Exhibit GMP-JL-4

Tropical Storm Irene
Plus 50-Percent Scenario

CLIMATE RESILIENCY STUDY

Winooski River Watershed, Vermont

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1 Introduction

To assist Green Mountain Power ("GMP") in planning for climate-change resiliency, this report assesses the potential effects of a storm event consisting of 50-percent more rainfall than Tropical Storm Irene in Vermont's Winooski River watershed.

1.1 Background

On August 27 and 28, 2011 Tropical Storm Irene caused widespread and severe flood damage in central and southern Vermont. In addition to extensive damage to private and commercial property, Vermont's transportation infrastructure was severely impacted in many areas. The Irene Recovery Report indicated that the state transportation system incurred damage to over 200 road segments and 200 bridges, while towns reported over 2,000 road segments, 300 bridges and more than 1,000 culverts were damaged or destroyed. In Central Vermont's Winooski River watershed, the storm deposited approximately five inches of rain and caused significant damage in Waterbury Village and other locations (refer to Figure 1 below). The United States Geological Survey ("USGS") reported record discharges for eight stream gauges in Vermont including two major tributaries within the Winooski River watershed: the Little River (Waterbury) and Mad River (Moretown) (Kirn, 2012; Lunderville, 2011).

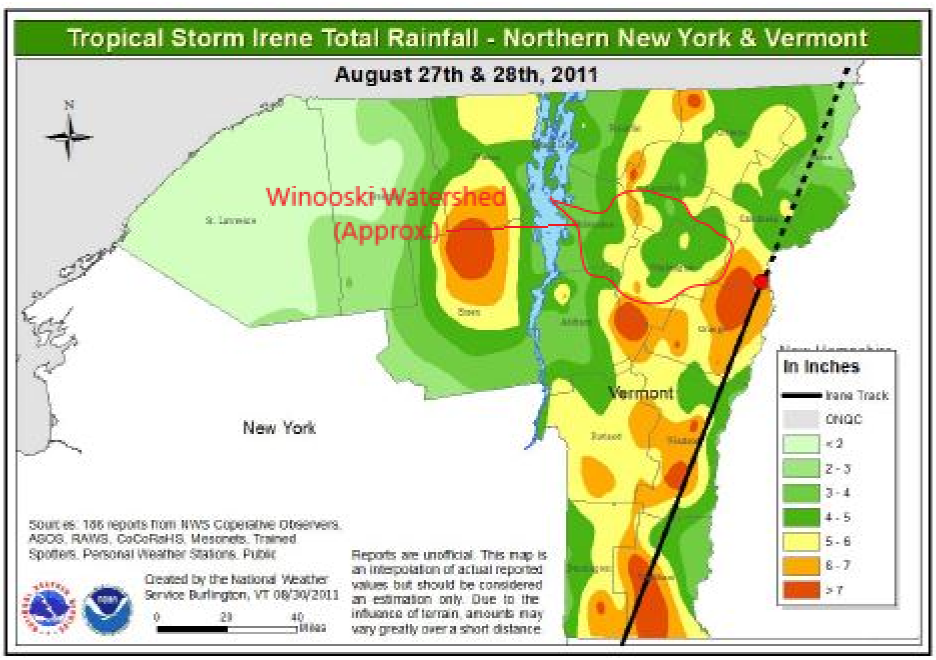

Figure 1: Tropical Storm Irene Rainfall Map
(from Kirn, 2012 and National Weather Service, 2011)

The severity of flooding during Tropical Storm Irene varied among locations within the Winooski River watershed. At the USGS Winooski River at Montpelier streamflow gauge, peak flows (14,600 cfs) were in-between a 10-year and 100-year flood (13,500 and 20,000 cfs respectively) as defined by the Federal Emergency Management Agency ("FEMA"). Similarly, at the USGS Winooski River near Essex Junction streamflow gauge, peak flows (35,000 cfs) were in-between a 10-year and 100-year flood (32,900 and 55,700 cfs respectively). Flooding was more severe at the USGS Mad River near Moretown gauge where peak flows of 24,200 cfs were in-between a 100-year and 500-year flood (20,700 and 31,400 cfs respectively). At the upper extreme, peak flows recorded at the Dog River at Northfield Falls USGS gauge (22,200 cfs) were in excess of FEMA's 500-year recurrence flood which is defined as 17,000 cfs (FEMA, 2013, 2014). The confluence of the peak flows from the Dog, Mad, and Winooski Rivers caused the damaging flooding in Waterbury Village.

1.2 Study Objective

Climate change, driven by manmade emissions of Carbon Dioxide and other Greenhouse Gases, is widely believed to contribute to future increases in frequency and intensity of damaging storms and floods in Vermont and the US Northeast (ANR, 2013; Austin, 2012; DPS, 2016; Hayhoe et. al., 2007; Pealer and Dunnington, 2011; UCS, 2006). For the purpose of identifying a "design storm" to represent a potential future climate change scenario, GMP requested this analysis of what could happen if 50-percent more rain than Tropical Storm Irene fell in the Winooski River watershed. This report describes the hydrologic modeling that was performed to assess this scenario, and the magnitudes of streamflow and water levels at key GMP locations in the watershed.

The modeling results presented in this report are estimates of the potential scale of a theoretical extreme storm event. Flows and water levels in an actual storm event with the rainfall amounts described herein may vary from these estimates depending on many factors, including geographic and temporal distribution of rainfall, soil moisture conditions, debris jams, operation of dams and flood-control infrastructure by GMP and others, among other variables that are beyond the scope of this simple modeling exercise.

2 Methods

A calibrated desktop hydrologic model was used to determine the likely amounts of streamflow and water levels during the design storm. The model evaluated rainfall and runoff during Tropical Storm Irene and during the design storm event, and analyzed the routing of runoff through the tributaries and Winooski River as well as through GMP's facilities in the watershed, as shown in Figure 2 below (a large-format map is also included in Appendix 1). The following GMP Facilities were analyzed:

1. Peacham Pond storage reservoir (Sucker Brook, Peacham VT)
2. Mollys Falls Reservoir / Marshfield Hydropower Station (Mollys Brook and Winooski River, Cabot and Marshfield VT)
3. Middlesex Hydropower Station (Winooski River, Middlesex and Moretown VT)
4. Waterbury Reservoir / Waterbury Hydropower Station (Little River, Waterbury VT)

5. Bolton Falls Hydropower Station (Winooski River, Waterbury and Duxbury VT)
6. Essex #19 Hydropower Station (Winooski River, Essex and Williston VT)
7. Gorge #18 Hydropower Station (Winooski River, South Burlington and Colchester VT)

