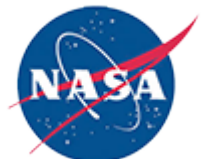


Ten days for flood protection

5 June 2019

Donghoon Lee and Paul Bock

University of Wisconsin-Madison

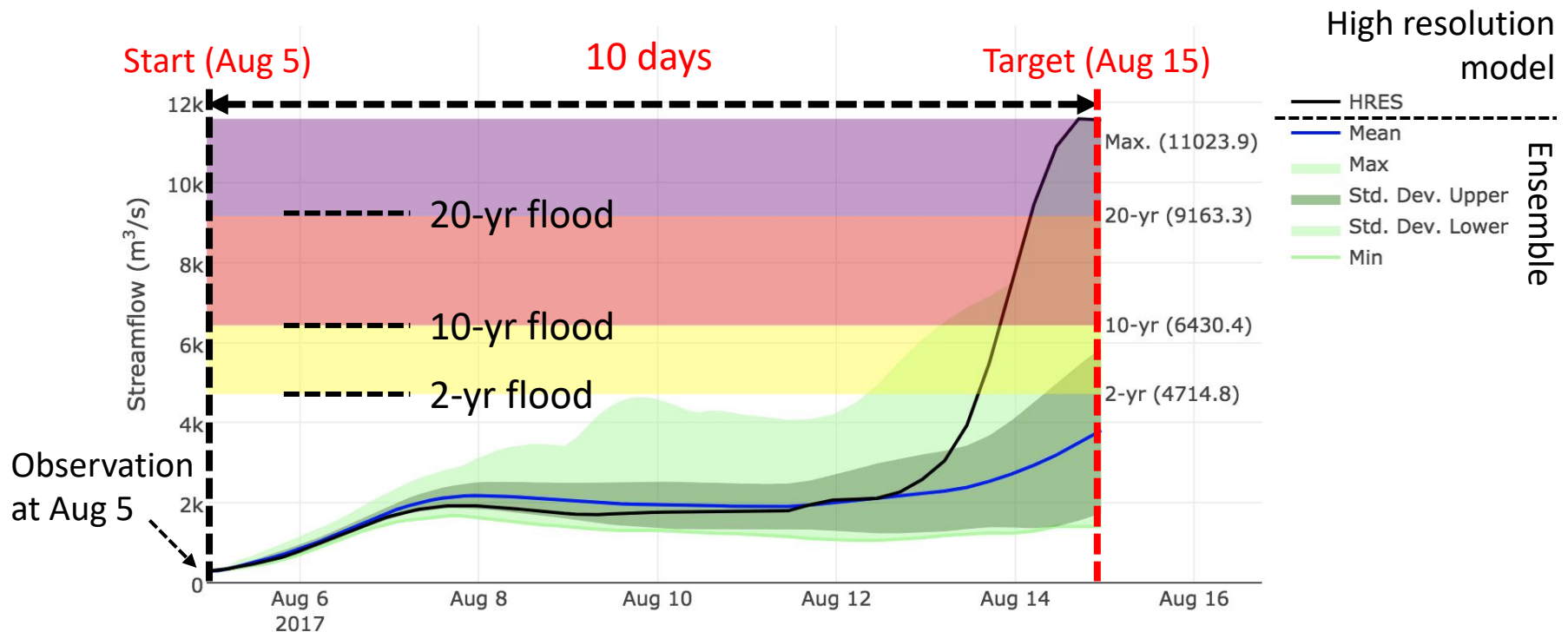


WHY PLAY GAMES?

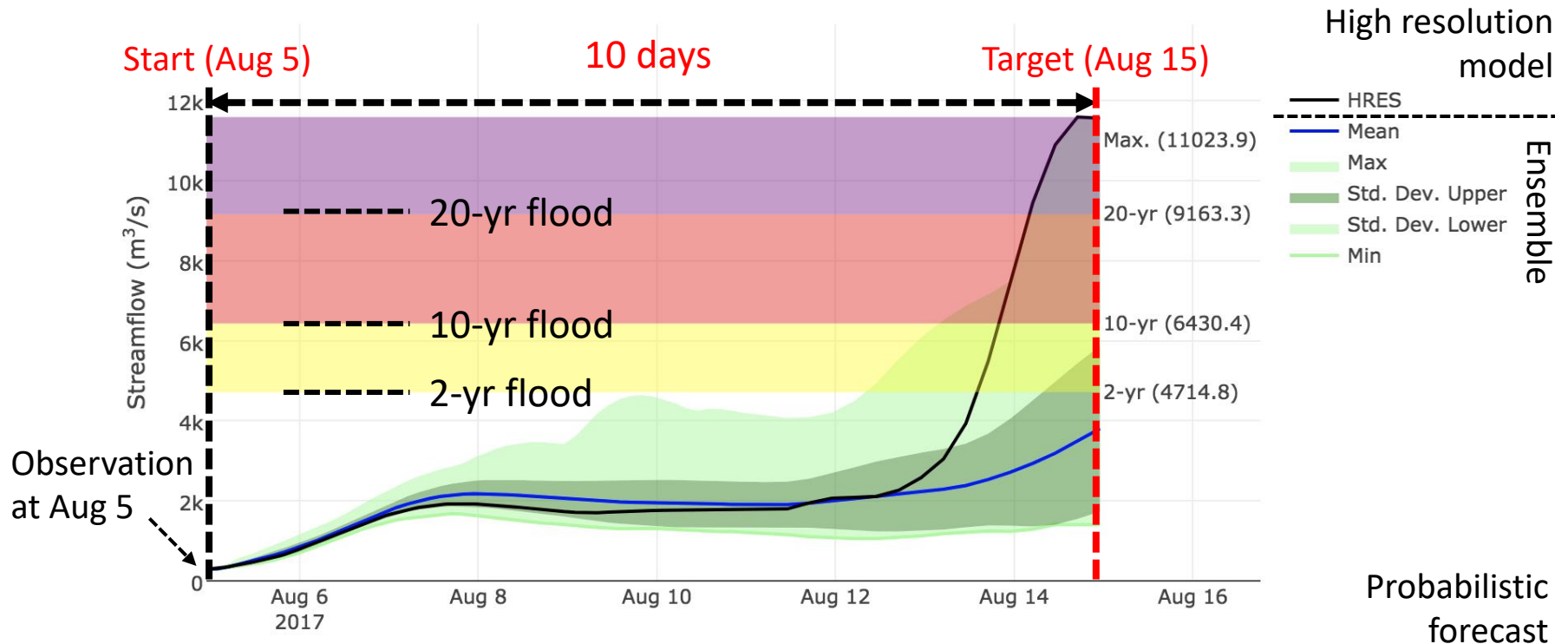
- Explore risk, uncertainty, and probability
 - in the context of forecasts
- Address why forecasts are commonly under-utilized:
 - communication failures
 - lack of identified preparedness actions
 - lack of available institutional funding
 - fear of acting in vain causing financial harm
- Opportunity to think creatively about the application of forecasts

- TenDays is designed to apply BYU/ECMWF 10 day streamflow forecasts for pre-flood management
- Teams of 3-4 people (diverse institutions)
- All teams have the same forecasts
- No communication with other teams
- Each team can select up to 3 flood preparedness actions:
 - Preposition of relief items
 - Evacuation of potential victims
 - Construction of defensive structures

Forecast example (D-day 10)



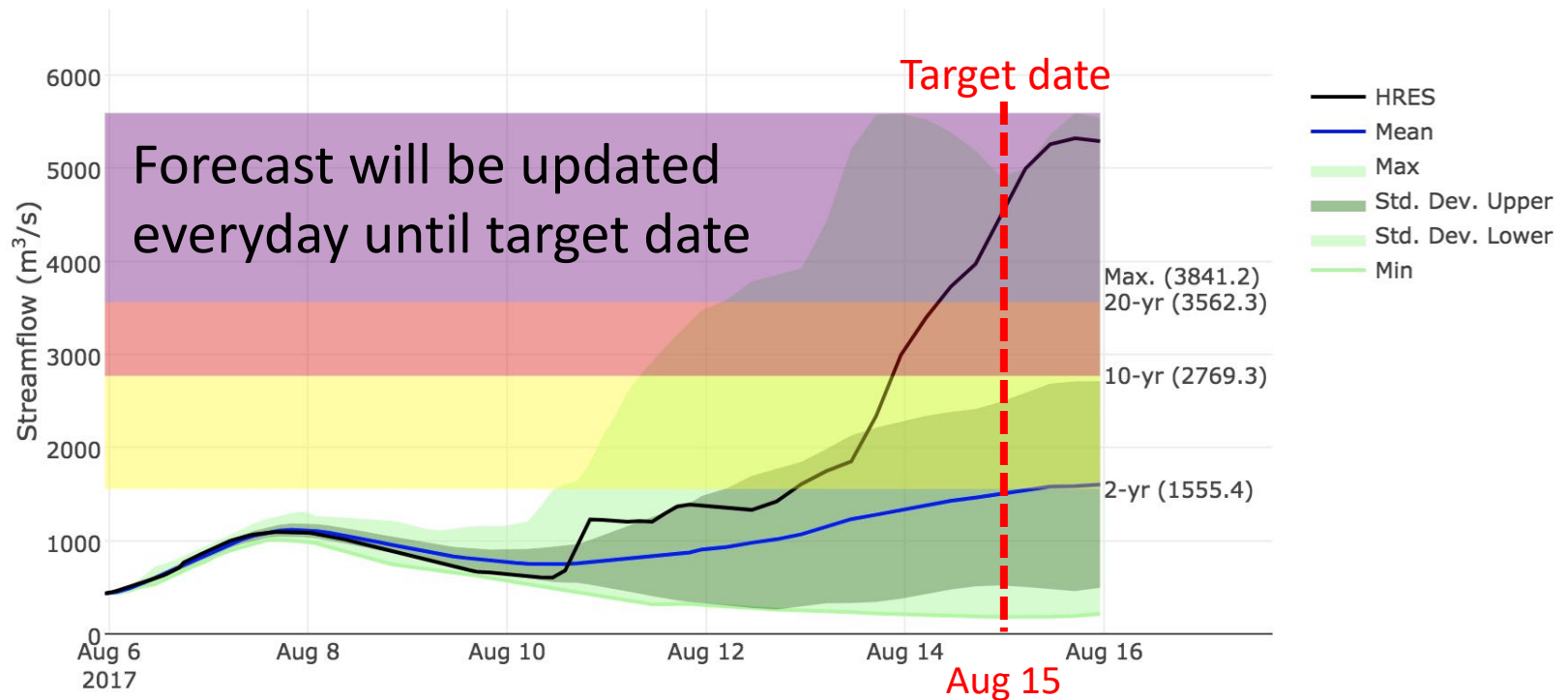
Forecast example (D-day 10)



Level	8/5	8/6	8/7	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15
2-yr	0	0	0	0	0	0	0	4	8	17	42
10-yr	0	0	0	0	0	0	0	0	2	8	17
20-yr	0	0	0	0	0	0	0	0	0	2	8

Ex) 42% chance
to above
the 2yr
flood level

Forecast example (D-day 9)



Level	8/6	8/7	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16
2-yr	0	0	0	0	2	8	16	29	41	45	51
10-yr	0	0	0	0	0	2	4	6	10	20	18
20-yr	0	0	0	0	0	0	4	6	6	6	6

Decision by lead-time

- Forecasts will be updated every day until target date
- Flooding before/after target date is ignored
- Each action can be taken once or not at all
- Some actions disallowed close to the target date

Target date

D-day
10

Level	8/5	8/6	8/7	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15
2-yr	0	0	0	0	0	0	0	4	8	17	42
10-yr	0	0	0	0	0	0	0	0	2	8	17
20-yr	0	0	0	0	0	0	0	0	0	2	8

