Bacteria TMDLs for Clear Creek

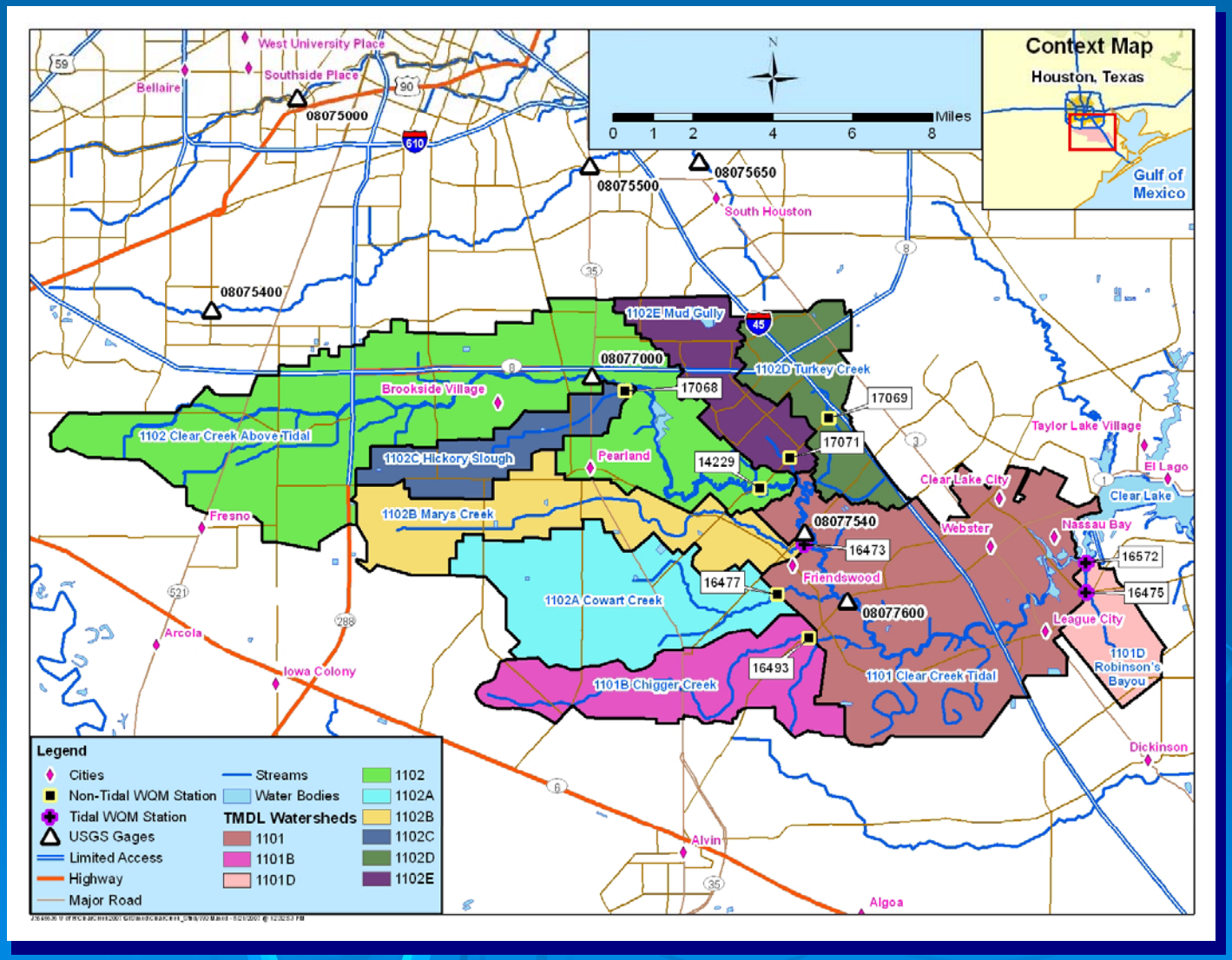
March 6, 2008

Outline

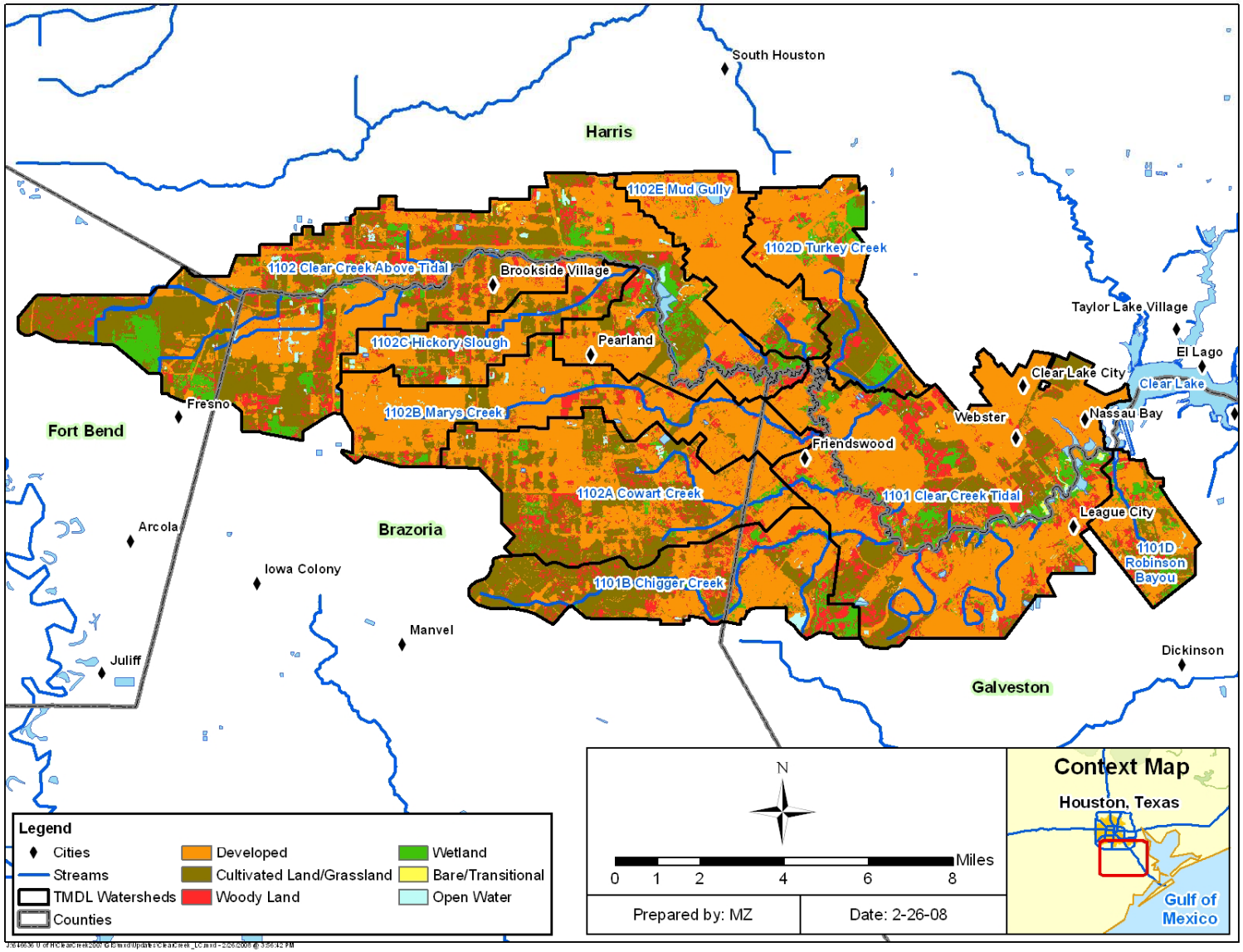
- Pollutant source assessment
- LDCs for non-tidal segments
- Tidal Prism methodology for tidal segments
- TMDL Calculations