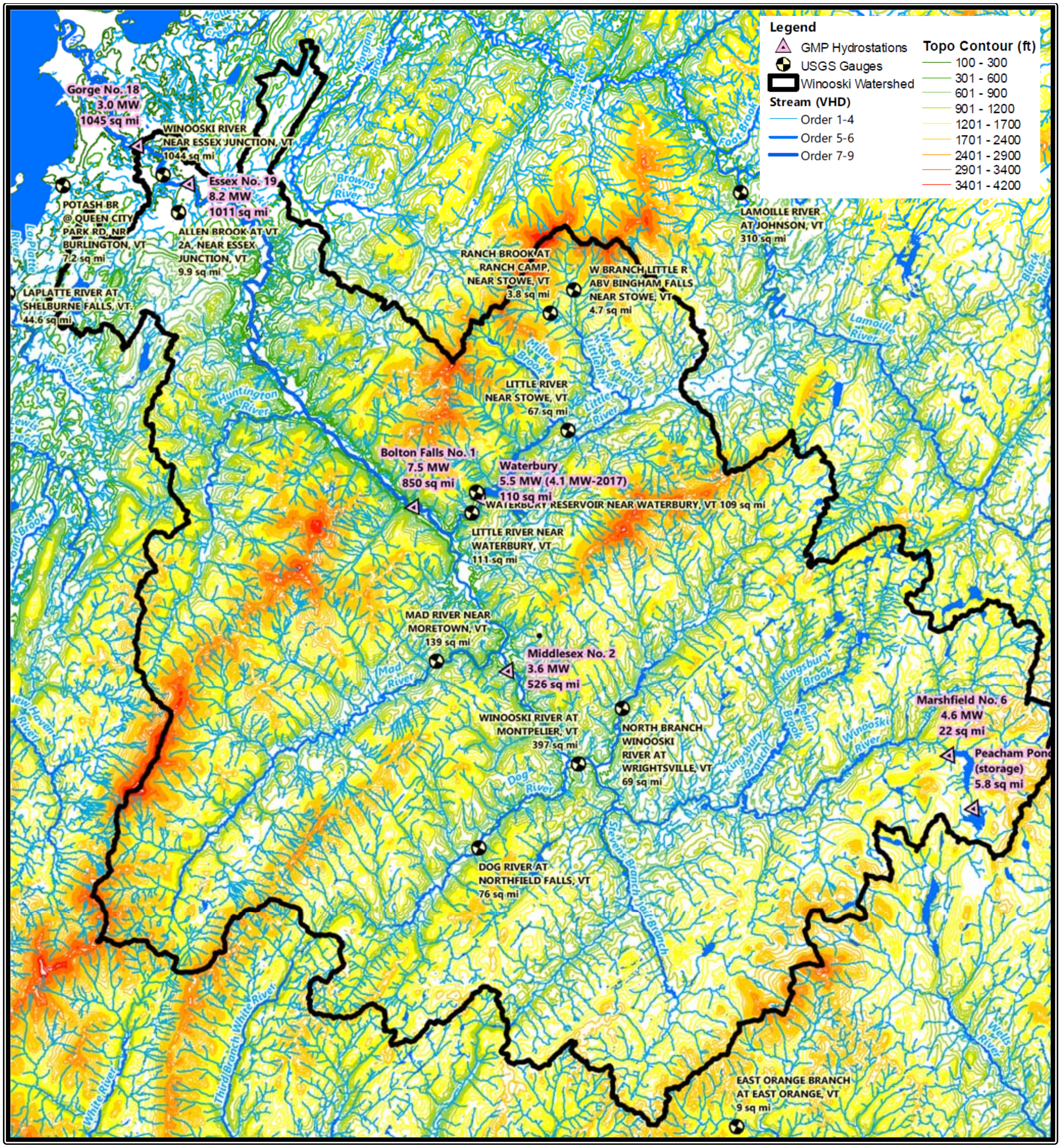

Figure 2: Map of Winooski River Watershed, GMP Facilities, and USGS Gauges

2.1 Assumptions

A general assumption used in this analysis was that the design storm would have 50% more rainfall than Tropical Storm Irene, but otherwise would have same duration, temporal rainfall distribution throughout the event, and same starting soil-moisture conditions. For all GMP facilities within the Winooski River watershed, the modeling was based on the assumptions that all hydropower stations and reservoirs would be in-service and operating normally in accordance with their permits, FERC licenses, and water quality certifications.

For GMP's Mollys Falls Reservoir (see Figure 3 below) and the associated Marshfield hydropower station in the Winooski headwaters, the design storm modeling included the assumption that the lowered new Normal Operating Level would be in effect pursuant to the August 2019 Memorandum of Understanding between GMP and the Vermont Agency of Natural Resources ("ANR"). In contrast, during Tropical Storm Irene this GMP facility was out-of-service and unable to generate renewable energy, thus unable to manage reservoir levels normally. Accordingly, the modeling of the Tropical Storm Irene event simulated the facility being out-of-service, for accurate calibration to actual flows and water levels at that location.

Figure 3: Mollys Falls Reservoir – winter 2015-16,
water levels lowered below dam crest providing storage for snowmelt events

For the Waterbury Reservoir flood-control dam that is owned and controlled by the State of Vermont, the modeling was based on the assumption that following standard protocols, the flood-control gates (Taintor gates) would be closed once water levels in the Winooski River at Waterbury exceed 417 feet; actual operations at the discretion of ANR may differ as was the case during Tropical Storm Irene. The model determines spillage through the Taintor gates based on simulated reservoir water levels and gate positions; the model determines spillage over the uncontrolled spillway based on simulated reservoir water levels. Note that the sill of the Taintor gates is at an elevation of 592 feet, the sill of the uncontrolled spillway is at 617.5 feet, and the nominal trigger for closing the Taintor gates is when the Winooski River in Waterbury Village exceeds 417 feet. Refer to Figure 4 below for a depiction of this infrastructure.

Figure 4: Waterbury Reservoir Dam – Spring 2018
Taintor gates (3) fully open and releasing flow
Uncontrolled spillway is left of Taintor gates (releases flow when reservoir levels >617.5 ft)

For the design storm model, the model was used to optimize storage in the reservoir, reducing downstream flows and avoiding the need for uncontrolled spillage. Generally, this simulation involved releasing 2,000 cfs through the Taintor gates once reservoir levels exceed 595 feet. Without these releases, the reservoir would be predicted to fill above the uncontrolled spillway and to cause high downstream flows of approximately 11,000 cfs in the Little River.

2.2 Modeling Methods

The HydroCAD-10 Hydrology & Hydraulics Software was used to simulate rainfall and determine rates of runoff. VHB & GMP's proprietary Winooski watershed forecaster program was used to route the runoff through the watershed including detailed analysis of reservoir operations, water storage, and flow releases at GMP's hydroelectric stations and reservoirs in the watershed. GMP and VHB have been using the proprietary Winooski watershed forecaster program daily since late 2017, and have determined that it accurately predicts river flows and water levels in a variety of weather and operating conditions, based on comparison of the forecast results to actual flows and energy generation.

An initial modeling run was performed to simulate Tropical Storm Irene in order to calibrate the model. Model inputs for antecedent soil moisture conditions, rainfall amounts, and rainfall distribution were adjusted to achieve accurate calibration. The timing and magnitude of actual streamflows recorded at USGS gauging stations in the watershed and actual water levels recorded at GMP facilities and USGS gauges, were compared to model results to verify accuracy. Calibration results are presented in Section 2.4 below.

Subsequently, a second modeling run was performed to assess the design storm, using 50-percent more rainfall than in Tropical Storm Irene in most of the watershed, but with other characteristics of the storm unchanged from the Tropical Storm Irene inputs. At the Dog River watershed where flows during Tropical Storm Irene already exceeded a 500-year event, design storm flows were assumed to be the same as during the 2011 storm. At the Mad River watershed where flows during Tropical Storm Irene were in-between a 100-year and 500-year flood, design storm flows were adjusted not to exceed the 500-year event.

2.3 Rainfall

Table 1 summarizes the key characteristics of the rain events used for the modeling of Tropical Storm Irene and the design storm (Tropical Storm Irene plus 50-percent more rainfall).

Table 1:
Model Input Rainfall Characteristics

Storm Event	Tropical Storm Irene	Irene Plus 50-Percent
Inches of Rainfall:	5.25	7.875
Storm Duration, hours:	24	24
SCS Rainfall Distribution:	Type I	Type I
Antecedent Moisture Condition:	1	1

Figure 5 below depicts the rainfall used as model input for each scenario.

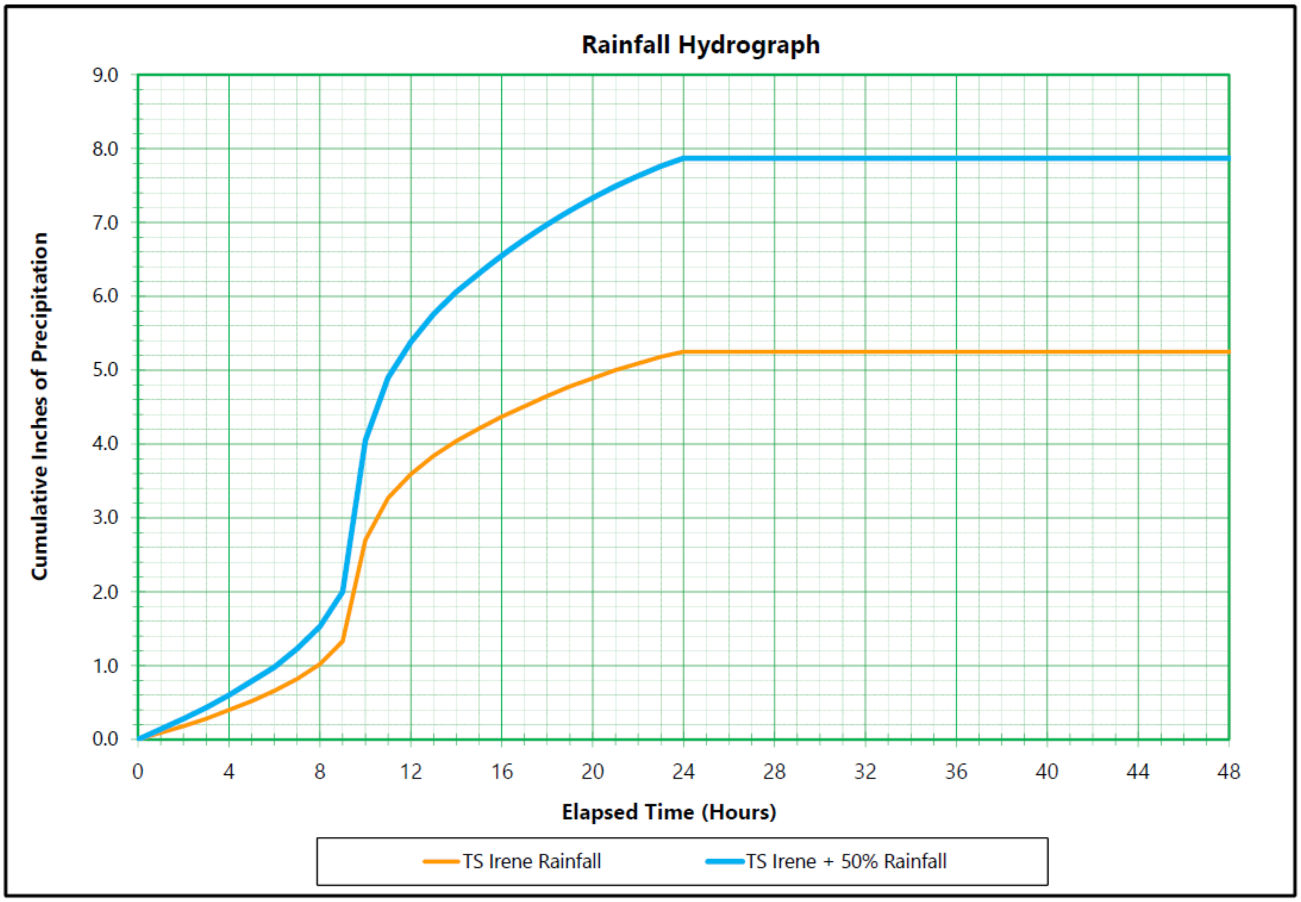

Figure 5: Model Input Rainfall Distribution

2.4 Calibration

As noted in Section 2.2 above, to verify accuracy of the modeling, Tropical Storm Irene was first simulated, and the model results were compared to actual flows and water levels. Actual streamflows recorded at USGS gauging stations in the watershed and actual water levels recorded at GMP facilities and USGS gauges were compared to model results to verify accuracy. Data were obtained from GMP's monitoring system which records water levels in reservoirs and impoundments, as well as approved USGS streamflows. Table 2 and Figure 6 below present key calibration results, showing that the modeling accurately predicted the timing and magnitude of streamflows and peak water levels. Additional calibration results are provided in Appendix 2.

