Total Maximum Daily Load for Dioxin in the Houston Ship Channel

University of Houston
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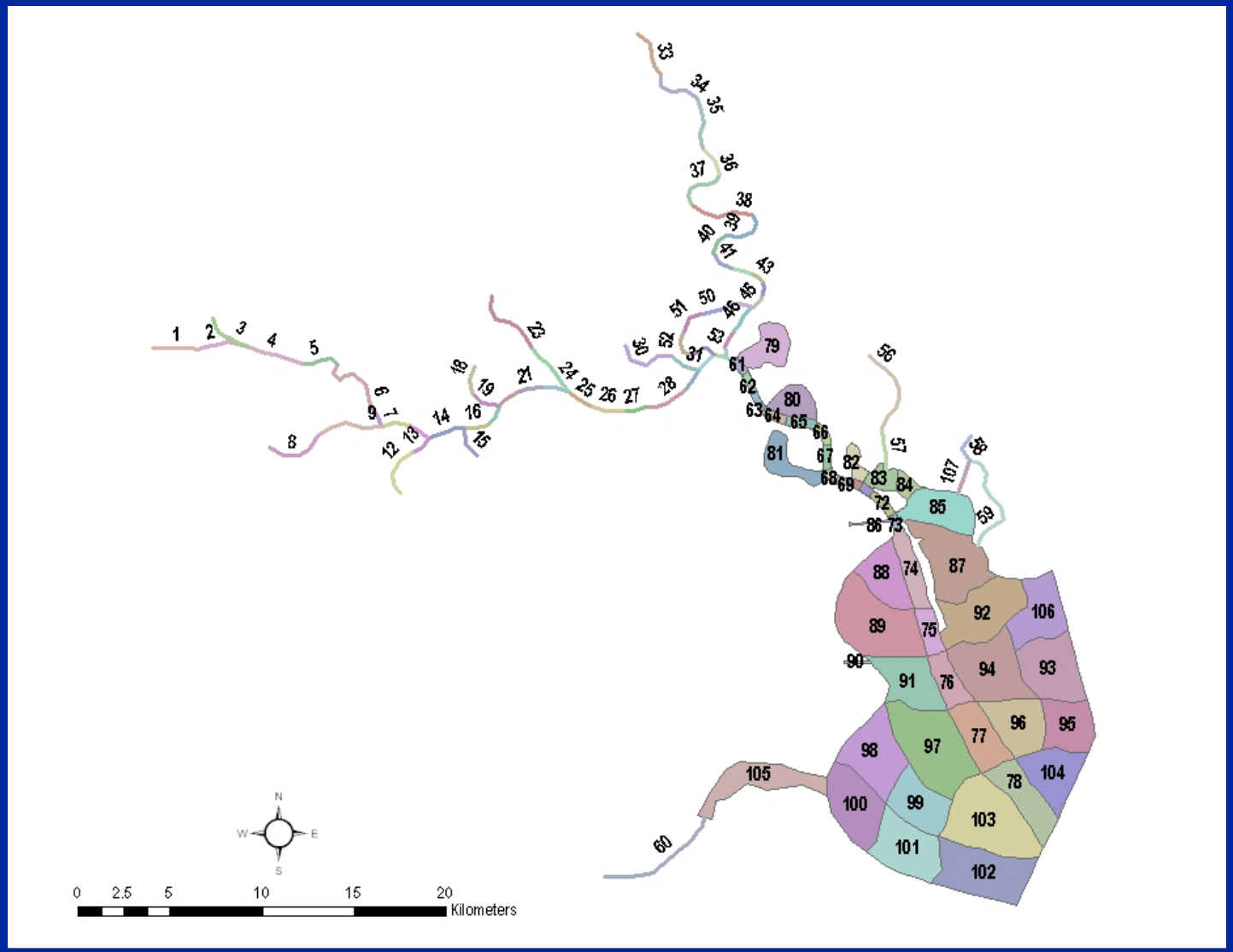
Focus

