SELECTIVE WITHDRAWAL WORKSHOP

Zhonglong Zhang, PhD, PE, PH
Portland State University

CE-QUAL-W2 Workshop

August 16 - 18, 2022

US Army Corps of Engineers

Environmental Systems Modeling Team

ERDC ENGINEER RESEARCH & DEVELOPMENT CENTER

Objectives

- This case study is used to demonstrate selective withdrawal blending algorithms in W2 V4.5 model. The W2 model estimates the temperatures released by those flows through the priority outlets, then adjusts the temperature target for the blended releases accordingly.

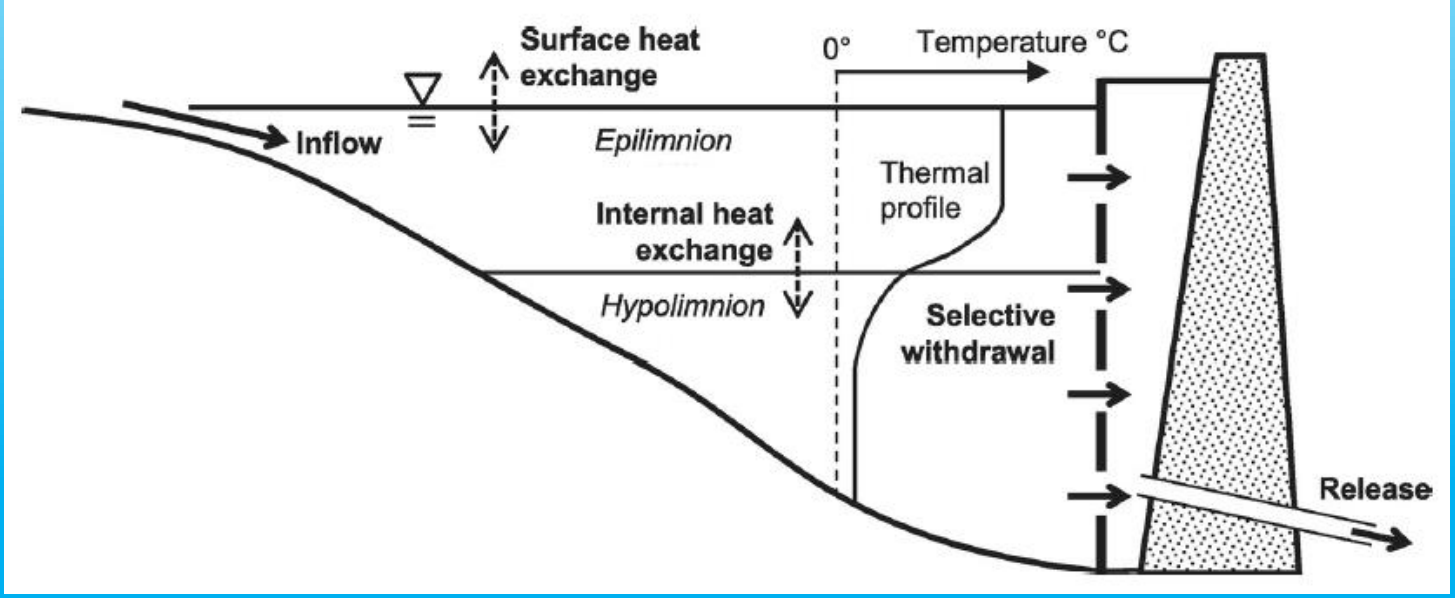
- Detroit lake impounds 455,100 acre-ft of water at full pool, making it one of the largest reservoirs in the Willamette River Basin. The North Santiam River is one of several major tributaries to the Willamette River. The fixed-elevation outlet was given a centerline elevation of 408.4 m (1,340 ft). The floating outlet was given a depth (DEPTH) of 2 m (6.56 ft) and a minimum flow of 11.327 m3/s (400 ft3/s).

Sullivan, A.B., Rounds, S.A., Sobieszczyk, S., and Bragg, H.M., 2007, Modeling hydrodynamics, water temperature, and suspended sediment in Detroit Lake, Oregon: U.S. Geological Survey Scientific Investigations Report 2007–5008

Selective Withdrawal

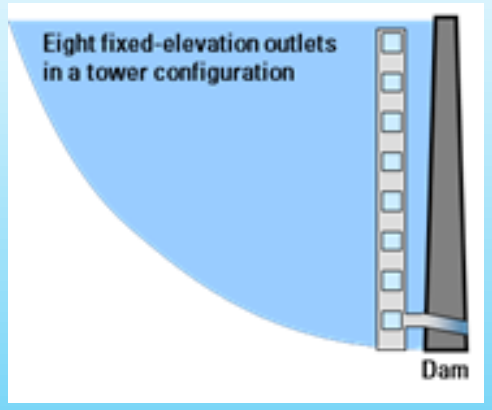
Selective withdrawal uses stratified flow to pull out water from selected depths of the pool.

