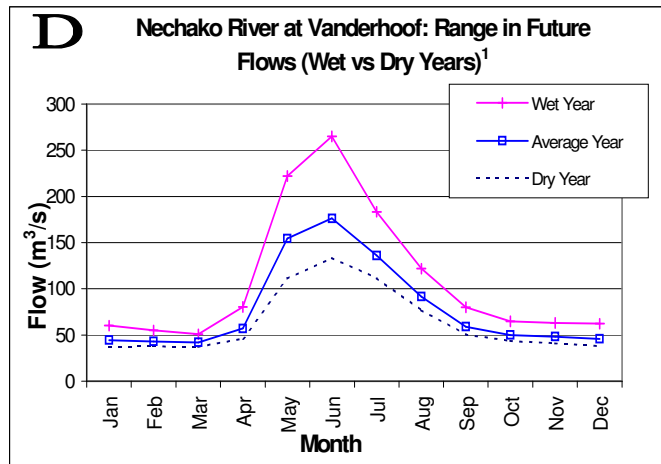
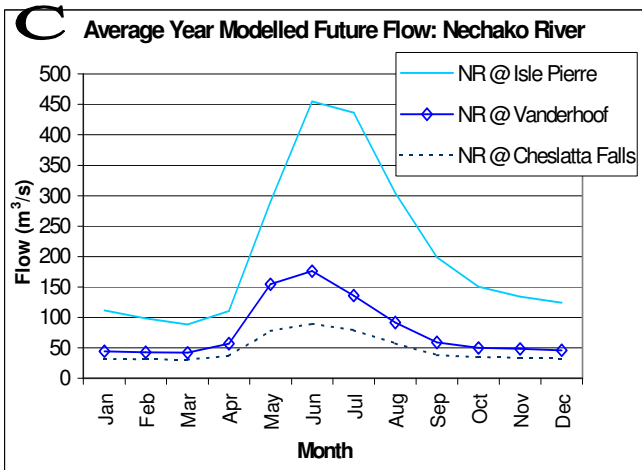
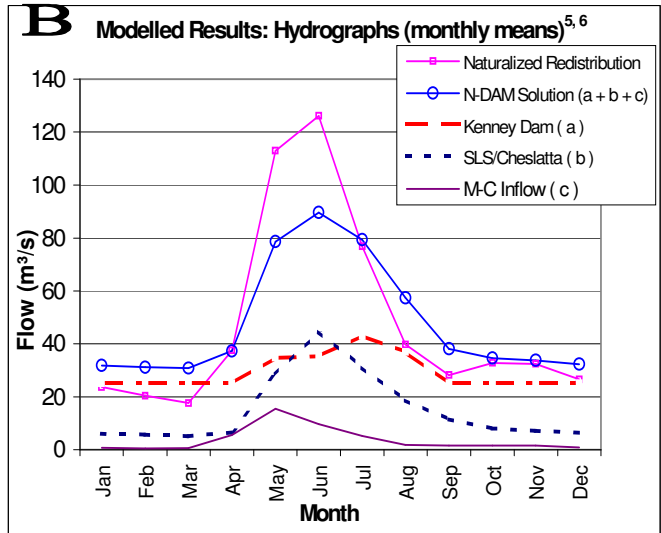
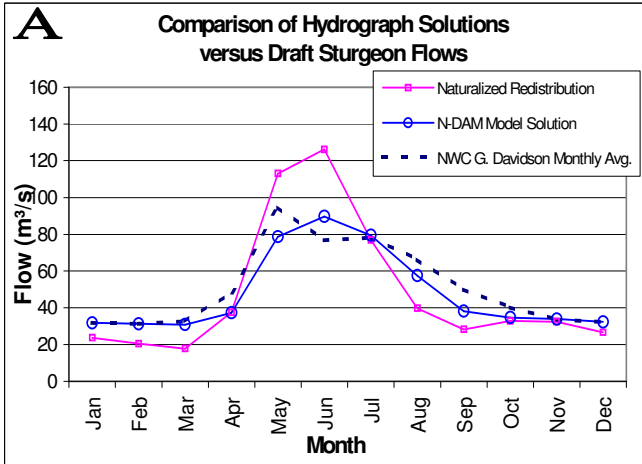
142	= Test of Fit ( $\sum  Modelled - Naturalized Solution $ )
85%	= Percentage of Monthly Tests Passed
15	= Average Shortfall per Monthly Test Failed ( $m^3/s$ )