Clear Creek Watershed

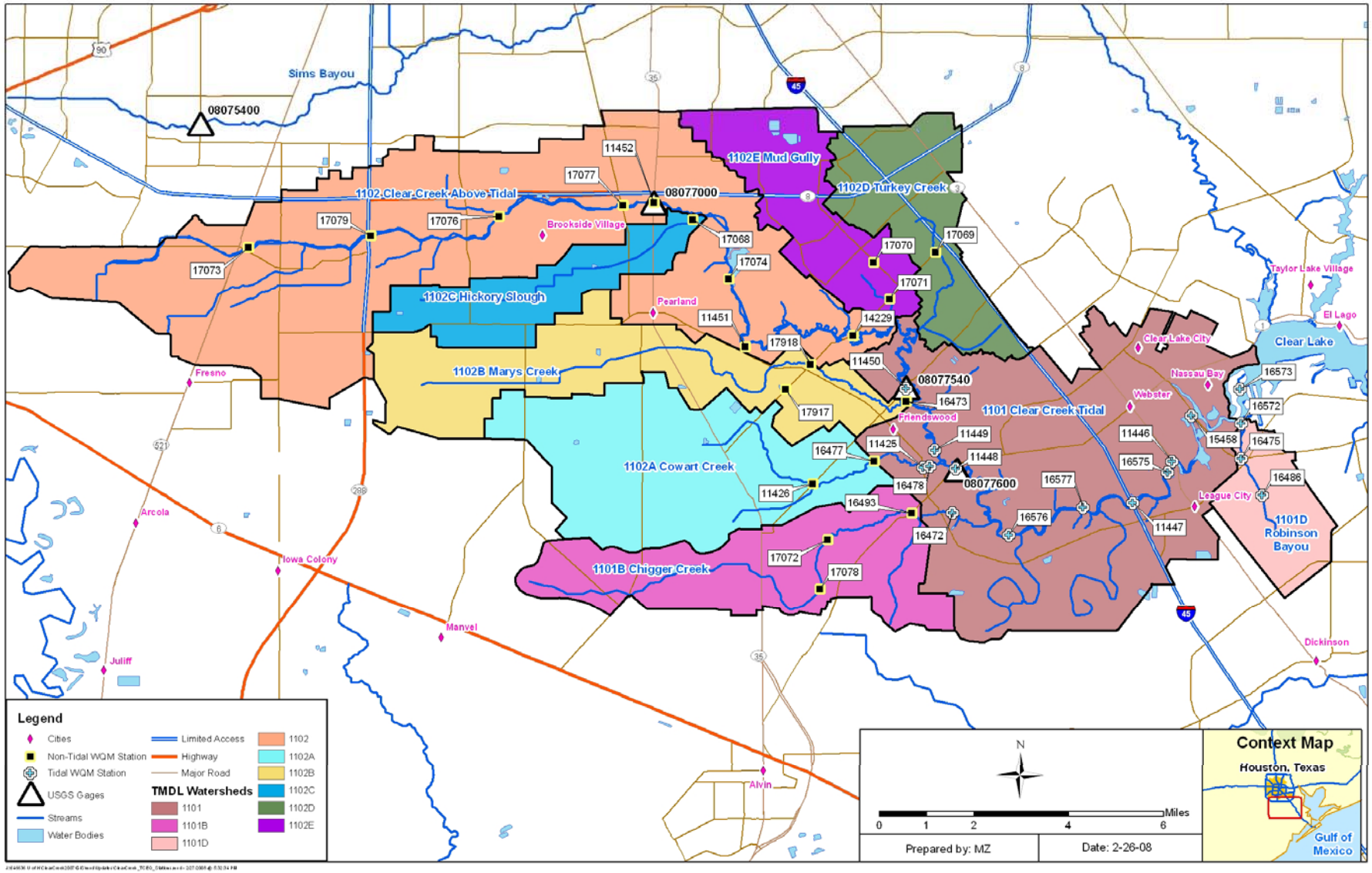
- 200 square miles
- Located within 4 counties (Harris, Galveston, Brazoria, Fort Bend)
- Average Annual Rainfall 53 inches (PRISM Group 2006)



Land Use/Land Cover



Water Quality Stations



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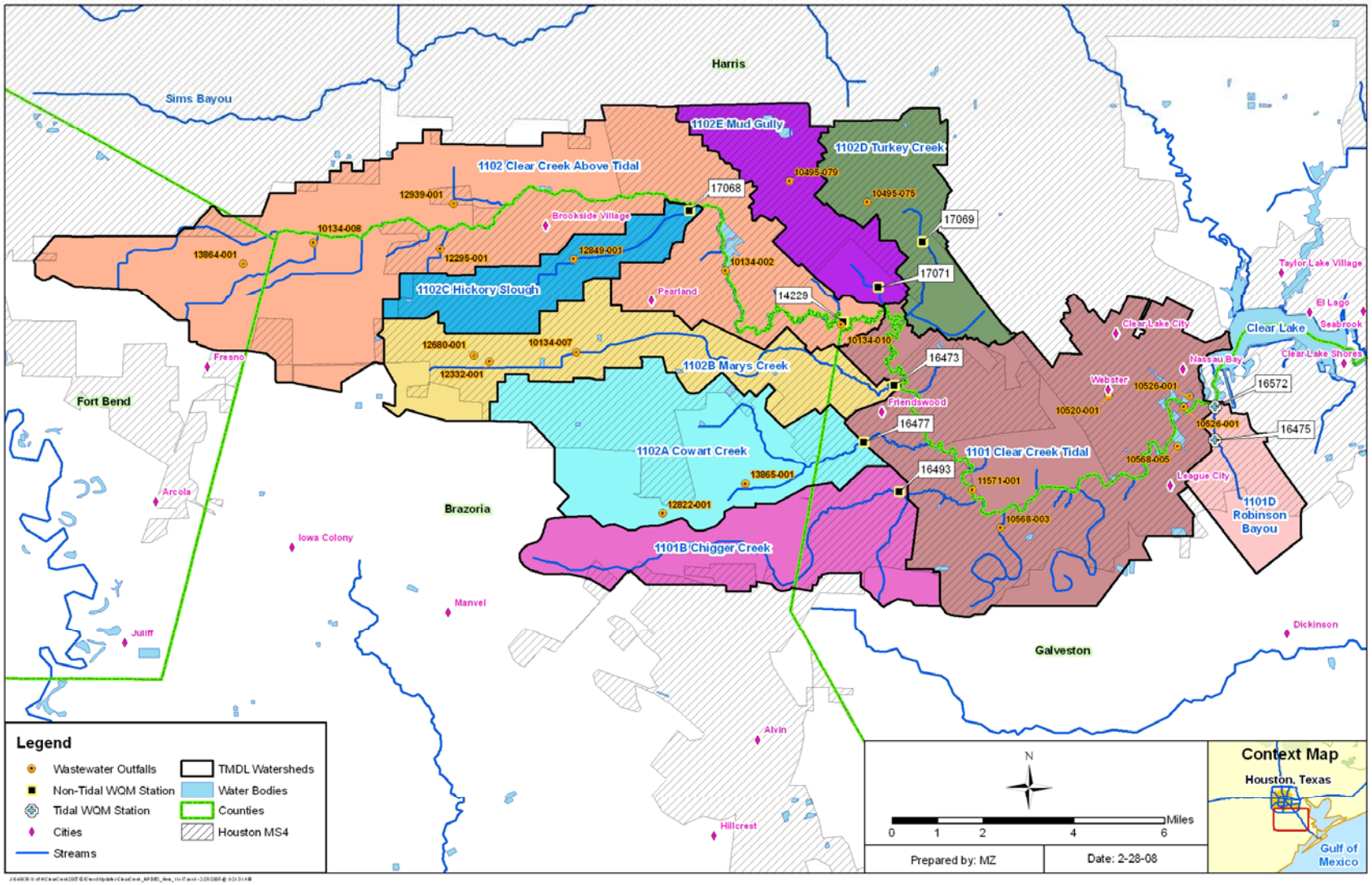
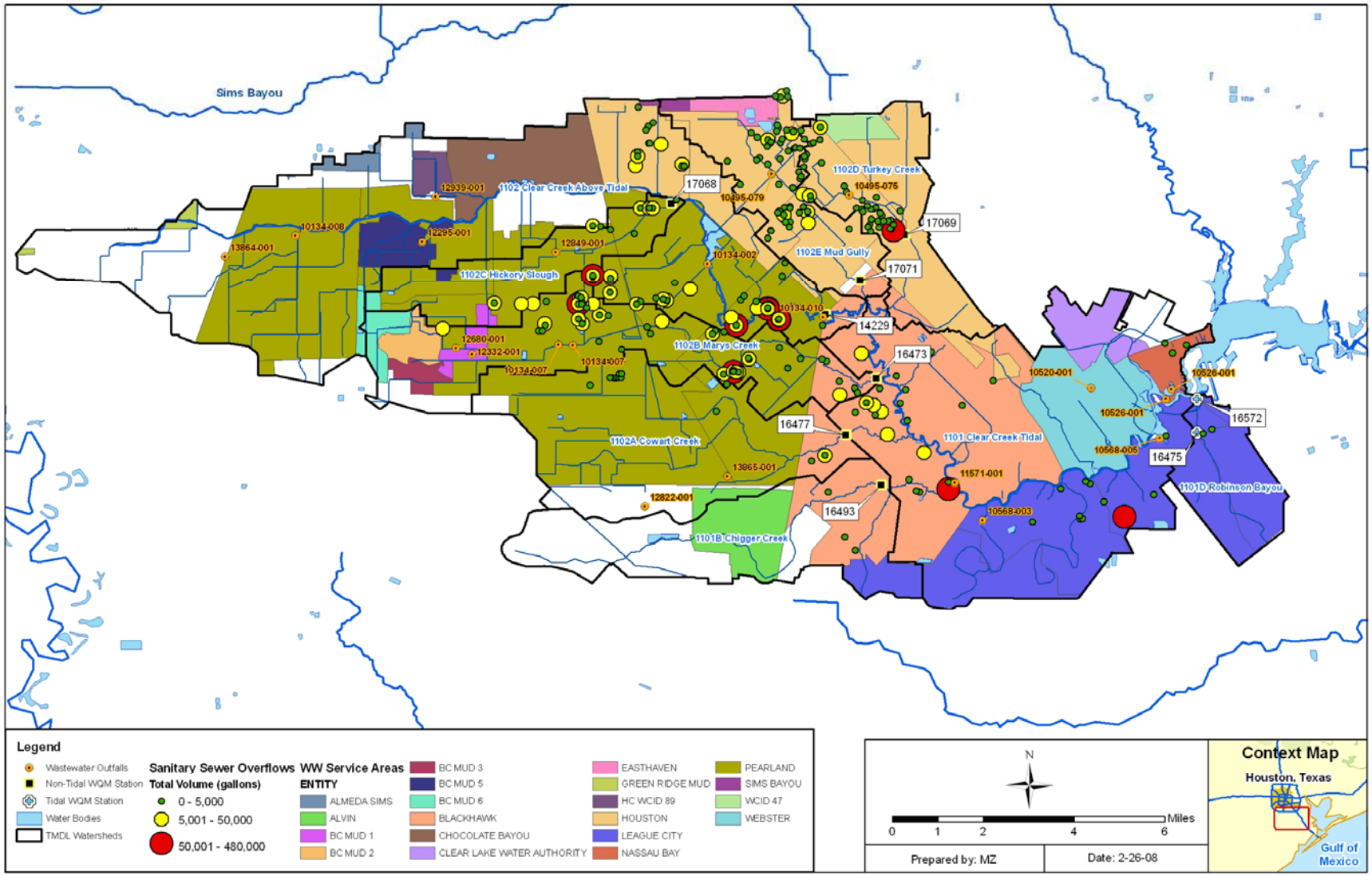
TPDES Facilities