Group 1	10	9	8	7	6	5	4	3	2	1
Preposition								-	-	-
Evacuation										
Construction						-	-	-	-	-

Decision by lead-time

- Forecasts will be updated every day until target date
- Flooding before/after target date is ignored
- Each action can be taken once or not at all
- Some actions disallowed close to the target date

Target date

D-day
9

Level	8/6	8/7	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16
2-yr	0	0	0	0	2	8	16	29	41	45	51
10-yr	0	0	0	0	0	2	4	6	10	20	18
20-yr	0	0	0	0	0	0	4	6	6	6	6

Group 1	10	9	8	7	6	5	4	3	2	1
Preposition		Act						-	-	-
Evacuation										
Construction						-	-	-	-	-

Decision by lead-time

- Forecasts will be updated every day until target date
- Flooding before/after target date is ignored
- Each action can be taken once or not at all
- Some actions disallowed close to the target date

Target date

D-day
8

Level	8/7	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17
2-yr	0	2	8	10	21	33	38	38	38	37	27
10-yr	0	0	0	0	6	12	13	21	19	12	10
20-yr	0	0	0	0	0	8	13	17	12	10	4

Group 1	10	9	8	7	6	5	4	3	2	1
Preposition		Act						-	-	-
Evacuation	←----- No act -----→									
Construction			Act			-	-	-	-	-

Cost, Benefit, and Damage

- Costs of action vary by lead-time
- Benefits and damages vary by flood level

Cost of protection

Actions	Lead-time (day)									
	10	9	8	7	6	5	4	3	2	1
Preposition	1,000	1,250	1,500	1,750	2,000	2,250	2,500	-	-	-
Evacuation	2,500	2,400	2,300	2,200	2,100	2,000	1,900	2,300	3,000	4,000
Construction	2,500	3,000	3,500	4,000	4,500	-	-	-	-	-

Benefit of protection

Actions	No flood	2yr	10yr	20yr
Preposition	0	3,000	3,500	4,000
Evacuation	0	1,000	3,000	5,000
Construction	0	6,500	7,500	8,500

Flood damage

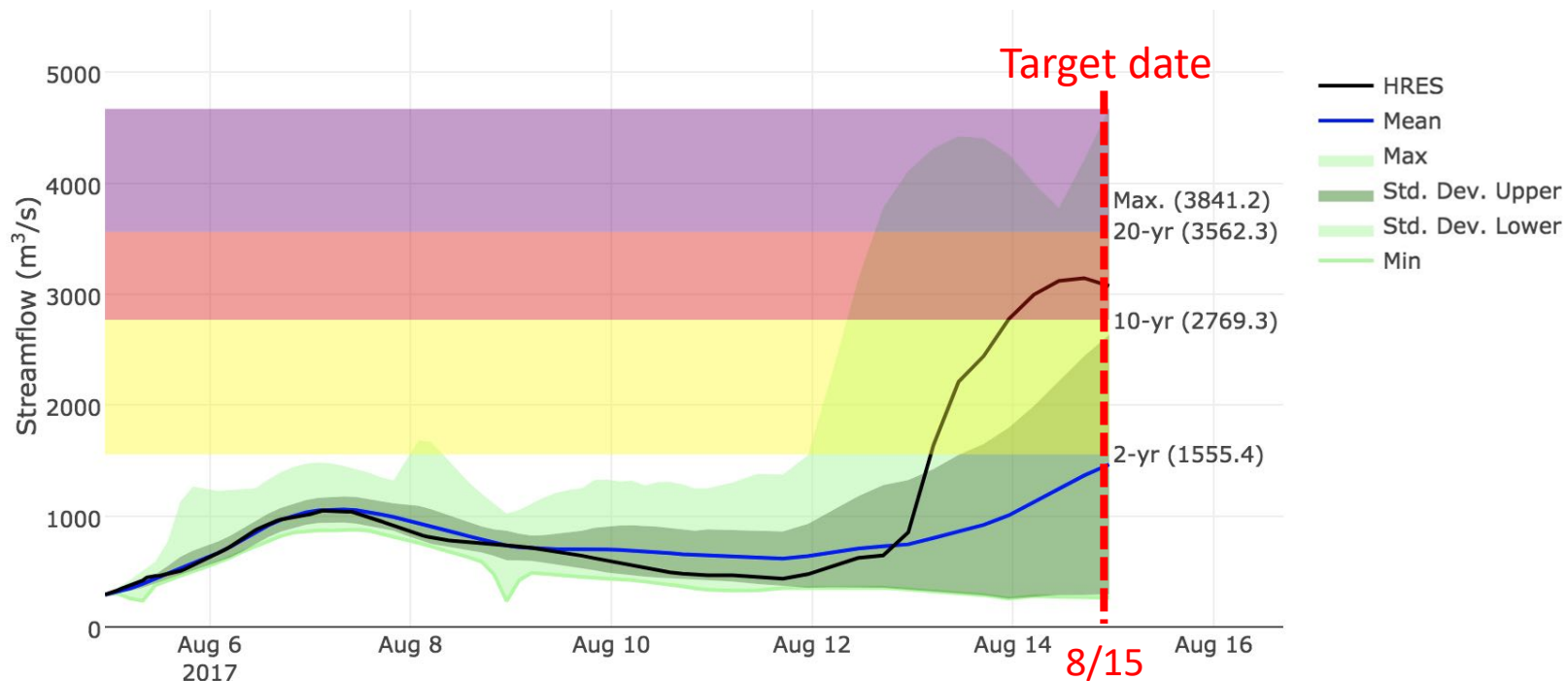
No flood	2yr	10yr	20yr
0	4,000	7,000	12,000

$$\text{Total} = \text{Benefit of protection} - \text{Cost of protection} - \text{Flood damage}$$

$$(11,000) - (4,750) - 7,000 = -750$$

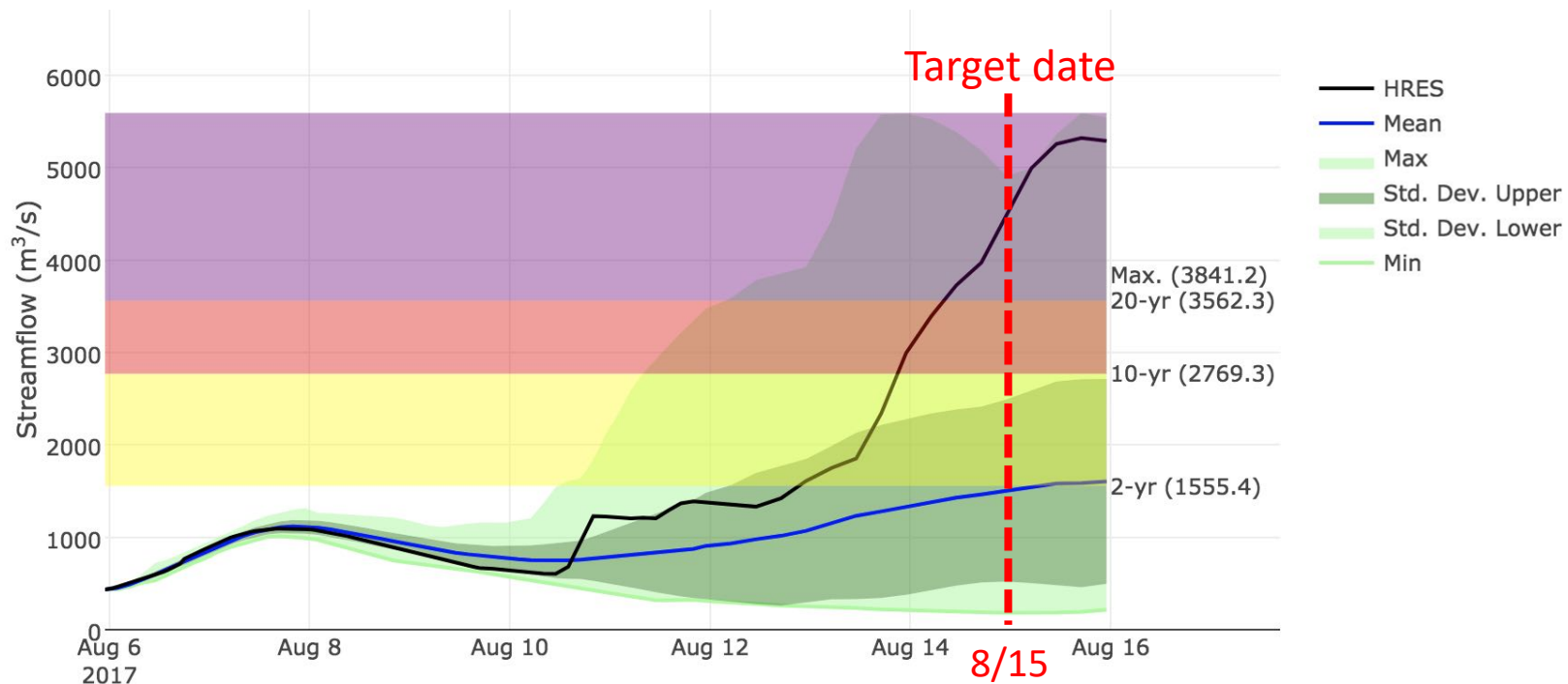
- Your goal: **minimize flood damage** (save money)
- Record your decisions on the worksheet daily
- Inform game leaders of decisions daily – we will update
- Group discussion
- We will play 2 rounds if there is time.

- Round 1: D-day 10



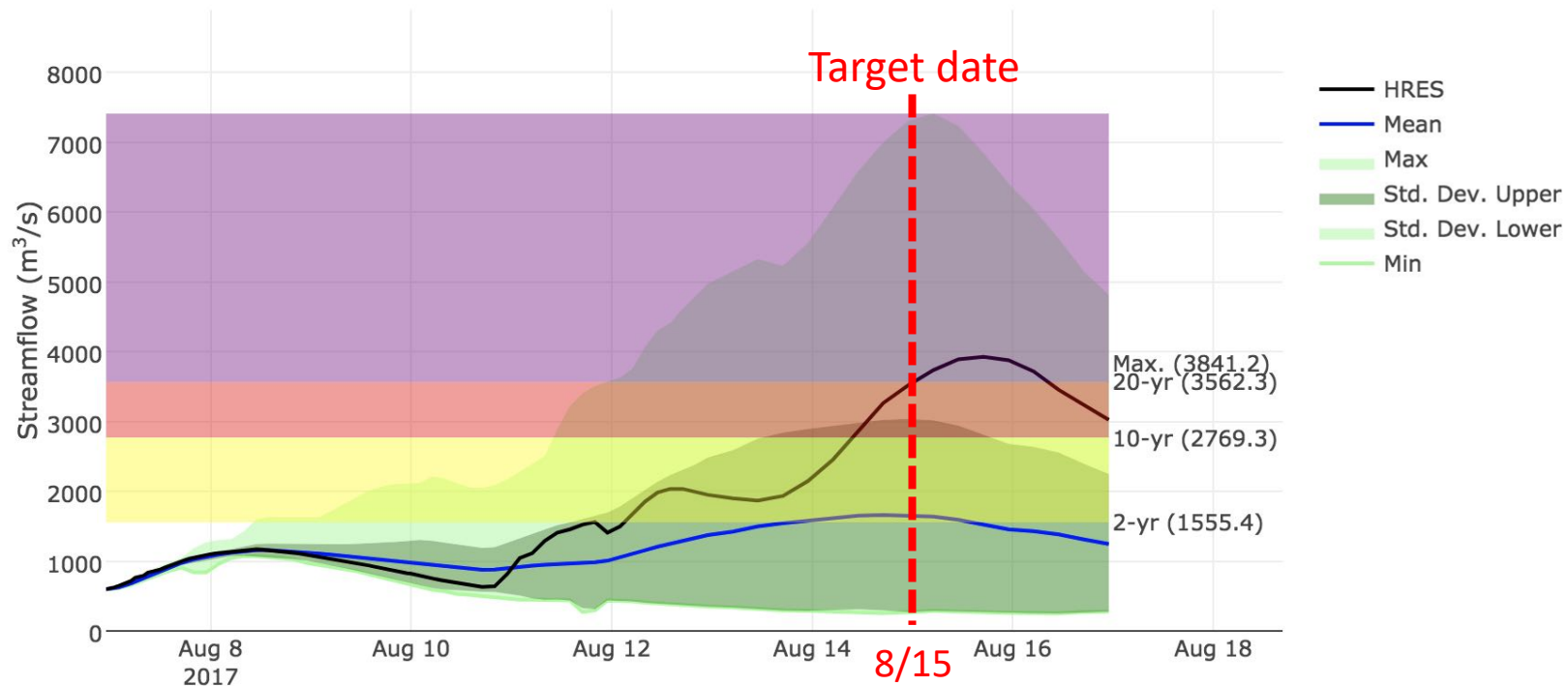
Level	8/5	8/6	8/7	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15
2-yr	0	0	0	2	0	0	0	8	18	31	49
10-yr	0	0	0	0	0	0	0	2	2	14	20
20-yr	0	0	0	0	0	0	0	2	2	10	12

