# Appendix F

## Option Development Process
## ARSP Modeling and Analysis
## of Lake Levels and River Flows

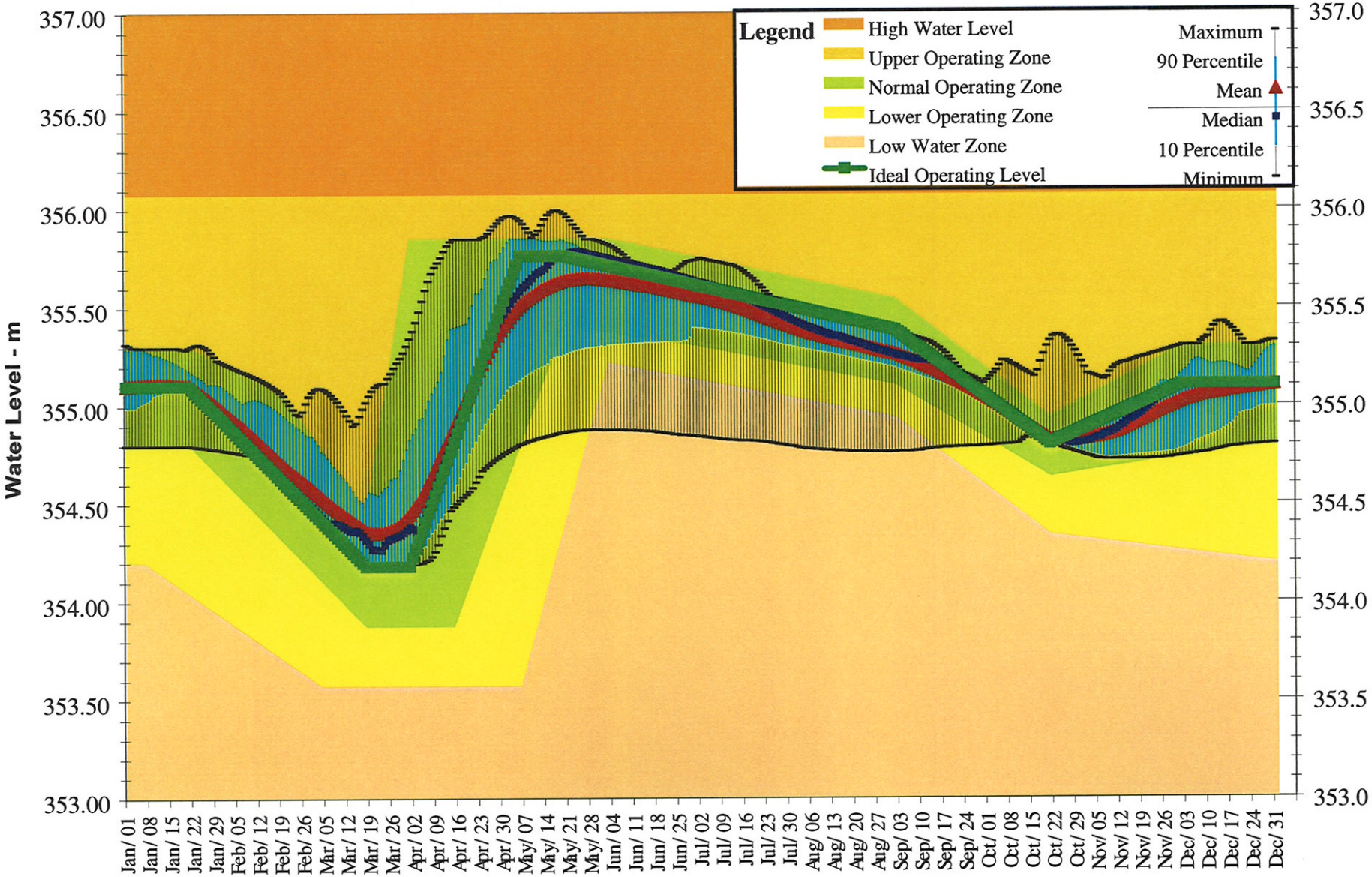
- **ARSP Base Case**
- **ARSP Case One**
- **ARSP Case Two**

**Kawagama Lake**

## Kawagama Lake Water Levels

## ARSP Simulation Base Case

## Operating Rules and Daily Water Level Statistics



**Kawagama Lake Water Levels**
**ARSP Simulation Base Case**

| **Peak Water Levels** | |
|---|---|
| HWZ | 356.07 |
| No of Days in Exceedance | 0 |
| No of Years Exceeded | 0 |
| Maximum WL | 356.00 |

| **Time of spring peak levels before April 30** | |
|---|---|
| Percentile | 0.90 |
| Peak percentile WL | 355.78 |
| Date of peak | 30-Apr |
| | |
| Tolerance | 0 |
| Tolerated WL | 355.78 |
| Date tolerated exceeded | 30-Apr |