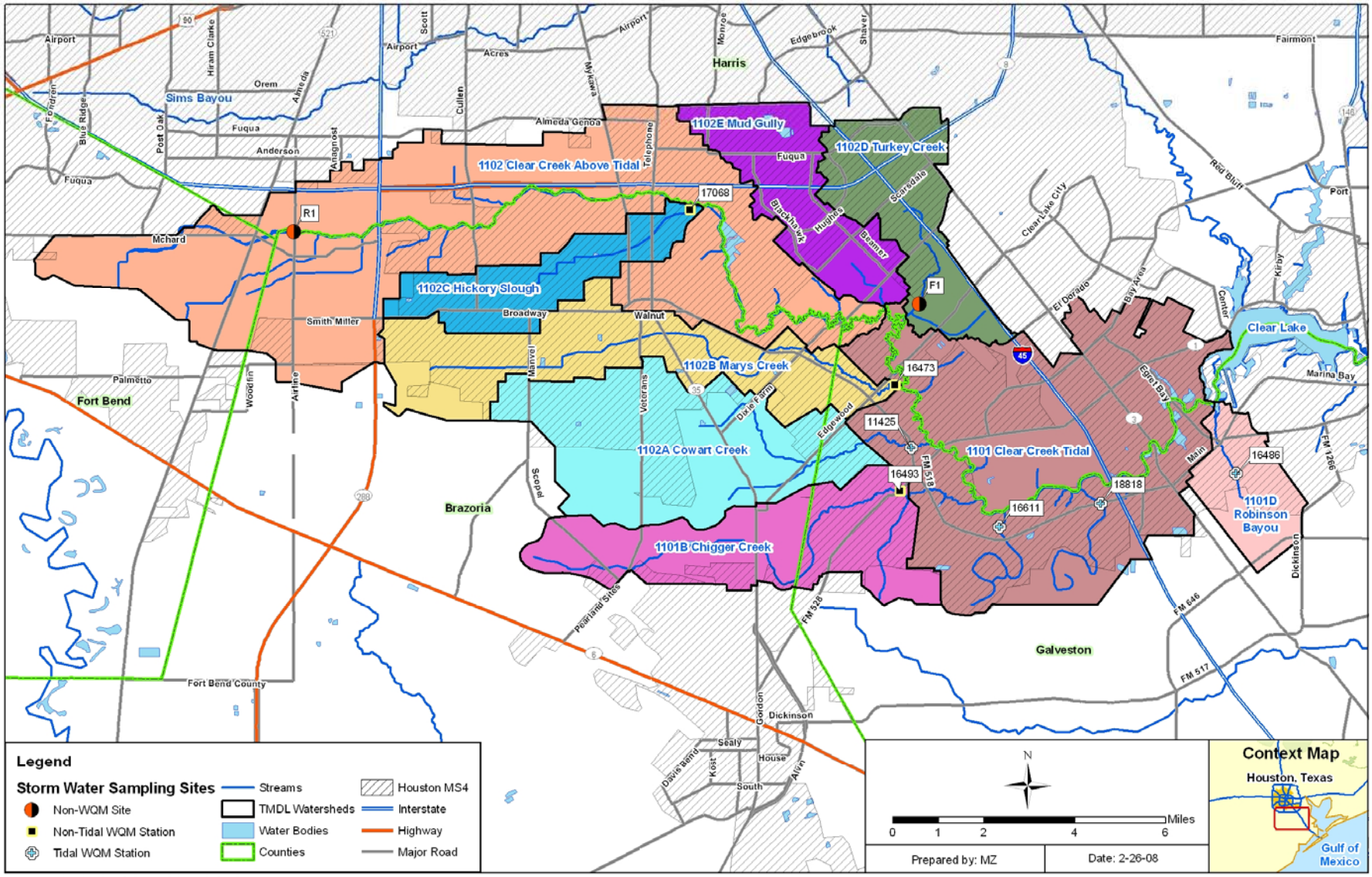
SSOs


Sims Bayou
1102 Clear Creek Above Tidal
1102D Turkey Creek
1102E Mud Gully
1102C Hickory Slough
1102B Marys Creek
1102A Cowart Creek
1101 Clear Creek Tidal
1101D Robinson Bayou
1101B Chigger Creek
17068
17069
17071
14229
16473
16477
16493
16572
16475
10495-079
10495-075
10134-008
13864-001
12939-001
12295-001
12849-001
10134-002
10134-010
12680-001
12332-001
10134-007
10134-007
10520-001
10526-001
10526-001
10568-005
11571-001
10568-003
13865-001
12822-001
Legend
Wastewater Outfalls
Non-Tidal WQM Station
Tidal WQM Station
Water Bodies
TMDL Watersheds
Sanitary Sewer Overflows
Total Volume (gallons)
0 - 5,000
5,001 - 50,000
50,001 - 480,000
WW Service Areas
ENTITY
ALMEDA SIMS
ALVIN
BC MUD 1
BC MUD 2
BC MUD 3
BC MUD 5
BC MUD 6
BLACKHAWK
CHOCOLATE BAYOU
CLEAR LAKE WATER AUTHORITY
EASTHAVEN
GREEN RIDGE MUD
HC WCID 89
HOUSTON
LEAGUE CITY
NASSAU BAY
PEARLAND
SIMS BAYOU
WCID 47
WEBSTER
N
Miles
0
1
2
4
6
Prepared by: MZ
Date: 2-26-08
Context Map
Houston, Texas
Gulf of Mexico

Permitted Stormwater

Segmt.	Receiving Stream	TPDES Number	Total Area (acres)	Area under MS4 Permit (acres)	Percent of Watershed under (MS4)
1101	Clear Creek Tidal	WQ0004685000	24,346.7	19,271.4	79%
1101B	Chigger Creek	WQ0004685000	9,526.2	4,127.3	43%
1102	CC above Tidal	WQ0004685000	33,084.3	15,366.8	46%
1102A	Cowart Creek	WQ0004685000	12,380.3	6,476.3	52%
1102B	Mary's Creek	WQ0004685000	10,375.3	9,316.6	90%
1102C	Hickory Slough	WQ0004685000	4,935.7	4,739.9	96%
1102D	Turkey Creek	WQ0004685000	6,482.0	4,829.3	75%
1102E	Mud Gully	WQ0004685000	6,009.1	4,967.7	83%
1101D	Robinson Bayou	WQ0004685000	3,480.8	2,475.9	71%

Sampled Runoff Sites 2006

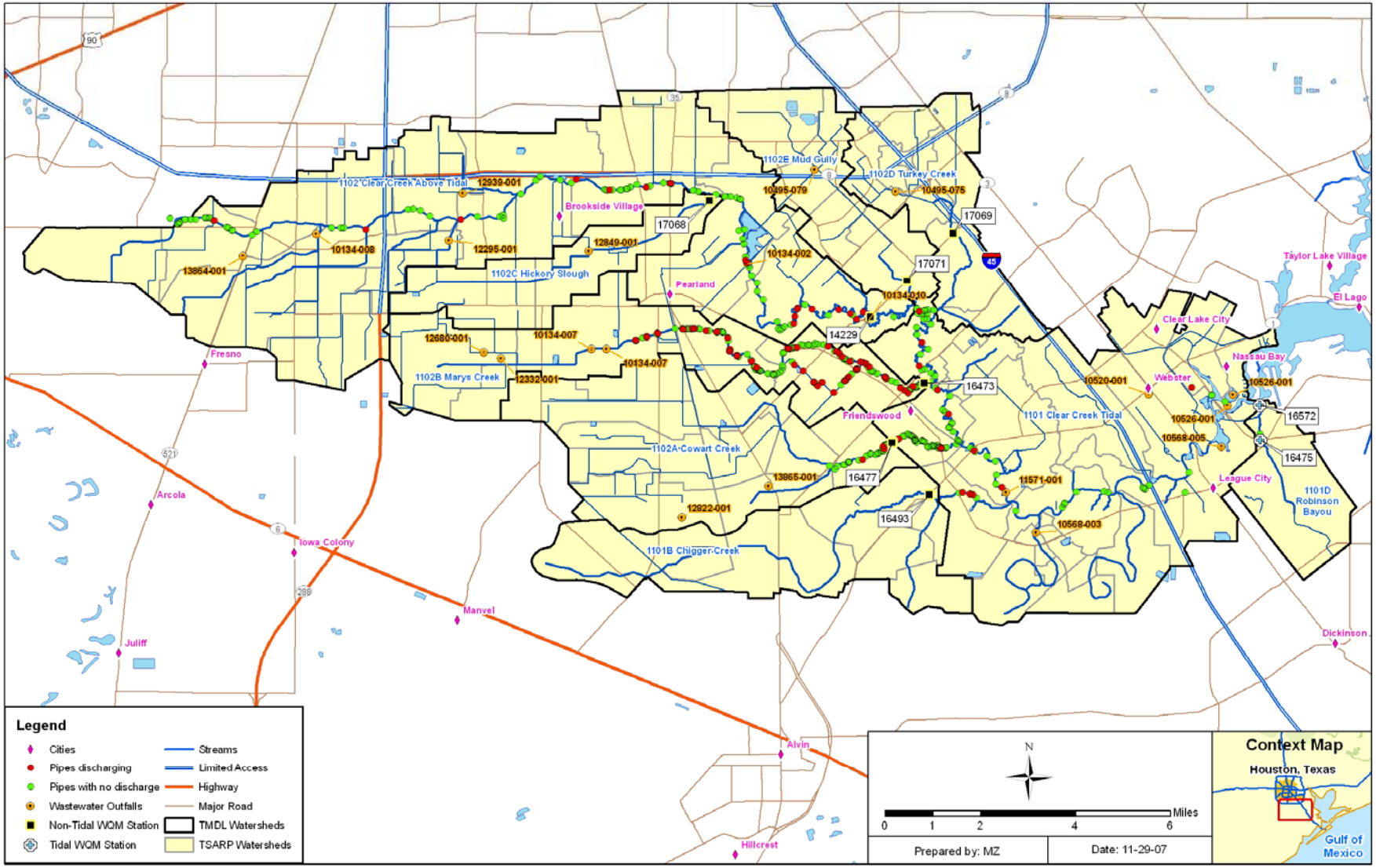


Stormwater Loads – 2006 Data

WQM Station ID	Tributaries	1st Storm Sampling		2nd Storm Sampling	
		Geomean of E.coli Load (MPN/day)	Geomean of Enterococci Load (MPN/day)	Geomean of E.coli Load (MPN/day)	Geomean of Enterococci Load (MPN/day)
R1	DITCH # 11 DD2	**3.05E+07**		**5.07E+11**	
17068	Hickory Slough	1.48E+12		9.34E+11	
F1	Turkey Creek	9.01E+12		9.56E+13	
16473	Mary's Creek	**9.95E+12**		**9.80E+13**	
11425	Cowart Creek	1.80E+12		1.28E+13	
16493	Chigger Creek	2.13E+10		2.14E+13	
16611	Magnolia Creek		**2.27E+12**		**3.44E+13**
18818	Unnamed Tributary		**3.67E+11**		**5.69E+10**
16486	Robinson Bayou		9.07E+11		3.80E+12
Total		**2.23E+13**	**3.54E+12**	**2.29E+14**	**3.82E+13**

Orange Color indicates Max and Green indicates Min Load.