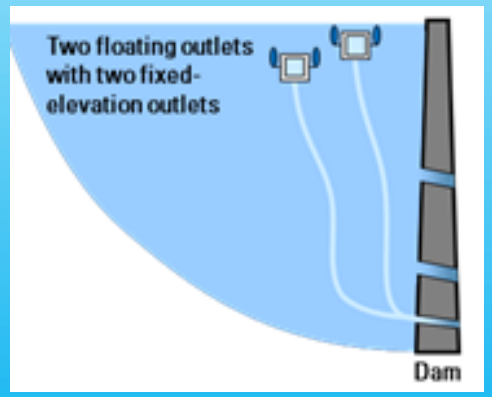
Selective withdrawal flow depends upon the discharge, stratification, geometry of the outlet, bathymetry of the impoundment, and any in-reservoir circulation.



Selective Withdrawal

- The first algorithm allows a single structure or withdrawal up to 10 discrete elevations to which it can be set.
- The second algorithm allows the blending of releases from 2 specified structures or withdrawals to match a user-specified release temperature.
- Blending algorithms will allow more complicated dam-operation scenarios to be evaluated somewhat automatically with the model





USGS blending algorithm allows blending 10 outlets to meet a user-specified temperature target, and additional user inputs are required to specify the depth of floating outlets, optional constraints on minimum and maximum head and release rates for each outlet, and a priority ranking for each outlet, among others.

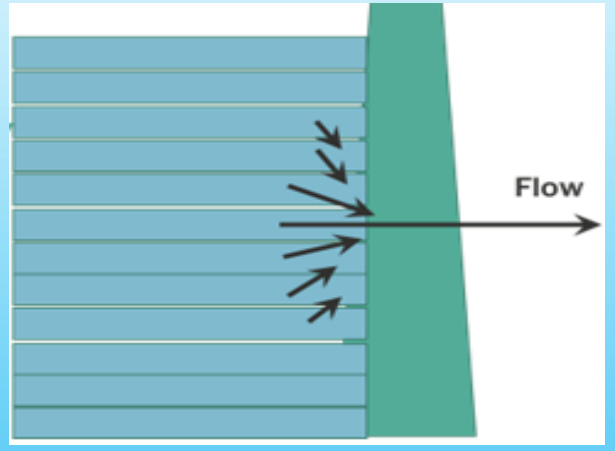
Selective Withdrawal

Rules for selective withdrawal when there are two outlets where flow is being split

If $T_{JS1} > T_{target}$ and $T_{JS2} > T_{target}$, take all flow from lower outlet (JS2)

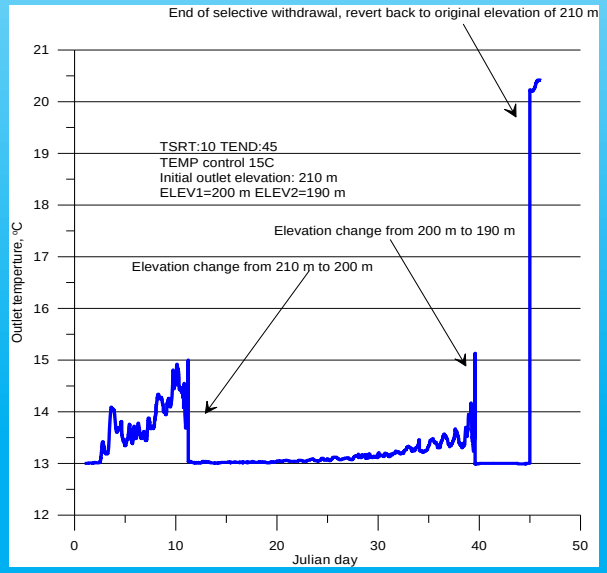
If $T_{JS1} < T_{target}$ and $T_{JS2} < T_{target}$, take all flow from upper outlet (JS1)

If $T_{JS1} > T_{target}$ and $T_{JS2} < T_{target}$, take apportion flow based on flow balance equation