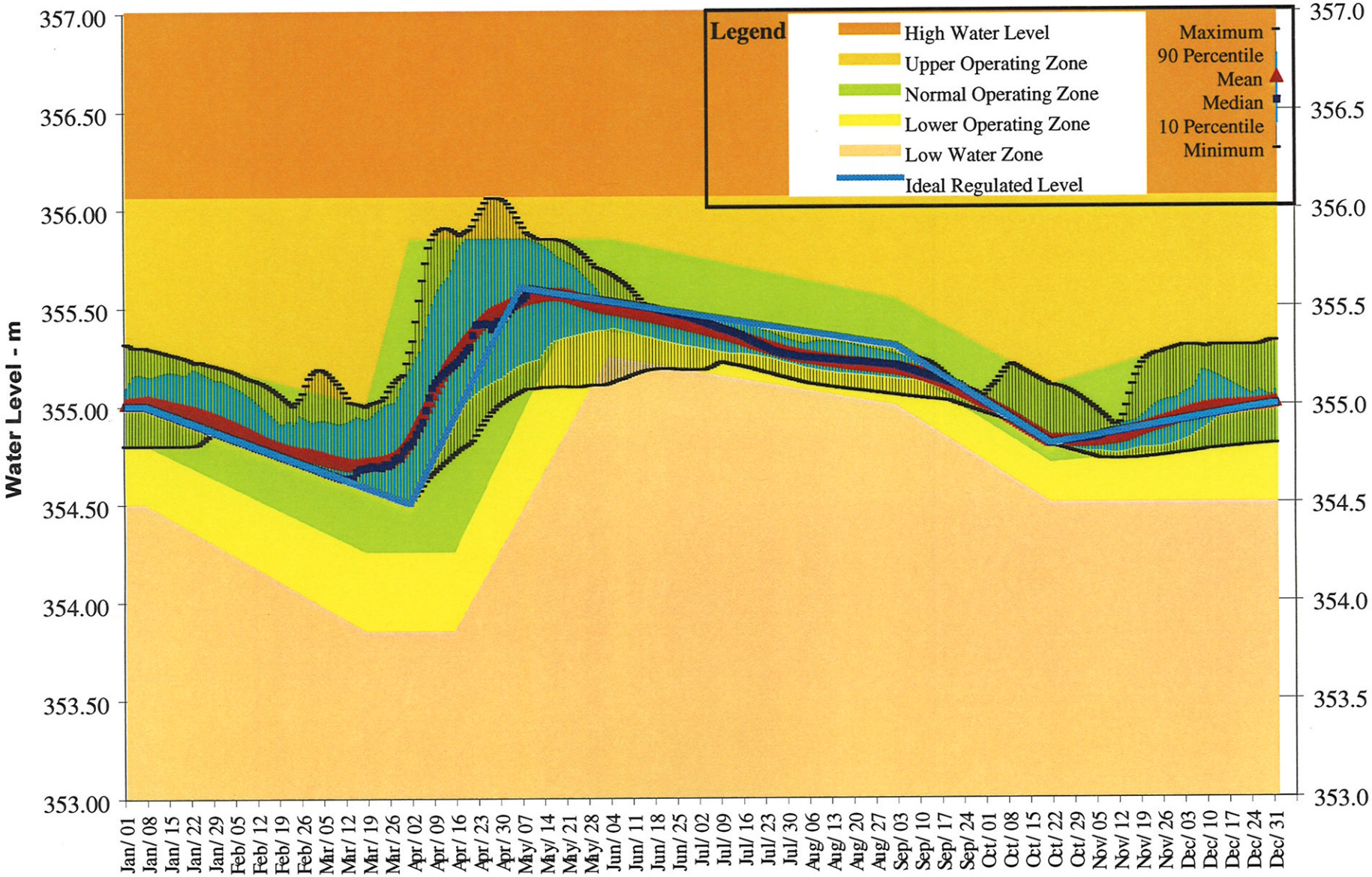
| **Summer recreation levels Jun-15 to Sep-30** | |
|---|---|
| *90 and 10 percentile range* | |
| Max 90% | 355.70 |
| Min 10% | 355.04 |
| Range | 0.67 |