Pipe Recon 05-06



FC from GCHD Discharge Data

Segment	Stream Name	Number of Fecal Coliform Samples	Fecal Coliform Geometric Mean
			(cfu/100mL)
1101	Clear Creek Tidal	27	179.8
1101B	Chigger Creek	31	230
1102	Clear Creek above Tidal	38	409.7
1102A	Cowart Creek	11	481
1102B	Mary's Creek	97	376.5
1102C	Hickory Slough	74	273
1102D	Turkey Creek	23	103.7
1102E	Mud Gully	37	290.5

Yellow indicates 200 – 400 cfu/100 ml and orange indicates > 400 cfu/100ml

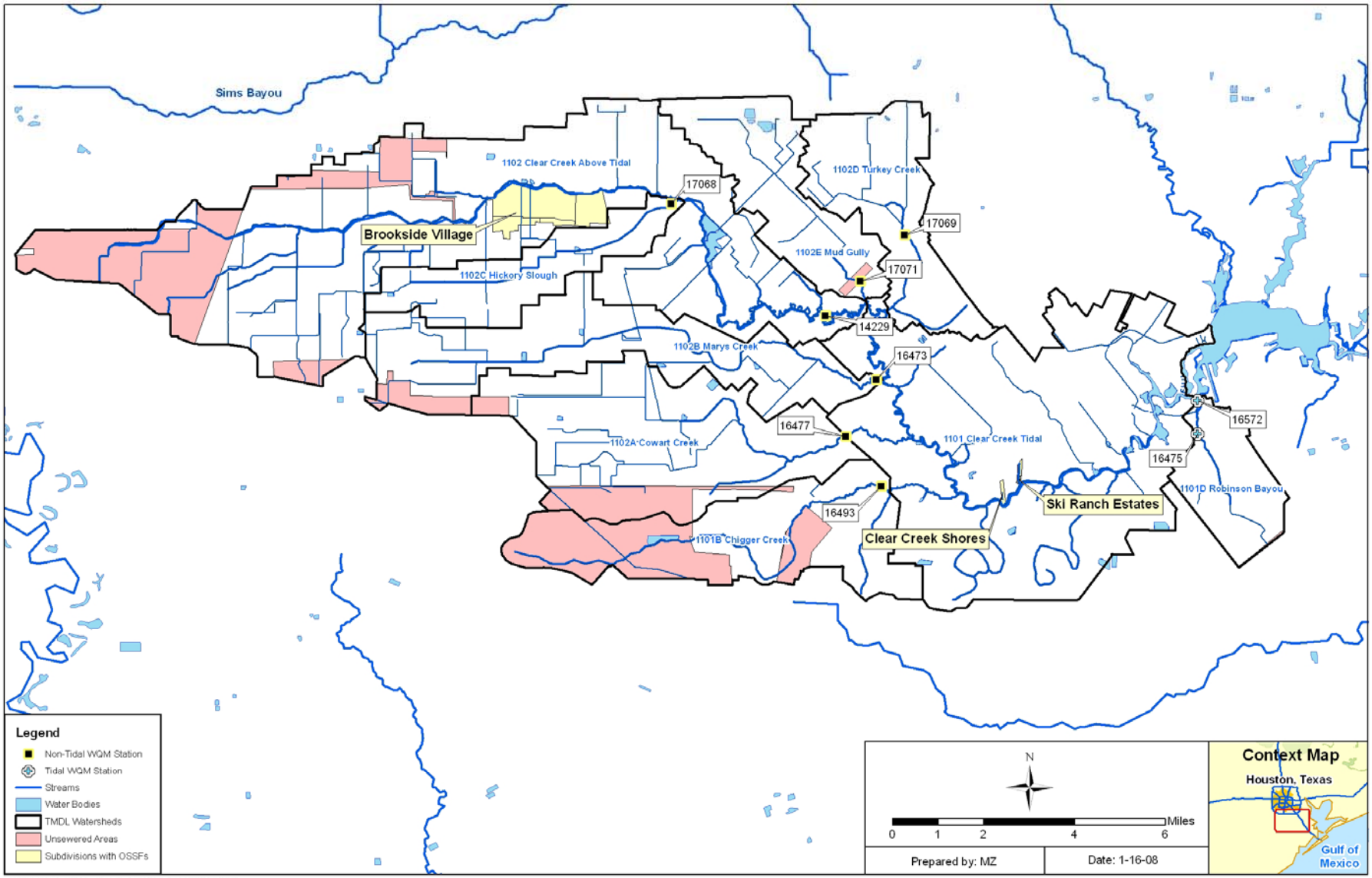
Dry weather Pipe Bacteria Loading

Segment	Stream Name	Ranking of Dry Weather Pipe Flow Value	Ranking of Dry Weather Bacteria Concentrations From Pipe Outfalls
1101	Clear Creek Tidal	Medium	Low
1101B	Chigger Creek	Low	Medium
1102	above Tidal	High	High
1102A	Cowart Creek	Low	High
1102B	Mary's Creek	High	Medium
1102C	Hickory Slough	ND	ND
1102D	Turkey Creek	ND	Low
1102E	Mud Gully	ND	Medium
1101D	Robinson Bayou	Low	ND

Livestock/Manure

Segment	Stream Name	Cattle & Calves-all	Dairy Cows	Horses	Sheep	Hogs	Ducks	Geese	Chickens	Turkeys	Ducks & Geese	Chickens & Turkeys
1101	Clear Creek Tidal	46	0	5	1	0	1	0	8	0	1	9
1101B	Chigger Creek	115	0	9	1	1	2	1	8	1	2	9
1102	Clear Creek above Tidal	37	0	2	0	1	0	0	62	0	0	62
1102A	Cowart Creek	8	0	1	0	0	0	0	1	0	0	1
1102B	Mary's Creek	595	0	34	5	19	2	3	769	2	5	771
1102C	Hickory Slough	583	0	29	6	22	0	3	969	1	3	971
1102D	Turkey Creek	802	9	93	14	9	17	4	160	3	21	163
1102E	Mud Gully	193	2	22	3	2	4	1	39	1	5	39
1101D	Robinson Bayou	306	0	25	1	3	5	2	22	2	7	24

OSSFs


Sims Bayou
1102 Clear Creek Above Tidal
1102D Turkey Creek
17068
17069
Brookside Village
1102E Mud Gully
17071
1102C Hickory Slough
14229
1102B Marys Creek
16473
16572
16477
1101 Clear Creek Tidal
1102A Cowart Creek
16475
1101D Robinson Bayou
Ski Ranch Estates
16493
Clear Creek Shores
1101B Chigger Creek
Legend
Non-Tidal WQM Station
Tidal WQM Station
Streams
Water Bodies
TMDL Watersheds
Unsewered Areas
Subdivisions with OSSFs
N
Miles
0
1
2
4
6
Prepared by: MZ
Date: 1-16-08
Context Map
Houston, Texas
Gulf of Mexico

OSSF Loads

Segment	Stream Name	OSSF Estimate using 1990 Census method	OSSF data from Harris County and OARS	# of Failing OSSFs	Estimated Loads from OSSFs (x 10^9 counts/day)
1101	Clear Creek Tidal	9	54	21	155
1101B	Chigger Creek	37		4	33
1102	Clear Creek above	420	72	59	435
1102A	Cowart Creek	22		3	19
1102B	Mary's Creek	12		1	11
1102C	Hickory Slough	1		0	1
1102D	Turkey Creek	0		0	0
1102E	Mud Gully	23		3	20
1101D	Robinson Bayou	0		0	0