Table 2: Model Calibration: Comparison of Actual TS Irene Flows and Water Levels to Model Results				
Location	**Parameter**	**Actual**	**Model**	**Notes**
Peacham Pond	Maximum Water Elevation (ft msl)	1,401.75	1,401.85	Model accuracy is very good
Mollys Falls Reservoir	Maximum Water Elevation (ft msl)	1,231.15	1,231.17	Model accuracy is very good
Mollys Falls Reservoir	8/29 Water Elevation (ft msl)	1,230.75	1,230.75	Model accuracy is very good
Mollys Falls Reservoir	8/30 Water Elevation (ft msl)	1,229.95	1,230.15	Model accuracy is very good
Mollys Falls Reservoir	8/31 Water Elevation (ft msl)	1,229.65	1,229.93	Model accuracy is very good
Winooski River at Montpelier USGS Gauge	Peak Flow (cfs)	14,600	13,699	Model accuracy is very good
GMP Middlesex Hydrostation	Peak Flow (cfs)	44,598 +/-	38,951	"actual" is estimated from nearby USGS gauges; model accuracy is very good
Little River at Waterbury USGS Gauge	Peak Flow (cfs)	1,300	603	Reservoir was impounding during Irene; model accuracy is good, however model simulated standard operations rather than actual impounding/releases that occurred
GMP Bolton Falls Hydrostation	Peak Flow (cfs)	74,726 +/-	50,866	"actual" is estimated from nearby USGS gauges; model accuracy is fair, estimated "actual" flow may not be accurate due to attenuation of Mad River peak
Winooski River at Essex USGS Gauge	Peak Flow (cfs)	35,000	41,532	Model accuracy is good

Notes

msl = mean sea level (NGVD 1929). At Peacham Pond and Mollys Falls Reservoir, subtract 691.65 feet to convert to GMP local datum.

cfs = cubic feet per second

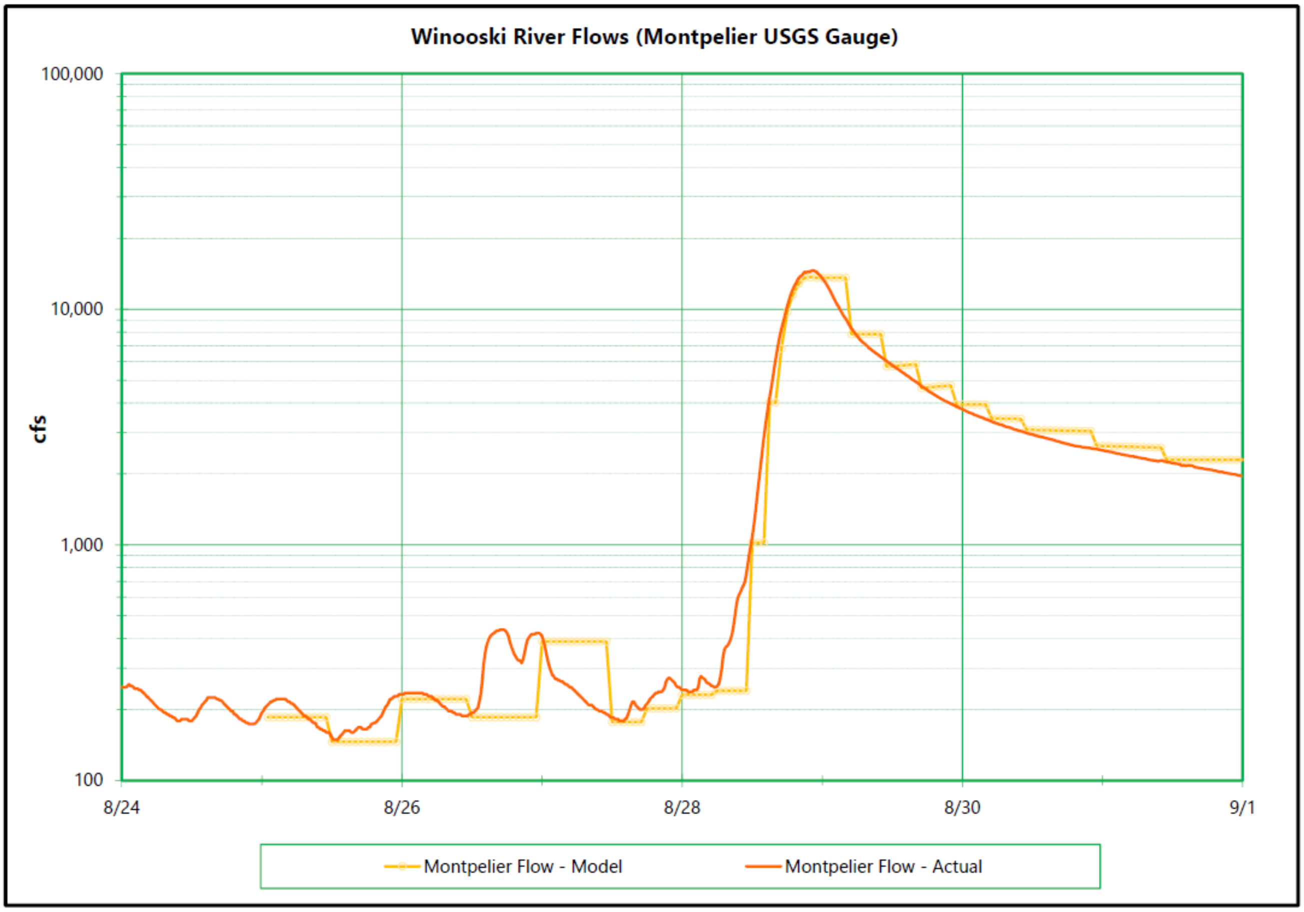

Figure 6: Model Calibration Results – Comparison to Tropical Storm Irene

3 Results

For a storm event that involves 50-percent more rain than Tropical Storm Irene falling in the Winooski River watershed, peak streamflows in many locations would be significantly higher than 50-percent more than those in Tropical Storm Irene. Before Tropical Storm Irene occurred in late August 2011, streamflows were low and soil moisture levels were fairly dry, absorbing a portion of the rainfall. Simulating the larger design storm on the same antecedent conditions, the hydrologic modeling predicts that peak runoff rates would be as much as 260-percent greater in headwater locations, because the soil's capacity to absorb rainfall would become depleted during the earlier portions of the rainfall event, leading to significantly higher rates of runoff during the later periods of the storm.

Figure 7 below illustrates the results at the Winooski River in Montpelier, comparing the streamflow rates during the design storm to the streamflows recorded during Tropical Storm Irene. Peak flows during the design storm are approximately 35,000 cfs, slightly more than twice the approximately 15,000-cfs peak recorded during Tropical Storm Irene at this location. Additional modeling results for other locations in the watershed are provided in Appendix 3.