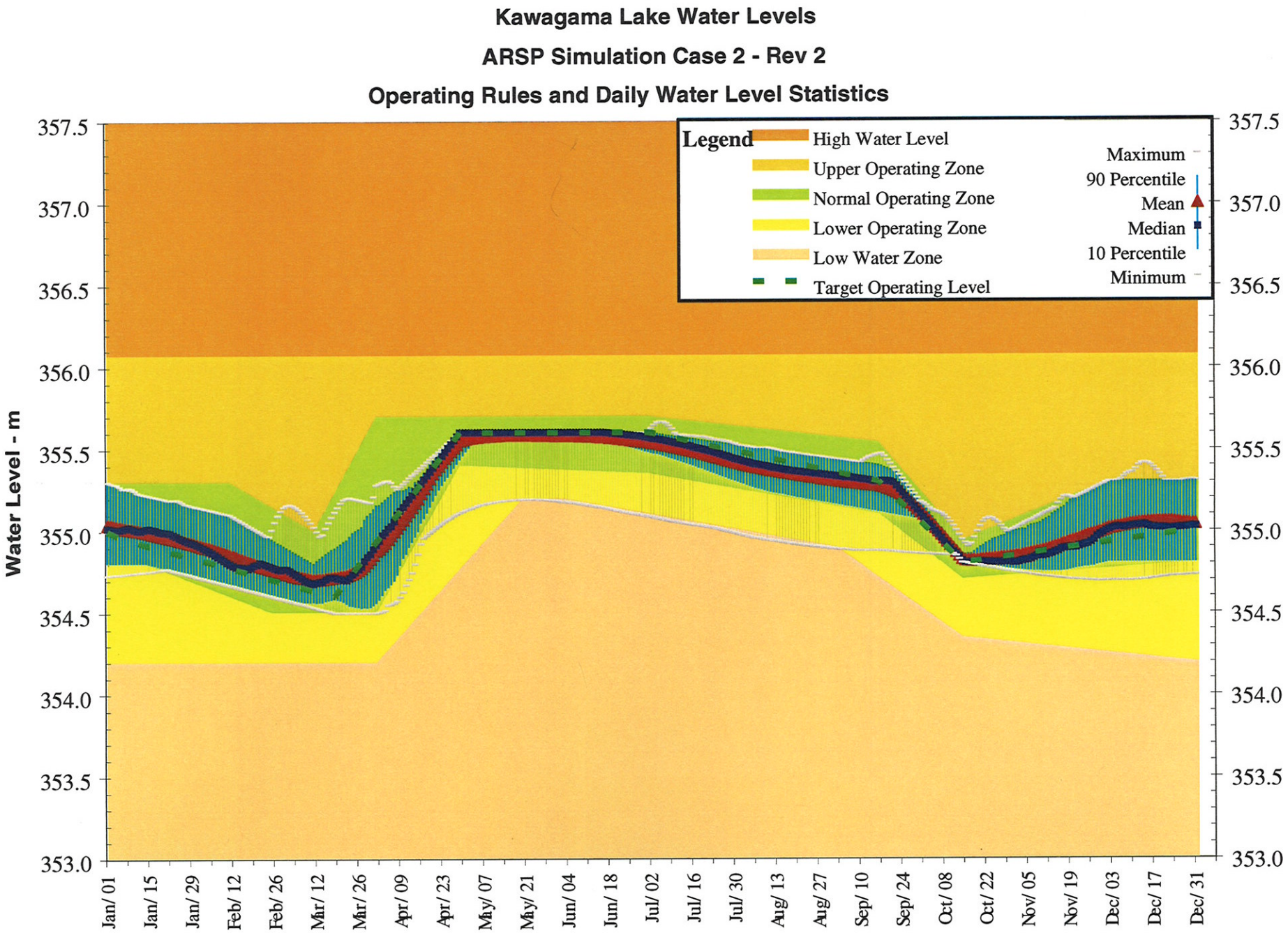
| *Median range* | |
|---|---|
| Max Median | 355.70 |
| Min Median | 355.06 |
| Range | 0.64 |

## Kawagama Lake Water Levels

## ARSP Simulation Proposed Case 1

## Operating Rules and Daily Water Level Statistics




Kawagama Lake Water Levels
ARSP Simulation Case 2 - Rev 2
Operating Rules and Daily Water Level Statistics
Legend
High Water Level
Upper Operating Zone
Normal Operating Zone
Lower Operating Zone
Low Water Zone
Target Operating Level
Maximum
90 Percentile
Mean
Median
10 Percentile
Minimum
Water Level - m
357.5
357.0
356.5
356.0
355.5
355.0
354.5
354.0
353.5
353.0
Jan/ 01
Jan/ 15
Jan/ 29
Feb/ 12
Feb/ 26
Mar/ 12
Mar/ 26
Apr/ 09
Apr/ 23
May/ 07
May/ 21
Jun/ 04
Jun/ 18
Jul/ 02
Jul/ 16
Jul/ 30
Aug/ 13
Aug/ 27
Sep/ 10
Sep/ 24
Oct/ 08
Oct/ 22
Nov/ 05
Nov/ 19
Dec/ 03
Dec/ 17
Dec/ 31

