SEF evaluation of Interim Guidance for Thermal Mitigation 2017 FFMP
June 2019 Progress Report

In August of 2018, the Regulated Flow Advisory Committee (RFAC) appointed 13 members to the Subcommittee on Ecological Flows (SEF) and charged the Subcommittee with reviewing the interim thermal mitigation in the Flexible Flow Management Program of 2017 (FFMP 2017).

This report summarizes SEF's research supporting our recommended alternative protocol. More detailed methods, results, and evaluations supporting this document can be provided to RFAC by request. SEF evaluations remain ongoing and we list below open issues and proposed additional research.

SEF's investigations relied on time-series trend analyses, simulations and statistical probability models. Development of a thermo-dynamic heat flux model could provide complementary findings and is part of the proposed continuation research. Additional progress reports will be submitted to RFAC as future investigations are completed. Eventually all analyses will be fully codified in a final report.

Evaluation

After reviewing and analyzing several alternate management protocols with a variety of thermal stress criteria ranging from 68˚F to 77˚F , SEF members conducted detailed evaluations of two alternatives:

> "**Interim Protocol**" – The current Interim Guidance for Thermal Mitigation as described within the 2017 FFMP. This policy includes a phase 1 during which a single day at 75°F triggers a mitigation release, and a phase 2 during which two consecutive days at 75°F or a single day at 77°F triggers a release. This policy also constrains the amount of the thermal bank that can be expended during phase 1 to 1,250 CFS days. The amount of water in the thermal bank is set at 2,500 CFS days beginning on June 1, and this bank amount carries over, if not exhausted, to May 31 of the following year.
>
> "**Simple 75 Protocol**" – a revision of the Interim Protocol that removes the 77˚F maximum and two successive days at 75°F temperature triggers at Lordville during the Secondary Phase and instead uses a single 75˚F maximum temperature trigger at Lordville during all time periods. The thermal bank is initiated as above at 2,500 cfs-days on June 1.

SEF evaluated the effectiveness of these two protocols using historical flows and temperature data at Lordville for the summers (May 1 to September 30) over the last 11 years, from 2008 – 2018, a period during which some version of the FFMP was in place. In all the evaluations discussed below, a day was considered in thermal stress if the maximum water daily temperature exceeded 75°F.

Because low base releases in the early years of the FFMP possibly contributed to the amount of thermal stress experienced historically, we also simulated the operations of FFMP 2017 in the years 2008 to 2012. With DRBC collaboration, this was done via OASIS modified hydrology and water temperatures for the period 2008-2012. These simulations validated our hypothesis that had FFMP 2017 been in operation throughout, thermal stress would have been less frequent.

In addition to these analyses, we conducted detailed analyses of the nine thermal releases that were made by NYSDEC over the 11 years of FFMP operations (Table 1).

	June of 2008	July of 2010	July of 2011	June of 2012	July of 2013	July of 2016	17-Jun-18	30-Jun-18	15-Jul-18
Bing MaxTemp at Pulse Start ˚F	89	90	93	90	87	88	84	88	84
Stilesville Base Rate (cfs)	253	372	598	510	567	498	389	383	389
Stilesville Pulse Level (cfs)	631	510	1050	897	923	776	677	709	637
Stilesville Pulse Magnitude (cfs)	378	138	387	387	356	278	288	326	248
Stilesville Ending Rate (cfs)	263	340	598	510	567	498	389	389	389
Lordville Base Rate (cfs)	852	662	1200	1350	1260	953	990	1260	918
Lordville Level During Pulse (cfs)	1100	835	1570	1600	1550	1200	1170	1460	1060
Release Start Time	6/9 21:30	7/5 23:30	7/22 14:25	6/20 5:15	7/16 23:30	7/23 15:00	6/17 11:45	6/30 12:30	7/15 15:45
Time Reached Pulse Level	6/10 2:15	7/6 2:30	7/22 19:00	6/20 20:00	7/17 4:45	7/23 19:00	6/18 16:15	6/30 15:45	7/15 19:15
Time Pulse Reached Lordville	6/10 11:30	7/6 16:30	7/23 6:15	6/21 7:15	7/17 14:45	7/24 7:15	6/18 2:15	7/1 4:00	7/16 8:45
Time Start Drop	6/11 7:30	7/9 22:30	7/24 12:00	6/21 11:30	7/19 0:00	7/25 15:15	6/18 10:30	7/4 11:30	7/16 14:45
Time Return to Base Rate	6/11 18:00	7/10 5:30	7/24 16:15	6/21 16:15	7/19 10:30	7/25 20:45	6/18 16:45	7/4 22:30	7/16/22:00
Total Additional Water	552	513	849	342	794	563	291	1202	268
Release Duration (days)	1.85	4.25	2.06	1.03	10:48	2.24	1.17	9.31	1.26
Pulse Duration (days)	1.22	3.83	1.7	0.64	1.8	1.84	0.78	3.76	0.81
Relative Temp Drop ˚C	1.70	-0.3	2.6	1.7	2.2	1.9	1.45	1.743	1.15
Impact Metric I (cfs/˚C)	222	-460	149	227	162	146	199	187	216
Impact Metric II (˚C/100 cfs)	0.45	-0.22	0.67	0.44	0.62	0.68	0.50	0.53	0.46