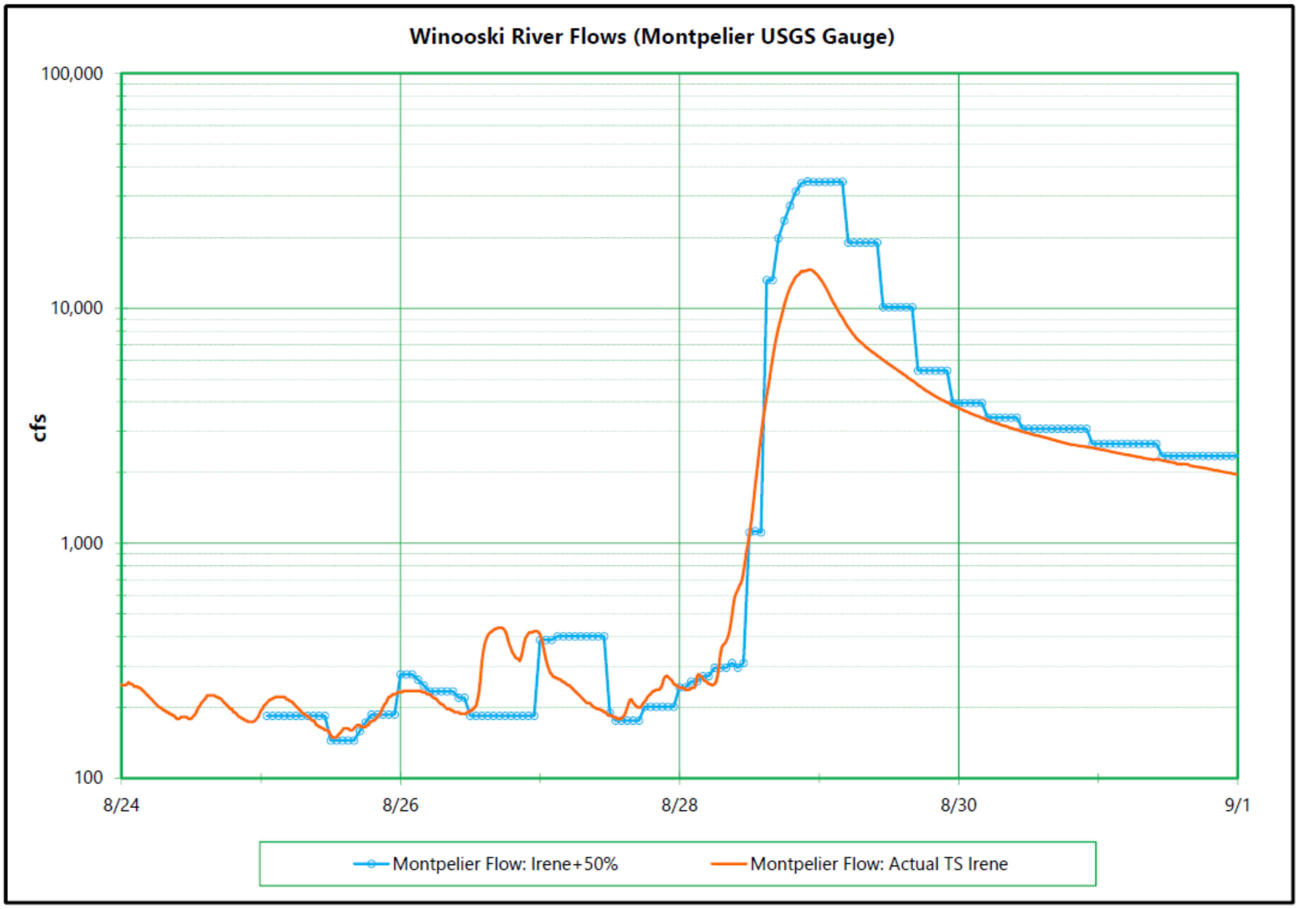

Figure 7: Model Results: Comparison of Irene+50% Scenario to Tropical Storm Irene

Table 3 below presents streamflow rates and water levels at key locations in the watershed, comparing Tropical Storm Irene to the design storm and to defined flood thresholds. Whereas peak flows recorded during Tropical Storm Irene at various locations within the watershed ranged from slightly higher than a 10-year flood to greater than a 500-year event, flows are expected to exceed a 500-year event in more parts of the watershed during the design event equivalent to Irene plus 50-percent more rainfall.

Table 3: Model Results – Comparison of Tropical Storm Irene to Irene+50% Event

Location	Parameter	TS Irene	Irene +50%	Notes
Peacham Pond	Maximum Water Elevation (ft msl)	1,401.8	1,402.9	Emergency Spillway crest = 1402.30 ft.
Peacham Pond	Emergency Spillway Flow (cfs)	0	112	
Mollys Falls Reservoir	Maximum Water Elevation (ft msl)	1,231.2	1,230.2	top of new slide gate = 1230.30 ft

Table 3: Model Results – Comparison of Tropical Storm Irene to Irene+50% Event				
Location	**Parameter**	**TS Irene**	**Irene +50%**	**Notes**
Mollys Falls Reservoir	Service Spillway Flow (cfs)	361	0	Flows during TS Irene are estimated based on known water level data (flow not measured)
Mollys Falls Reservoir	Emergency Spillway Flow (cfs)	0	0	
Winooski River at Montpelier USGS Gauge	Maximum Water Level (ft local)	19.1	39.0	Irene+50% water level from USGS Rating Curve, projected to 34,704 cfs NWS Major Flooding Level = 17.5 ft
Winooski River at Montpelier USGS Gauge	Peak Flow (cfs)	14,600	34,704	FEMA 10 year flood = 13,500 cfs FEMA 100 year flood = 20,000 cfs FEMA 500 year flood = 26,500 cfs
GMP Middlesex Hydrostation	Maximum Water Elevation (ft msl)	495.3	498.9	dam crest = 487.00 ft. TS Irene level from SCADA (8.3 ft above crest)
GMP Middlesex Hydrostation	Peak Flow (cfs)	44,598	61,744	
Waterbury Reservoir	Maximum Water Elevation (ft msl)	600.3	612.3	Uncontrolled spillway crest = 617.5 ft
Little River at Waterbury USGS Gauge	Maximum Water Level (ft local)	8.8	11	Irene+50% water level from USGS Rating Curve
Little River at Waterbury USGS Gauge	Peak Flow (cfs)	1,300	2,579	Controlled Taintor gate releases during TS Irene managed reservoir levels. Model assumes generation plus controlled releases at 2,000 cfs once reservoir reaches 595 ft, to prevent uncontrolled spillage.
GMP Bolton Falls Hydrostation	Maximum Water Elevation (ft msl)	403.9	416.1	dam crest = 392.0 ft (bag deflated). TS Irene level from SCADA (11.88 ft above crest)
GMP Bolton Falls Hydrostation	Peak Flow (cfs)	74,726	79,688	Flow is partially controlled by flood-control operations at Waterbury Reservoir
Winooski River at Essex USGS Gauge	Maximum Water Level (ft local)	22	35	Water level from USGS Rating Curve, NWS Major Flooding Level = 18.0 ft
Winooski River at Essex USGS Gauge	Peak Flow (cfs)	35,000	68,214	FEMA 10 year flood = 32,900 cfs FEMA 100 year flood = 55,700 cfs FEMA 500 year flood = 76,900 cfs
Notes msl = mean sea level cfs = cubic feet per second ft local = feet above local datum				

Water levels in the Winooski River during Tropical Storm Irene exceeded the National Weather Service ("NWS") Major Flooding levels at Montpelier and Essex Junction, and flows were generally on the order of a 100-year recurrence event. In most of the Winooski River watershed, the Irene plus 50-percent more rainfall scenario is predicted to be a significantly larger event with higher streamflows and water levels. However, Table 3 notes that at GMP's Mollys Falls Reservoir, water levels and downstream flows would be lower in this design storm than during Tropical Storm Irene. This situation is the result of changes in reservoir operation which will establish a lower Normal Operating Level, creating additional reservoir storage that would reduce peak water levels and outflows during this scenario. Although the operational changes at Mollys Falls Reservoir would reduce the severity of local flooding, these benefits do not extend a great distance downstream; as Table 3 indicates, peak flows in Montpelier in this scenario would be more than twice the peak flows during Tropical Storm Irene.

4 Conclusions

For a design storm with 50-percent more total rainfall than Tropical Storm Irene, but otherwise the same duration, temporal rainfall distribution, and starting soil-moisture conditions, greater than a 50-percent increase in peak streamflow would occur in most of the Winooski River watershed, due to increased rates of runoff once the soil has absorbed the initial portion of rainfall.

Locally, water levels and streamflow rates would be reduced compared to Tropical Storm Irene at and downstream of GMP's Mollys Falls Reservoir, due to a lowered new normal operating level in the reservoir that would increase capacity to store waters during high-flow events. The benefits of this reservoir storage are localized near this facility, whereas in the majority of the watershed further downstream the design storm scenario would cause significantly higher flow rates and water levels than Tropical Storm Irene.

Waterbury Reservoir could potentially fill above the level of its uncontrolled spillway during the design storm, depending on the State's operation of the Taintor gates as the reservoir fills. This situation would result in significantly higher outflows to the Little River than experienced during Tropical Storm Irene, and could be mitigated with pre-emptive releases from the reservoir such as those analyzed in the modeling exercise described above.

Developing state- and federally-approved protocols for proactive reservoir drawdowns prior to forecasted major storms at Waterbury and other reservoirs would help to reduce downstream flooding during events such as the Tropical Storm Irene plus 50-percent more precipitation scenario.