**Kawagama Lake Water Levels**
**ARSP Simulation Case 2 - Rev 2**

| **Peak Water Levels** | |
|---|---|
| HWZ | 356.07 |
| No of Days in Exceedance | 0 |
| No of Years Exceeded | 0 |
| Maximum WL | 355.67 |

| **Time of spring peak levels before April 30** | |
|---|---|
| Percentile | 0.90 |
| Peak percentile WL | 355.60 |
| Date of peak | 29-Apr |
| | |
| Tolerance | 0 |
| Tolerated WL | 355.60 |
| Date tolerated exceeded | 29-Apr |

**Summer recreation levels Jun-15 to Sep-30**

*90 and 10 percentile range*

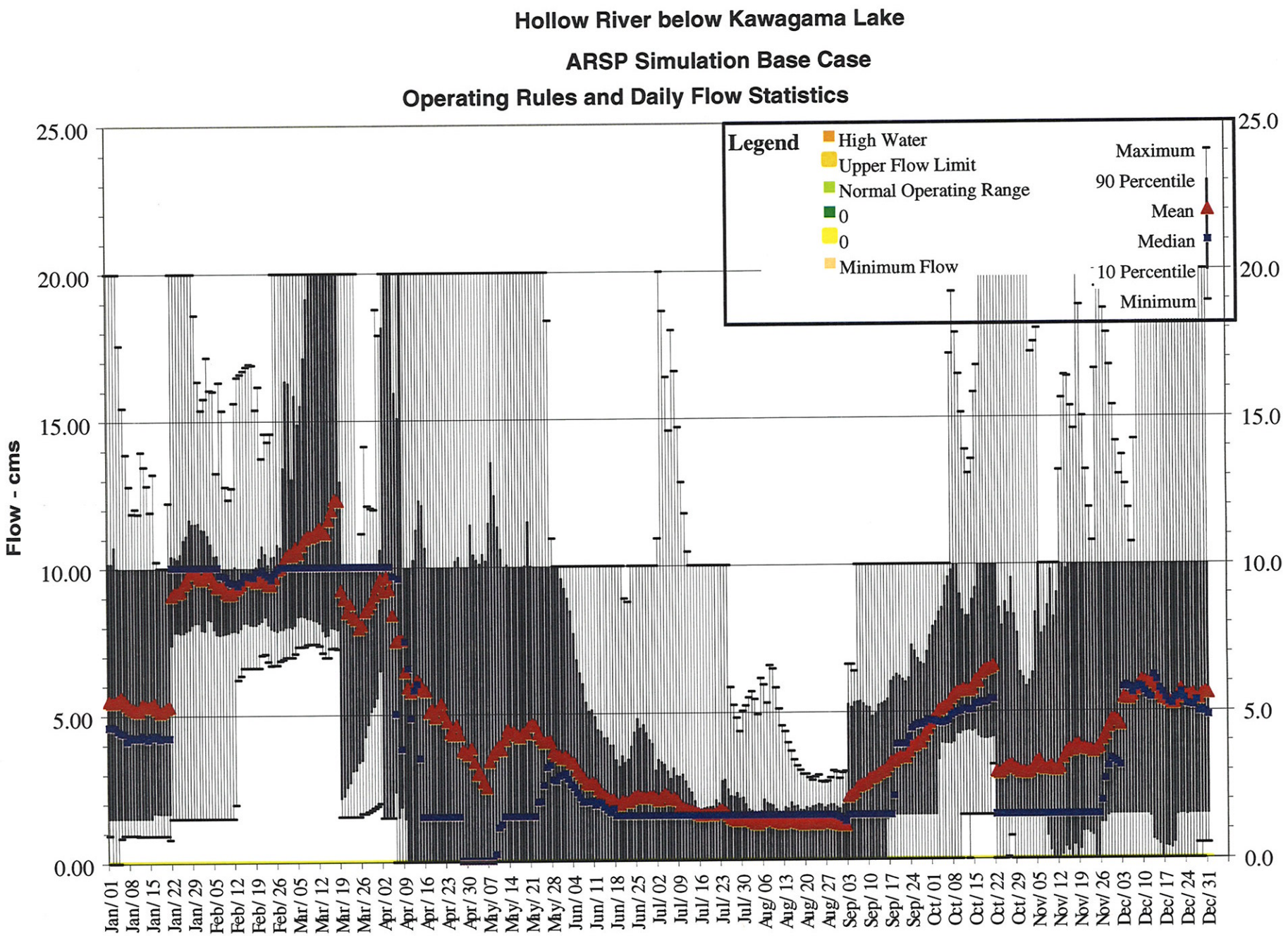
| | |
|---|---|
| Max 90% | 355.60 |
| Min 10% | 355.06 |
| Range | 0.54 |