Table 1. Summary Analyses of Nine Thermal Releases: 2008 to 2018

Evaluations were predicated on the magnitude and duration of simulated thermal releases. Two release regimes were evaluated:

> **"STATS"**, (100 cfs per 1.242˚F [0.69˚C]) a regime based on a statistical calibration regression predicting water temperatures at Lordville based on up-river observations and prevailing meteorological conditions.
>
> **"EXPER",** an experience-based release (331 cfs per thermal stress event day, actual average daily use in existing FFMP) was also evaluated as an alternative to the rate inferred by the STATS model. Duration of thermal releases in all scenarios were simulated to fully encompass all identified thermal stress days. The efficacy of the thermal bank (i.e., 2,500 cfs-days) was estimated by a statistical multiple linear regression inclusive of upriver observations and meteorological conditions.

A general note is worth adding for all the analyses. These simulations assume perfect forecasting of stress conditions, and hence are optimistic regarding policy performance.

Based on historical USGS gage data at Lordville, a total of 78 days exceeded the 75°F stress definition. (Table 2).

	Days When Tmax >= 75 F Exceeded					
	May	Jun	Jul	Aug	Sep	Season
2008	0	8	9	1	0	18
2009	0	0	0	0	0	0
2010	4	2	15	1	2	24
2011	0	0	3	0	0	3
2012	0	1	5	8	0	14
2013	0	0	2	0	0	2
2014	0	0	0	0	0	0
2015	0	2	0	0	0	2
2016	4	0	4	1	0	9
2017	0	0	0	0	0	0
2018	0	0	6	0	0	6
11 Years	8	13	44	11	2	78

Table 2. Frequency of Thermal Stress at Lordville by Year and Month: 2008 to 2018

Application of OASIS/PST adjustment/simulation of FFMP 2017 in 2008 to 2012 reduced the total thermal stress days to 41 days (Table 3), suggesting the 2017 FFMP conservation releases (i.e., Table 3) are inherently proactive in mitigating the frequency of thermal stress at Lordville.

	Actual Stress Days					
	May	Jun	Jul	Aug	Sep	Season
2008	0	8	9	1	0	18
2009	0	0	0	0	0	0
2010	4	2	15	1	2	24
2011	0	0	3	0	0	3
2012	0	1	5	8	0	14
Five Years	4	11	32	10	2	59

	Sttess Days Under Simulated FFMP 2017					
	May	Jun	Jul	Aug	Sep	Season
2008	0	4	0	0	0	4
2009	0	0	0	0	0	0
2010	1	1	1	1	0	4
2011	0	1	4	0	0	5
2012	3	4	1	1	0	9
Five Years	4	10	6	2	0	22

Table 3. Historical vs. OASIS Simulated Lordville Stress Days: 2008to 2012

Performance of the "Interim Protocol" Under the STATS release regime (100 cfs per 1.242˚F [0.69˚C]), because lower volumes of water are used for each thermal event, there were no "unmitigated stress days", and the Thermal Mitigation Bank was never completely utilized in any year (An average of 640 cfs-days was used per year) (Table 4).