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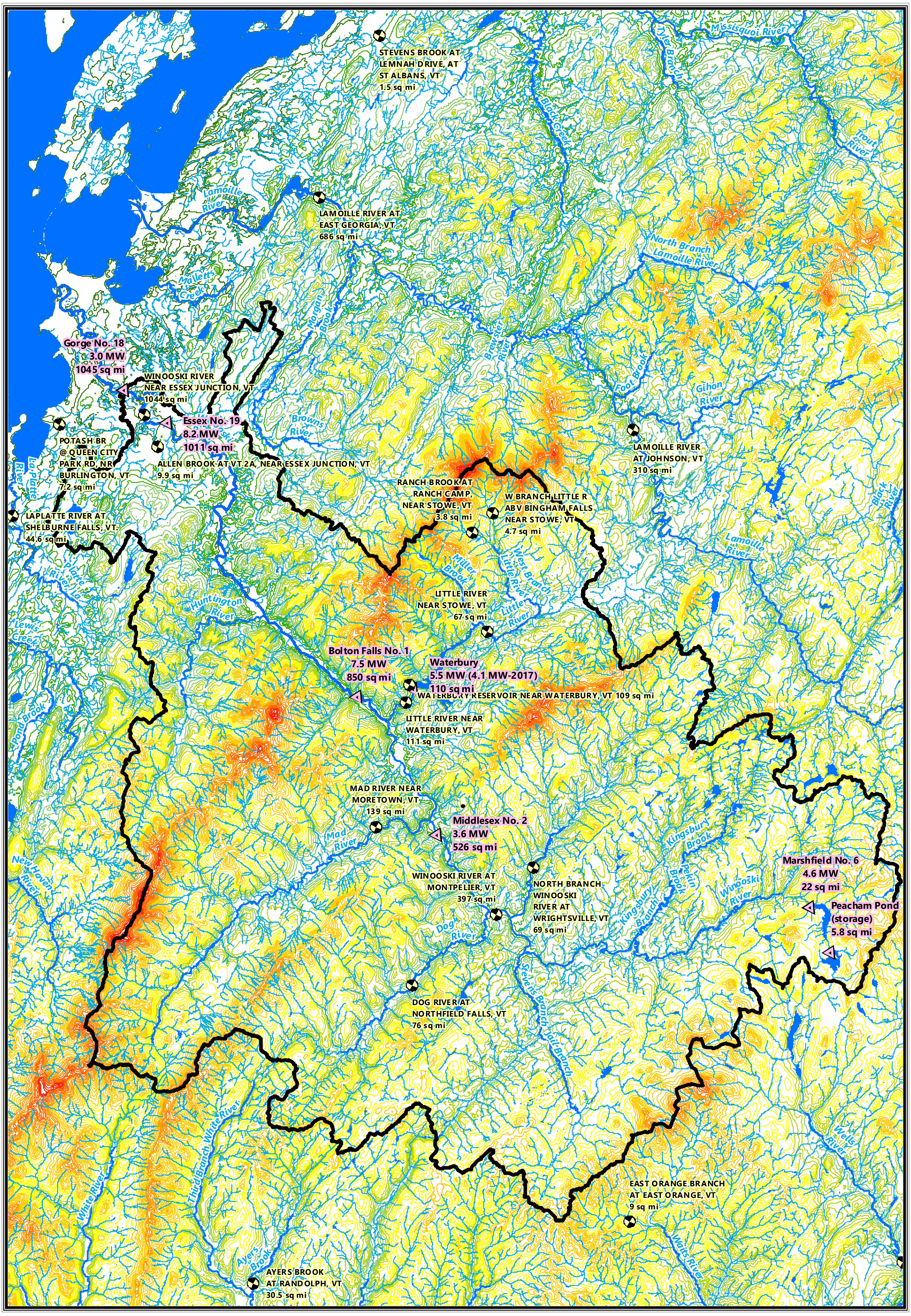
APPENDIX 1



Legend

- GMP Hydrostations
- USGS Gauges
- Winooski Watershed

Stream (VHD)

- Order 1-4
- Order 5-6
- Order 7-9

Topo Contour (ft)

- 100 - 300
- 301 - 600
- 601 - 900
- 901 - 1200
- 1201 - 1700
- 1701 - 2400
- 2401 - 2900
- 2901 - 3400
- 3401 - 4200

N

0 4.5 9 Miles

GMP: Winooski River Watershed Hydroelectric Stations Map

September 22, 2017

vhb

Sources: Watershed boundaries by VHB (2017); USGS gauges provided by the USGS, digitized by VHB (2015); Streams and waterbodies provided by VT Hydrography dataset and VCGI (2010); Contours by VCGI (2012); GMP Hydroelectric Stations from VT Dam Inventory (VT DEC).

Prepared by: JWG/MJP

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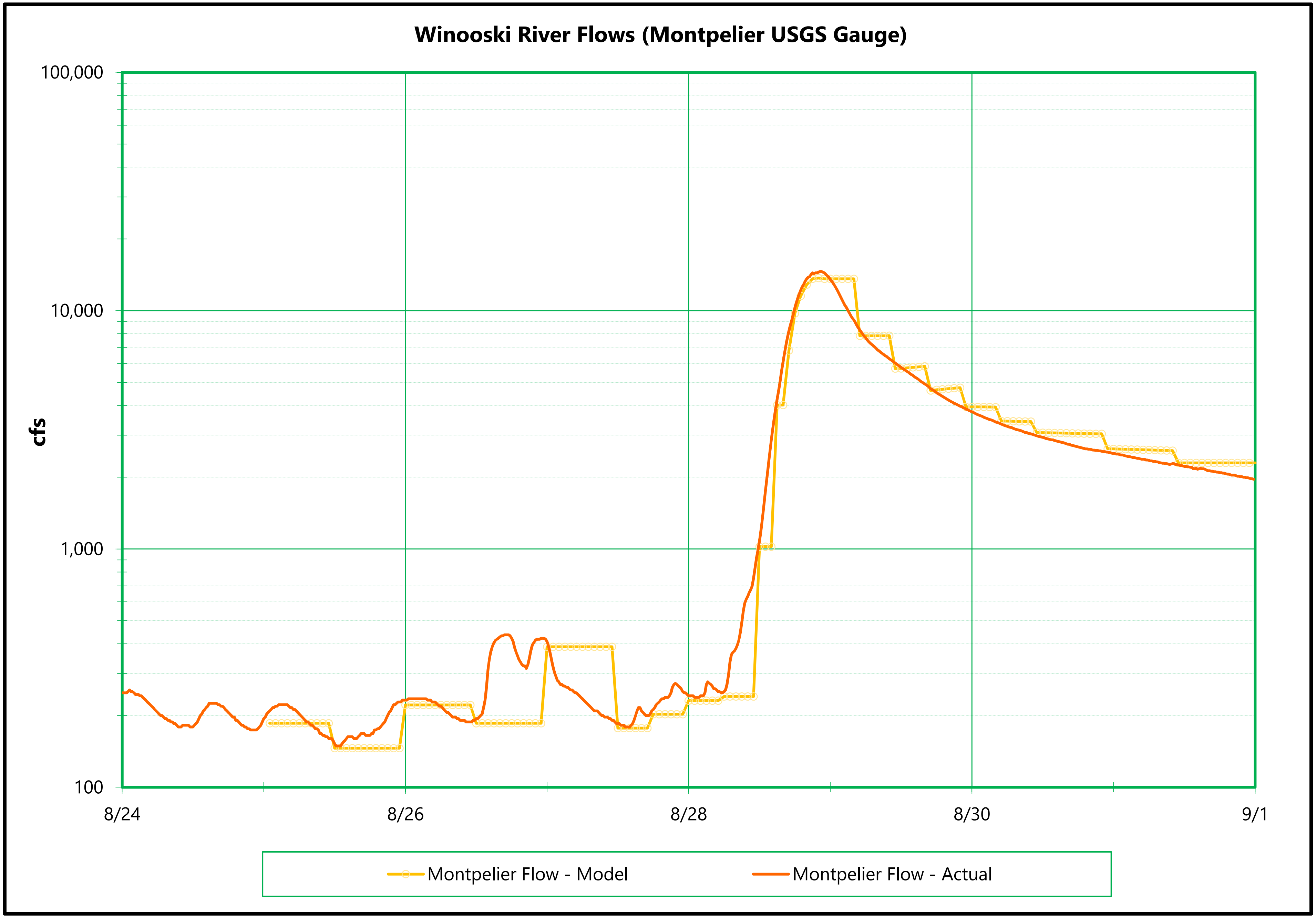
APPENDIX 2

Model Calibration: Actual TS Irene Flows



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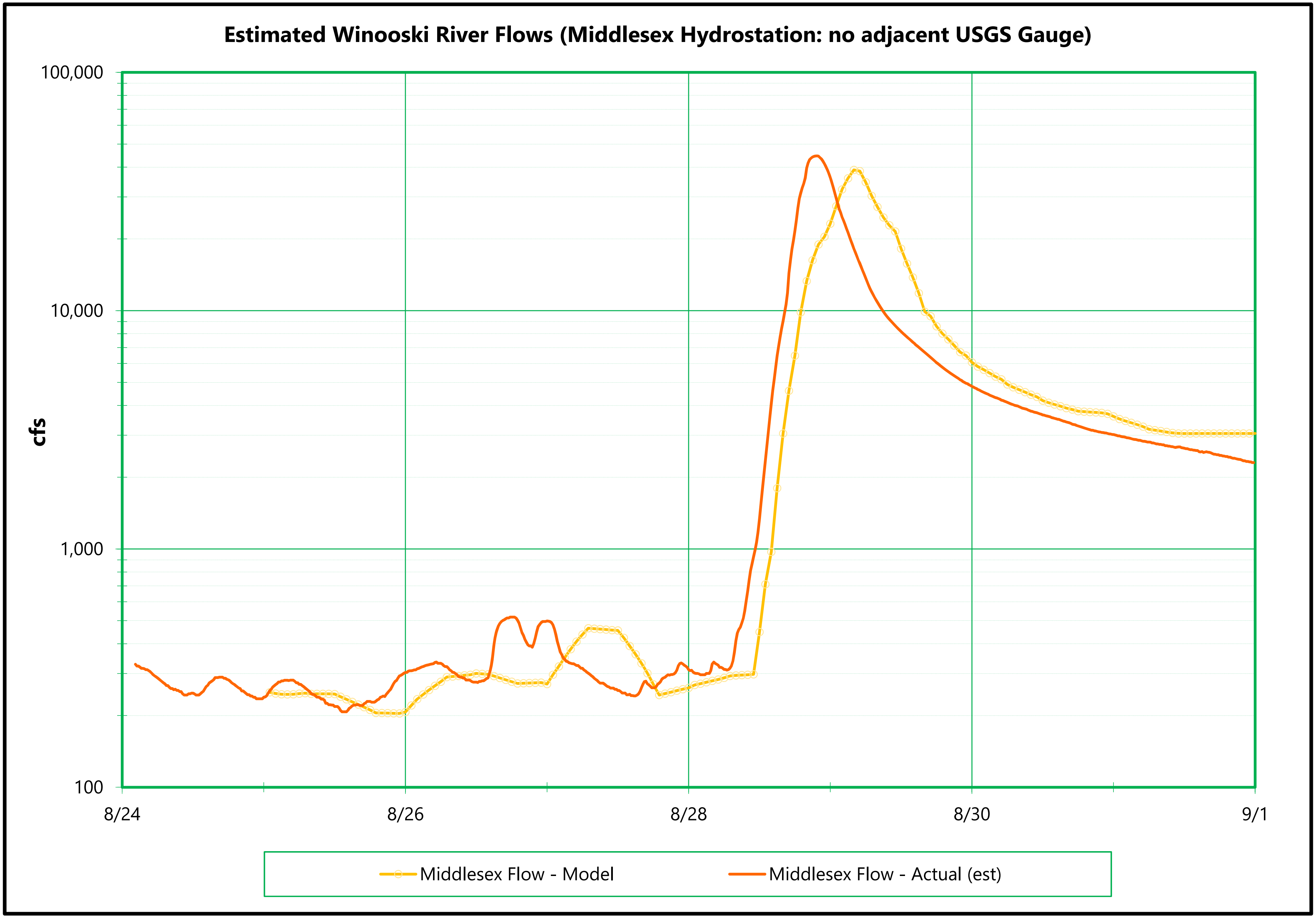