\*\*\*WATER IS AVAILABLE\*\*\*

\*\*\*ADJUSTMENT TO NFCP MONTHLY FLOWS REQUIRED\*\*\*

\*\*\*SOLUTION IS POSSIBLE\*\*\*

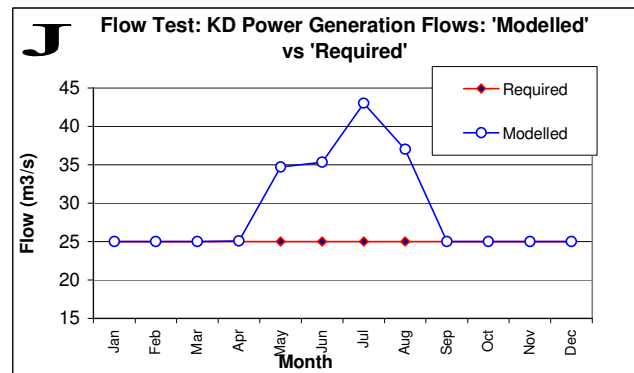
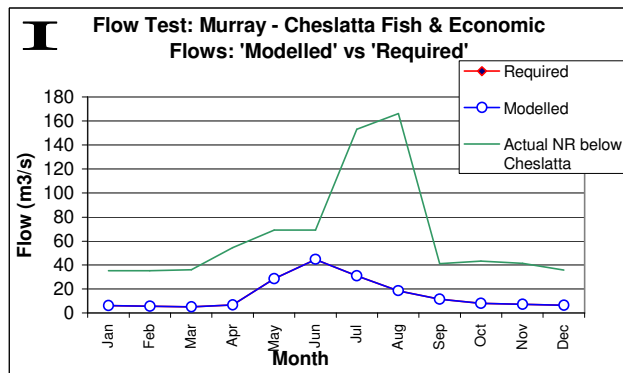
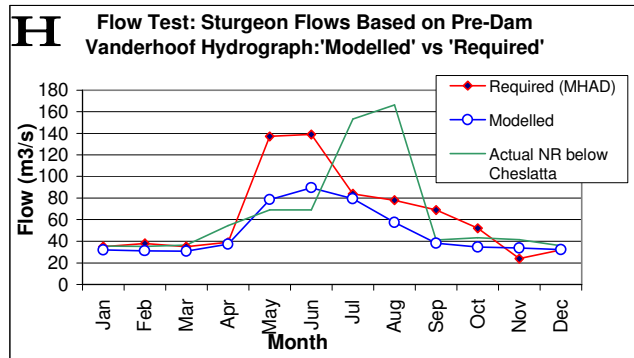
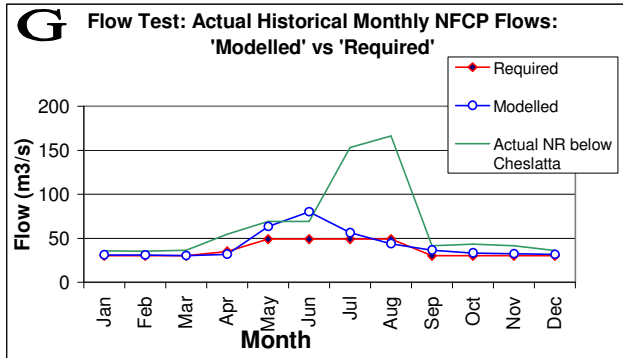
Parameter Choices From 'Model & Results' Work Sheet	
15	Choose Skins Lake Spillway (SLS) Release Annualized <sup>1</sup>
25	Choose Kenney Dam (KD) Constant Daily Release
12	Choose Temperature Target for Water Release Facility
2.5	Average Cooling Release Annualized (Split 60:40 July:August)
12.9	Average Freed Up Flow (FUF) Available for Redistribution
4.9	Average Flow (FUF) to Redistribute in the Nechako River
8	Choose Average Freed-Up Flow (FUF) to Stay in Reservoir



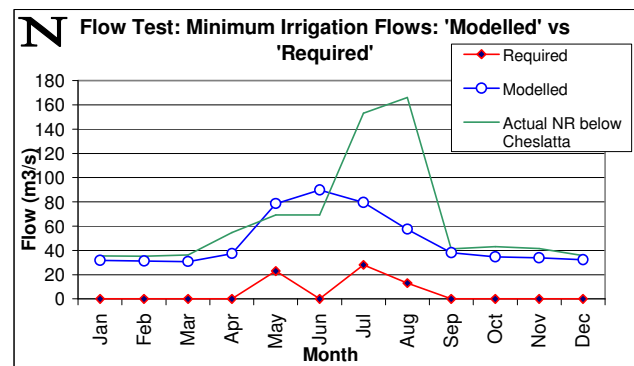
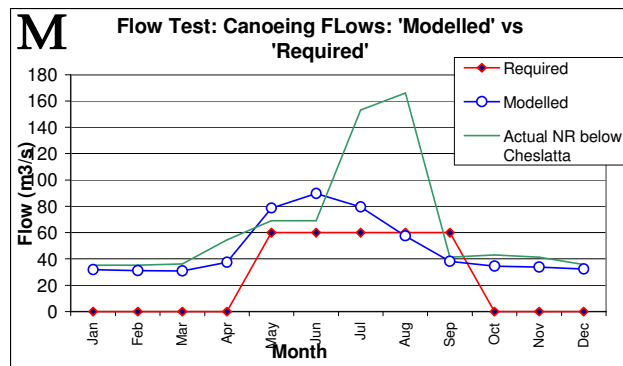
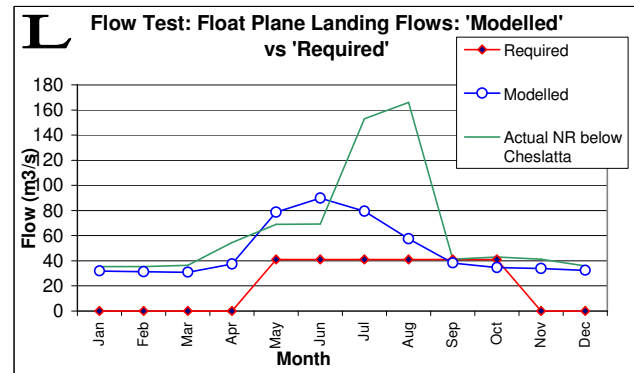
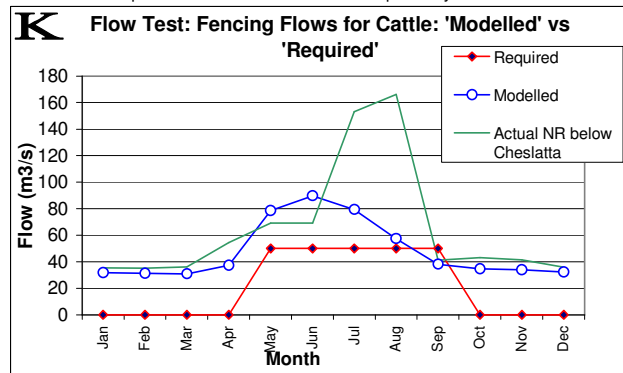
# Summary of Flow Tests to Compare Modelled Output to Needs as Defined by Stakeholders:

FUF to River =	<b>49</b>
SLS Release =	<b>15</b>
CWRP Temp Target =	<b>12</b>

FUF to Reservoir =	<b>8</b>
KD Release =	<b>25</b>



Note: Required and Modelled results overlap exactly above.



FUF to Reservoir =	<b>9.5</b>
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FUF to River =	<b>3.4</b>
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SLS Release =	<b>15</b>
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KD Release =	<b>25</b>
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CWRF Temp Target =	<b>12</b>
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Lowest Score = Best Fit:

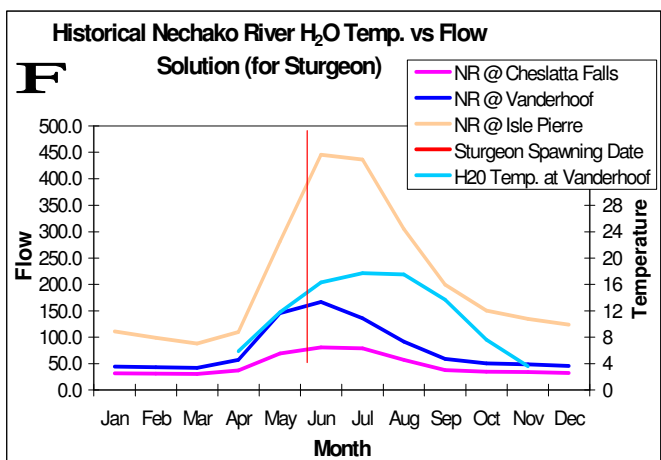
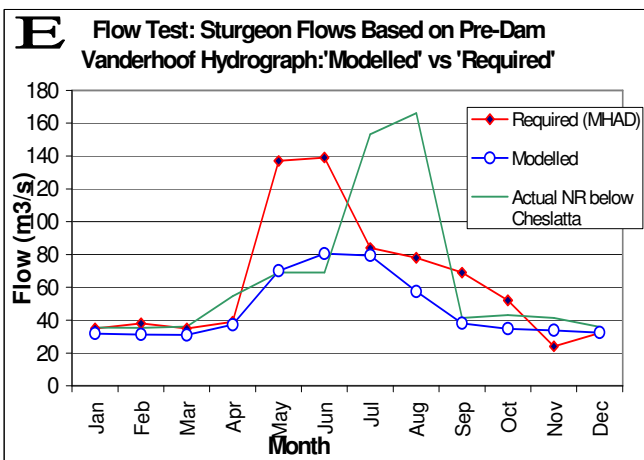
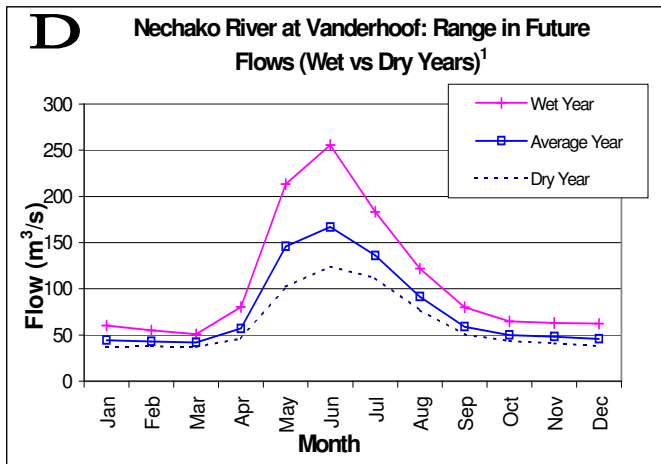
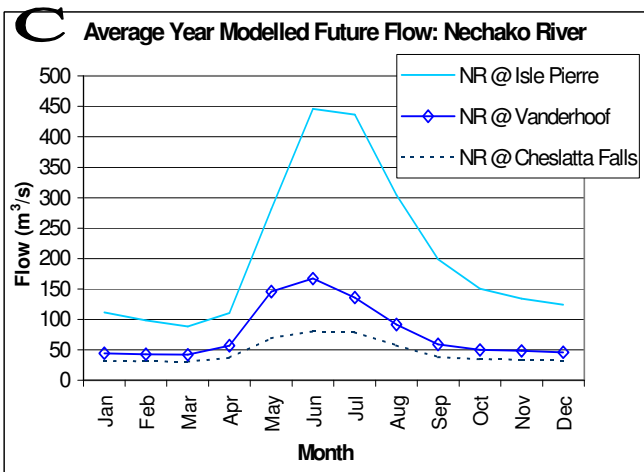
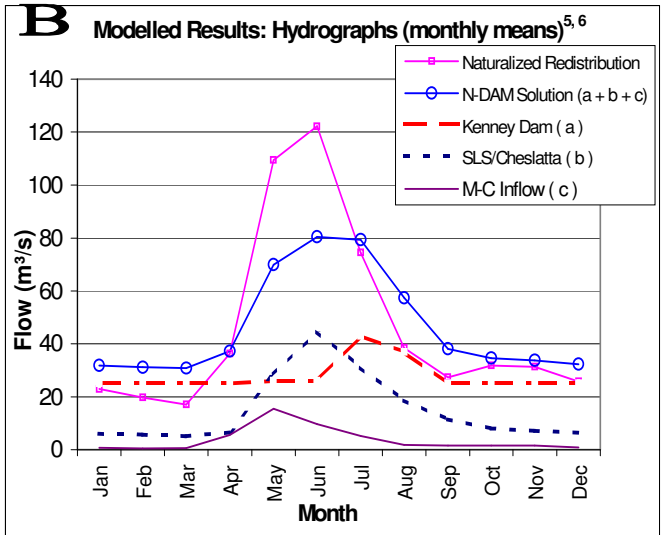
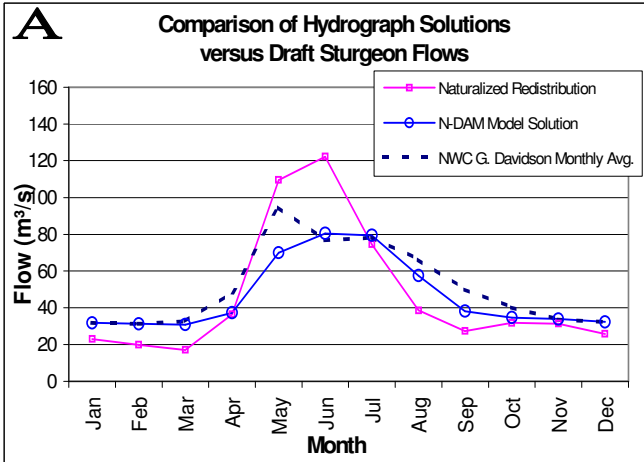
163	= Test of Fit ( $\sum  Modelled - Naturalized Solution $ )
85%	= Percentage of Monthly Tests Passed
17	= Average Shortfall per Monthly Test Failed ( $m^3/s$ )