- Round 1: D-day 9



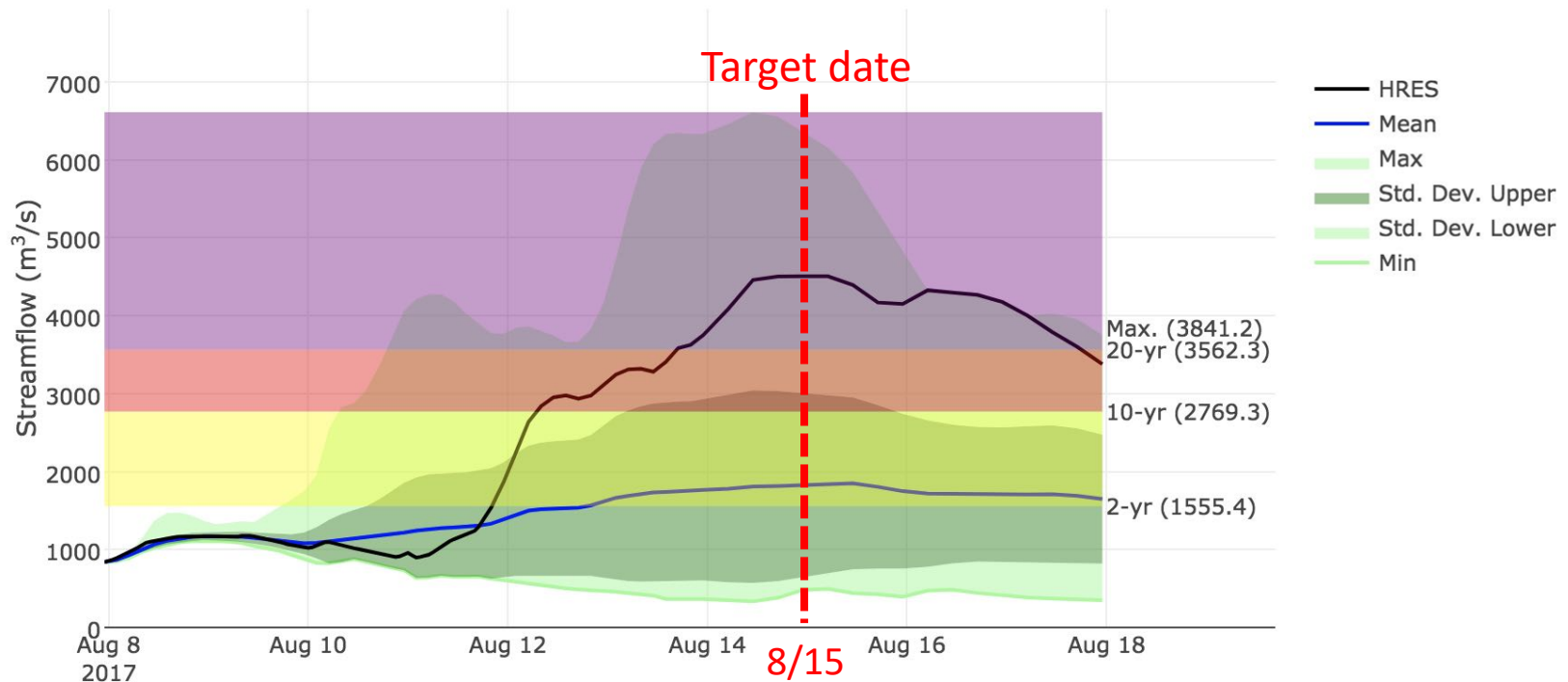
Level	8/6	8/7	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16
2-yr	0	0	0	0	2	8	16	29	41	45	51
10-yr	0	0	0	0	0	2	4	6	10	20	18
20-yr	0	0	0	0	0	0	4	6	6	6	6

- Round 1: D-day 8



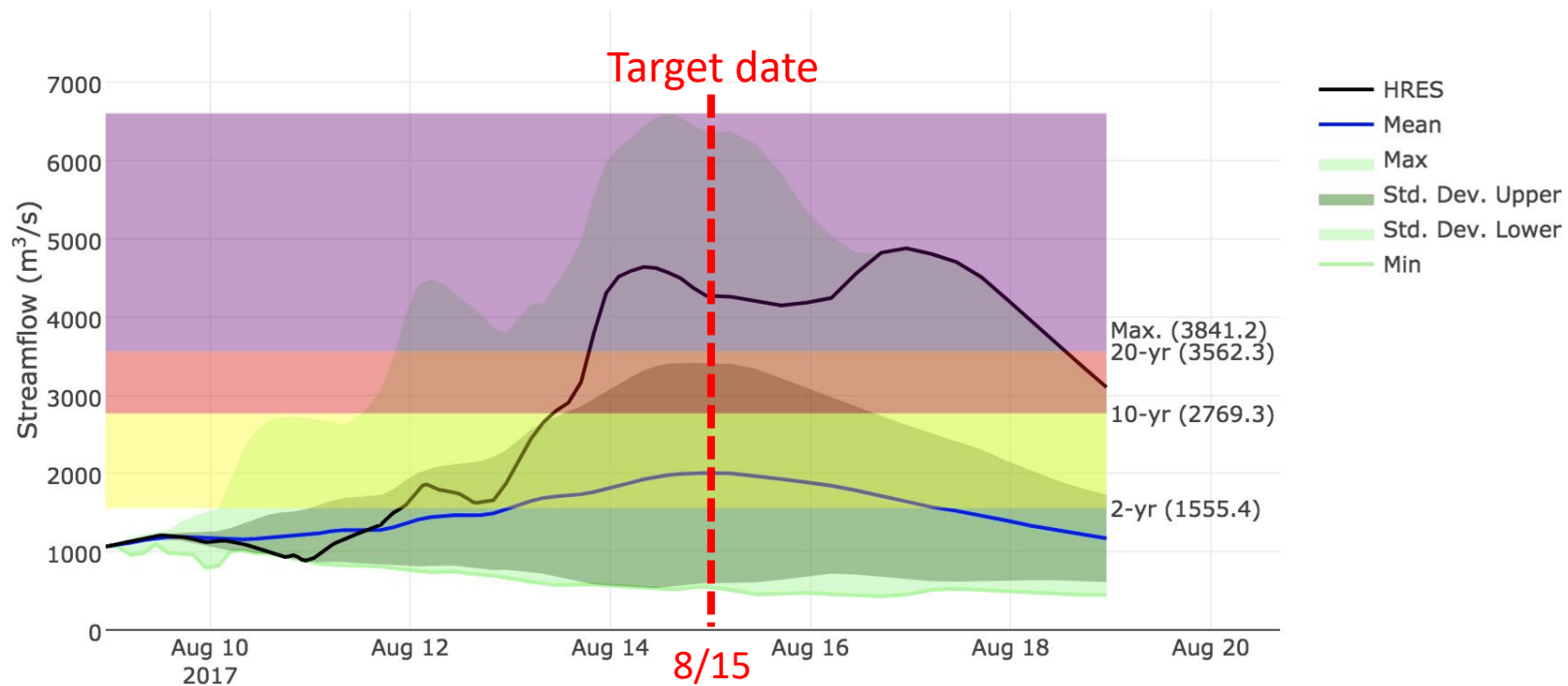
Level	8/7	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17
2-yr	0	2	8	10	21	33	38	38	38	37	27
10-yr	0	0	0	0	6	12	13	21	19	12	10
20-yr	0	0	0	0	0	8	13	17	12	10	4

- Round 1: D-day 7



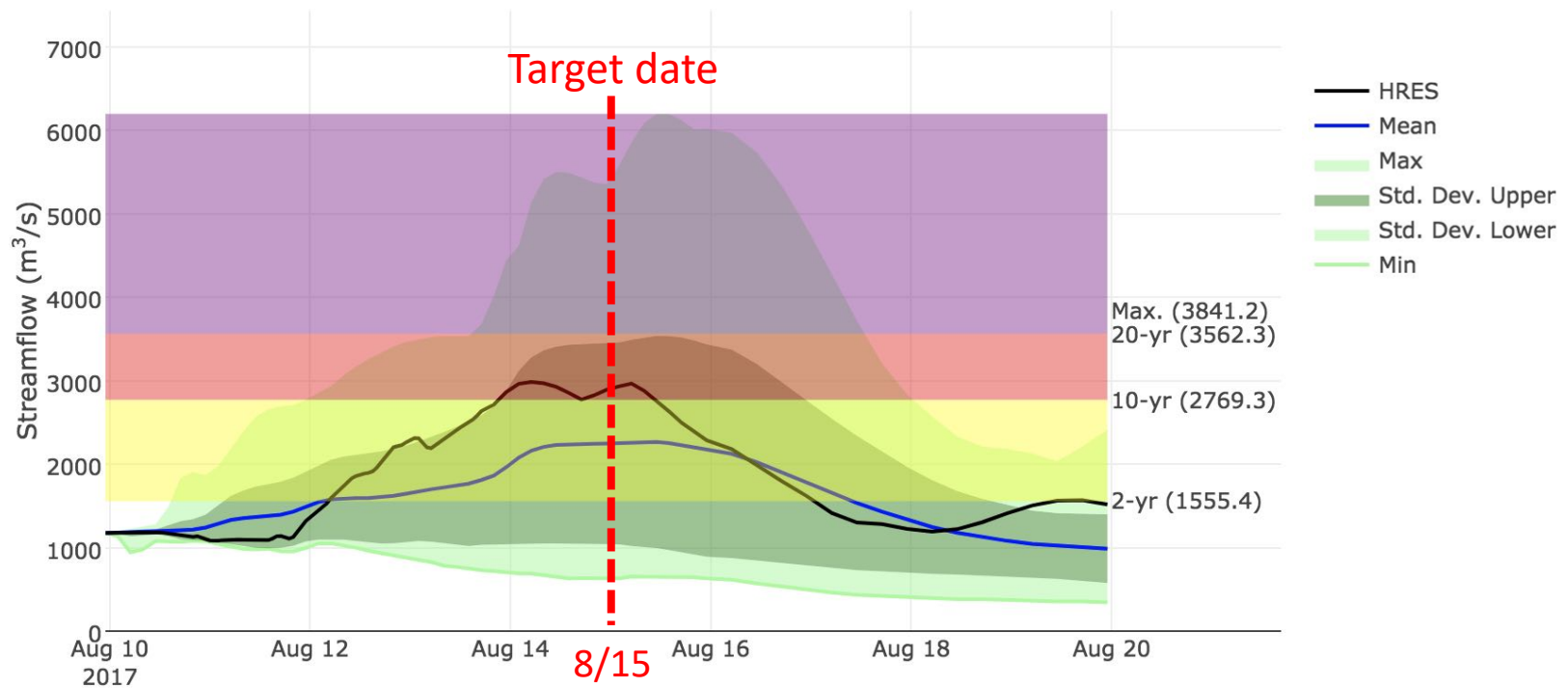
Level	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17	8/18
2-yr	0	2	15	23	38	48	56	58	56	56	48
10-yr	0	0	4	8	17	19	19	17	19	19	12
20-yr	0	0	2	6	8	12	12	12	4	4	2