- WASP modeling update
- TMDL endpoint

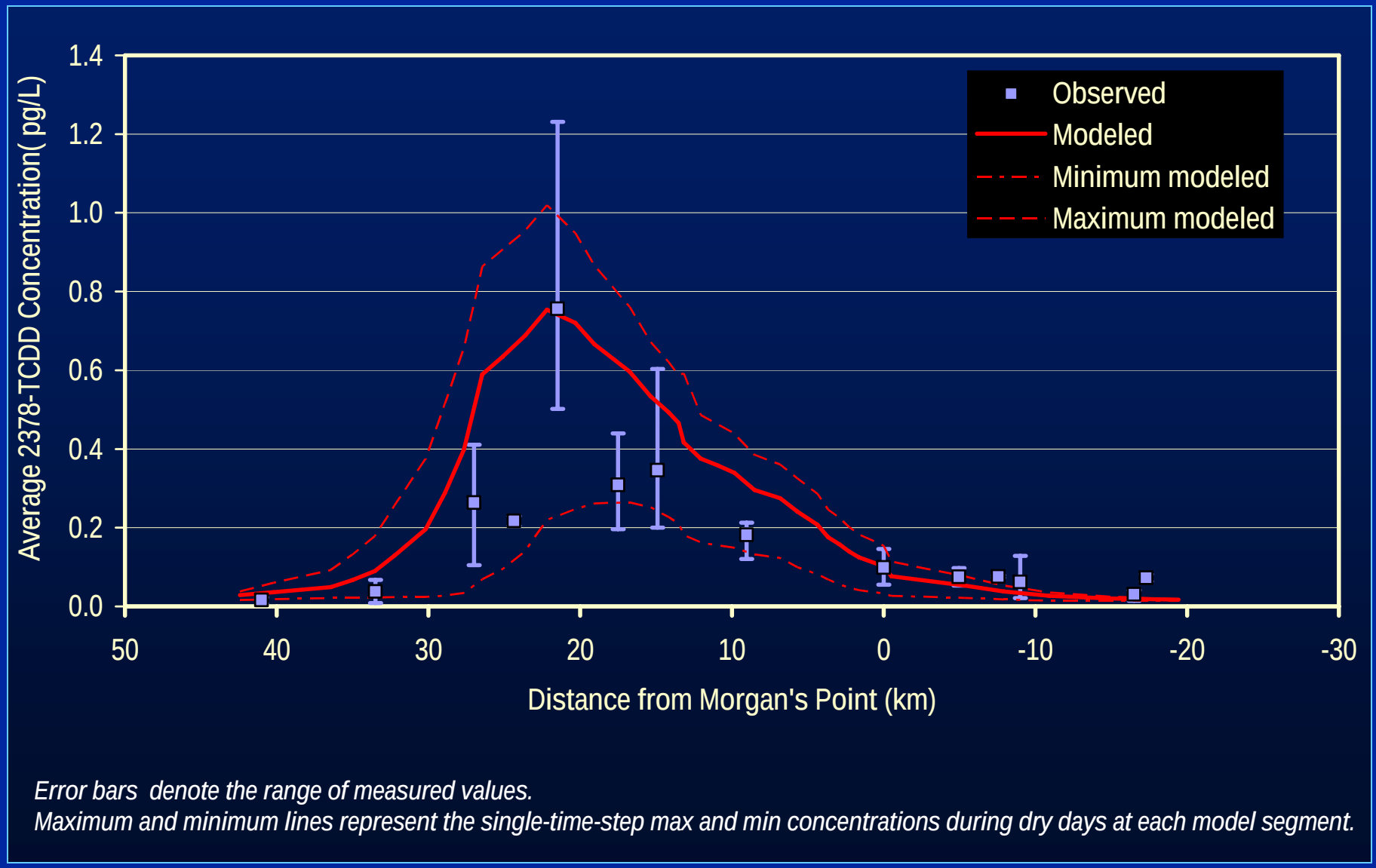
WASP final model segmentation



Update WASP 2378-TCDD model

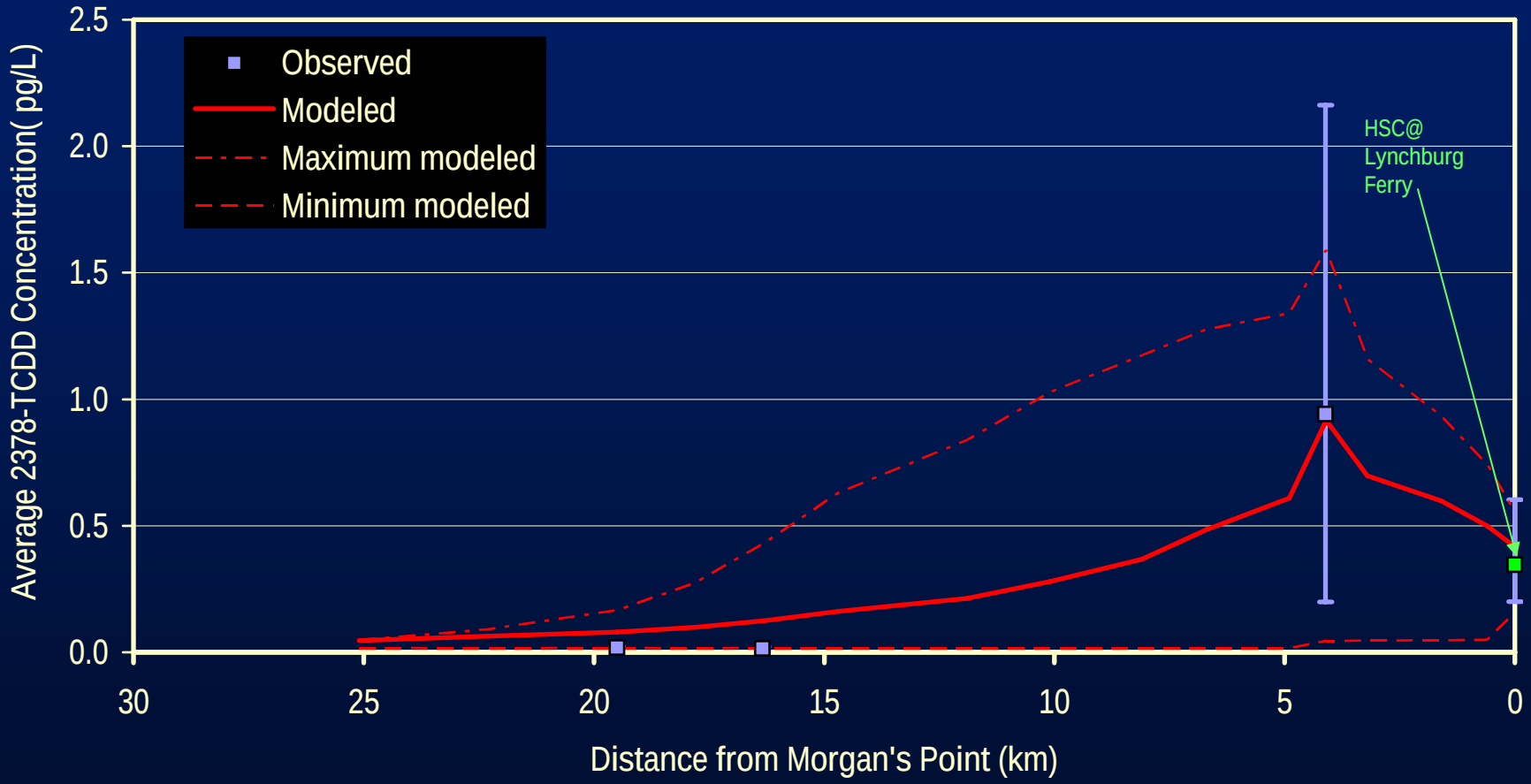
- High settling rates around “hot-spots” to better match narrow peaks observed in measured data
- Average model concentrations for DRY days were used to compare to measured data

WASP 2378-TCDD calibration – main channel



Error bars denote the range of measured values.
Maximum and minimum lines represent the single-time-step max and min concentrations during dry days at each model segment.

WASP 2378-TCDD calibration – San Jac



Error bars denote the range of measured values.
Maximum and minimum lines represent the single-time-step max and min concentrations during dry days at each model segment.

TMDL Endpoint

Toxic equivalence of a mixture (TEQ)

- TEQ is calculated as: $$TEQ = \sum C_i \cdot TEF_i$$
- where C_i and TEF_i are concentration and toxicity equivalent factor for congener *i*
- Texas TEFs:

Congener	Texas TEF
2378-TCDD	1
12378-PeCDD	0.5
123478-HxCDD	0.1
123678-HxCDD	0.1
123789-HxCDD	0.1
2378-TCDF	0.1
12378-PeCDF	0.05
23478-PeCDF	0.5
123478-HxCDF	0.1
123678-HxCDF	0.1
123789-HxCDF	0.1

Congeners in orange contribute more than 96% of the TEQ in tissues from the HSC.

Current TX dioxin standards

Average concentration levels (TCEQ WQS 2000)

Saltwater (Fish Only) 9.33×10^{-8} μg/L = 0.093 pg/L (ppq)

*Fish Tissue** 4.7×10^{-4} μg/kg = 0.47 ng/kg (ppt)