Domesticated Animals

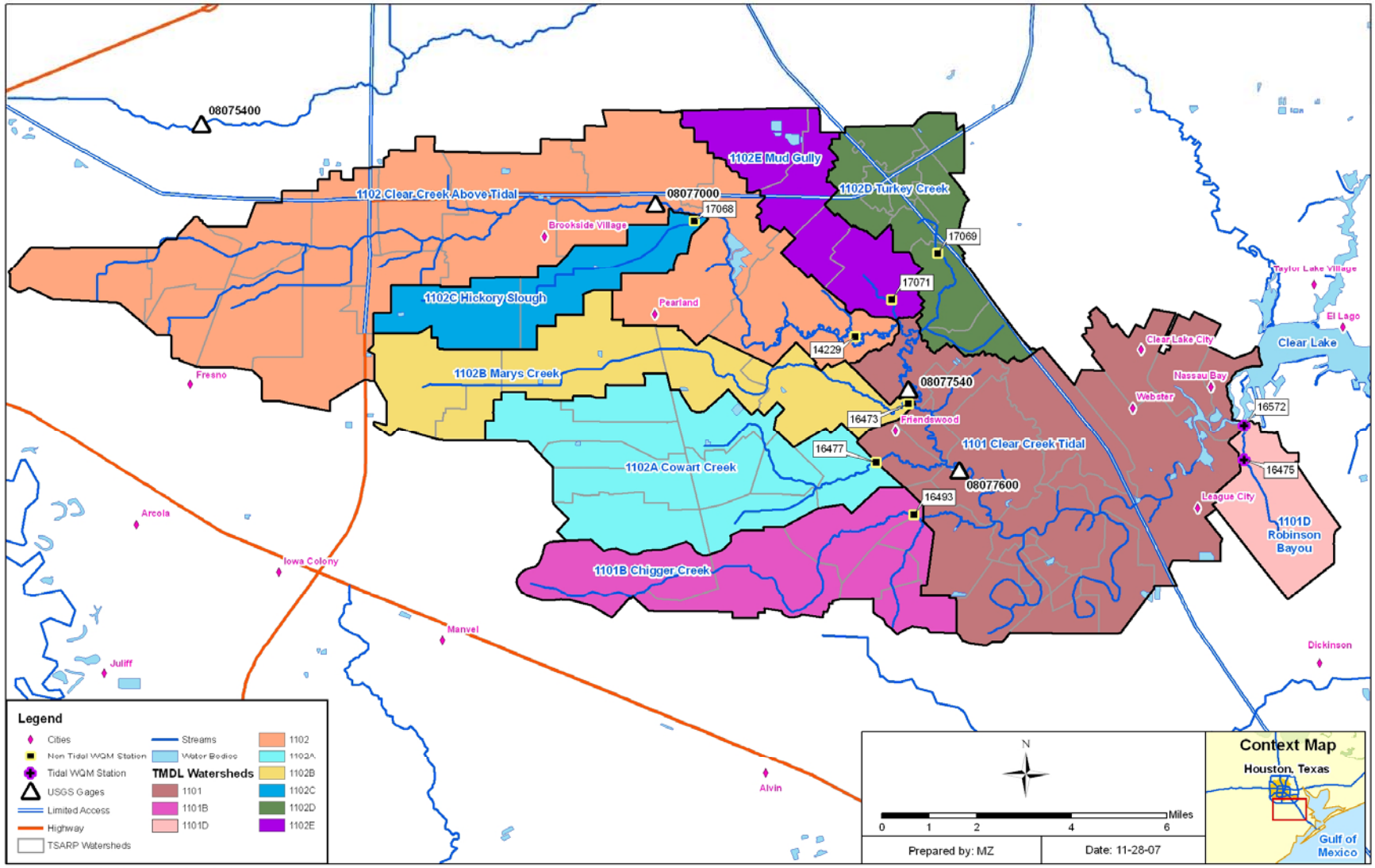
X 10^9

Segment	Stream Name	Dogs	Cats	Total (cfu/day)
1101	Clear Creek Tidal	4,313	803	5,116
1101B	Chigger Creek	1,582	295	1,876
1102	Clear Creek above Tidal	4,282	797	5,079
1102A	Cowart Creek	2,282	425	2,706
1102B	Mary's Creek	1,312	244	1,556
1102C	Hickory Slough	356	66	423
1102D	Turkey Creek	1,291	240	1,531
1102E	Mud Gully	122	23	145
1101D	Robinson Bayou	861	160	1,021

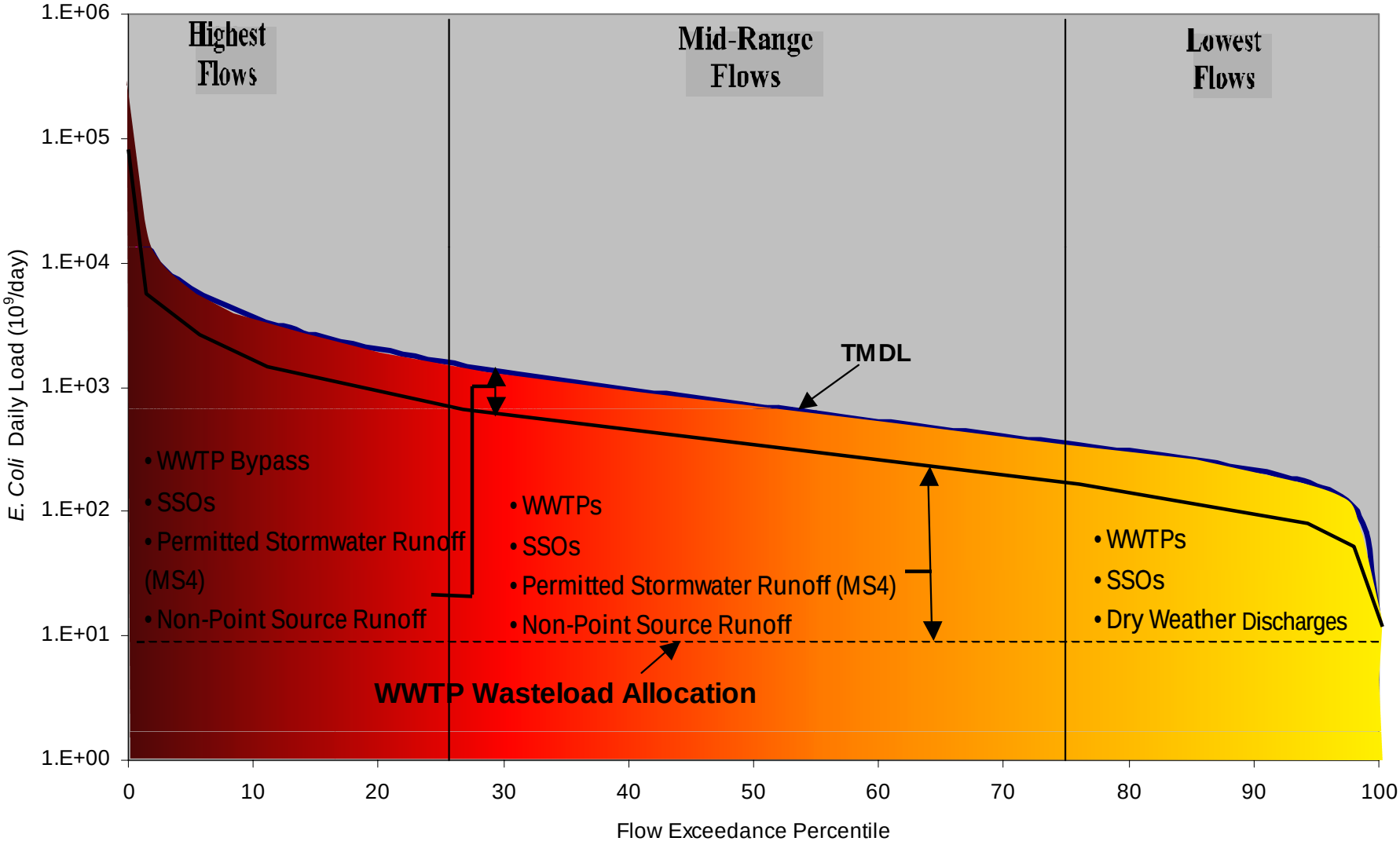
Outline

- Pollutant source assessment
- LDCs for non-tidal segments
- Tidal Prism methodology for tidal segments
- TMDL Calculations