- Round 1: D-day 6



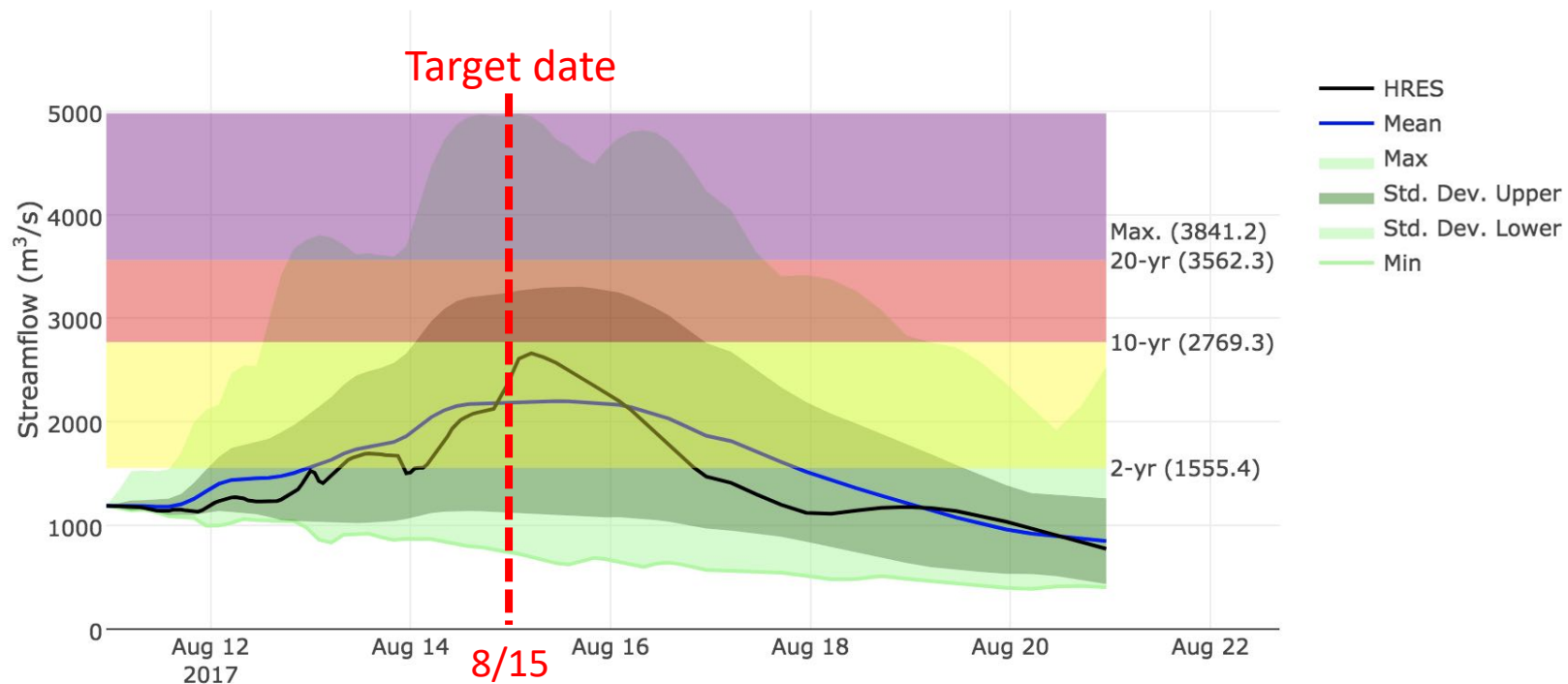
Level	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17	8/18	8/19
2-yr	0	10	27	44	52	44	46	50	48	31	19
10-yr	0	0	2	6	21	29	31	25	12	8	2
20-yr	0	0	0	2	15	21	19	12	8	4	0

- Round 1: D-day 5



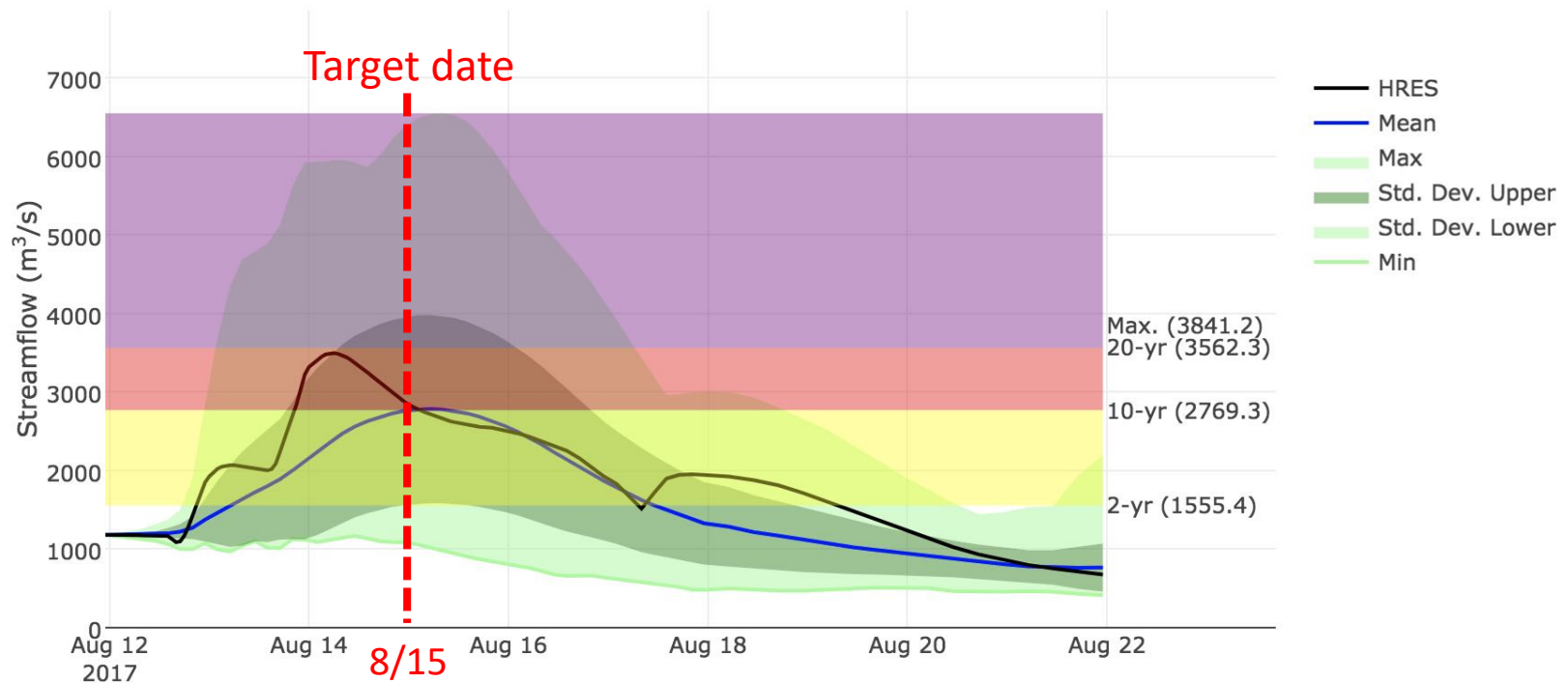
Level	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20
2-yr	2	27	50	65	73	67	63	52	35	17	12
10-yr	0	0	6	15	33	31	25	13	2	0	2
20-yr	0	0	0	4	17	23	13	10	0	0	0

- Round 1: D-day 4



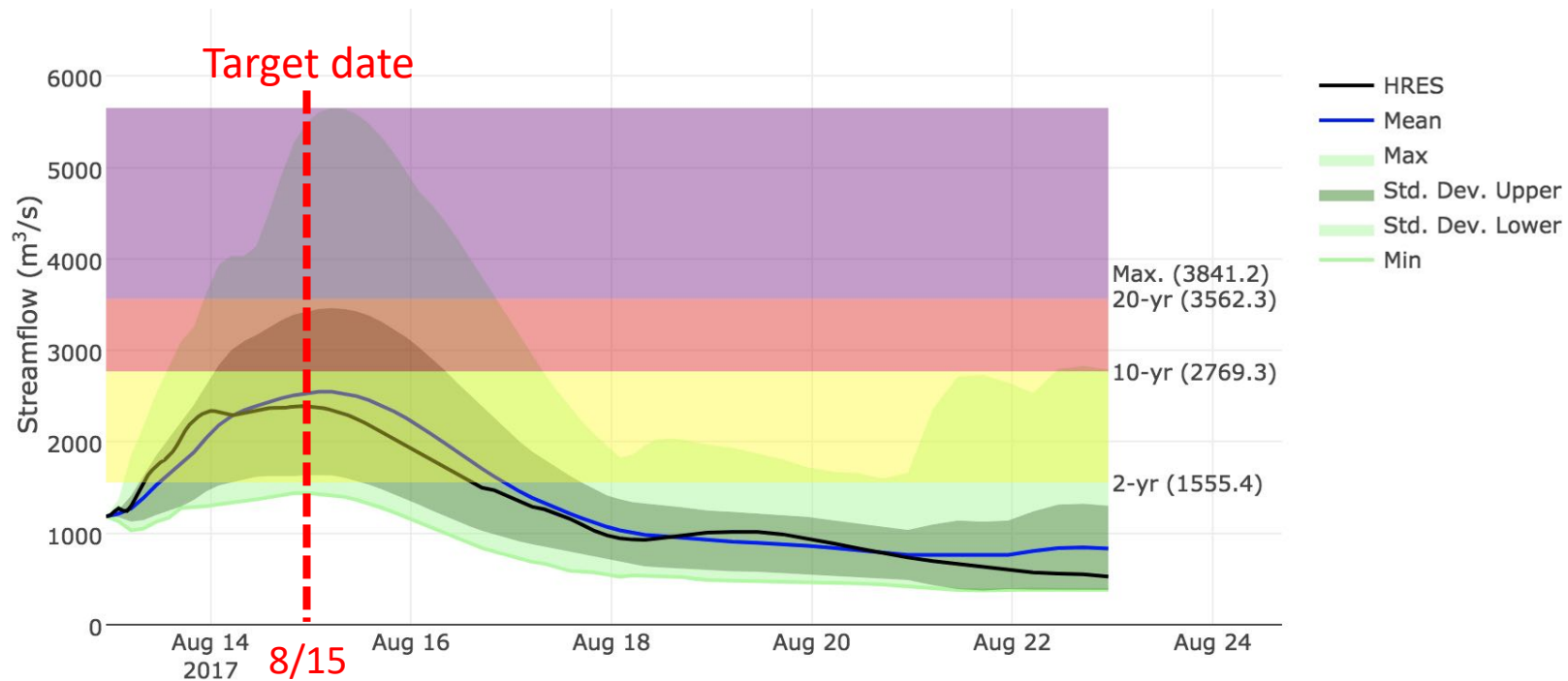
Level	8/11	8/12	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21
2-yr	4	33	54	65	71	71	60	42	19	13	8
10-yr	0	2	17	35	35	29	19	8	4	0	2
20-yr	0	2	8	17	19	17	4	0	0	0	2