** back-calculated from fish WQS using TCEQ assumptions*

Risk management assumptions

$$WQ_{standard} = RL \times BW / CSF \times CR \times BAF$$

$$TRC = RL \times BW / CSF \times CR$$

RL = risk level = 10^{-5}

CSF = cancer slope factor = $1x10^{5}$ kg-day/mg

BW = body weight = 70 kg

CR = mean daily consumption rate = 0.015 kg/day

BAF = bioaccumulation factor = 5000 L/kg

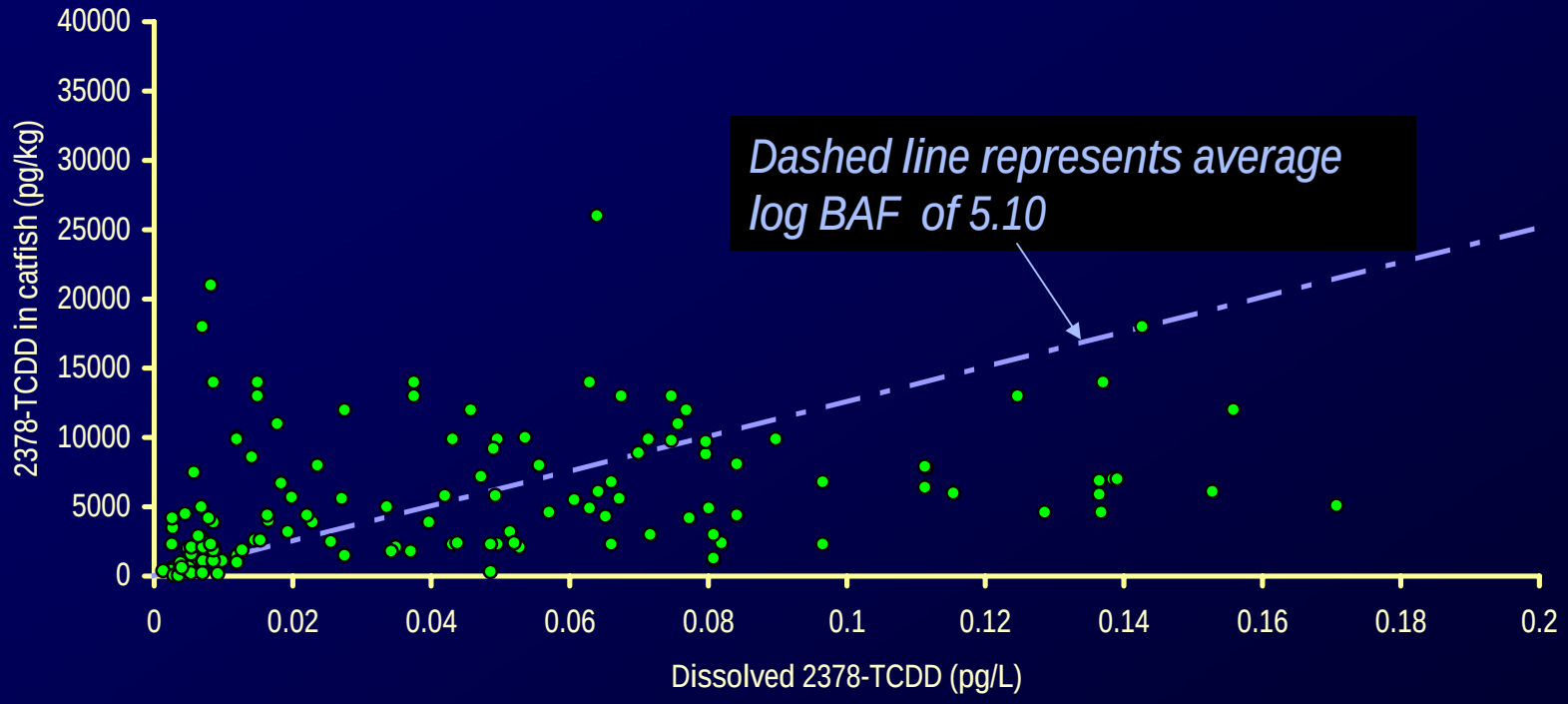
TRC = tissue residue concentration = 0.47 ng/kg

$$WQ_{standard} = (10^{-5}x70)/(1x10^{5}x0.015x5000)$$

$$= 9.33x10^{-11} \text{ mg/L} = 0.0933 \text{ pg/L}$$

Bioaccumulation factor

$$BAF = \frac{C_{tissue}}{C_{dissolved}}$$



Issues to consider for TMDL endpoint

- HSC site-specific BAFs
- Tissue-based standard versus water standard
- Individual congener standards versus TEQ standard

TMDL targets

- Determine WQ targets for congeners that contribute more than 1% to TEQ in tissue using BAFs and suspended-dissolved partitioning ratios (K_p's) from measured data.
- WQ target for a given congener is:

$$C_{w,d} = \frac{TRC * f_i^{TEQ}}{BAF_i * TEF_i}$$

where TRC is the tissue residue criterion (0.47 ng/kg), $C_{w,d}$ is dissolved concentration, f_i^{TEQ} is average contribution to TEQ, TEF is toxic equivalent factor of congener *i*.