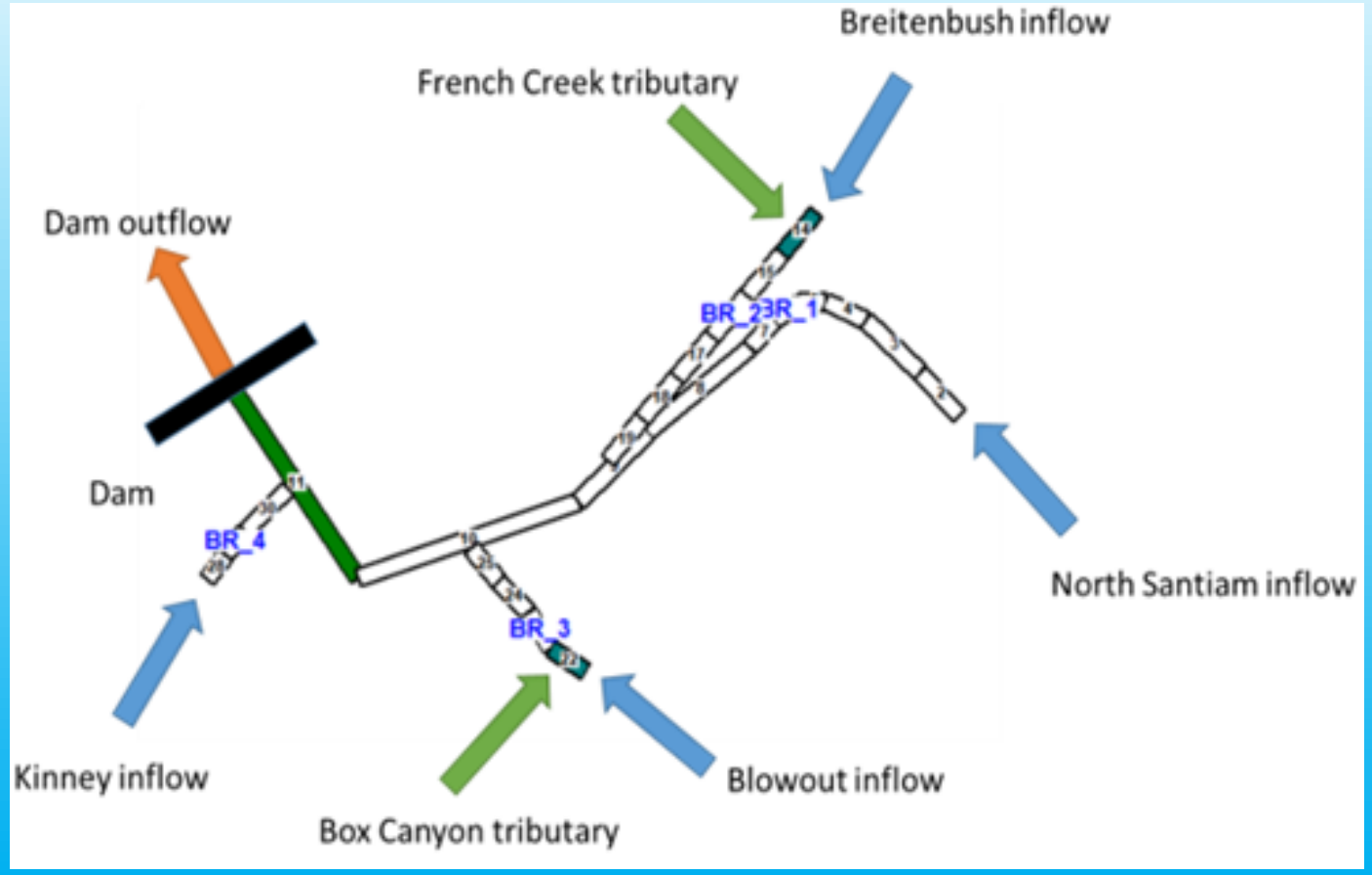
$$Q_{JS1} = \frac{(Q_{sum}(T_{target} - T_{JS2}))}{(T_{JS1} - T_{JS2})}$$