\*\*\*WATER IS AVAILABLE\*\*\*

\*\*\*ADJUSTMENT TO NFCP MONTHLY FLOWS REQUIRED\*\*\*

\*\*\*SOLUTION IS POSSIBLE\*\*\*

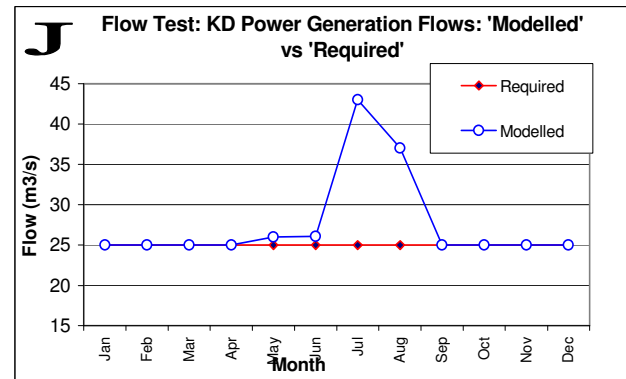
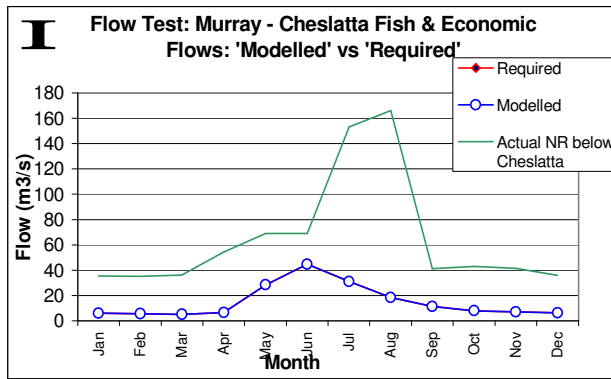
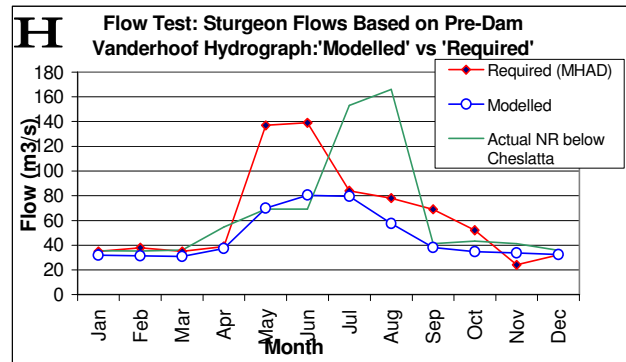
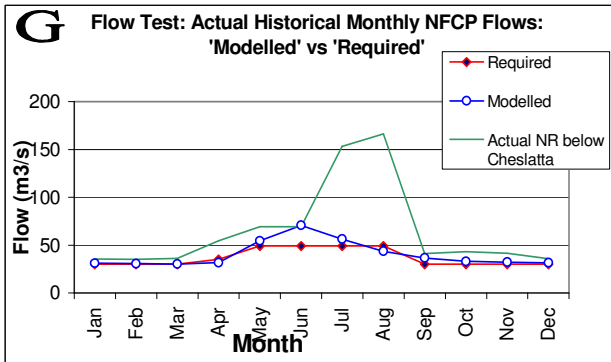
Parameter Choices From 'Model & Results' Work Sheet	
15	Choose Skins Lake Spillway (SLS) Release Annualized <sup>1</sup>
25	Choose Kenney Dam (KD) Constant Daily Release
12	Choose Temperature Target for Water Release Facility
2.5	Average Cooling Release Annualized (Split 60:40 July:August)
12.9	Average Freed Up Flow (FUF) Available for Redistribution
3.4	Average Flow (FUF) to Redistribute in the Nechako River
9.5	Choose Average Freed-Up Flow (FUF) to Stay in Reservoir



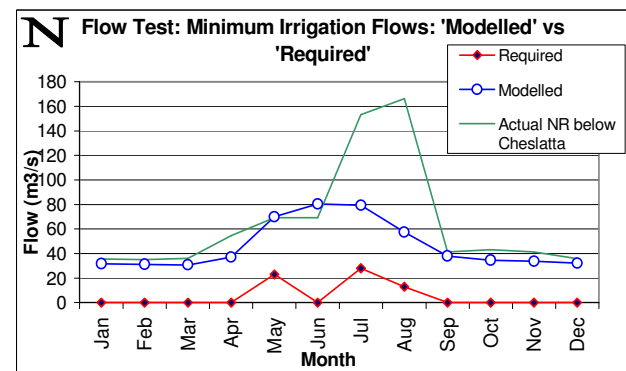
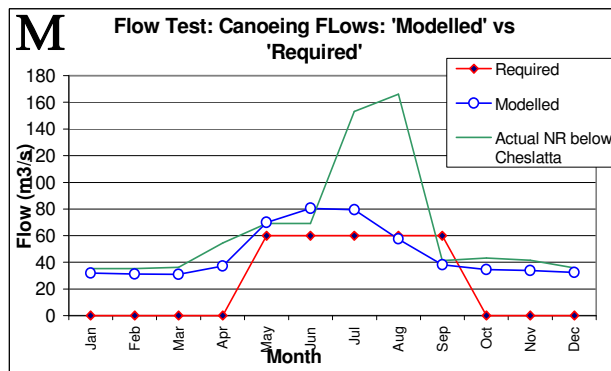
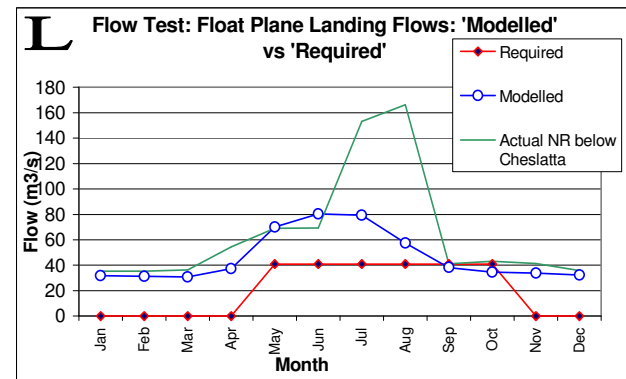
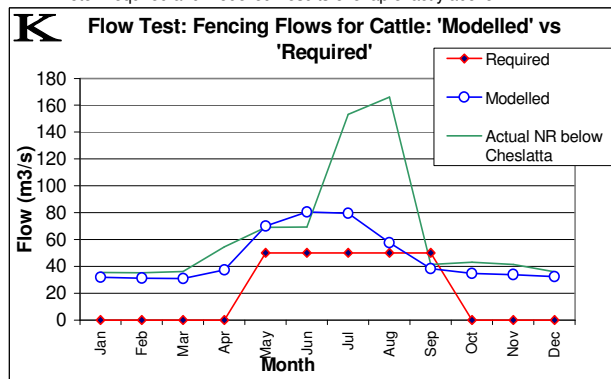
# Summary of Flow Tests to Compare Modelled Output to Needs as Defined by Stakeholders:

FUF to River =	<b>34</b>
SLS Release =	<b>15</b>
CWRF Temp Target =	<b>12</b>

FUF to Reservoir =	<b>9.5</b>
KD Release =	<b>25</b>



Note: Required and Modelled results overlap exactly above.