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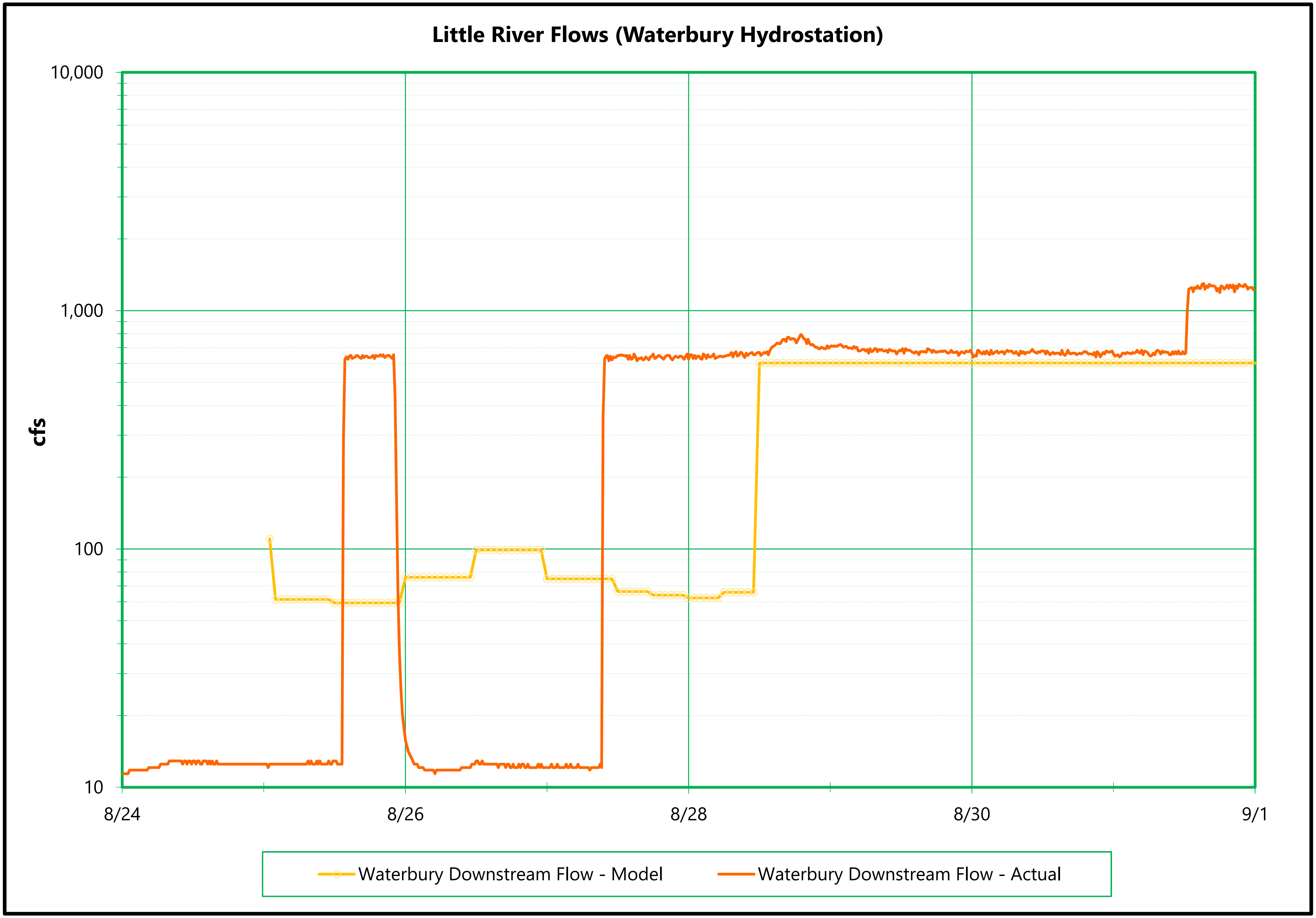

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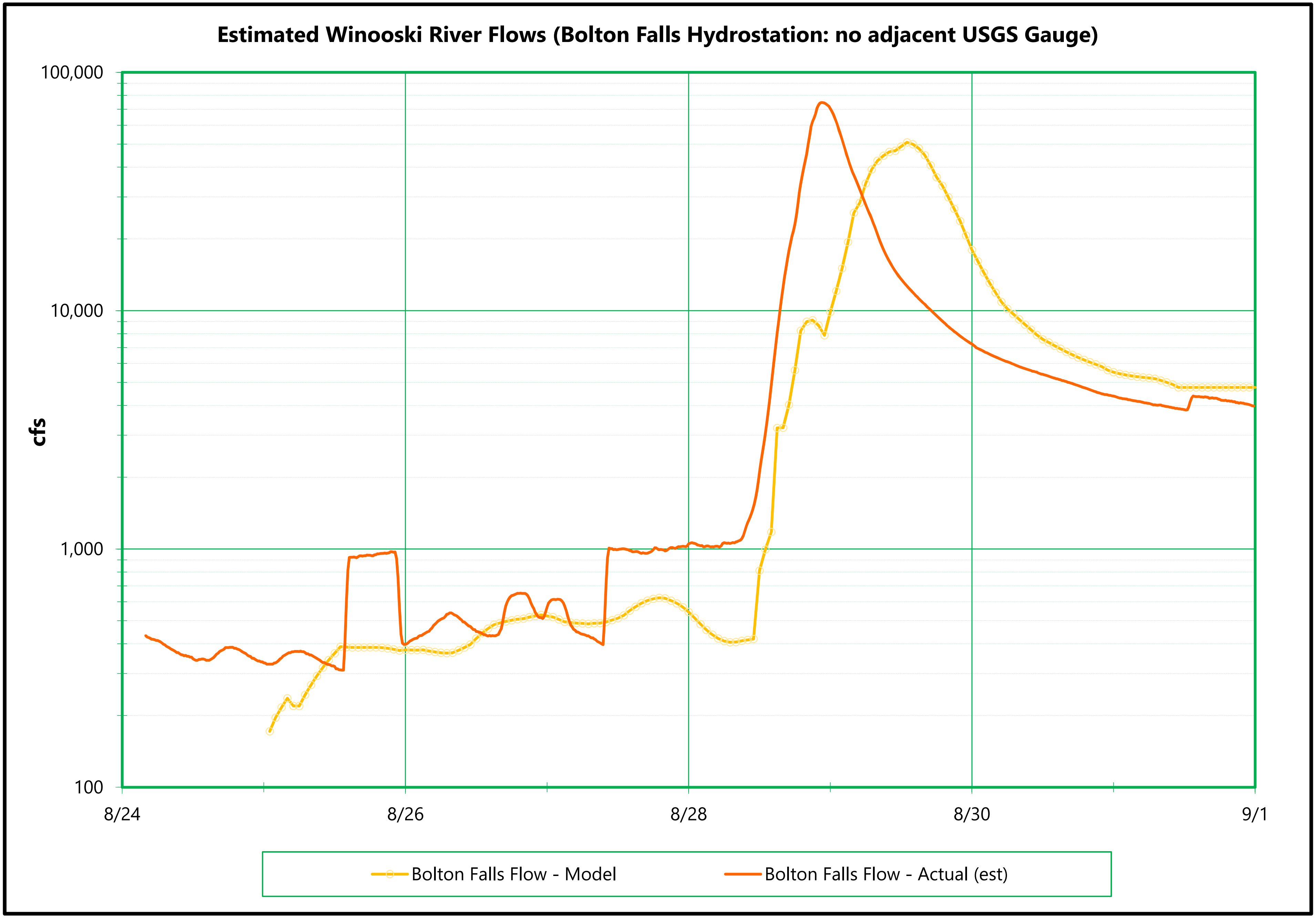