- Round 1: D-day 3



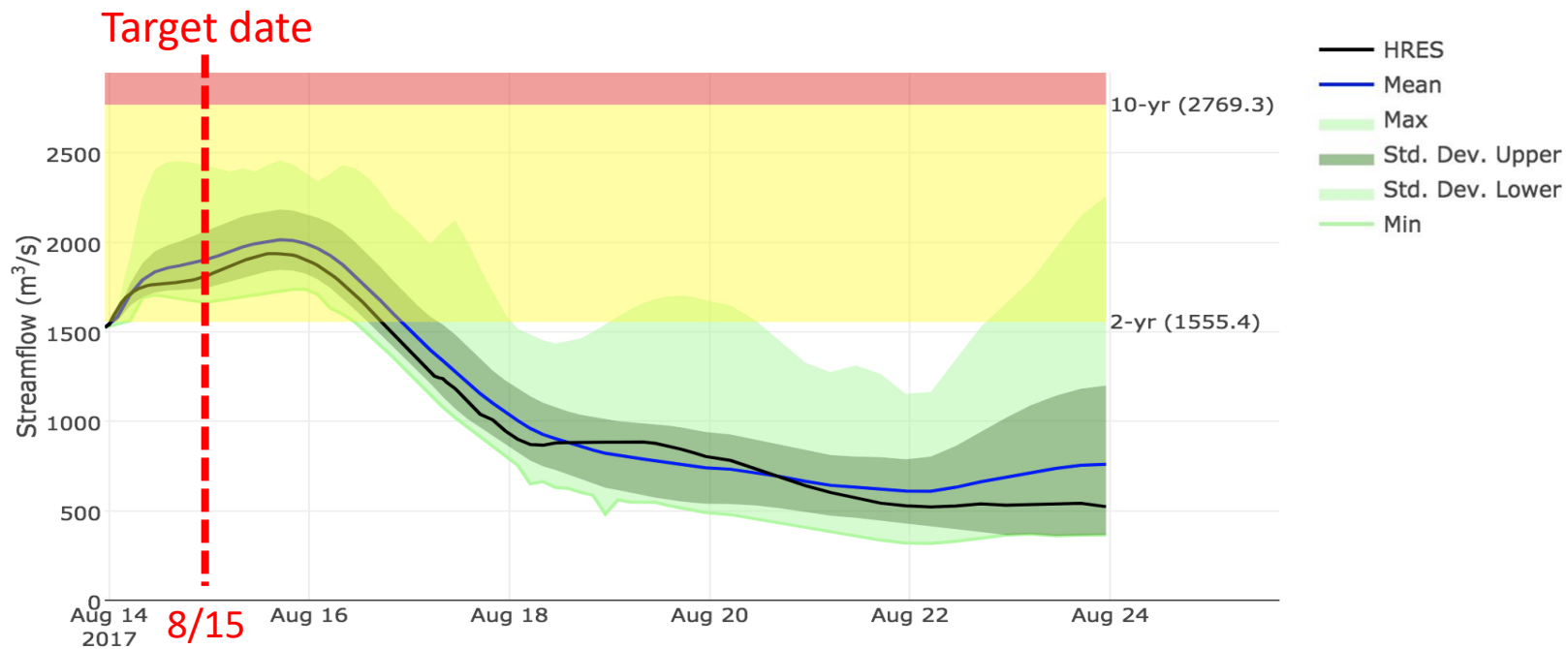
Level	8/12	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22
2-yr	6	62	88	88	81	60	29	13	4	2	6
10-yr	0	21	40	52	37	17	2	0	0	0	2
20-yr	0	8	21	21	19	4	0	0	0	0	0

- Round 1: D-day 2

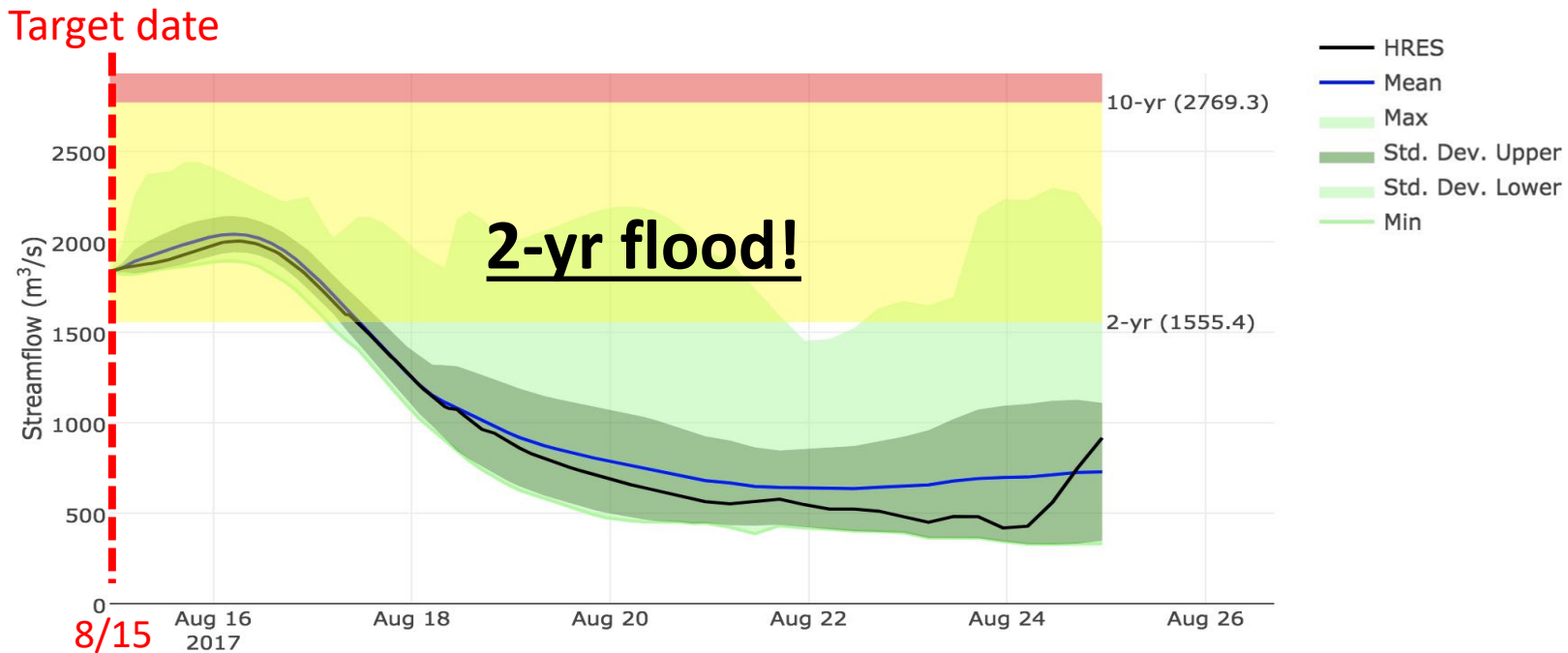


Level	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22	8/23
2-yr	63	94	90	75	42	10	6	8	2	6	10
10-yr	10	38	40	23	6	0	0	0	0	2	2
20-yr	0	15	13	8	0	0	0	0	0	0	0

- Round 1: D-day 1

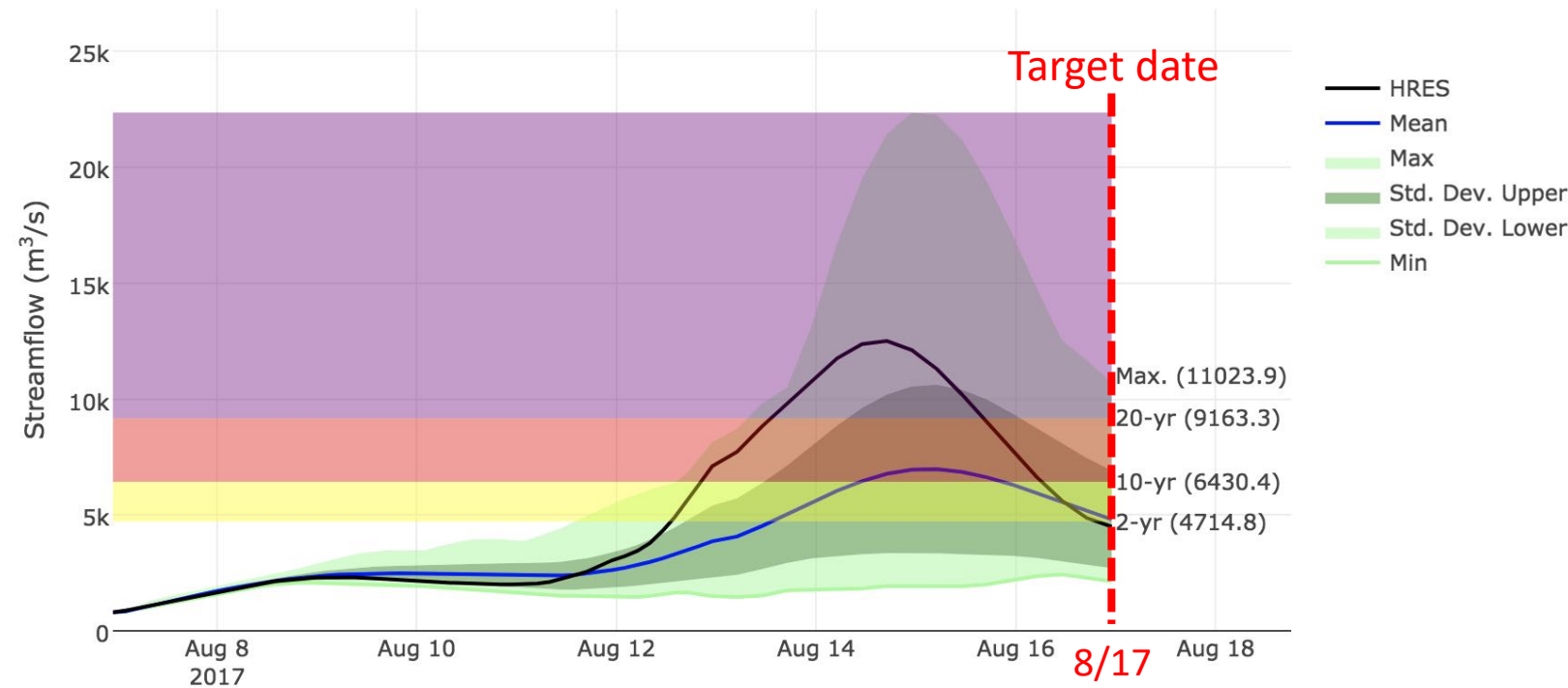
[illegible]

- Round 1: Target day!