*Median range*

| | |
|---|---|
| Max Median | 355.60 |
| Min Median | 355.10 |
| Range | 0.50 |

**Spring Peak Water Level**

| | |
|---|---|
| Maximum - 50 yr Average | 355.58 |
| Date - 50 yr Average | 29/Apr |
| | |
| Summer Average Level | 355.39 |


Hollow River below Kawagama Lake
ARSP Simulation Base Case
Operating Rules and Daily Flow Statistics
Legend
High Water
Upper Flow Limit
Normal Operating Range
0
0
Minimum Flow
Maximum
90 Percentile
Mean
Median
10 Percentile
Minimum
Flow - cms
25.00
20.00
15.00
10.00
5.00
0.00
Jan/ 01
Jan/ 08
Jan/ 15
Jan/ 22
Jan/ 29
Feb/ 05
Feb/ 12
Feb/ 19
Feb/ 26
Mar/ 05
Mar/ 12
Mar/ 19
Mar/ 26
Apr/ 02
Apr/ 09
Apr/ 16
Apr/ 23
Apr/ 30
May/ 07
May/ 14
May/ 21
May/ 28
Jun/ 04
Jun/ 11
Jun/ 18
Jun/ 25
Jul/ 02
Jul/ 09
Jul/ 16
Jul/ 23
Jul/ 30
Aug/ 06
Aug/ 13
Aug/ 20
Aug/ 27
Sep/ 03
Sep/ 10
Sep/ 17
Sep/ 24
Oct/ 01
Oct/ 08
Oct/ 15
Oct/ 22
Oct/ 29
Nov/ 05
Nov/ 12
Nov/ 19
Nov/ 26
Dec/ 03
Dec/ 10
Dec/ 17
Dec/ 24
Dec/ 31

## Flow Evaluation

Yellow cells indicate values that can be changed for analysis

Hollow River below Kawagama Lake
ARSP Simulation Base Case
Daily Flows Model Results 1951 to 2000

**Walleye Spawning**

**Min Flow** **0** m³/s Achieved 100% of time

**No of days above minumum flow**

| *First half of season* | | | *Last half of season* | | | *For whole season* | | |
|---|---|---|---|---|---|---|---|---|
| Min | 0 | days | Min | 0 | days | Min | 0 | days |
| Avg | 11.6 | days | Avg | 15.82 | days | Avg | 27.42 | days |
| Years Provided | 18% | | Years Provided | 48% | | Years Provided | 18% | |

*From flow duration curve*

| % | Flow | | *No of days* | | | |
|---|---|---|---|---|---|---|
| 99% | - | m³/s | *min flow is achievd* | - | days | |
| 95% | - | m³/s | | | | |

| | |
|---|---|
| *90%* | *percentile peak flow* |
| 10 | m3/s |

**Summer Minimum 7-day Flow**

| | | | |
|---|---|---|---|
| | Maximum | 1.93 | m³/s |
| | Minimum | 0.00 | m³/s |
| 90% | Percentile | 1.45 | m³/s |
| 10% | Percentile | 0.00 | m³/s |
| | Median | 0.70 | m³/s |
| | Mean | 0.67 | m³/s |

**Maximum Flows**

| Regulatory Flood Outflow | | No of years exceeded | Maximum Daily Flow | |
|---|---|---|---|---|
| N/A | m³/s | 0 | 20.00 | m³/s |

**Minumum Flows**

| *Min Daily flow* | | *7-day minimums* | | | |
|---|---|---|---|---|---|
| | | 2 | 10 | 20 | return period |
| | | -yr 7Q2 | -yr 7Q10 | -yr 7Q20 | |
| 0.00 | m³/s | 0.00 | 0.00 | 0.00 | m³/s |

**Summer Fluctuations**

| Delta Flow | Average number of daily flow fluctuations per year | | |
|---|---|---|---|
| 1 | 3.40 | | |
| 3 | 0.66 | | |
| 5 | 0.12 | | |
| >0.75 | 4.34 | 0.5 | ratio of summer median |

**Water Usage**

| *Median Flow* | | *10% Percentile* | |
|---|---|---|---|
| summer | winter | summer | winter |
| m³/s | m³/s | m³/s | m³/s |
| 1.50 | 8.07 | 0.00 | 0.00 |