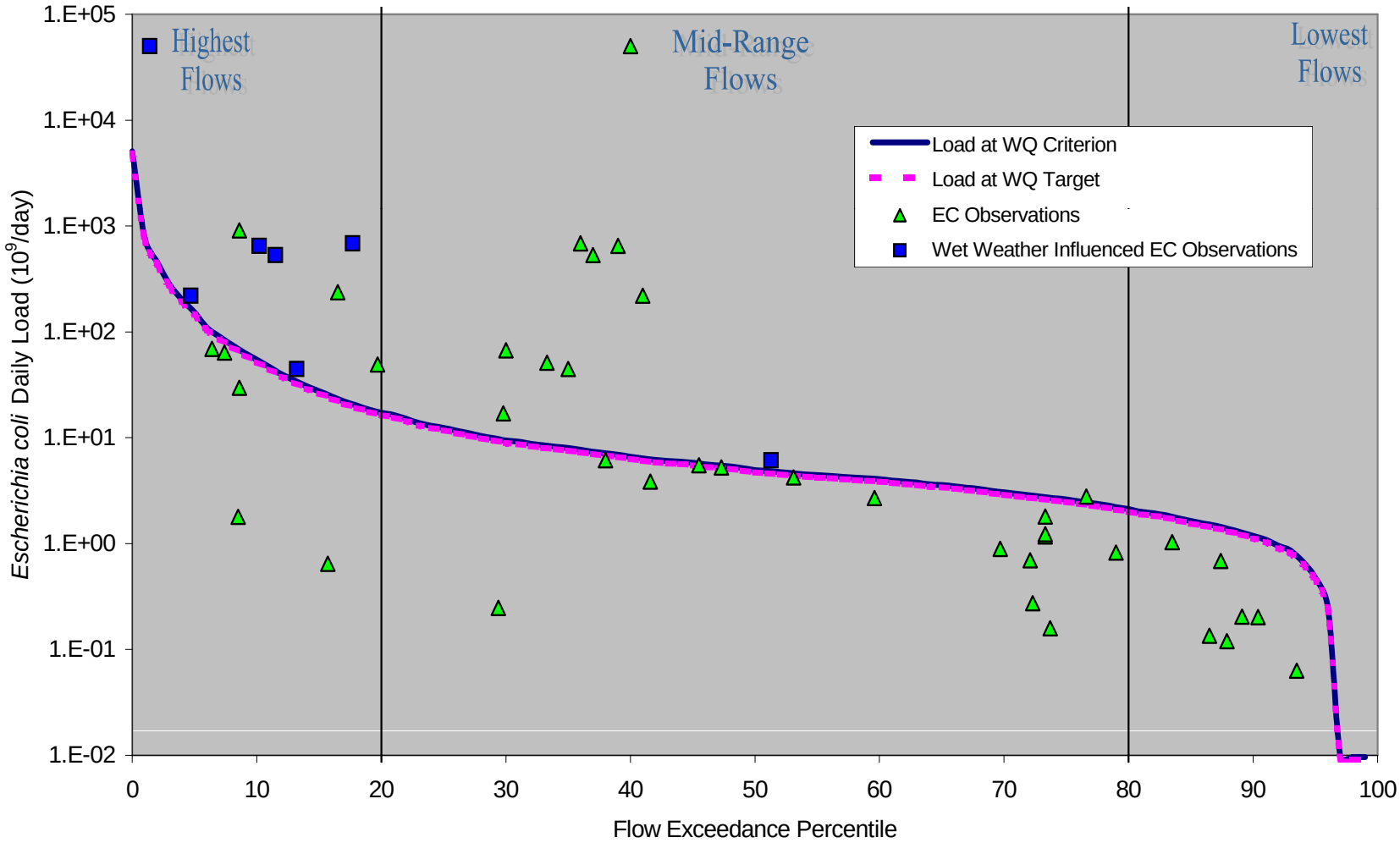
TMDL WQ Stations



LDC Schematic



Chigger Creek LDC



Reductions for Freshwater Segments

Segment	WQM Station	Stream Name	% Reduction Required		
			Indicator Bacteria Species	Instant-aneous	Geo-mean
1101B	16493	Chigger Creek	*E. coli*	27%	54%
1102	14229	Clear Creek above Tidal	*E. coli*	62%	26%