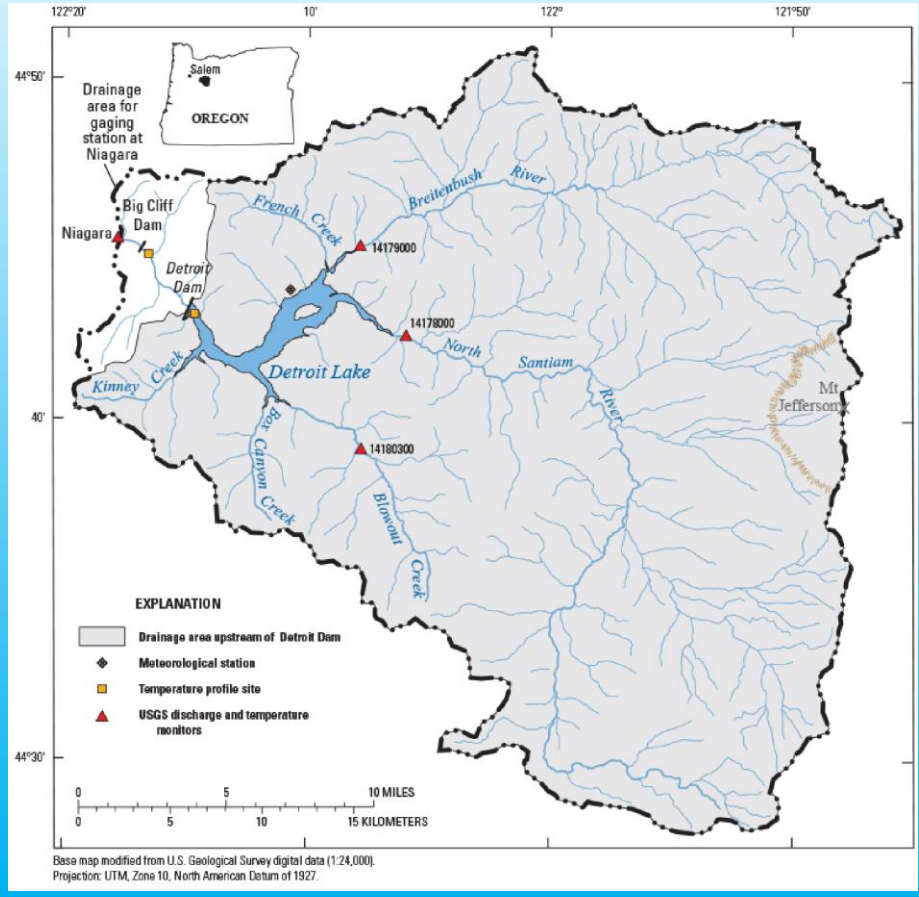
$$Q_{JS2} = Q_{sum} - Q_{JS1}$$



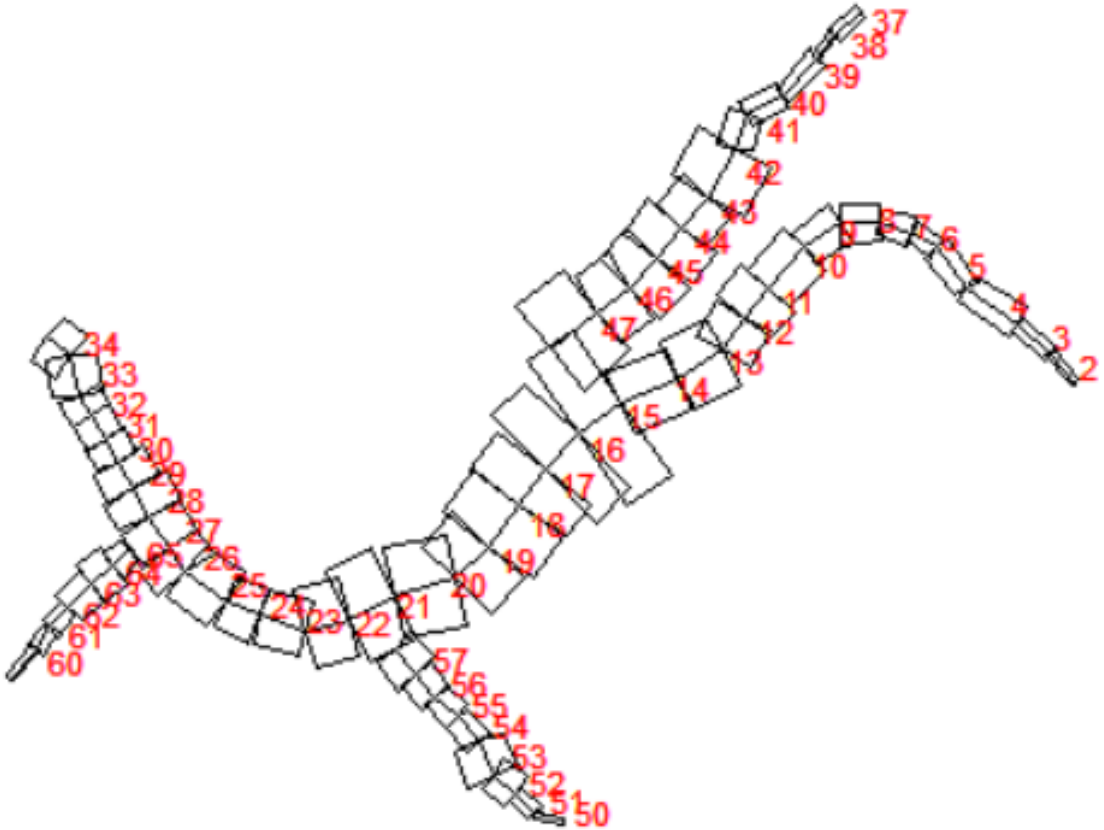
If water elevation is below the outlet elevation for the upper outlet (JS1), take all flow from the lower outlet (JS2).