[illegible]

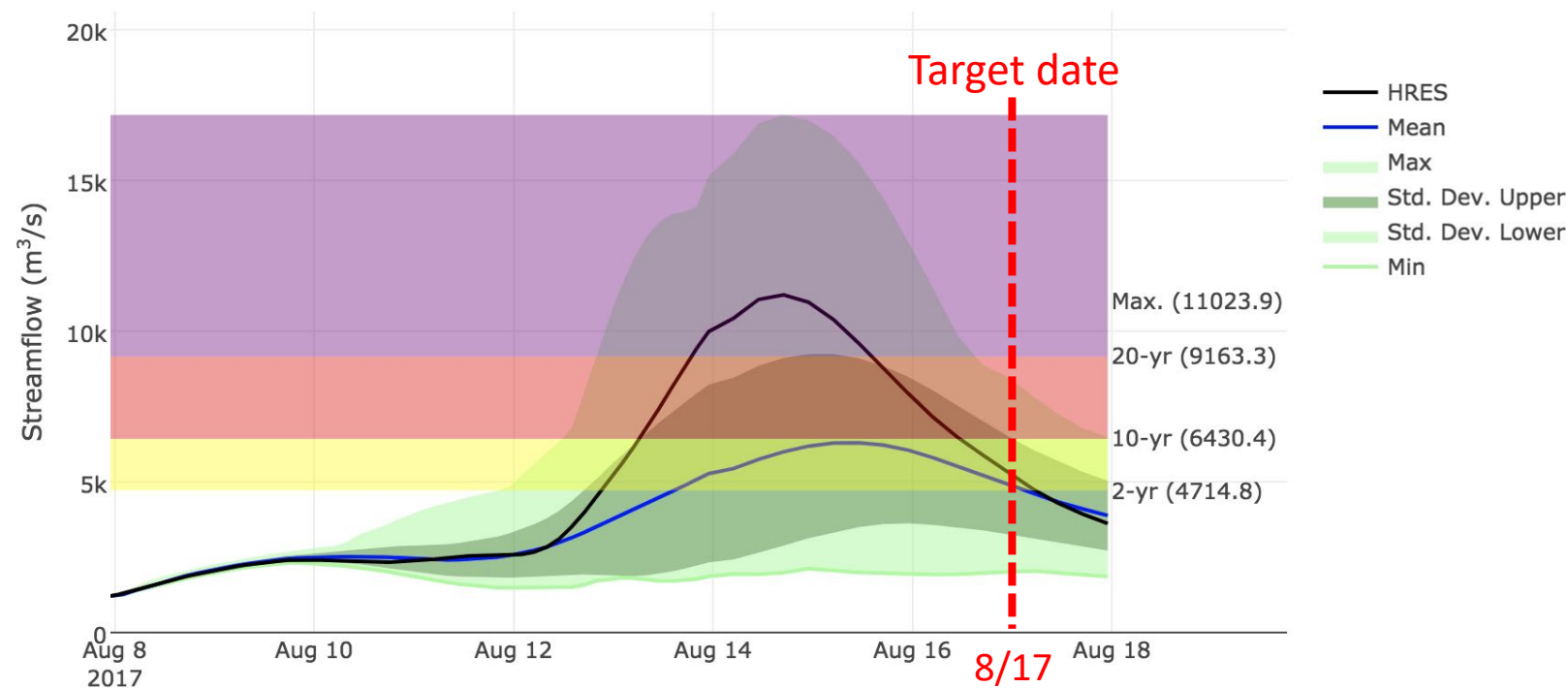
- How did your team do?
- Please fill out your Decision and Balance tables
- Let's move to Round 2

• Round 2: D-day 10



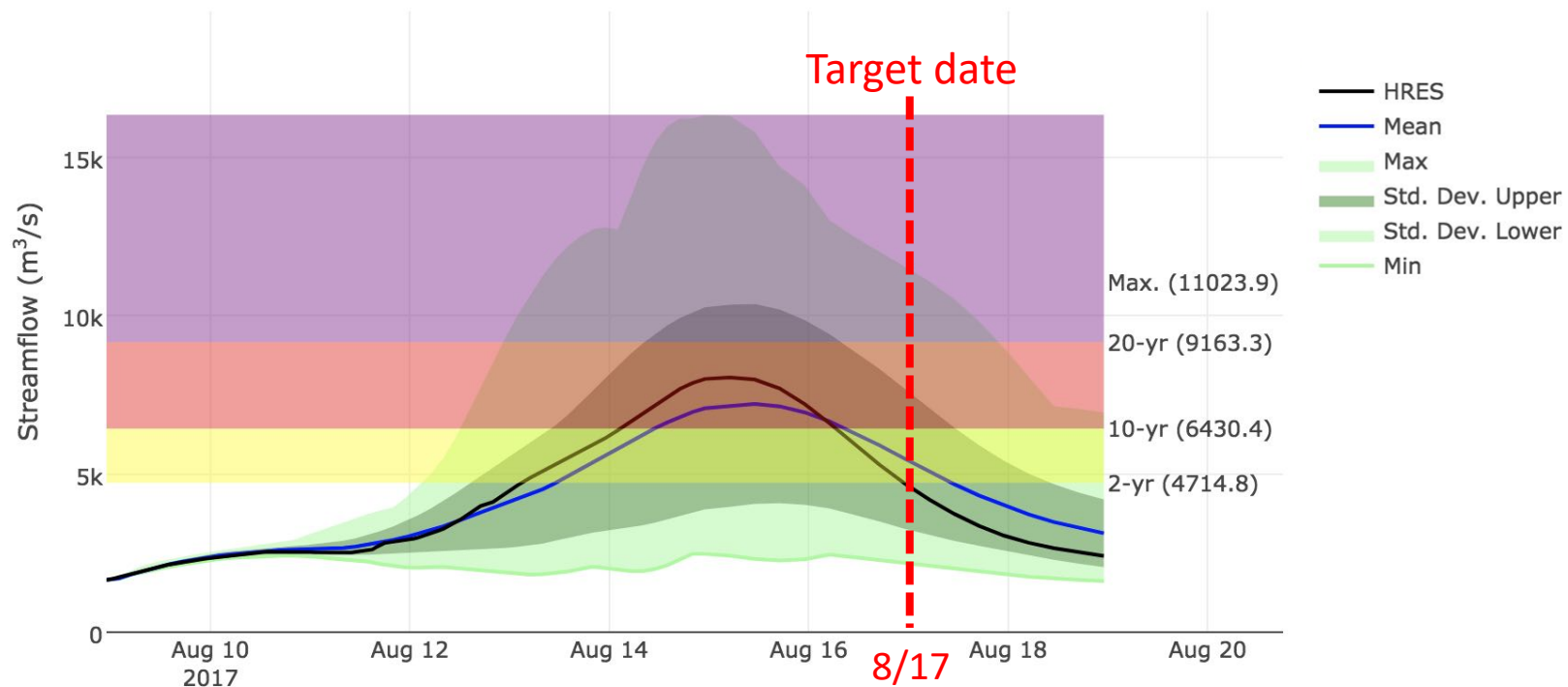
Level	8/7	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17
2-yr	0	0	0	0	2	17	60	73	81	65	38
10-yr	0	0	0	0	0	6	23	50	48	38	23
20-yr	0	0	0	0	0	0	6	21	25	15	6

• Round 2: D-day 9



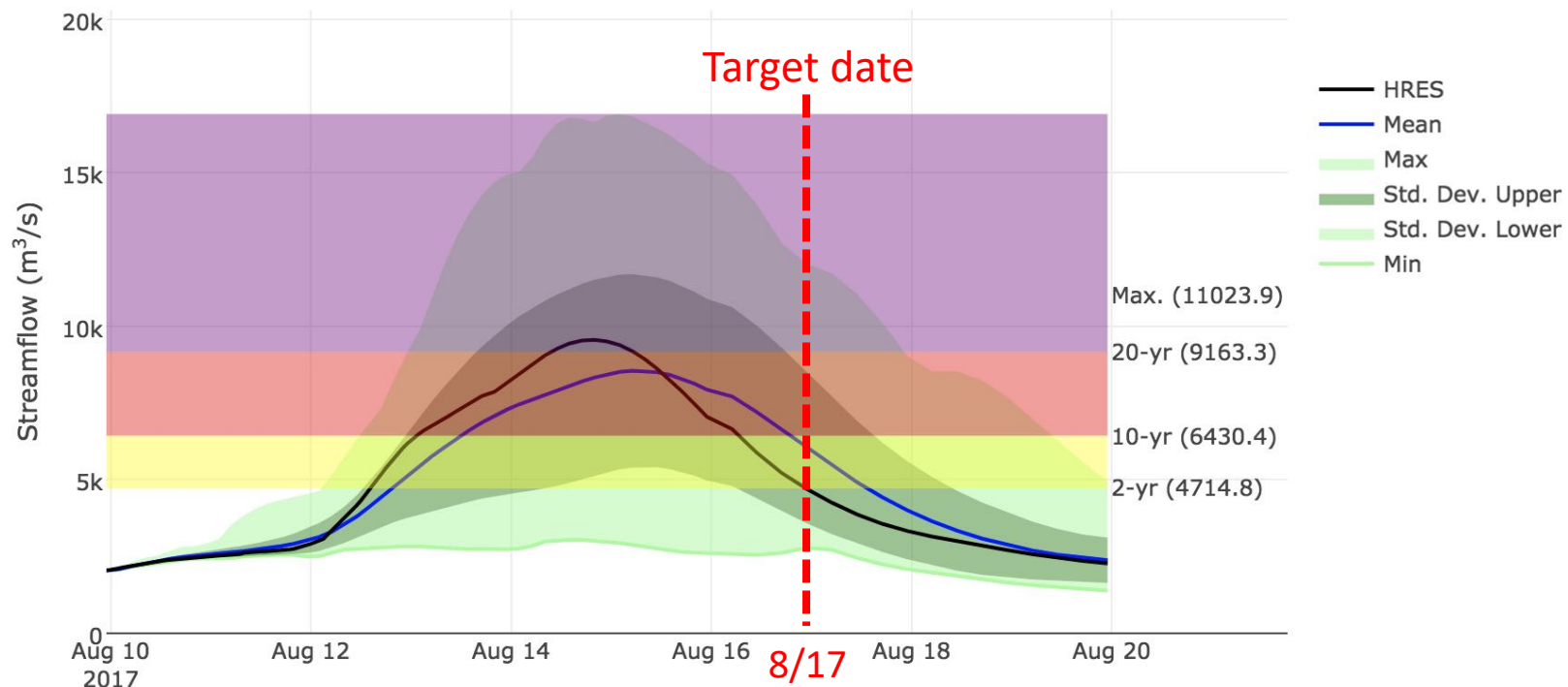
Level	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17	8/18
2-yr	0	0	0	0	17	42	60	71	67	56	25
10-yr	0	0	0	0	6	21	38	54	46	17	2
20-yr	0	0	0	0	2	10	17	17	12	0	0

- Round 2: D-day 8



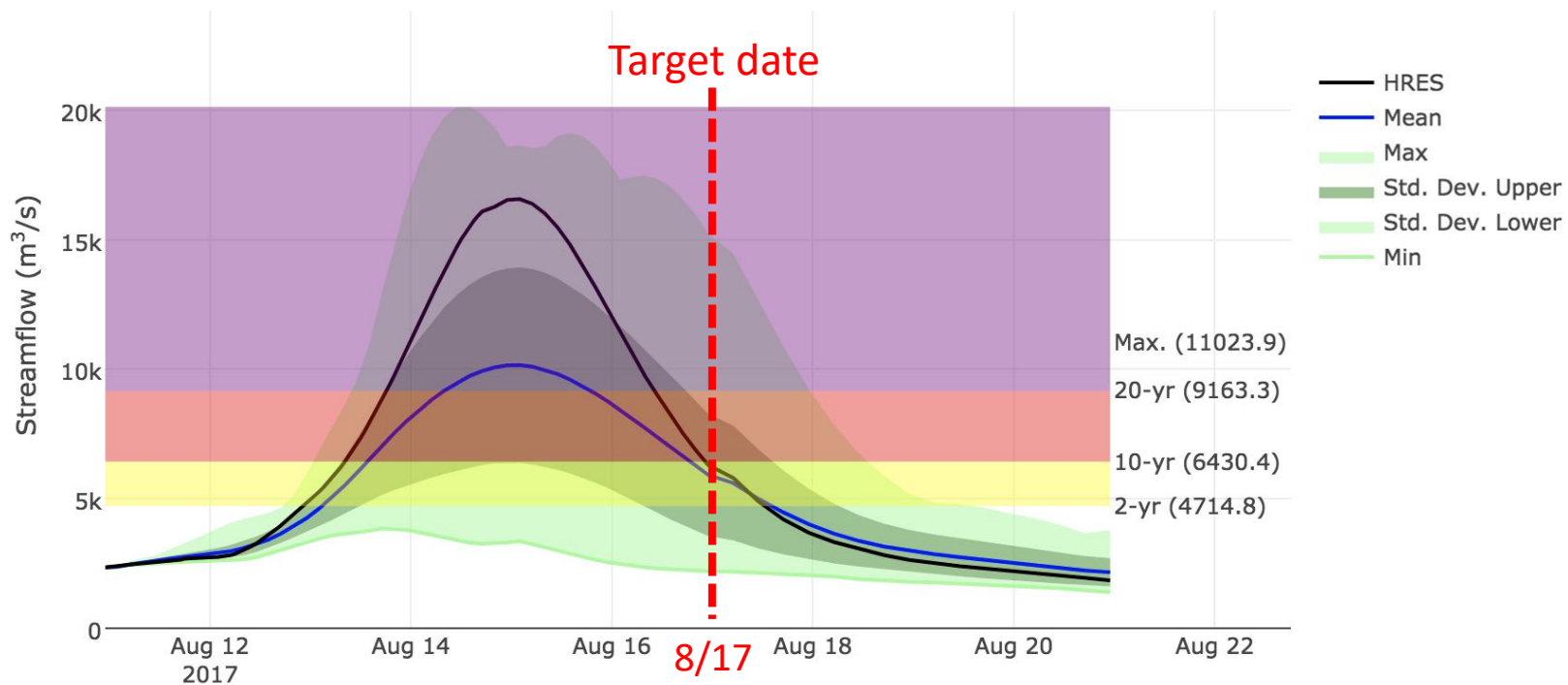
Level	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17	8/18	8/19
2-yr	0	0	0	21	54	79	79	77	58	25	8
10-yr	0	0	0	6	27	50	63	58	29	8	2
20-yr	0	0	0	0	10	19	29	23	8	0	0