1102A	16477	Cowart Creek	*E. coli*	35%	0%
1102B	16473	Marys Creek	*E. coli*	0%	48%
1102C	17068	Hickory Slough	*E. coli*	14%	25%
1102D	17069	Turkey Creek	*E. coli*	58%	0%
1102E	17071	Mud Gully	Fecal coliform	92%	74%

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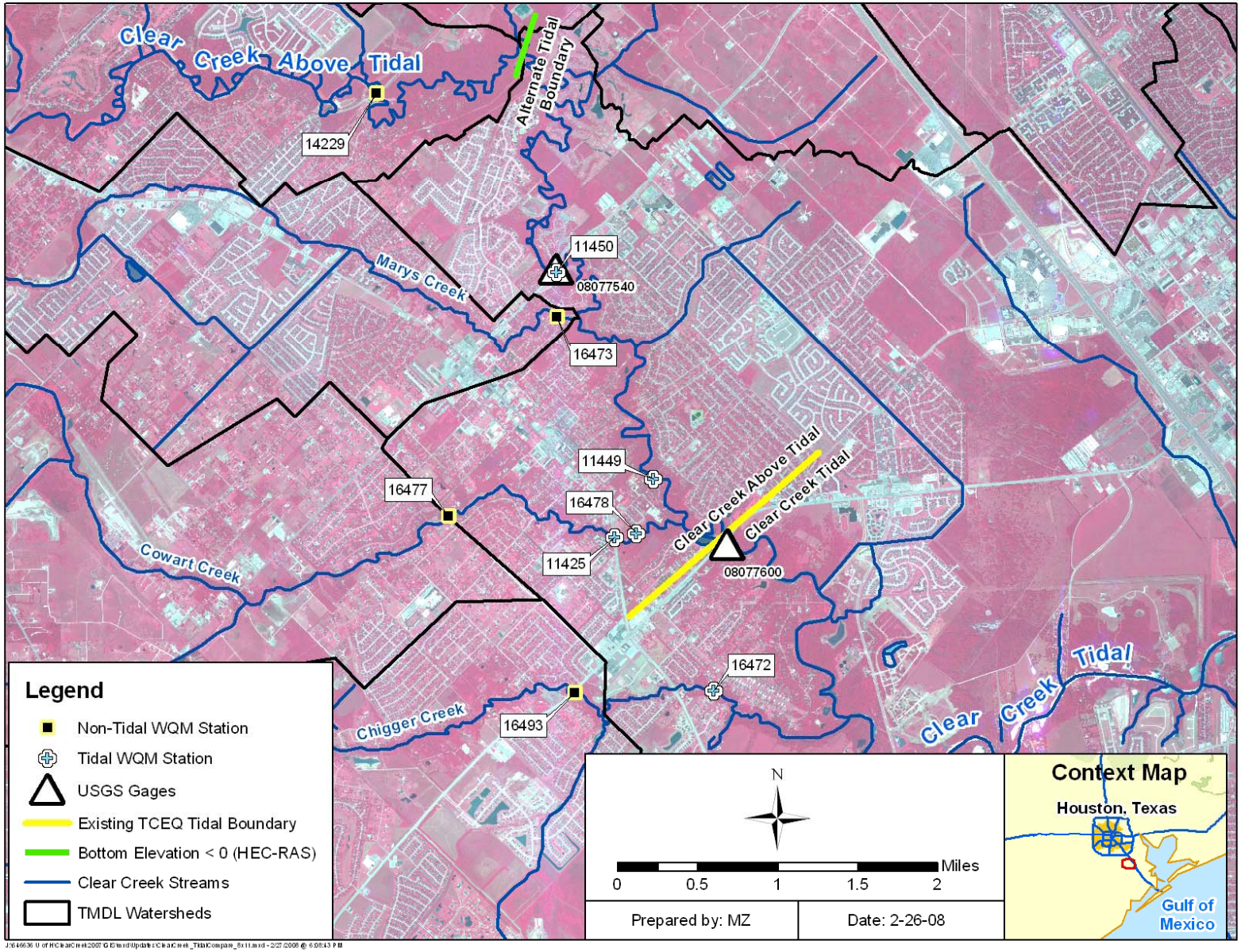
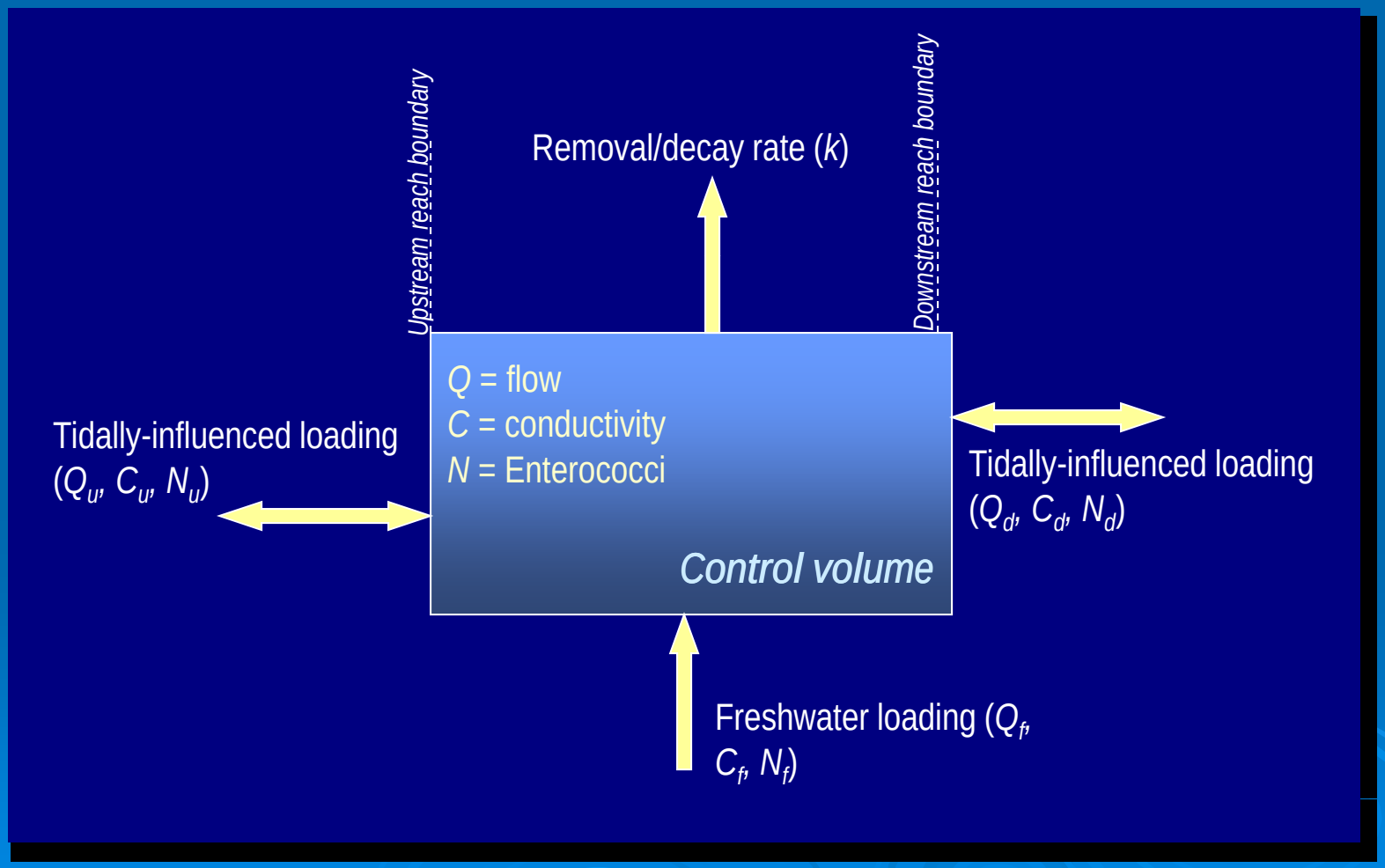
Tidal Boundary