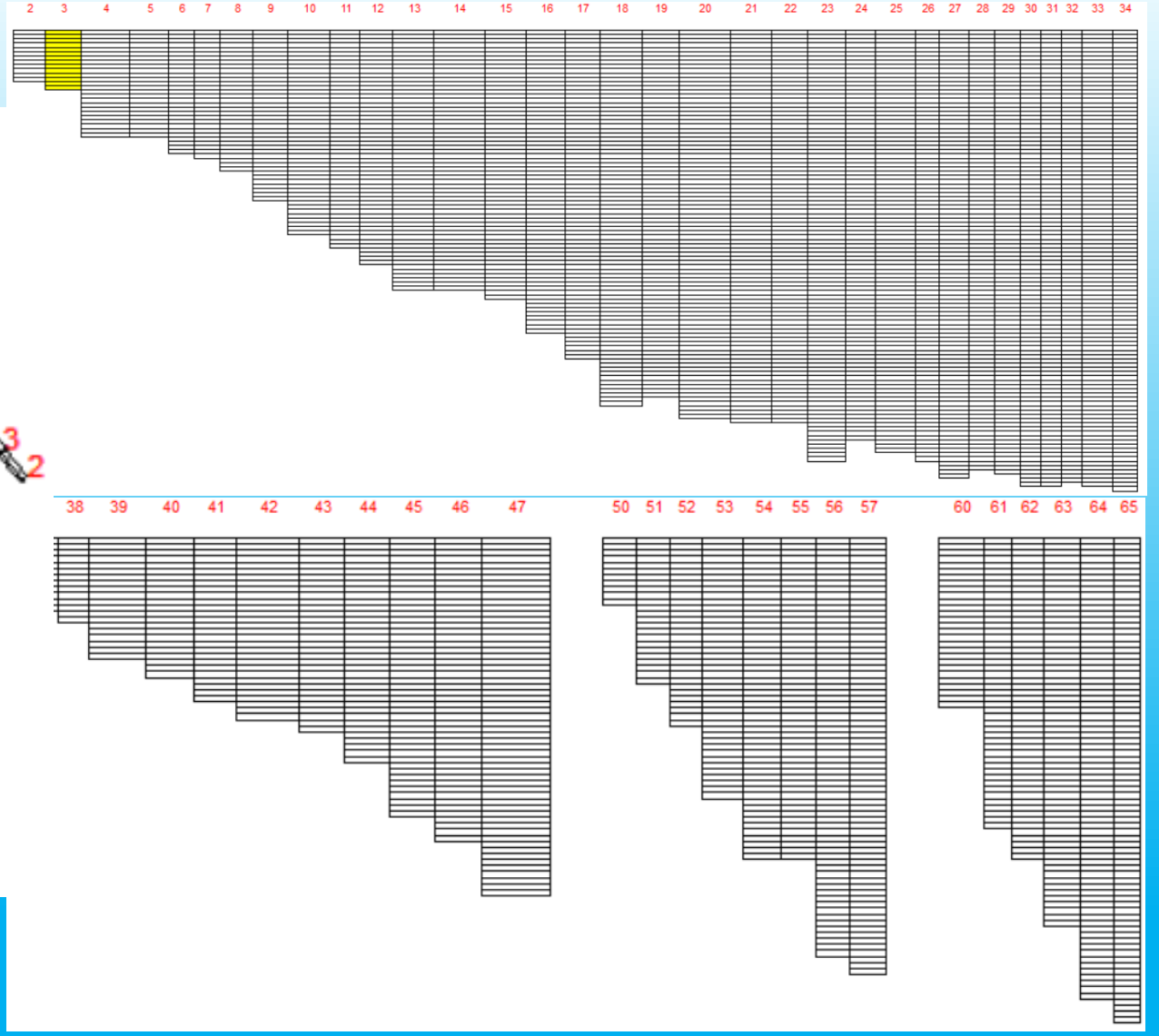
Detroit Lake Conceptual Model





Detroit Lake Model Grids





Detroit Lake Model Inputs: w2_con.csv

GRID/NPROC/CLOSE DIALOG BOX	NWB	NBR	IMX	KMX	NPROC	CLOSEC		
	1	4	66	117	1	ON		
IN/OUTFLOW	NTR	NST	NIW	NWD	NGT	NSP	NPI	NPU
	2	4	0	0	0	0	0	0
el control rules								
CONSTITUENTS	NGC	NSS	NAL	NEP	NBOD	NMC	NZP	
s in COL C - these are checked by the program	1	2	0	0	0	0	1	
ut dates or timestep related changes								
MISCELLANEOUS	NDAY	SELECTC	HABTATC	ENVIRPC	AERATEC	INITUWL	ORGCC	SED_DIAG
analyses for fish and eutrophication variables	1000	USGS	OFF	OFF	OFF	OFF	OFF	OFF
ental performance criteria								
TIME CON	TMSTRT	TMEND	YEAR					
These are computed from formula in Column A-->	5.000	364.000	2006					
tter as C rather than organic matter								
DLT CON	NDLT	DLTMIN	DLTINTER					
Time step control parameters	4	0.1	OFF					
DLT DATE	DLTD	DLTD	DLTD	DLTD				
Date of time step change in JDAY	1	1.5	220	280				
DLT MAX	DLTMAX	DLTMAX	DLTMAX	DLTMAX				
Maximum time step in seconds	10	100	10	20				
DLT FRN	DLTF	DLTF	DLTF	DLTF				
Fraction of maximum theoretical time step	0.5	0.5	0.5	0.5				

1: floating weir, priority 1, 2.3 m depth, minimum 400 cfs, maximum 5600 cfs

2: spillway, priority -1 (nonblended)