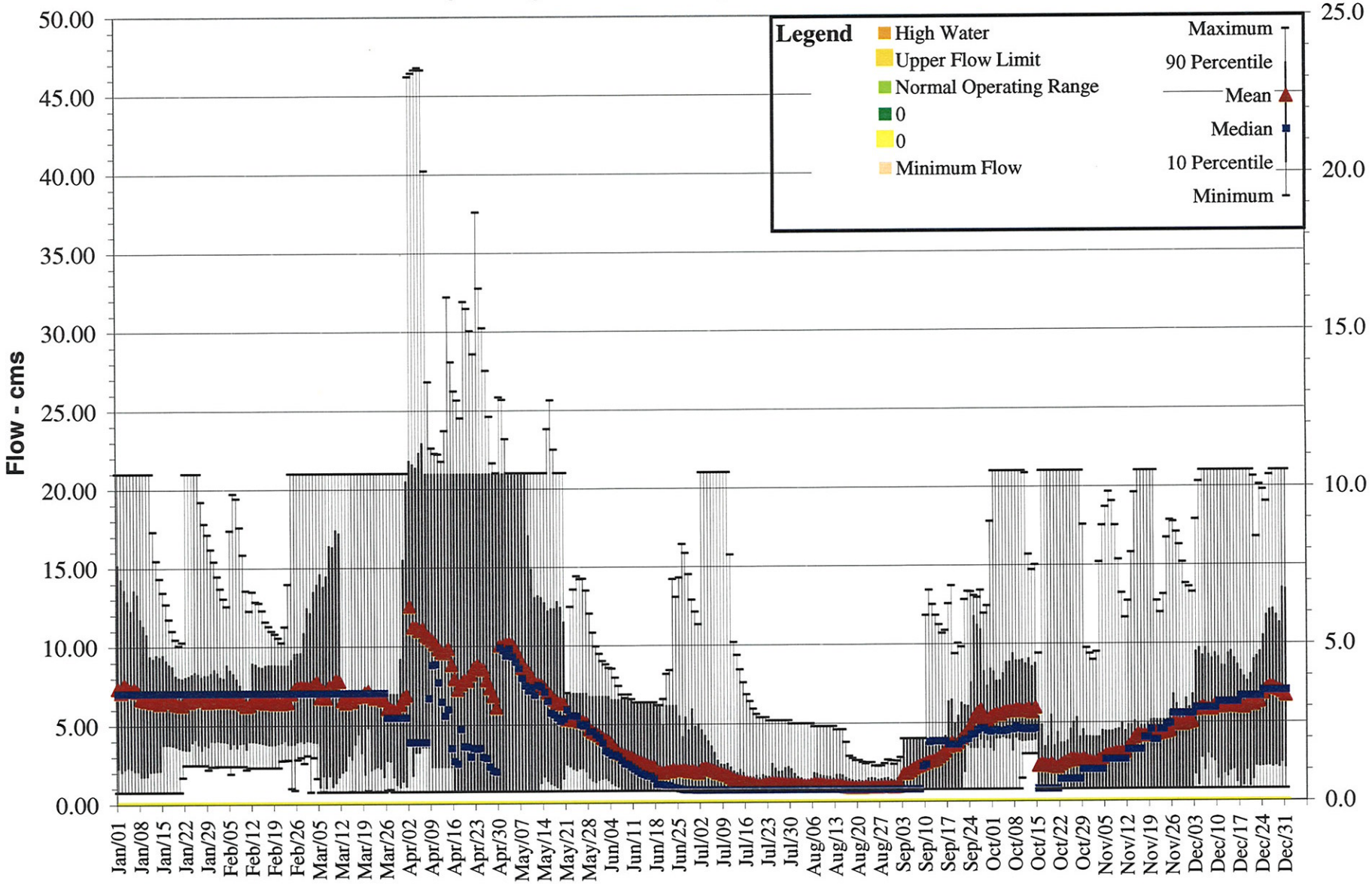
**Power Generation**

| | Quarter | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Annual | |
| Flow | 8.74 | 4.10 | 2.00 | 4.65 | 4.85 | m³/s |

## Hollow River below Kawagama Lake

## ARSP Simulation Case 2 - Rev 1

## Operating Rules and Daily Flow Statistics



## Flow Evaluation

Yellow cells indicate values that can be changed for analysis

Hollow River below Kawagama Lake
ARSP Simulation Case 2 - Rev 1
Daily Flows Model Results 1951 to 2000

**Walleye Spawning**

**Min Flow** **0** $m^3/s$ Achieved #N/A of time

**No of days above minumum flow**

| *First half of season* | | *Last half of season* | | *For whole season* | |
|---|---|---|---|---|---|
| Min | 25 days | Min | 24 days | Min | 49 days |
| Avg | 25 days | Avg | 24 days | Avg | 49 days |
| Years Provided | 100% | Years Provided | 100% | Years Provided | 100% |

*From flow duration curve*

| % | Flow | *No of days* |
|---|---|---|
| 99% | 0.75 $m^3/s$ | *min flow is achievd* |
| 95% | 0.75 $m^3/s$ | 49 days |