- Round 2: D-day 7



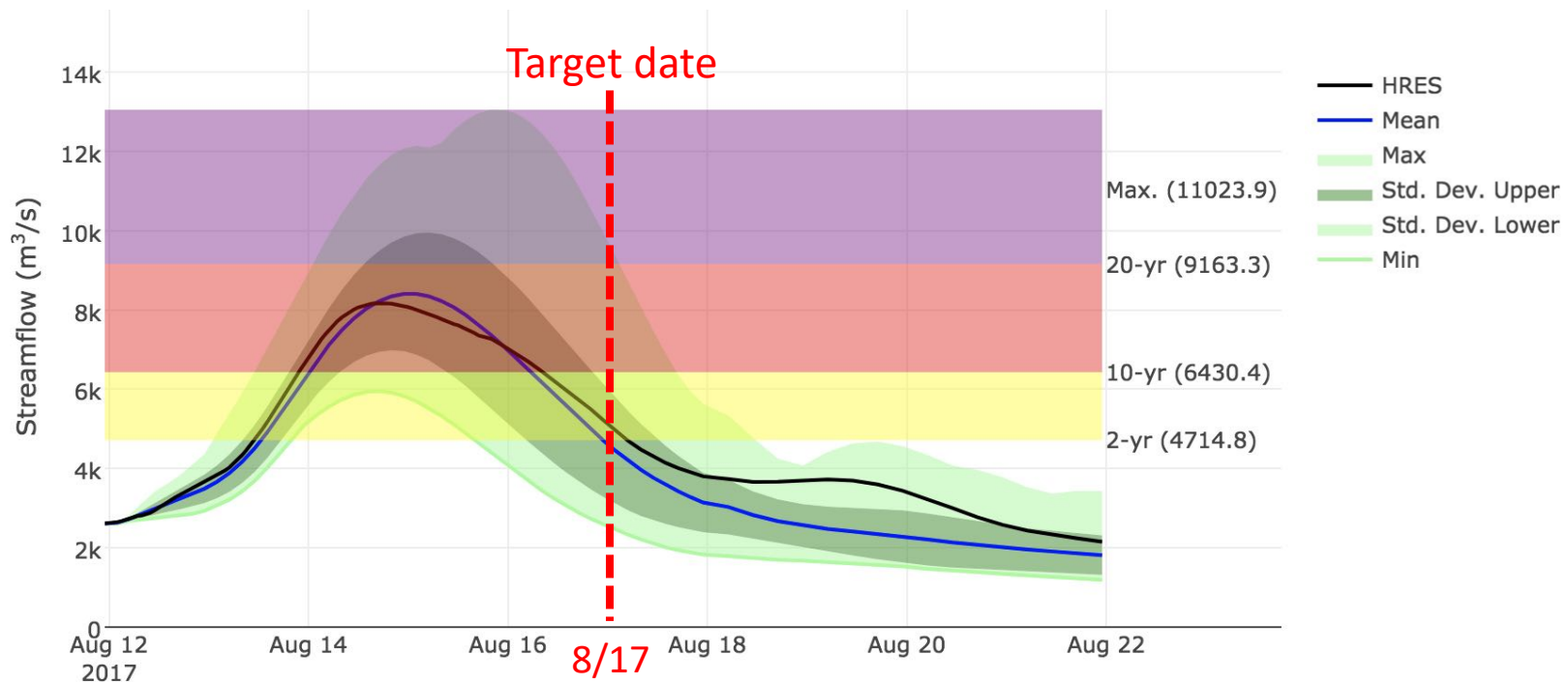
Level	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20
2-yr	0	0	52	79	87	94	88	65	25	8	4
10-yr	0	0	10	63	77	77	65	33	10	2	2
20-yr	0	0	0	19	37	50	35	17	0	0	0

- Round 2: D-day 6



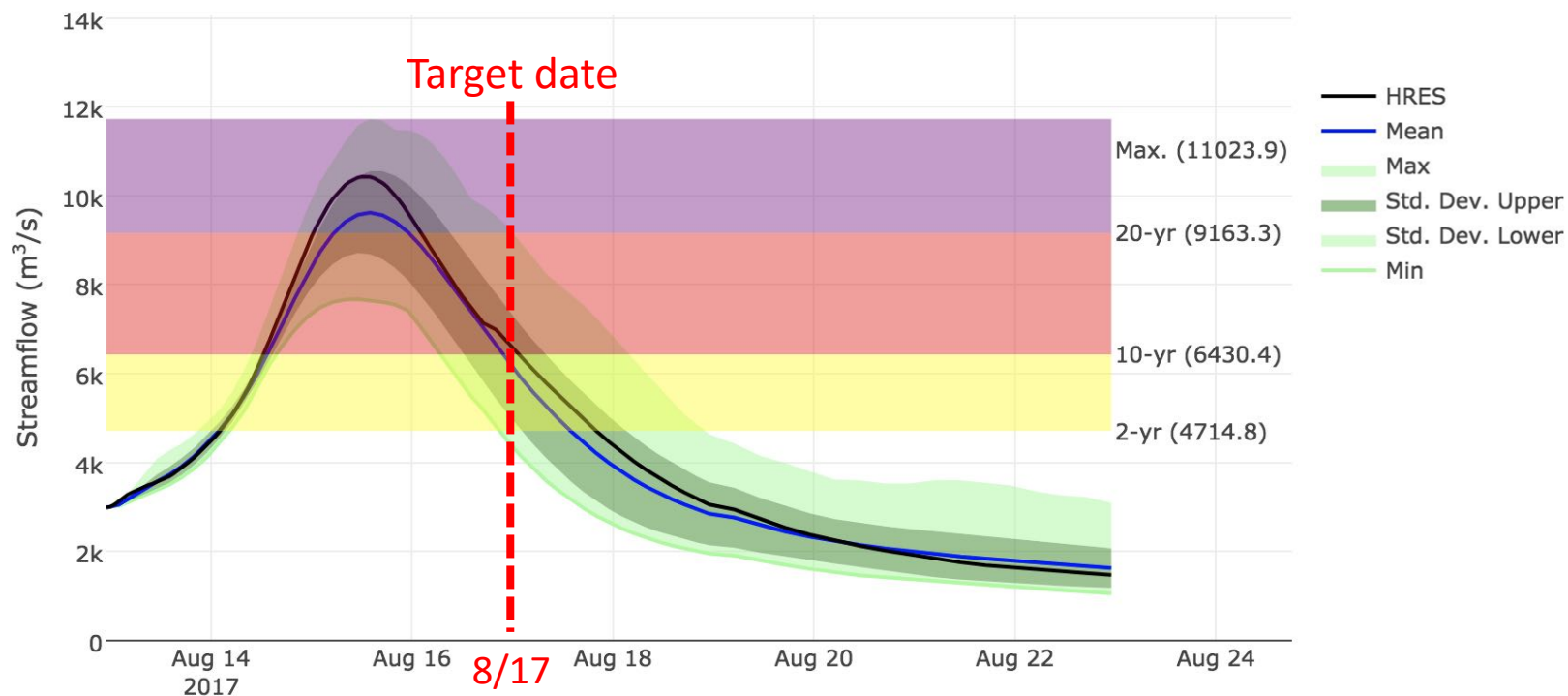
Level	8/11	8/12	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21
2-yr	0	6	94	94	96	87	58	25	4	0	0
10-yr	0	0	63	85	85	75	38	2	0	0	0
20-yr	0	0	21	56	62	37	6	2	0	0	0

- Round 2: D-day 5



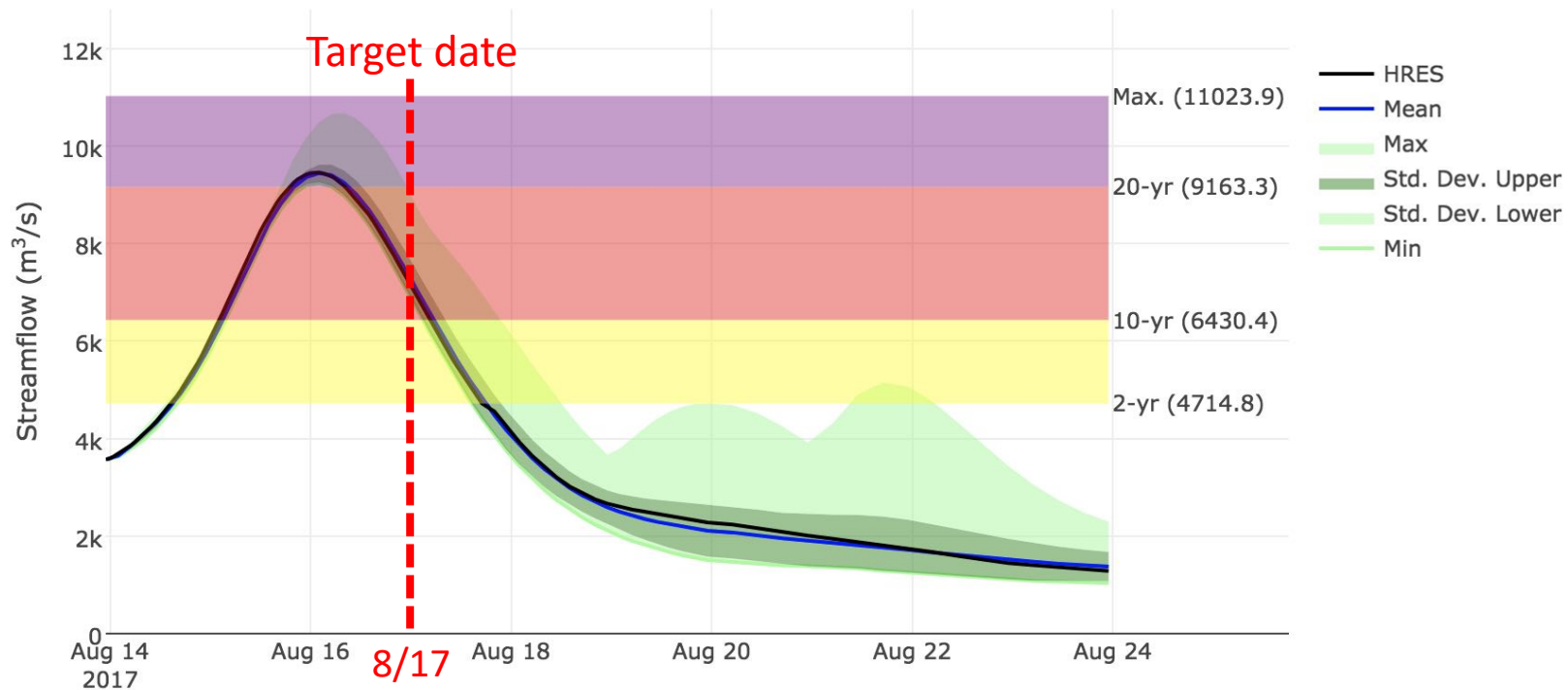
Level	8/12	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22
2-yr	0	100	100	100	92	48	4	0	0	0	0
10-yr	0	23	94	92	62	10	0	0	0	0	0
20-yr	0	0	27	35	12	2	0	0	0	0	0