3: lower power outlet, priority 1, maximum 5600 cfs

4: regulating outlet, priority -1 (nonblended), maximum 5600 cfs

STRUCTURES for each branch. These are known out	BR1
NSTR - Number of branch outlet structures	4
DYNSTRUC - Dynamic elevation of structure control	OFF
STRIC1-Turns ON/OFF interpolation of structure out	OFF
STRIC2-Turns ON/OFF interpolation of structure out	OFF
STRIC3-Turns ON/OFF interpolation of structure out	OFF
STRIC4-Turns ON/OFF interpolation of structure out	OFF
STRIC5-Turns ON/OFF interpolation of structure out	OFF
KTSTR1-Top layer above which selective withdrawal	2
KTSTR2-Top layer above which selective withdrawal	2
KTSTR3-Top layer above which selective withdrawal	2
KTSTR4-Top layer above which selective withdrawal	2
KTSTR5-Top layer above which selective withdrawal	2
KBSTR1-Bottom layer below which selective withdra	109
KBSTR2-Bottom layer below which selective withdra	50
KBSTR3-Bottom layer below which selective withdra	109
KBSTR4-Bottom layer below which selective withdra	109
KBSTR5-Bottom layer below which selective withdra	109
SINKC1 - Sink type used in the selective withdrawal a	LINE
SINKC2 - Sink type used in the selective withdrawal a	LINE
SINKC3 - Sink type used in the selective withdrawal a	LINE
SINKC4 - Sink type used in the selective withdrawal a	LINE
SINKC5 - Sink type used in the selective withdrawal a	LINE
ESTR1-Centerline elevation of structure 1, m	479
ESTR2-Centerline elevation of structure 2, m	469.7
ESTR3-Centerline elevation of structure 3, m	408.4
ESTR4-Centerline elevation of structure 4, m	410
ESTR5-Centerline elevation of structure 5, m	410
WSTR1 - Structure 1 width if "LINE" chosen, Width o	6.8
WSTR2- Structure 2 width if "LINE" chosen, Width of	25
WSTR3- Structure 3 width if "LINE" chosen, Width of	6.8
WSTR4- Structure 4 width if "LINE" chosen, Width of	6.8
WSTR5- Structure 5 width if "LINE" chosen, Width of	6.8

Detroit Lake Model Inputs

File type		File name			
Wind sheltering	WSCFN	wsc.npt			
Shading	SHDFN	shade.npt			
Bathymetry	BTHFN	bth1.csv			
Met	METFN	0609_met_stay_raws.npt			
Tributary inflow	QTRFN - tributary flow	0609_french_q_est.npt	0609_boxCan_q_est.npt		
	TTRFN - tributary temp	0609_french_t_est.npt	0609_boxCan_t_est.npt		
Branch inflow	QINFN branch inflow	0609_nsboulder_q.npt	0609_breitenbush_q.npt	0609_blowout_q.npt	0609_kinney_q_est.npt
	TINFN branch temp	0609_nsboulder_t.npt	0609_breitenbush_t.npt	0609_blowout_t.npt	0609_kinney_t_est.npt
	QDTFN Distributed flow	0609_qdt_br1_est.npt	0609_qdt_br2.npt	0609_qdt_br3.npt	0609_qdt_br4.npt
	TDTFN Distributed temp	0609_tdt_br1_est.npt	0609_tdt_br2.npt	0609_tdt_br3.npt	0609_tdt_br4.npt
Precipitation	PREFN flow	0609_pre_detroit.npt	0609_pre_detroit2.npt	0609_pre_detroit3.npt	0609_pre_detroit4.npt
	TPRFN temp	0609_tpr_detroit.npt	0609_tpr_detroit2.npt	0609_tpr_detroit3.npt	0609_tpr_detroit4.npt
Structure outflow	QOTFN	0609_qot_det_max.npt			