*90% percentile peak flow*
20 m3/s

**Summer Minimum 7-day Flow**

| | | |
|---|---|---|
| | Maximum | 1.59 $m^3/s$ |
| | Minimum | 0.75 $m^3/s$ |
| 90% | Percentile | 0.79 $m^3/s$ |
| 10% | Percentile | 0.75 $m^3/s$ |
| | Median | 0.75 $m^3/s$ |
| | Mean | 0.81 $m^3/s$ |

**Maximum Flows**

DOM Flood Damage Zone No of years exceeded Maximum Daily Flow

| | | | |
|---|---|---|---|
| 21.2 m³/s | 13 | | 46.78 m³/s |

**Minumum Flows**

| *Min Daily flow* | *7-day minimums* | | |
|---|---|---|---|
| 0.75 m³/s | 2 | 10 | 20 return period |
| | -yr 7Q2 | -yr 7Q10 | -yr 7Q20 |
| | 0.75 | 0.75 | 0.75 m³/s |

**Summer Fluctuations**

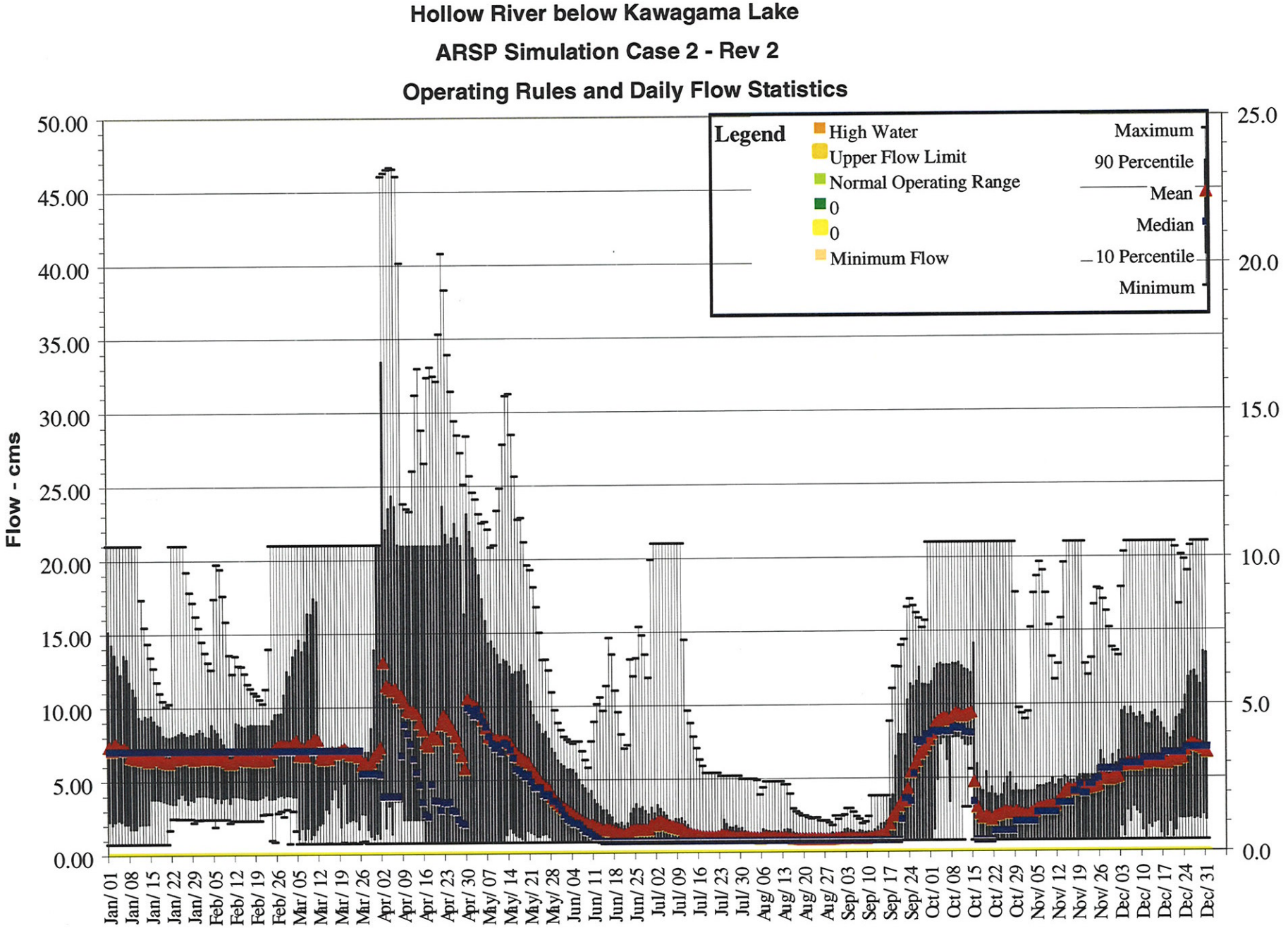
| Delta Flow | Average number of daily flow fluctuations per year | | |
|---|---|---|---|
| 1 | 4.22 | | |
| 3 | 1.44 | | |
| 5 | 0.54 | | |
| >0.375 | 8.32 | 0.5 | ratio of summer median |