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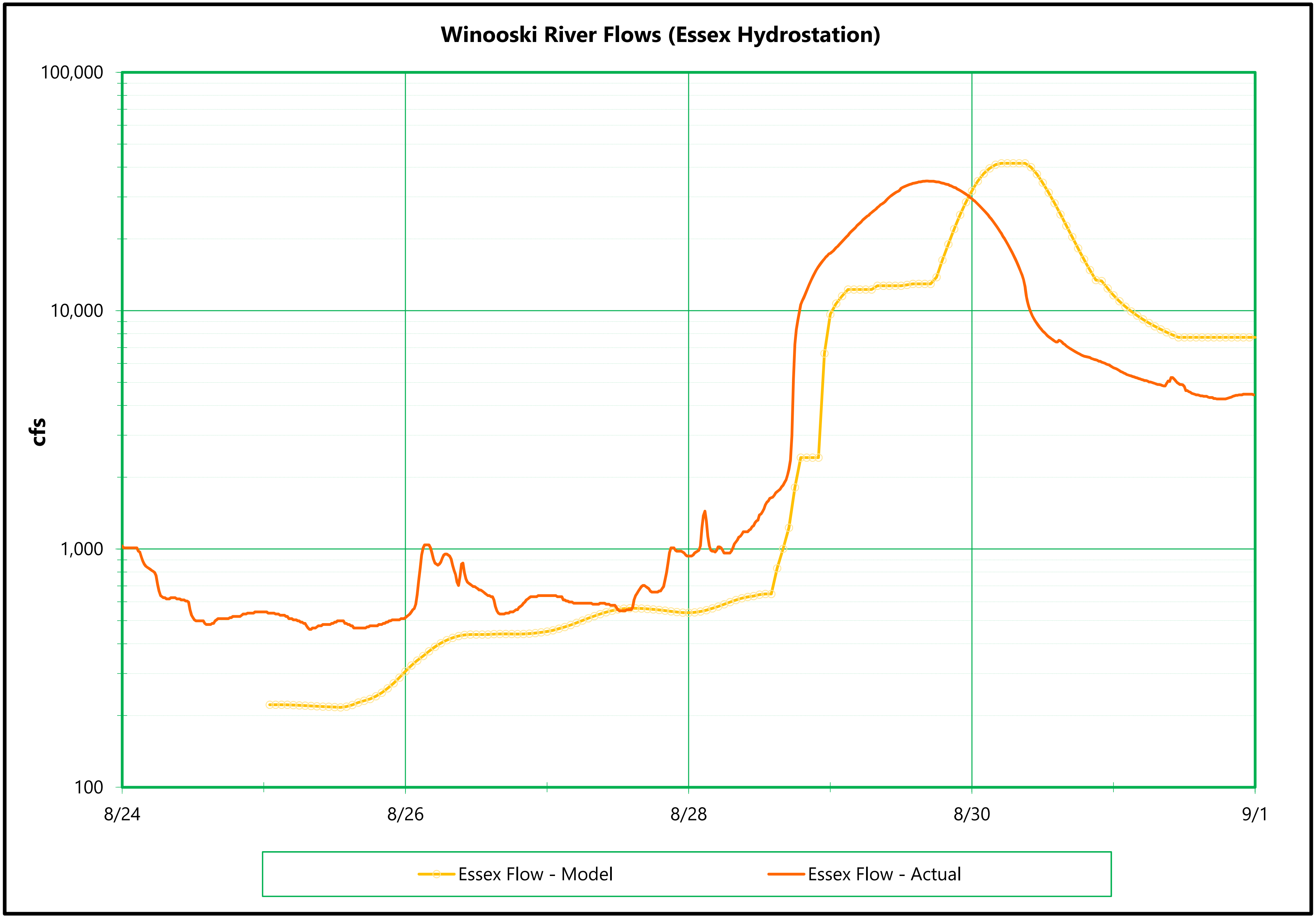
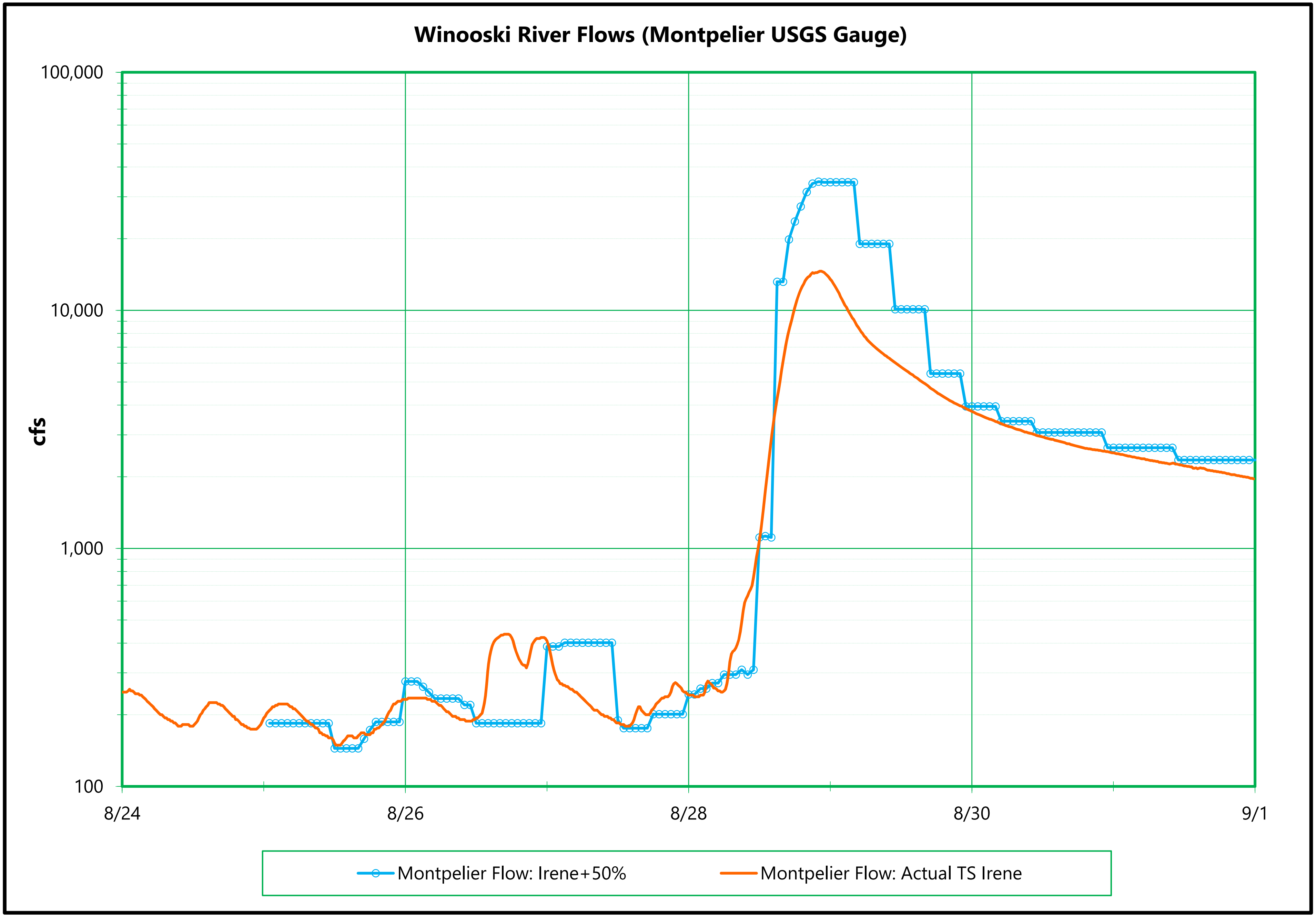


APPENDIX 3

Model Results: Comparison of Irene+50% to TS Irene Flows



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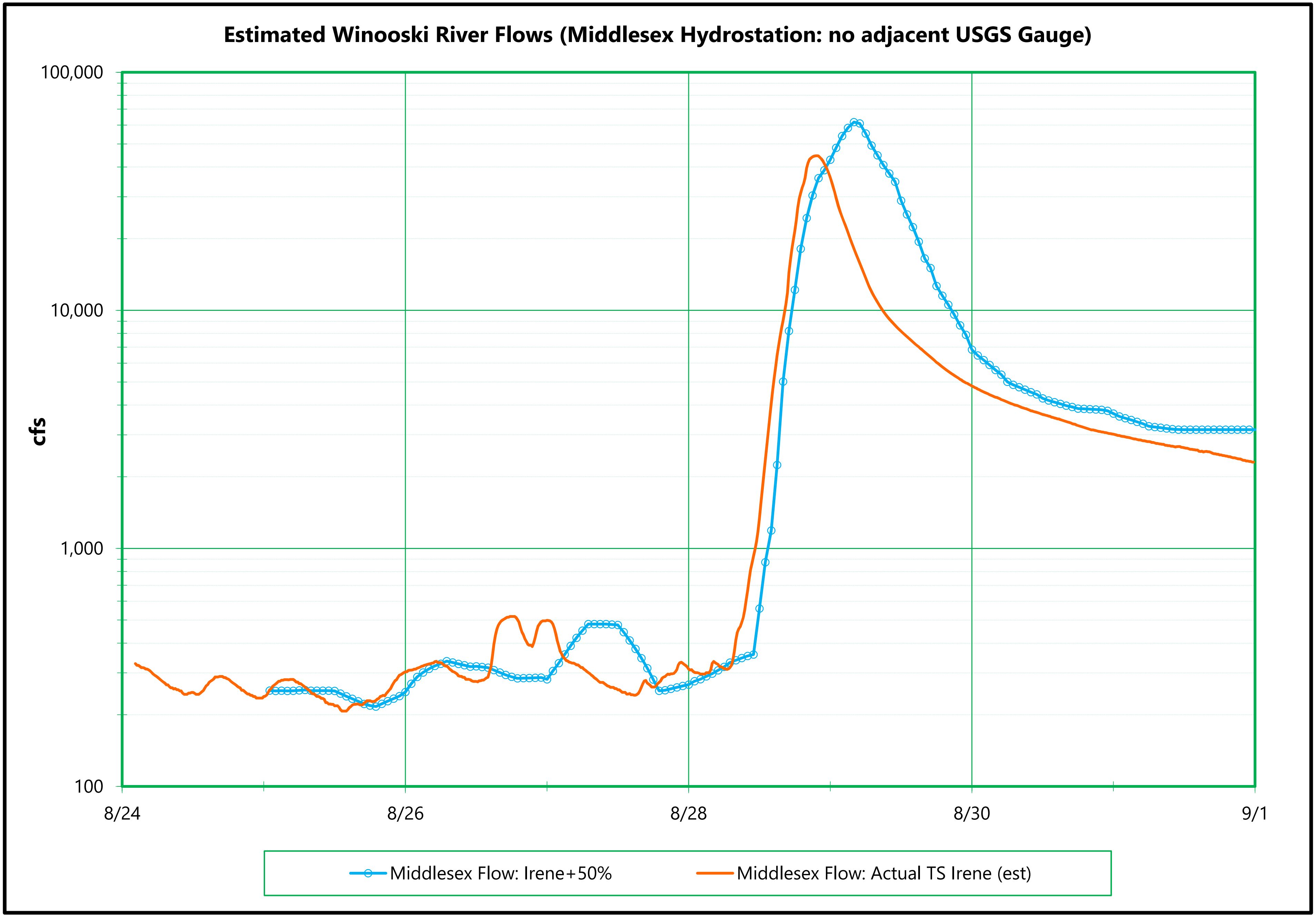