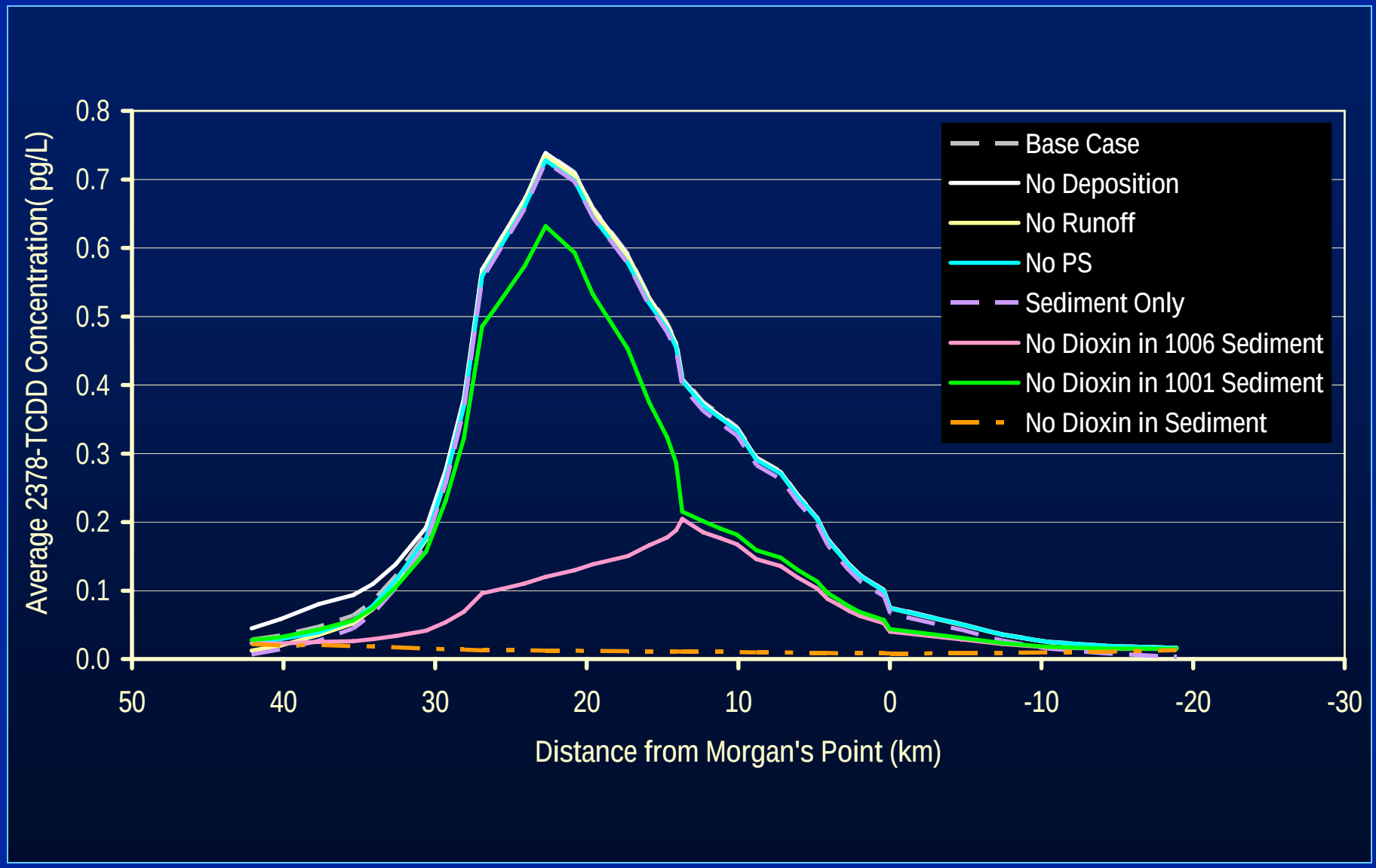
WQ Targets

Congener	TEF	log BAF[a]	Average contribution to TEQ (%)			Water Quality Target - Diss (pg/L)[c]	Average log Kp[d]	WQ Target - Total (pg/L)[e]
			Tissue[b]	Water	Sediment			
2378-TCDD	1	5.10	80.3	46.6	51.7	0.0030	5.38	0.022
12378-PeCDD	0.5	4.78	4.5	5.3	6.4	0.0007	5.40	0.005
123678-HxCDD	0.1	4.57	1.4	5.3	4.4	0.0018	5.49	0.016
2378-TCDF	0.1	3.49	2.1	15.4	14.3	0.0319	5.31	0.201
23478-PeCDF	0.5	4.60	6.5	8.4	9.5	0.0015	5.32	0.010
123678-HxCDF	0.1	4.45	1.4	2.3	1.5	0.0023	5.47	0.020
Σ $TEQ_{major\ congeners}$[f]			96.2%	83.2%	87.7%	0.0077		0.053
Total TEQ[g]								0.064