## **Appendix 1**

Two additional model outputs are presented here (see description in intro).

In general the results show that ....



FUF to Reservoir =	<b>3.9</b>
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FUF to River =	<b>9.9</b>
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SLS Release =	<b>15</b>
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KD Release =	<b>25</b>
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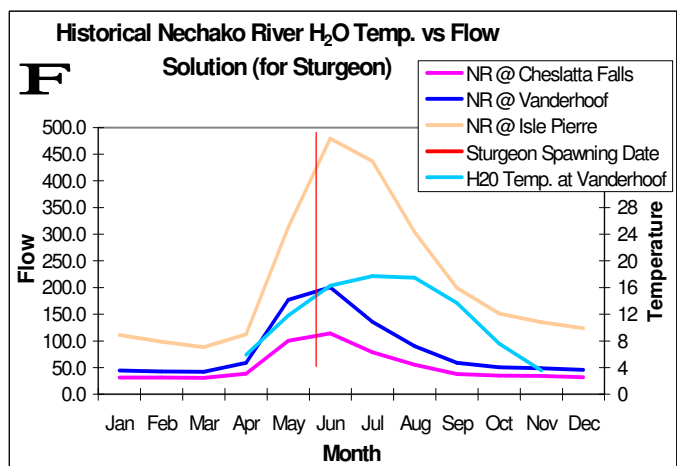
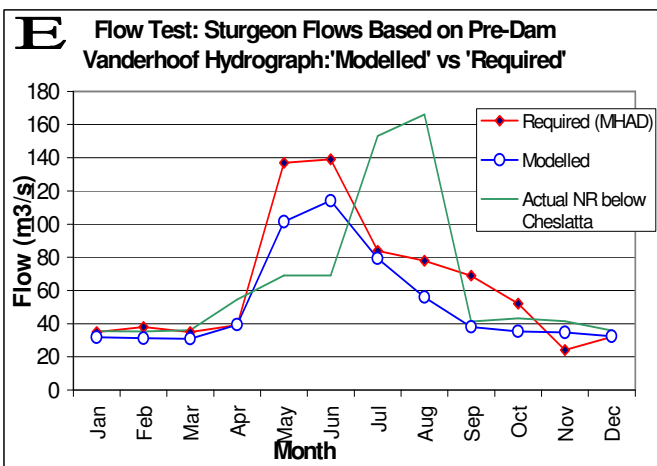
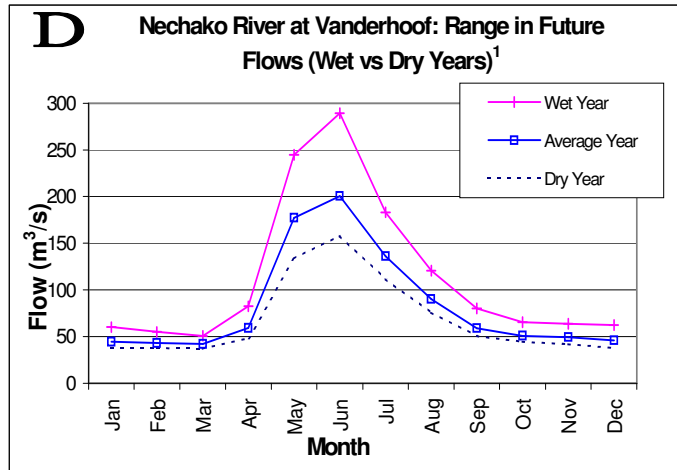
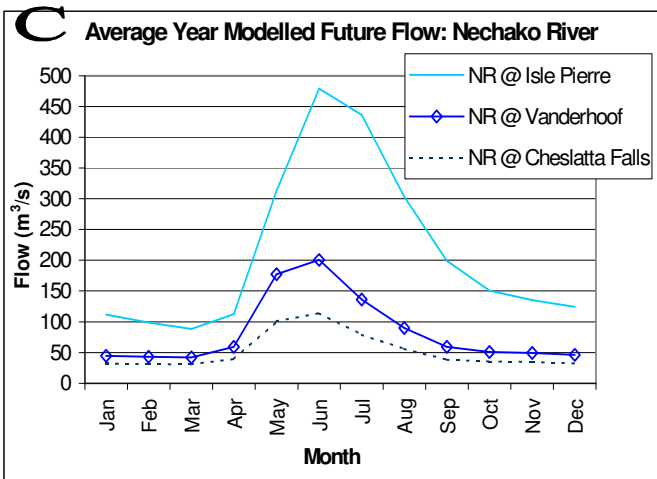
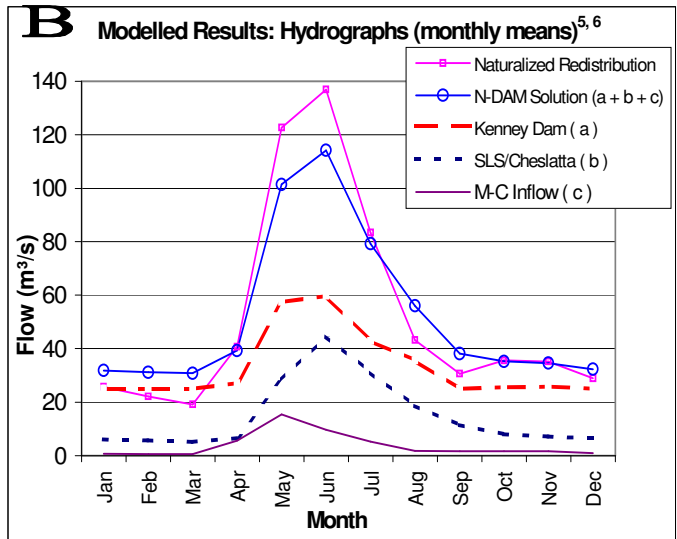
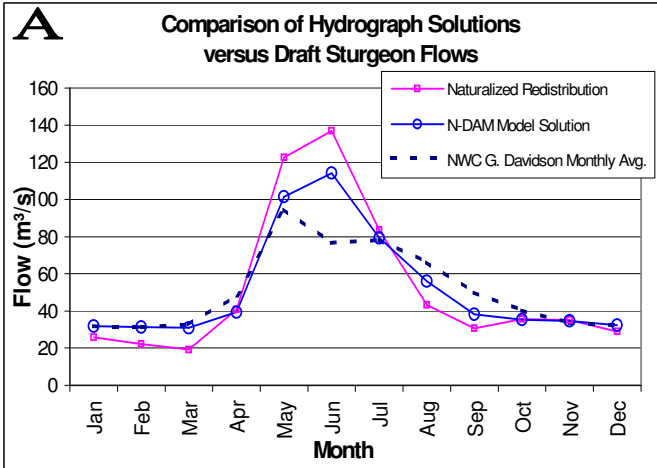
CWRF Temp Target =	<b>10</b>
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Lowest Score = Best Fit:

101	= Test of Fit ( $\sum  Modelled - Naturalized Solution $ )
86%	= Percentage of Monthly Tests Passed
12	= Average Shortfall per Monthly Test Failed ( $m^3/s$ )

\*\*\*WATER IS AVAILABLE\*\*\*  
 \*\*\*ADJUSTMENT TO NFCP MONTHLY FLOWS REQUIRED\*\*\*  
 \*\*\*SOLUTION IS POSSIBLE\*\*\*

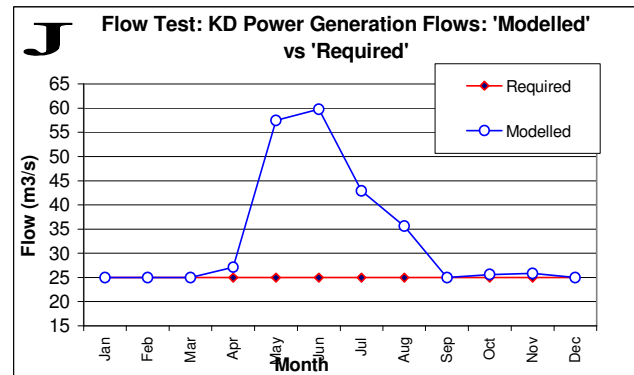
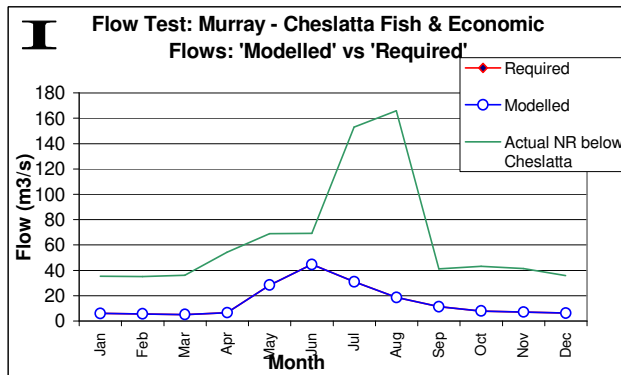
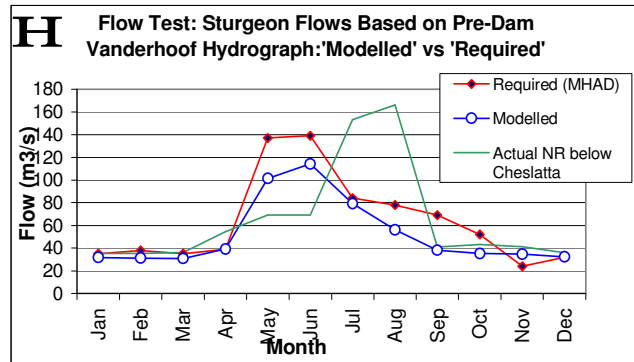
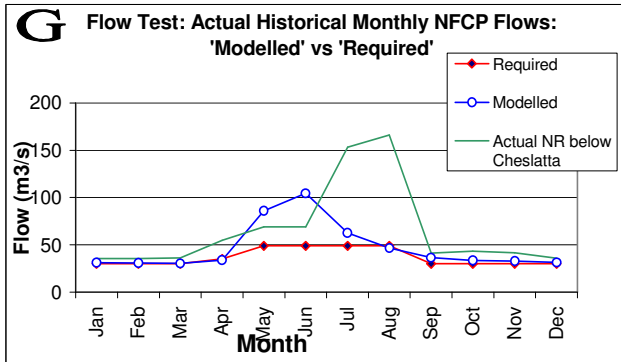
Parameter Choices From 'Model & Results' Work Sheet	
15	Choose Skins Lake Spillway (SLS) Release Annualized <sup>1</sup>
25	Choose Kenney Dam (KD) Constant Daily Release
10	Choose Temperature Target for Water Release Facility
1.6	Average Cooling Release Annualized (Split 60:40 July:August)
13.8	Average Freed Up Flow (FUF) Available for Redistribution
9.9	Average Flow (FUF) to Redistribute in the Nechako River
3.9	Choose Average Freed-Up Flow (FUF) to Stay in Reservoir



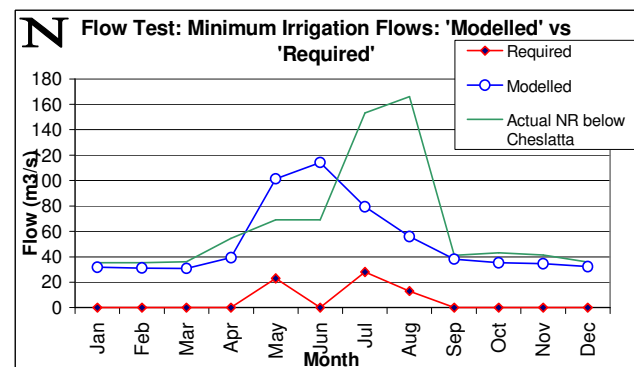
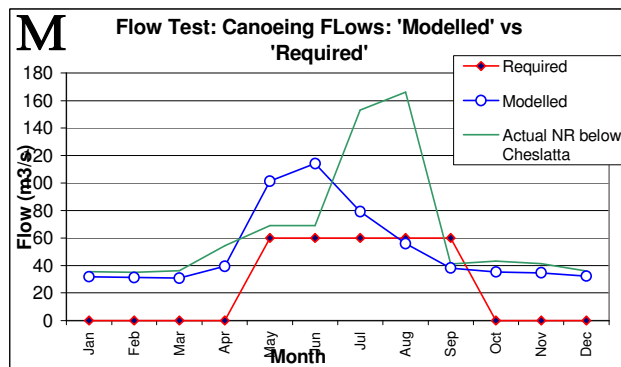
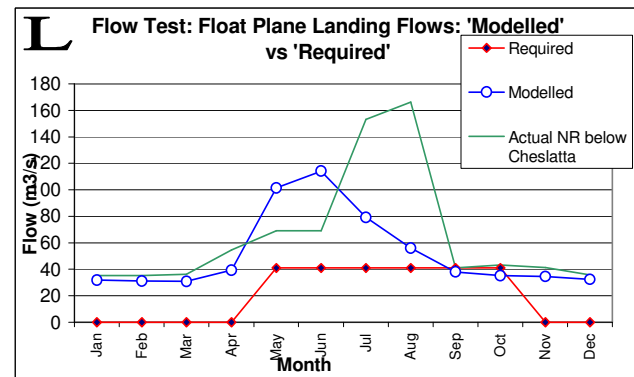
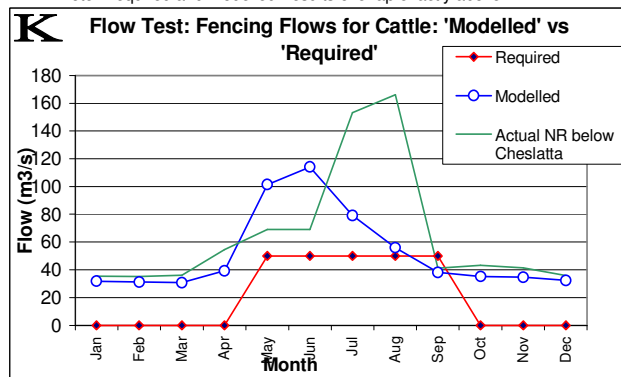
# Summary of Flow Tests to Compare Modelled Output to Needs as Defined by Stakeholders:

FUF to River =	<b>9.9</b>
SLS Release =	<b>15</b>
CWRF Temp Target =	<b>10</b>

FUF to Reservoir =	<b>3.9</b>
KD Release =	<b>25</b>



Note: Required and Modelled results overlap exactly above.



FUF to Reservoir =	<b>3.9</b>
--------------------	------------

FUF to River =	<b>9</b>
----------------	----------

SLS Release =	<b>15</b>
---------------	-----------

KD Release =	<b>26.4</b>
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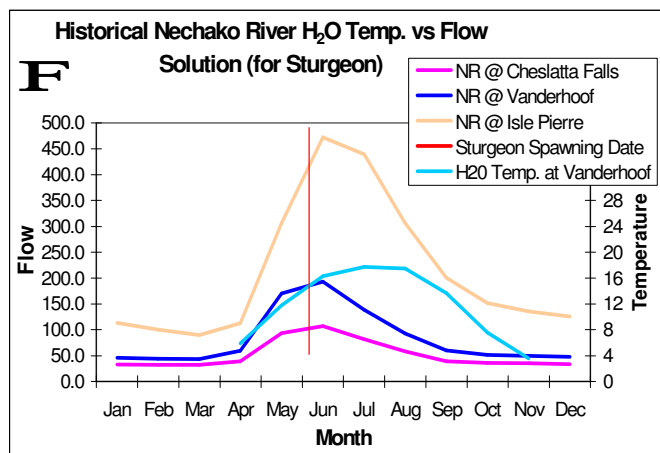
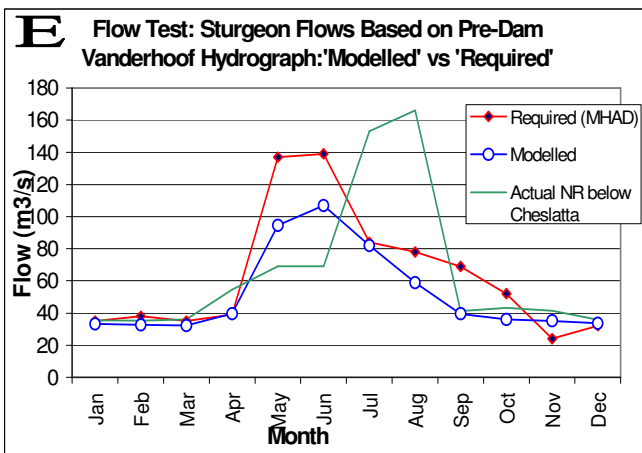
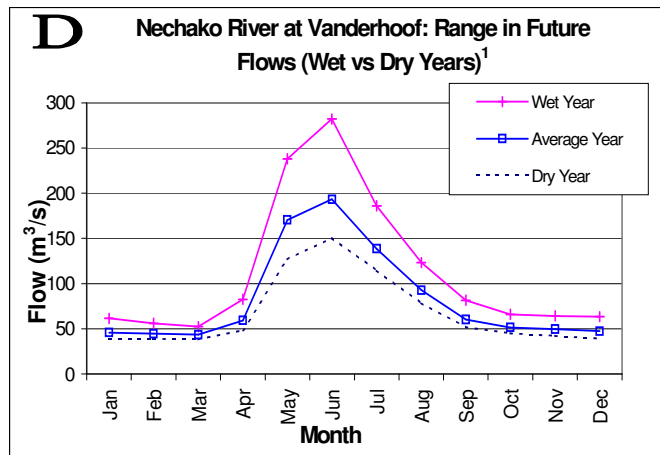
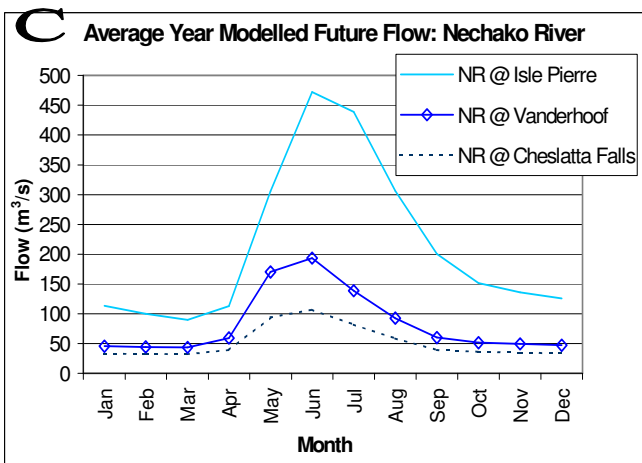
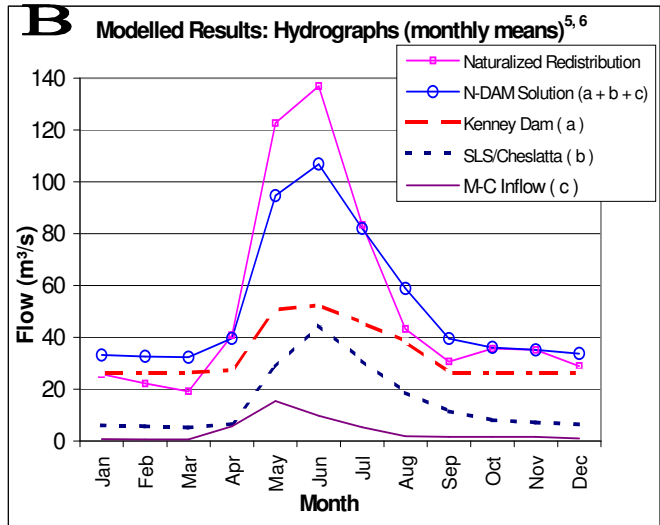
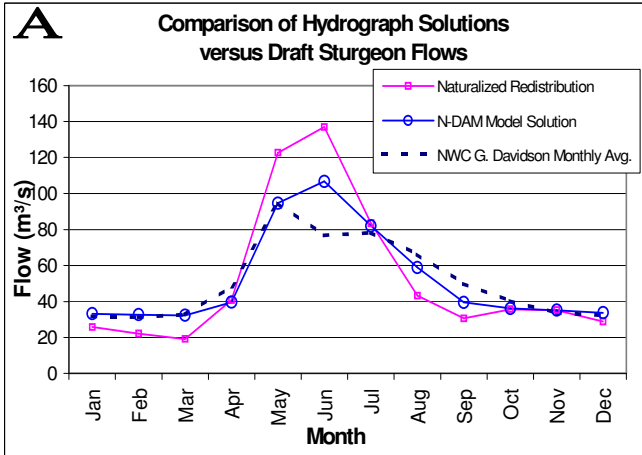
CWRF Temp Target =	<b>12</b>
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Parameter Choices From 'Model & Results' Work Sheet	
15	Choose Skins Lake Spillway (SLS) Release Annualized <sup>1</sup>
26.4	Choose Kenney Dam (KD) Constant Daily Release
12	Choose Temperature Target for Water Release Facility
2.5	Average Cooling Release Annualized (Split 60:40 July:August)
12.9	Average Freed Up Flow (FUF) Available for Redistribution
9	Average Flow (FUF) to Redistribute in the Nechako River
3.9	Choose Average Freed-Up Flow (FUF) to Stay in Reservoir