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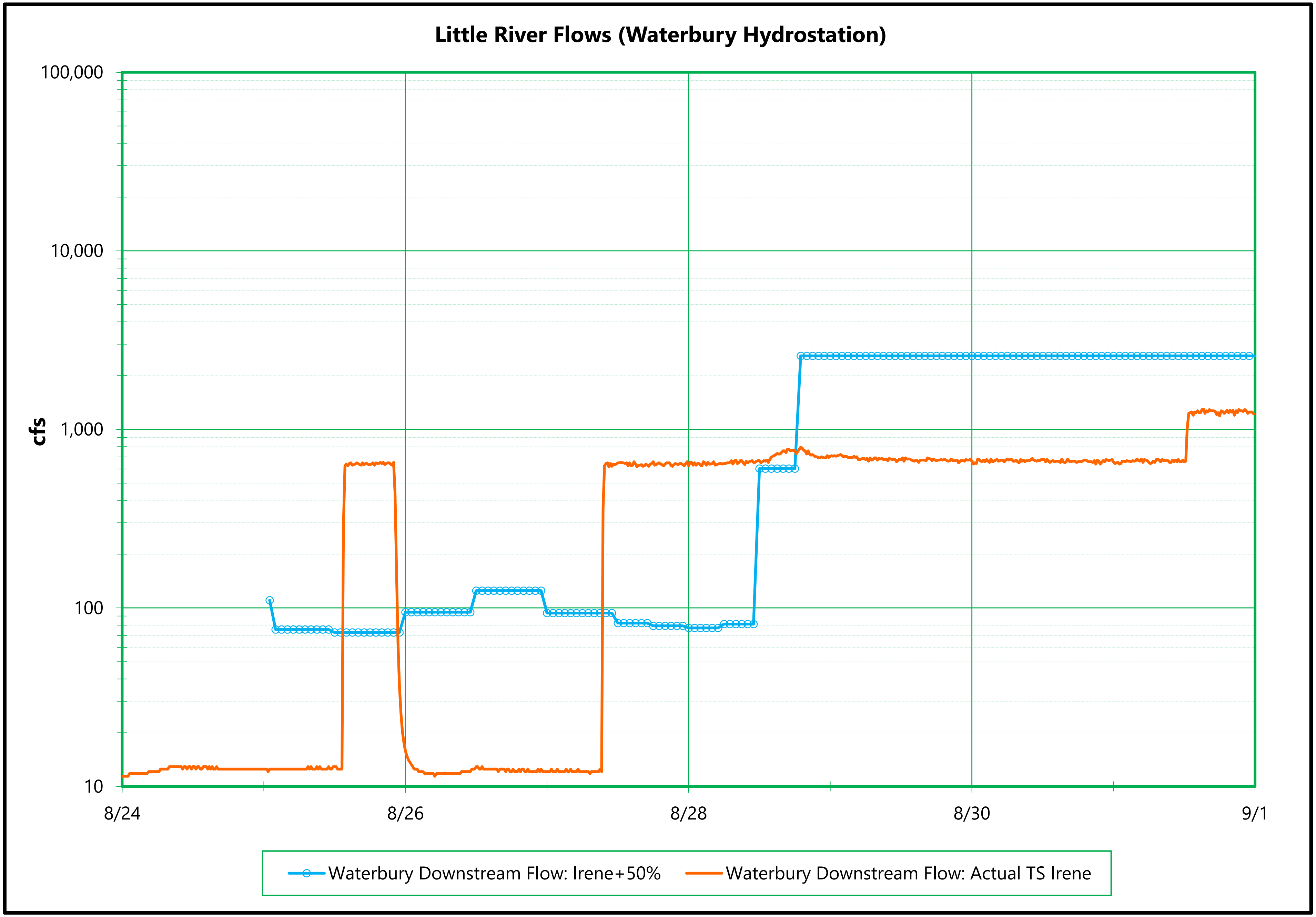

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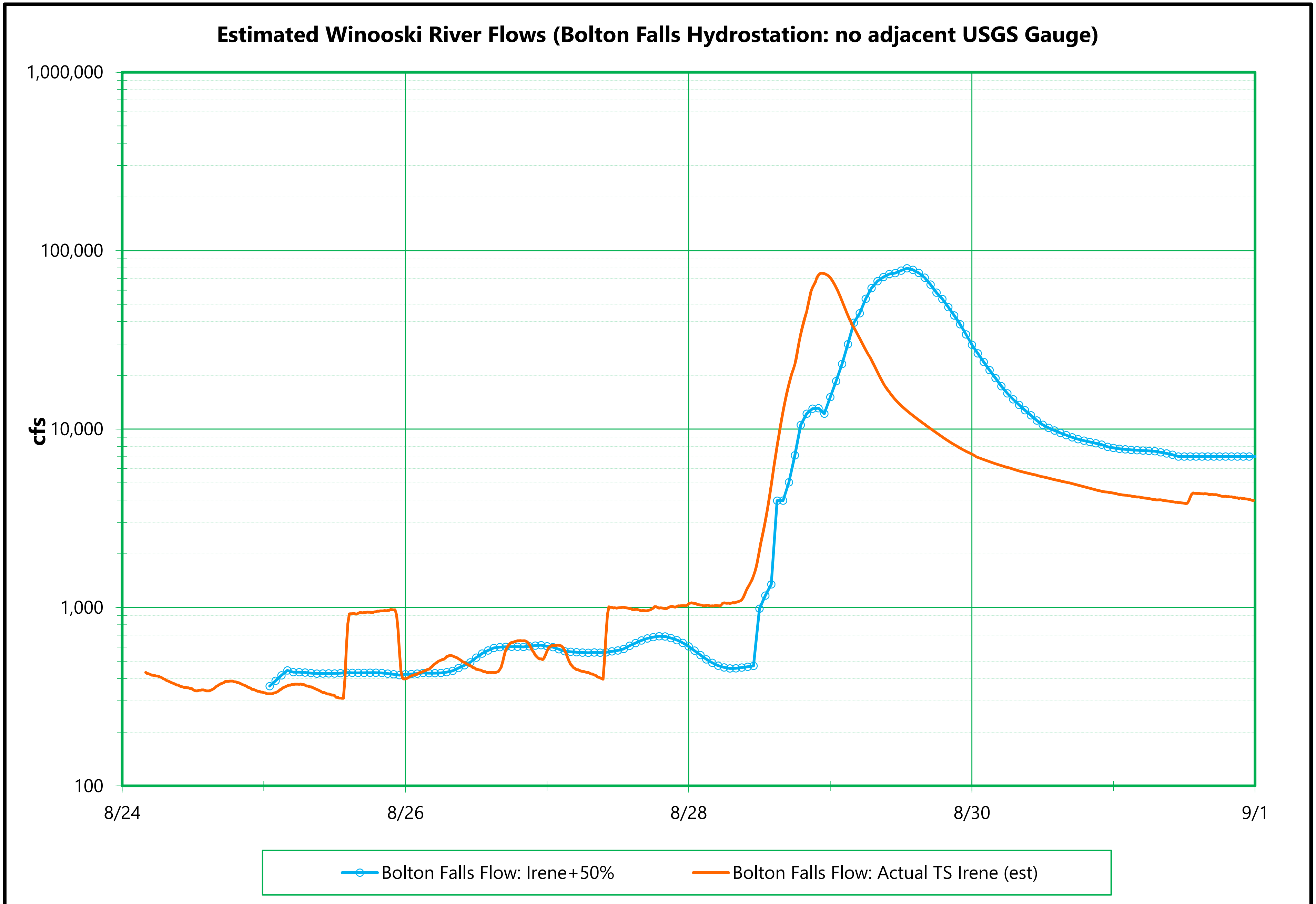

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