W2 Selective Inputs

w2_selective.npt

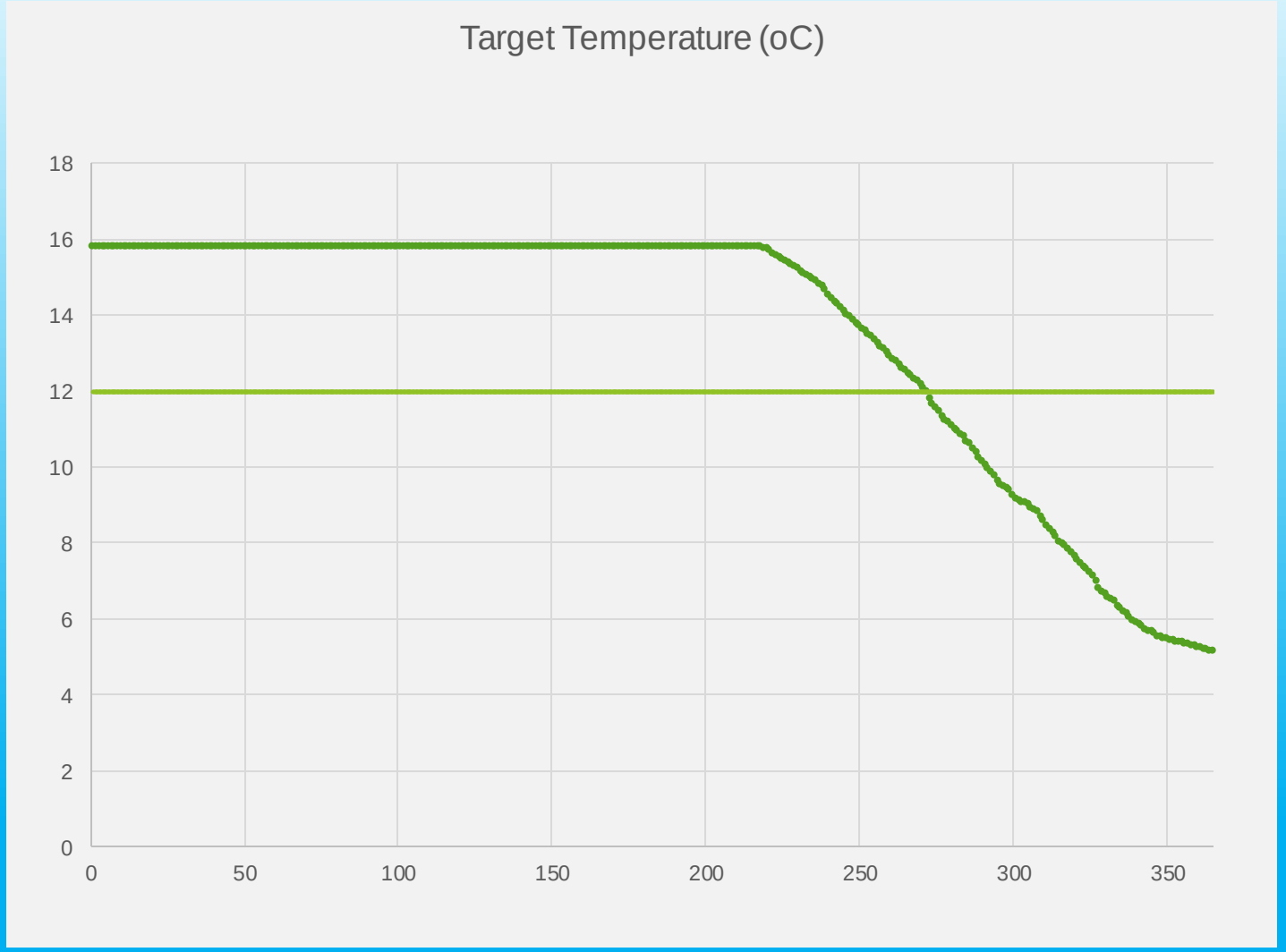
```
OUT FREQ TFRQTMP
           0.125
Structure outlet control based on time and temperature and branch
DYNSTR1  CONTROL     NUM TCDFREQ
             OFF       1   0.125

DYNSTR2     ST/WD      JB   JS/NW  YEARLY     TSTR     TEND     TEMP    NELEV    ELEV1    ELEV2
1              ST       1       1      ON      1.0    151.0     10.0        2     340.     330.

MONITOR LOC ISEG     ELEV  DYNCEL
1              0     -185     OFF

AUTO ELEVCONTROL
1            OFF

SPLIT1       CNTR      NUM  TSFREQ  TSCONV
               ON       1   0.125   0.005

SPLIT2      ST/WD      JB  YEARLY     TSTR     TEND TTARGET  DYNSEL  ELCONT    NOUTS TSSHARE
1              ST       1      ON       1.    99999     12.      ON     OFF        4     OFF

SPLITOUT JS1/NW1 JS2/NW2 JS3/NW3 JS4/NW4 JS5/NW5 JS6/NW6 JS7/NW7 JS8/NW8 JS9/NW9 JS0/NW0
1              1       2       3       4

DEPTH     DEPTH1  DEPTH2  DEPTH3  DEPTH4  DEPTH5  DEPTH6  DEPTH7  DEPTH8  DEPTH9 DEPTH10
1            2.3       0       0       0

MINFRAC  MINFRC1 MINFRC2 MINFRC3 MINFRC4 MINFRC5 MINFRC6 MINFRC7 MINFRC8 MINFRC9 MNFRC10
1        -11.326     0.0     0.0       0

PRIORITY  PRIOR1  PRIOR2  PRIOR3  PRIOR4  PRIOR5  PRIOR6  PRIOR7  PRIOR8  PRIOR9 PRIOR10
1              1      -1       1      -1
```