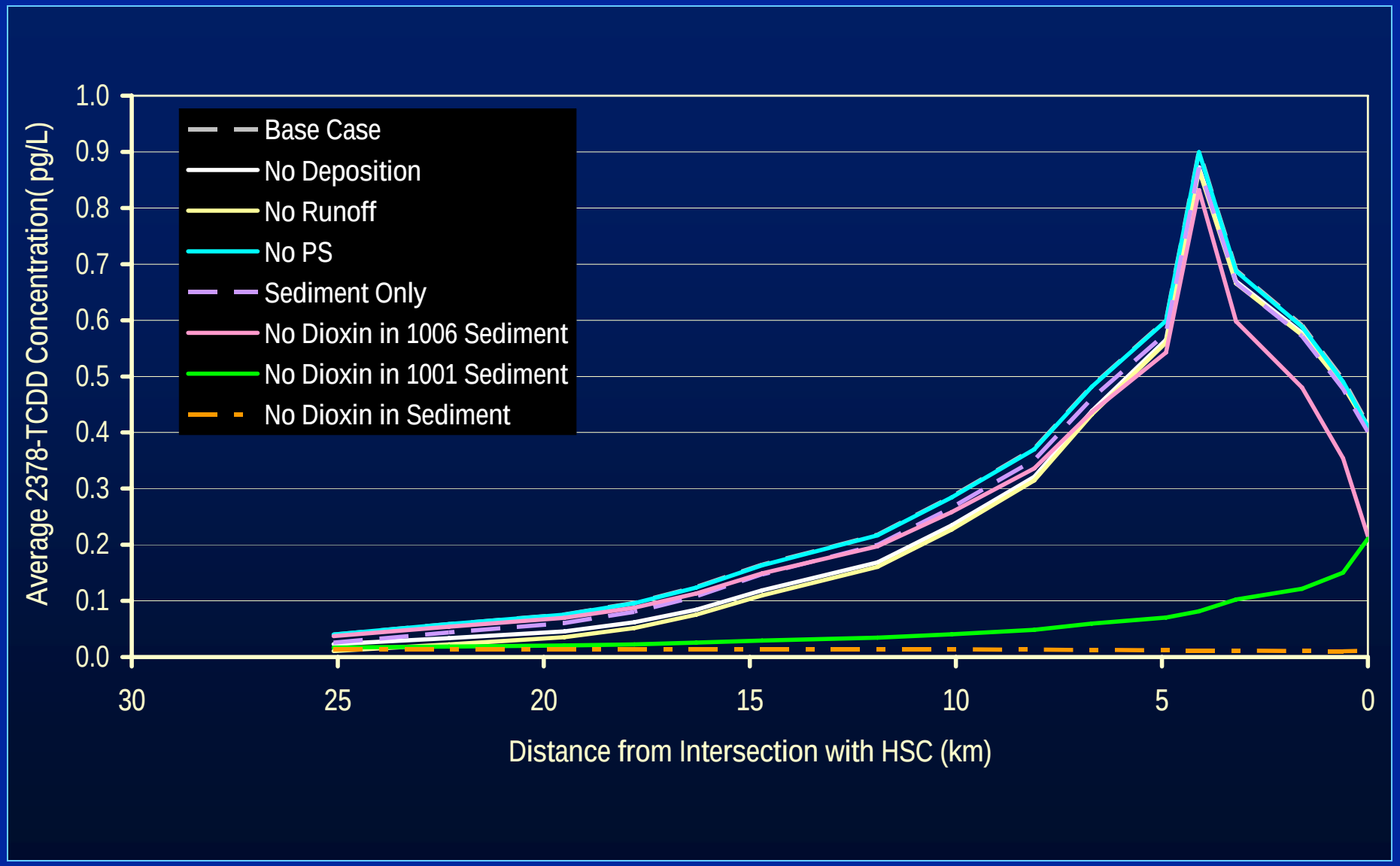
[a] Average of the logarithms of the catfish/dissolved ratios for samples collected in this project.
[b] Average contribution of each congener to TEQ in catfish, similar contributions were obtained when using crab data.
[c] Calculated using equation in previous slide.
[d] Average of the logarithms of the suspended/dissolved ratios for each of the water samples.
[e] Dissolved + Suspended concentrations. Suspended concentrations are calculated as $C_{diss}*10^{log\ Kp}*TSS_{average}$. $TSS_{average}$ is 26 mg/L.
[f] Σ TEQmajor congeners = (Σ $Target_i$*TEFi) for the six major congeners.
[g] Total TEQ target = Σ $TEQ_{major\ congeners}$/total contribution of the six congeners to TEQ in water = 0.053/0.832