Under the EXPER release regime (331 cfs per event day), the average amount of water used for thermal mitigation was 962 cfs-days. The maximum used was 2,472 cfs-days in 2011. Thus, the thermal bank of 2,500 cfs-days was never exhausted in any of the 11 years evaluated (2008-2018). However, 14 unmitigated thermal stress days were experienced -- all due to the Second Phase constraints which conserved water while Lordville was already in stress at 75°F. These occurred in 2008, 2010, 2011, 2012, and in 2018. (Table 4)

	Release 100 cfs per 0.69℃				Release 331 cfs per stress day			
	Oasis 75/77	Oasis Stress Days?	Oasis No Phase 75	Oasis Stress Days?	Oasis 331 Per Diem 75/77	Oasis Stress Days?	Oasis 331 Per Diem 75	Oasis Stress Days?
Year	Release 100 cfs per 0.69°C	Release 100 cfs per 0.69°C	Release 100 cfs per 0.69°C	Release 100 cfs per 0.69°C	Release 331 cfs per stress day	Release 331 cfs per stress day	Release 331 cfs per stress day	Release 331 cfs per stress day
2008	1241	None	1241	None	1585	1x (Phase 2)	1916	None
2009	95	None	95	None	331	None	331	None
2010	543	2x (Phase 2)	653	None	874	2x (Phase 2)	1536	None
2011	1528	4x (Phase 2)	1826	None	2472	3x (Phase 2)	3465	3x NO WATER
2012	563	2x (Phase 2)	616	None	1358	3x (Phase 2)	2351	none
2013	671	-	685	-	671	-	1002	-
2014	0	-	0	-	0	-	0	-
2015	101	-	101	-	993	-	993	-
2016	510	-	597	-	510	-	1172	-
2017	0	-	0	-	0	-	0	-
2018	1793	5x total all in phase 2 (1x - 1250 water exceeded, 4x date)	2039	None	1793	5x (Phase 2)	3448	2x NO WATER

Table 4. Comparison Table of Interim Protocol and Simple 75 Protocol with both lower thermal releases (100 cfs per 0.69°C) and experienced based thermal releases (331 cfs per stress day)

Performance of the "Simple 75 Protocol"

As with the "Interim Protocol," under the STATS release regime (100 cfs per 1.242˚F [0.69˚C]), there were no "stress days" that went unmitigated, and the Thermal Mitigation Bank was never completely utilized in any year (average of 714 cfs-days used per year) (Table 4).

Under EXPER release regime (331 cfs per event day), the average amount of water needed for thermal mitigation was 1,474 cfs-days. The maximum needed was 3,465 cfs-days in 2011, and in 2018 3,448 cfs-days were needed. Thus, the thermal bank of 2,500 cfs-days was exhausted in 2 of the 11 years evaluated. There were 5 unmitigated thermal stress days in the simulations due to the exhaustion of the 2,500 cfs-day bank (3 in 2011, 2 in 2018) (Table 4).

Recommendation from SEF

The Subcommittee on Ecological Flows recommends eliminating the two-phase approach within the Interim Protocol; and, retain only Phase 1 which is consistent with the "Simple 75 Protocol" evaluated in these simulations.

While SEF acknowledges trade-offs among different strategies for using the 2,500 cfs-day Thermal Mitigation Bank, the Subcommittee feels this revised "Simple 75 Protocol" makes important improvements to the Interim Protocol by eliminating potentially stressful maximum temperatures of 77°F as was originally permitted in Phase II. The elimination of Phase II will, by mitigating more 75°F stress days, offer better protection for the cold-water fishery of the upper mainstem Delaware River while better utilizing the available bank of cold-water releases.

The Subcommittee wishes to emphasize the adaptive nature of this thermal mitigation protocol, and with implementation experience with our suggested protocol and further research adding to our understanding of the trade-offs among different strategies, additional improvements are possible. As a result, SEF requests that RFAC charge the subcommittee with continued evaluation of thermal mitigation issues in the expectation that additional revisions to the protocol could be recommended in future years.

SEF also acknowledges that, similar to deliberations for thermal events prior to the 2017 FFMP and the establishment of the 2500 cfs-day bank, extraordinary thermal events may occur after the bank is exhausted for which RFAC and the Decree Parties may be petitioned for special releases, should sufficient water be available in the New York City reservoirs.

Continued Work under RFAC Charge

SEF members request additional time to evaluate items related to the August 2018 RFAC charge, including:

- The ability of the Thermal Mitigation Bank to adequately reduce or prevent a standard which considers the average water temperatures at Lordville from exceeding 72˚F over a 24-hour period.
- An evaluation of other more protective temperature triggers or targets;
- The adequacy of the size of the Thermal Mitigation Bank for protecting the upper mainstem Delaware River in a manner consistent with the goals identified in the FFMP.
- Develop and evaluate thermal dynamic models, as complementary to the statistical probability model.

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