W2 Selective Inputs

dynsplit_selective1.npt

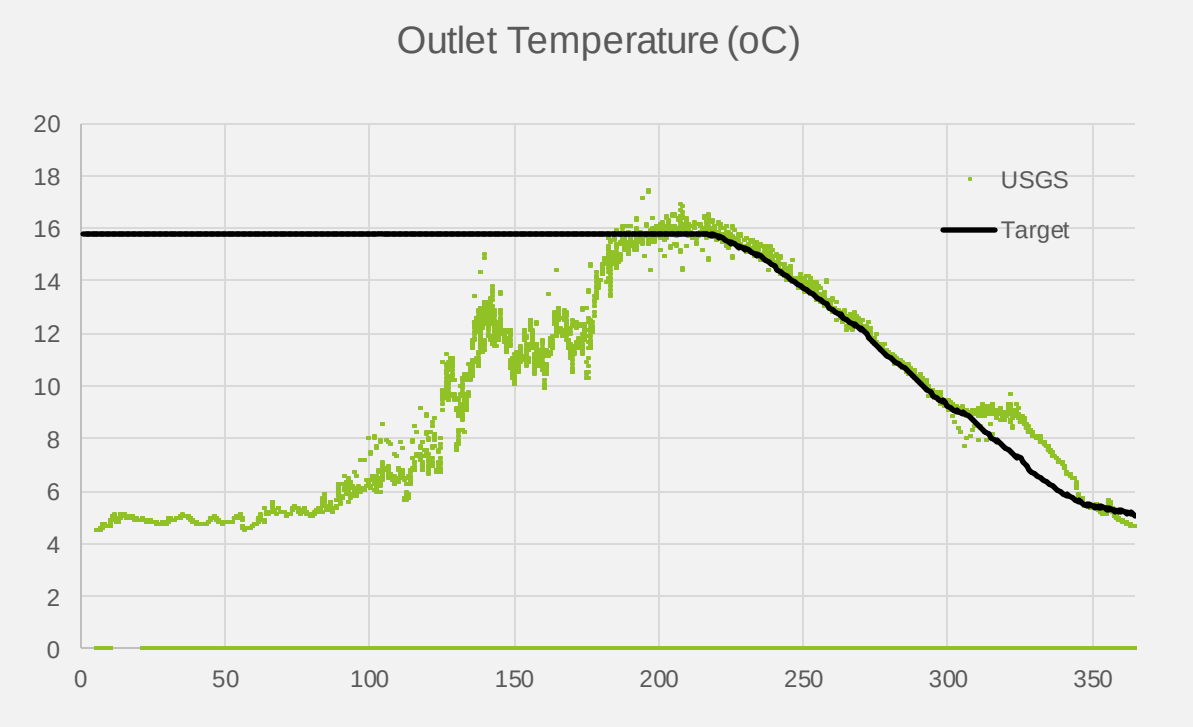
dynsplit_selective1.npt

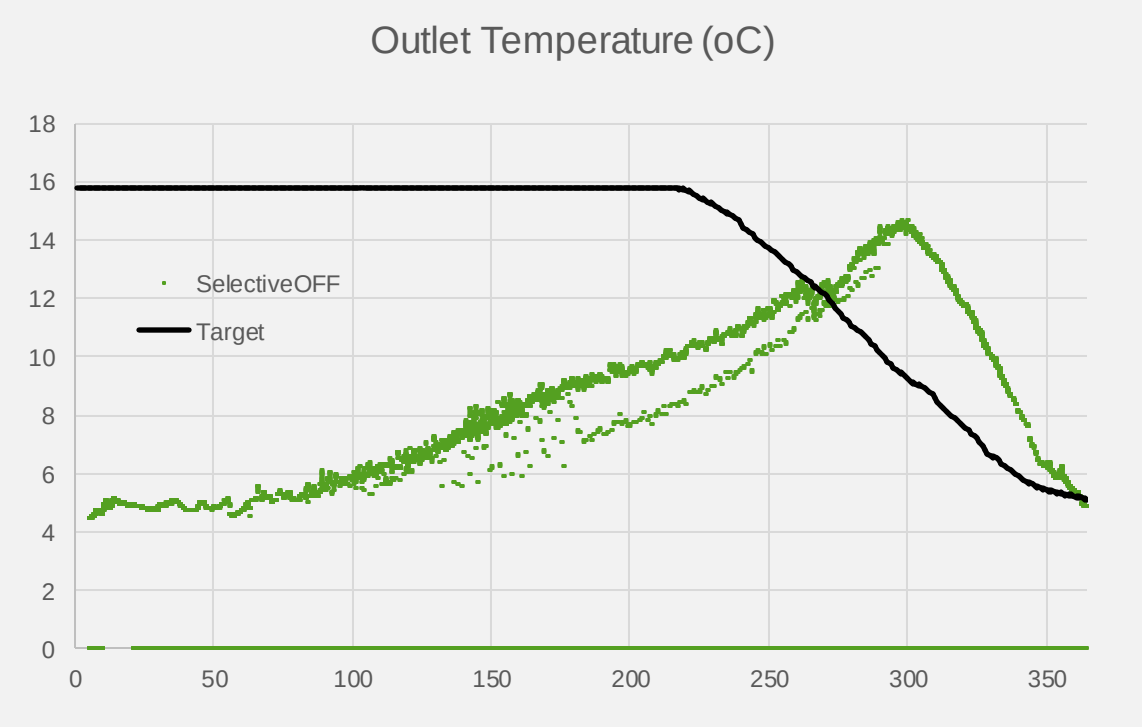
```
#15-day moving aver
#
# JDAY,    T.C
         1  15.790
         2  15.790
         3  15.790
         4  15.790
         5  15.790
         6  15.790
         7  15.790
         8  15.790
         9  15.790
        10  15.790
        11  15.790
        12  15.790
        13  15.790
        14  15.790
        15  15.790
        16  15.790
        17  15.790
        18  15.790
        19  15.790
        20  15.790
```



Model Results

Effect of dam operations on release water temperature, with and without selective withdrawal





Hands-On Exercises

Questions?