Load Allocation

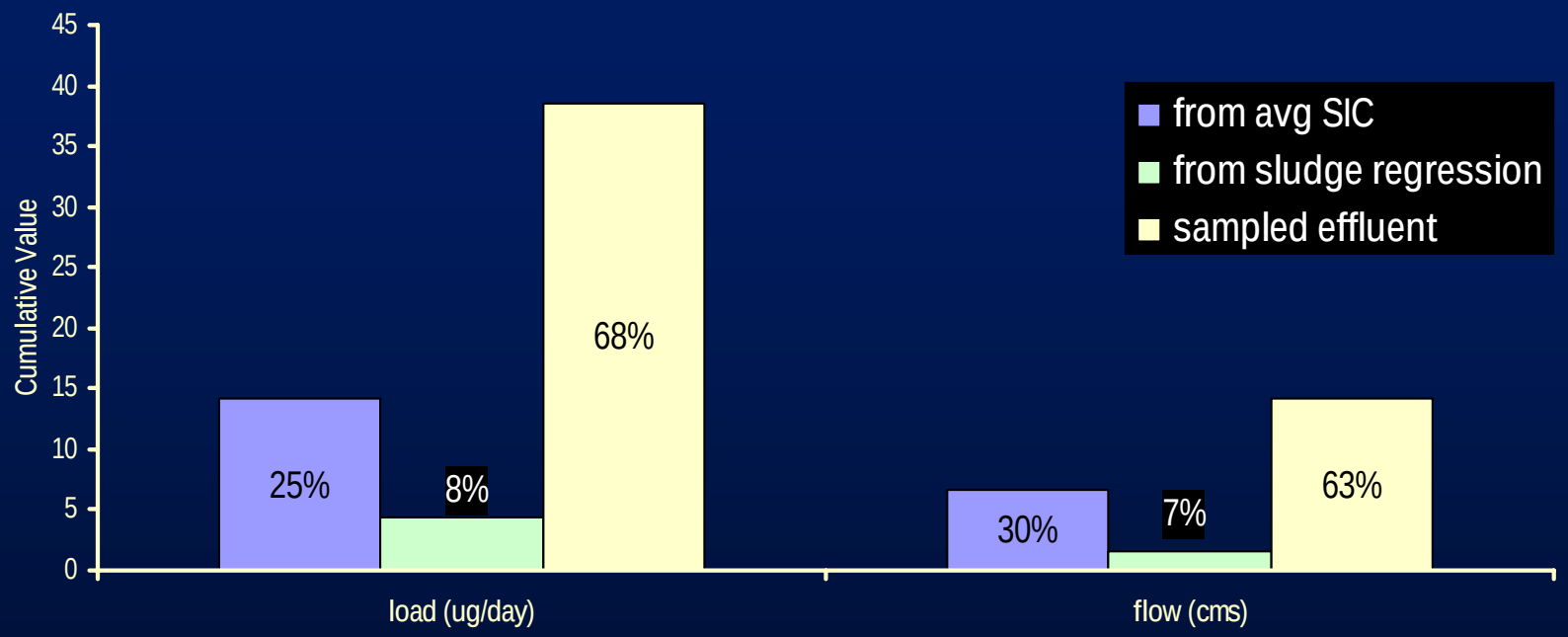
WASP load scenarios – main channel



WASP load scenarios – San Jacinto River



Measured vs. estimated TCDD loads from PS

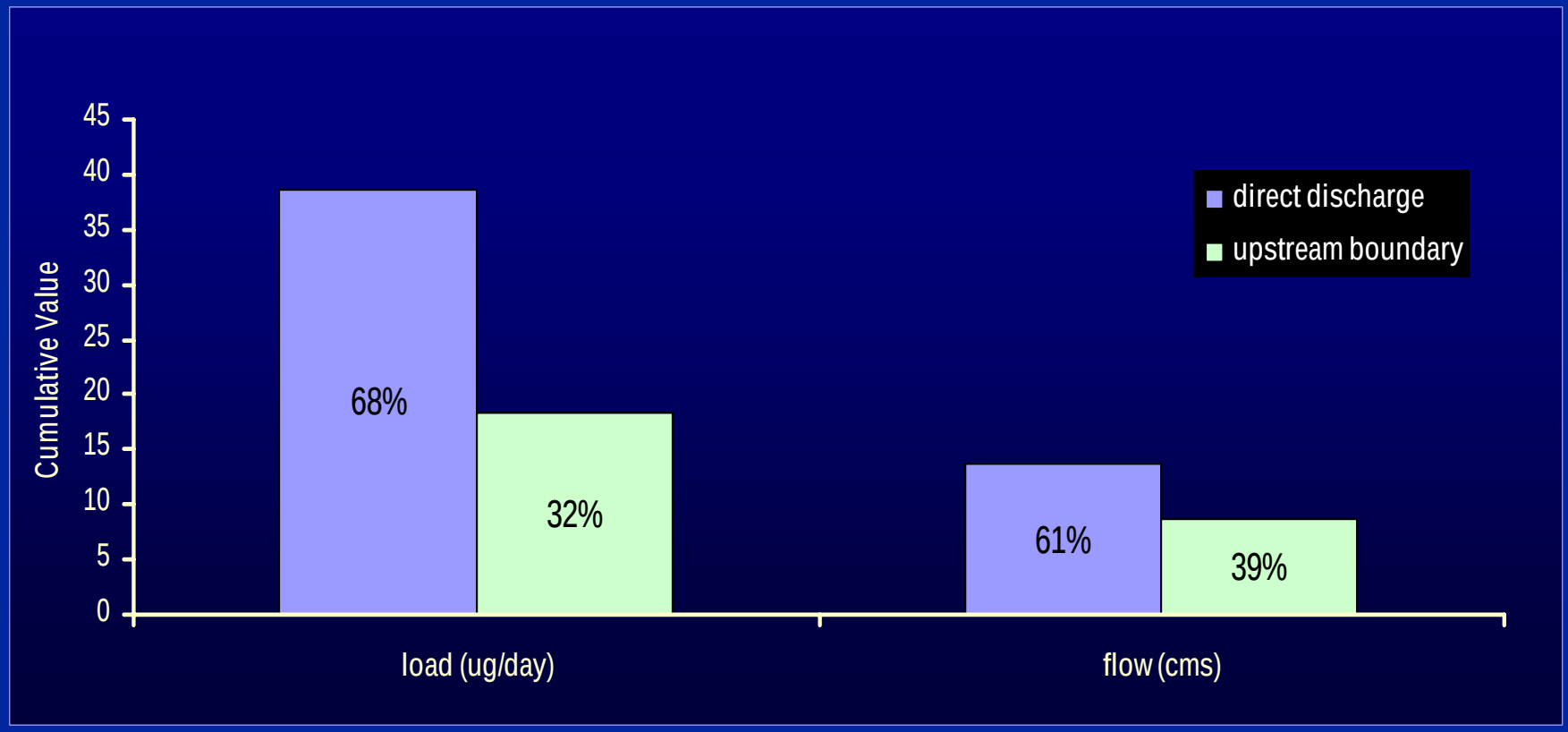


100% of the effluent samples exhibited 2378-TCDD concentrations below MDL, ½ MDL used for calculations

7% of the loads calculated using sludge data were derived from concentrations above MDL, the remaining 93% was calculated using ½ MDL

Loads from average concentrations by SIC code were calculated using effluent data and, thus, correspond to ½ MDL

Direct vs. Boundary Loads from PS



Load spreadsheet – preliminary overall reduction - TCDD

Segment	Net Flow[a] (m^3/s)	Allowable Load (ng/day)[b]	In-stream Load (ng/day)	% Overall Reduction
1014+1017	23.6	44,842	58,267	23%
1007	40.9	77,767	2,320,038	97%
1016	9.1	17,319	53,352	68%
1006	50.4	95,762	854,514	89%
1001 upper	138.1	262,582	3,469,301	92%
1001 lower	138.0	262,314	4,780,351	95%
Old River	0.7	1,331	28,984[d]	95%
1005 upper	188.2	357,724	1,427,912	75%
2430	0.0	94	1,538	94%
2429	0.0	77	984	92%
2428	0.0	23	143	84%
2427	0.1	150	1,154	87%
2426	2.7	5,061	20,937	76%
2436	0.0	2	8	71%
1005 lower	191.7	364,456	-5,263,367	0%
2438	0.0	0	0	13%
2421	348.6	662,647	-1,326,510	0%
901	2.6	4,910	9,976	51%
Clear Lake	2.1	3,944	1,751[d]	0%

[a] Average of simulated flows out of segment for period July 2002 to April 2005

[b] Net outflow times the calculated WQ target for TCDD (0.022 pg/L)

[c] Average in-stream load using modeled concentrations and subtracting upstream segment loads

[d] No dioxin data are available, thus, values are rough estimates

Next steps

- Model additional congeners
- Run load reduction scenarios
- Update load spreadsheet model and define TMDL