**Water Usage**

| *Median Flow* | | *10% Percentile* | |
|---|---|---|---|
| summer m³/s | winter m³/s | summer m³/s | winter m³/s |
| 1.49 | 6.27 | 0.75 | 0.75 |

**Power Generation**

| | Quarter | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Annual |
| Flow | 6.72 | 6.21 | 1.90 | 4.65 | 4.86 m³/s |


Hollow River below Kawagama Lake
ARSP Simulation Case 2 - Rev 2
Operating Rules and Daily Flow Statistics
Flow - cms
Legend
High Water
Upper Flow Limit
Normal Operating Range
0
0
Minimum Flow
Maximum
90 Percentile
Mean
Median
10 Percentile
Minimum
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
25.0
20.0
15.0
10.0
5.0
0.0
Jan/ 01
Jan/ 08
Jan/ 15
Jan/ 22
Jan/ 29
Feb/ 05
Feb/ 12
Feb/ 19
Feb/ 26
Mar/ 05
Mar/ 12
Mar/ 19
Mar/ 26
Apr/ 02
Apr/ 09
Apr/ 16
Apr/ 23
Apr/ 30
May/ 07
May/ 14
May/ 21
May/ 28
Jun/ 04
Jun/ 11
Jun/ 18
Jun/ 25
Jul/ 02
Jul/ 09
Jul/ 16
Jul/ 23
Jul/ 30
Aug/ 06
Aug/ 13
Aug/ 20
Aug/ 27
Sep/ 03
Sep/ 10
Sep/ 17
Sep/ 24
Oct/ 01
Oct/ 08
Oct/ 15
Oct/ 22
Oct/ 29
Nov/ 05
Nov/ 12
Nov/ 19
Nov/ 26
Dec/ 03
Dec/ 10
Dec/ 17
Dec/ 24
Dec/ 31

## Flow Evaluation

Yellow cells indicate values that can be changed for analysis

Hollow River below Kawagama Lake
ARSP Simulation Case 2 - Rev 2
Daily Flows Model Results 1951 to 2000

**Walleye Spawning**

**Min Flow** 0 m³/s Achieved #N/A of time

**No of days above minumum flow**

*First half of season*

| | | |
|---|---|---|
| Min | 25 | days |
| Avg | 25 | days |
| Years Provided | 100% | |

*Last half of season*

| | | |
|---|---|---|
| Min | 24 | days |
| Avg | 24 | days |
| Years Provided | 100% | |

*For whole season*

| | | |
|---|---|---|
| Min | 49 | days |
| Avg | 49 | days |
| Years Provided | 100% | |

*From flow duration curve*

| % | Flow | | *No of days* | | *percentile peak* | |
|---|---|---|---|---|---|---|
| 99% | 0.75 | m³/s | *min flow is achievd* | | *90%* | *flow* |
| 95% | 0.75 | m³/s | 49 | days | 17 | m3/s |

**Summer Minimum 7-day Flow**

| | | | |
|---|---|---|---|
| | Maximum | 1.16 | m³/s |
| | Minimum | 0.75 | m³/s |
| 90% | Percentile | 0.75 | m³/s |
| 10% | Percentile | 0.75 | m³/s |
| | Median | 0.75 | m³/s |
| | Mean | 0.77 | m³/s |

**Maximum Flows**

| DOM Flood Damage Zone | | No of years exceeded | Maximum Daily Flow | |
|---|---|---|---|---|
| 21.2 | m³/s | 23 | 46.65 | m³/s |

**Minumum Flows**

| *Min Daily flow* | | *7-day minimums* | | | |
|---|---|---|---|---|---|
| | | 2 | 10 | 20 | return period |
| | | -yr 7Q2 | -yr 7Q10 | -yr 7Q20 | |
| 0.75 | m³/s | 0.75 | 0.75 | 0.75 | m³/s |

**Summer Fluctuations**

| Delta Flow | Average number of daily flow fluctuations per year | | |
|---|---|---|---|
| 1 | 4.02 | | |
| 3 | 1.76 | | |
| 5 | 0.84 | | |
| >0.375 | 8.34 | 0.5 | ratio of summer median |

**Water Usage**

| *Median Flow* | | *10% Percentile* | |
|---|---|---|---|
| summer | winter | summer | winter |
| m³/s | m³/s | m³/s | m³/s |
| 0.75 | 6.27 | 0.75 | 0.75 |

**Power Generation**

| | Quarter | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Annual | |
| Flow | 6.74 | 5.89 | 1.65 | 5.19 | 4.86 | m³/s |