- Round 2: D-day 4



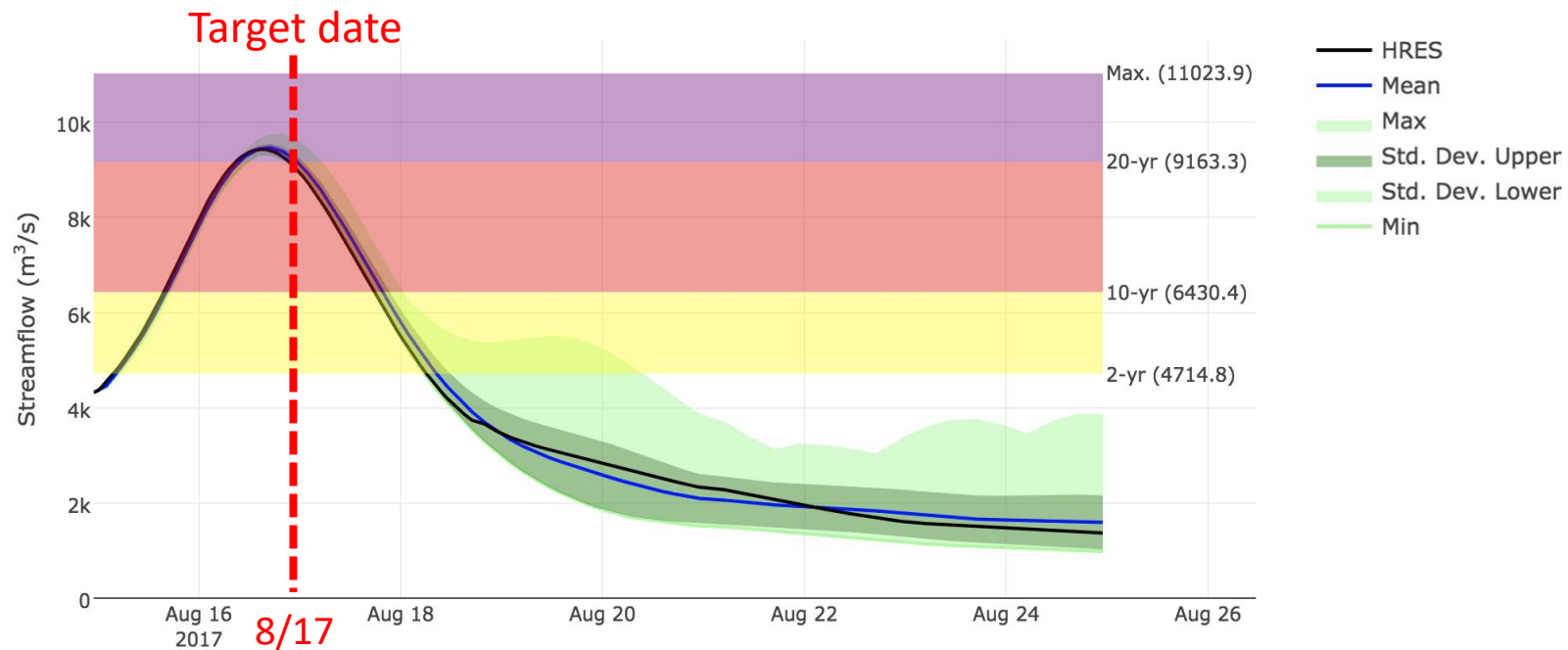
Level	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22	8/23
2-yr	0	100	100	100	92	17	0	0	0	0	0
10-yr	0	100	100	100	40	4	0	0	0	0	0
20-yr	0	0	67	56	2	0	0	0	0	0	0

- Round 2: D-day 3



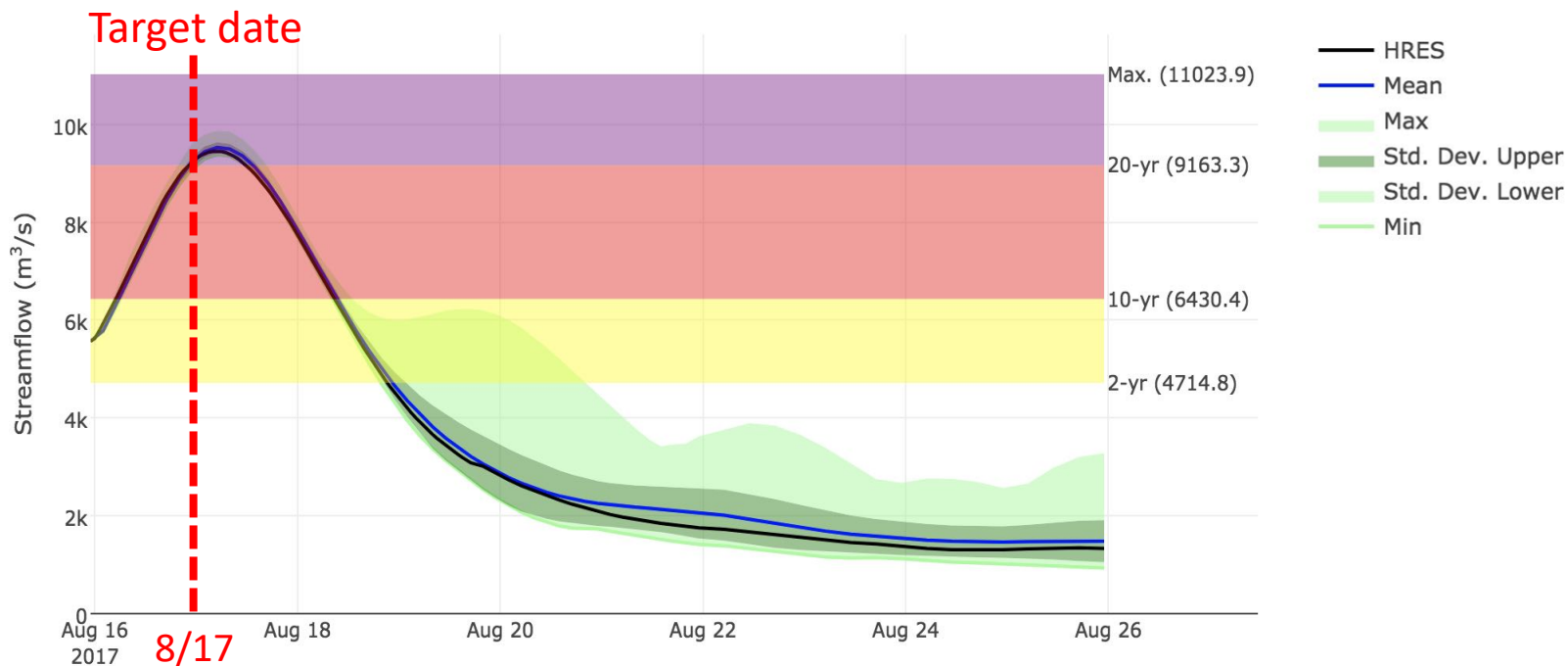
Level	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22	8/23	8/24
2-yr	100	100	100	100	10	0	2	2	2	0	0
10-yr	0	100	100	100	0	0	0	0	0	0	0
20-yr	0	35	100	2	0	0	0	0	0	0	0

- Round 2: D-day 2

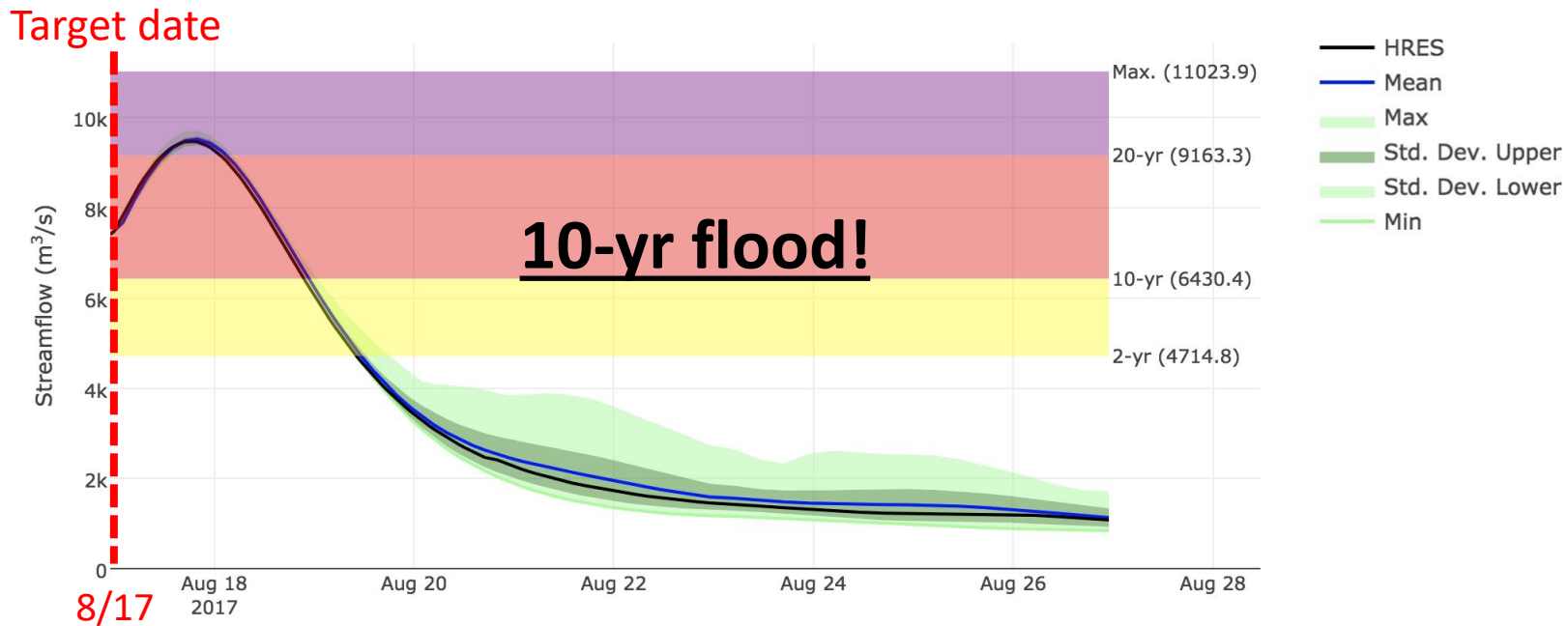


Level	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22	8/23	8/24	8/25
2-yr	100	100	100	100	4	2	0	0	0	0	0
10-yr	100	100	100	12	0	0	0	0	0	0	0
20-yr	0	100	56	0	0	0	0	0	0	0	0

- Round 2: D-day 1

[illegible]

- Round 2: Target day!

[illegible]

Please fill out your Decision and Balance tables



Winners!

Actual forecasts for Rapti River (Round 1) and Kalindri River (Round 2)

Discussion

- Did you use the Figure or Table or both? How? Thresholds?
- Presentation/'usefulness' of probabilistic information
- Did your change strategy between rounds?
- Communication from *developer* and *user* perspectives
- Realistic?
- Additions or suggestions?