Lowest Score = Best Fit:

122	= Test of Fit ( $\sum  Modelled - Naturalized Solution $ )
86%	= Percentage of Monthly Tests Passed
12	= Average Shortfall per Monthly Test Failed (m <sup>3</sup> /s)

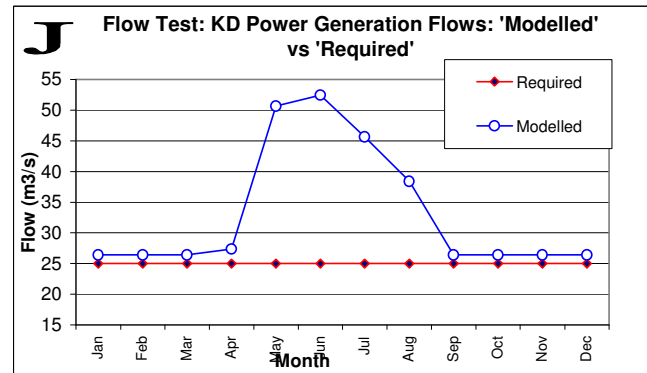
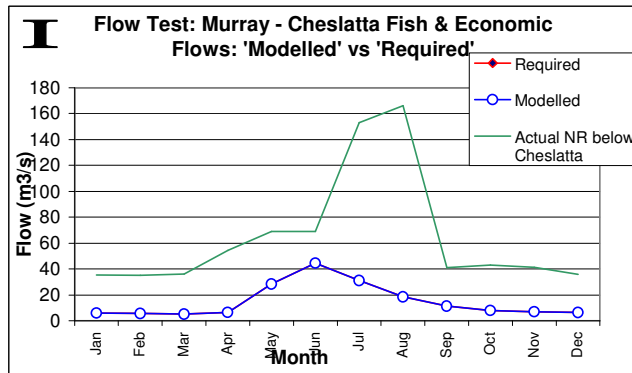
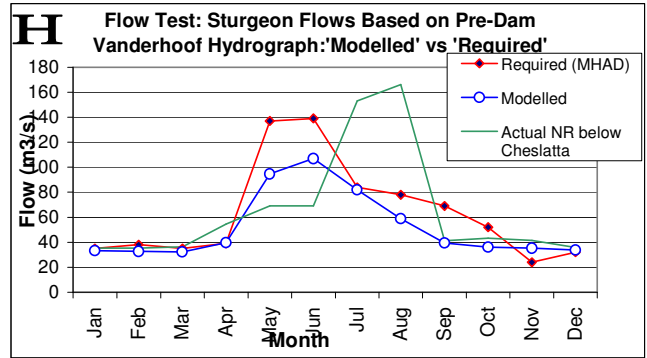
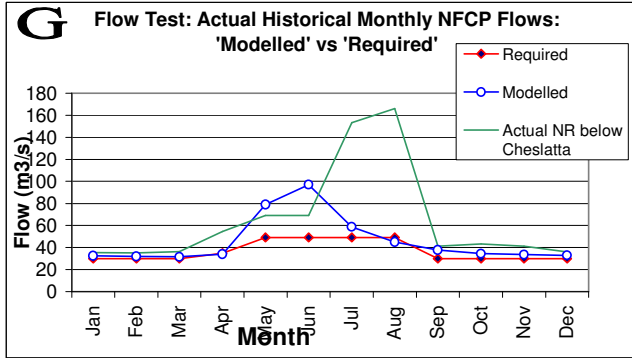
\*\*\*WATER IS AVAILABLE\*\*\*  
 \*\*\*ADJUSTMENT TO NFCP MONTHLY FLOWS REQUIRED\*\*\*  
 \*\*\*SOLUTION IS POSSIBLE\*\*\*



# Summary of Flow Tests to Compare Modelled Output to Needs as Defined by Stakeholders:

FUF to River =	<b>9</b>
SLS Release =	<b>15</b>
CWRF Temp Target =	<b>12</b>

FUF to Reservoir =	<b>3.9</b>
KD Release =	<b>26.4</b>



Note: Required and Modelled results overlap exactly above.