Tidal prism model

- Volume of water between low and high tide levels
- Model incorporates the following sources of ENT
  - Storm water runoff loadings
  - WWTP point source loadings
  - Tidally-influenced loadings
- ENT removal mechanisms include
  - Net estuarine flow loadings
  - Decay (first-order)

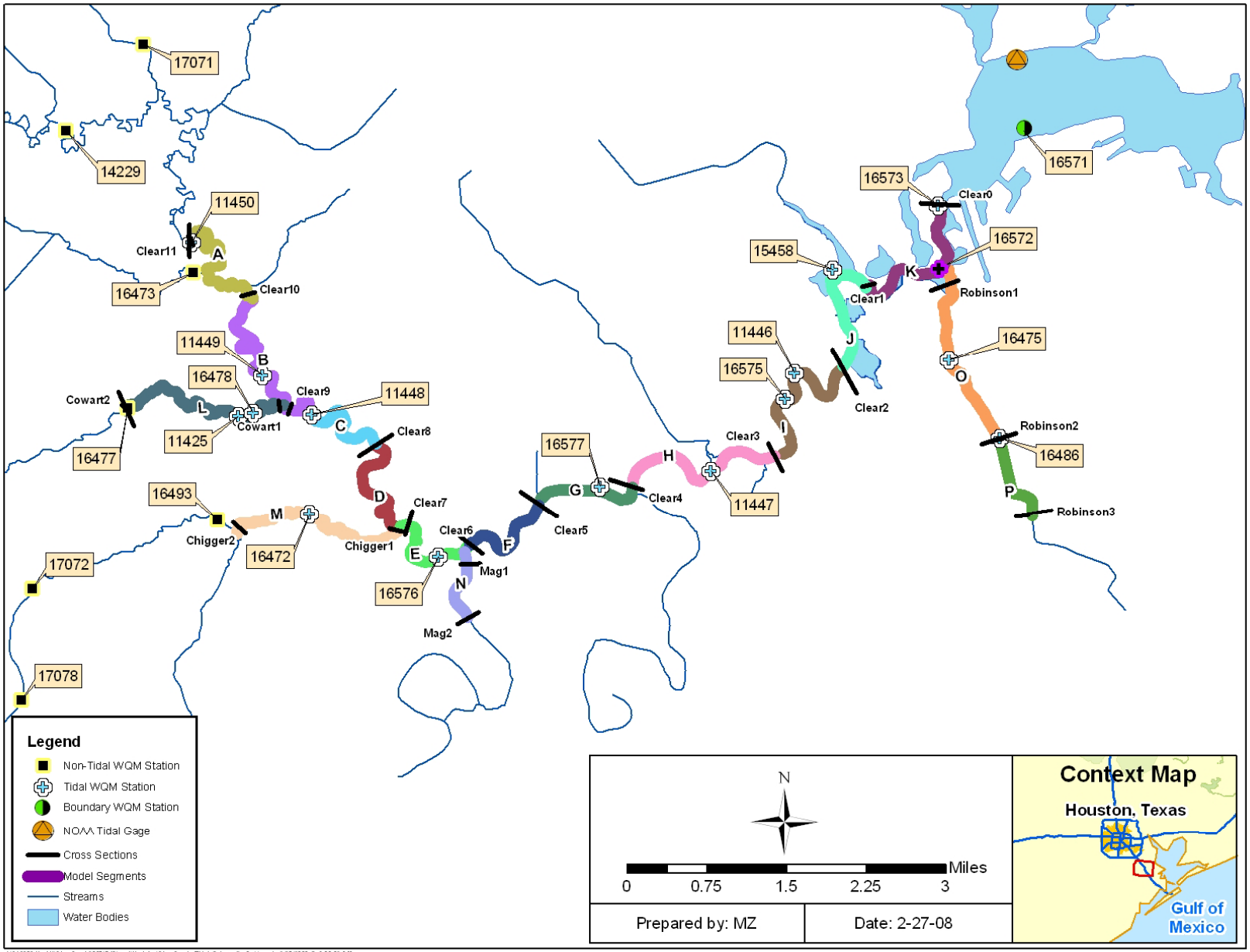
Tidal prism conceptual model



Tidal prism model for Clear Creek Tidal

- Time variable (1 hour time steps)
- 11 reaches in main stem and 6 for major tributaries
- Simulation period: 1/1/2000 to 9/30/2006

Tidal prism final model segmentation



Input data

- Tide elevations from NOAA gage at Clear Lake
- Cross-sectional areas for boundaries of reaches

Support volume and flow calculations

- Flows and concentrations for u/s freshwater streams

Boundary conditions for five headwaters. Load is Q*C

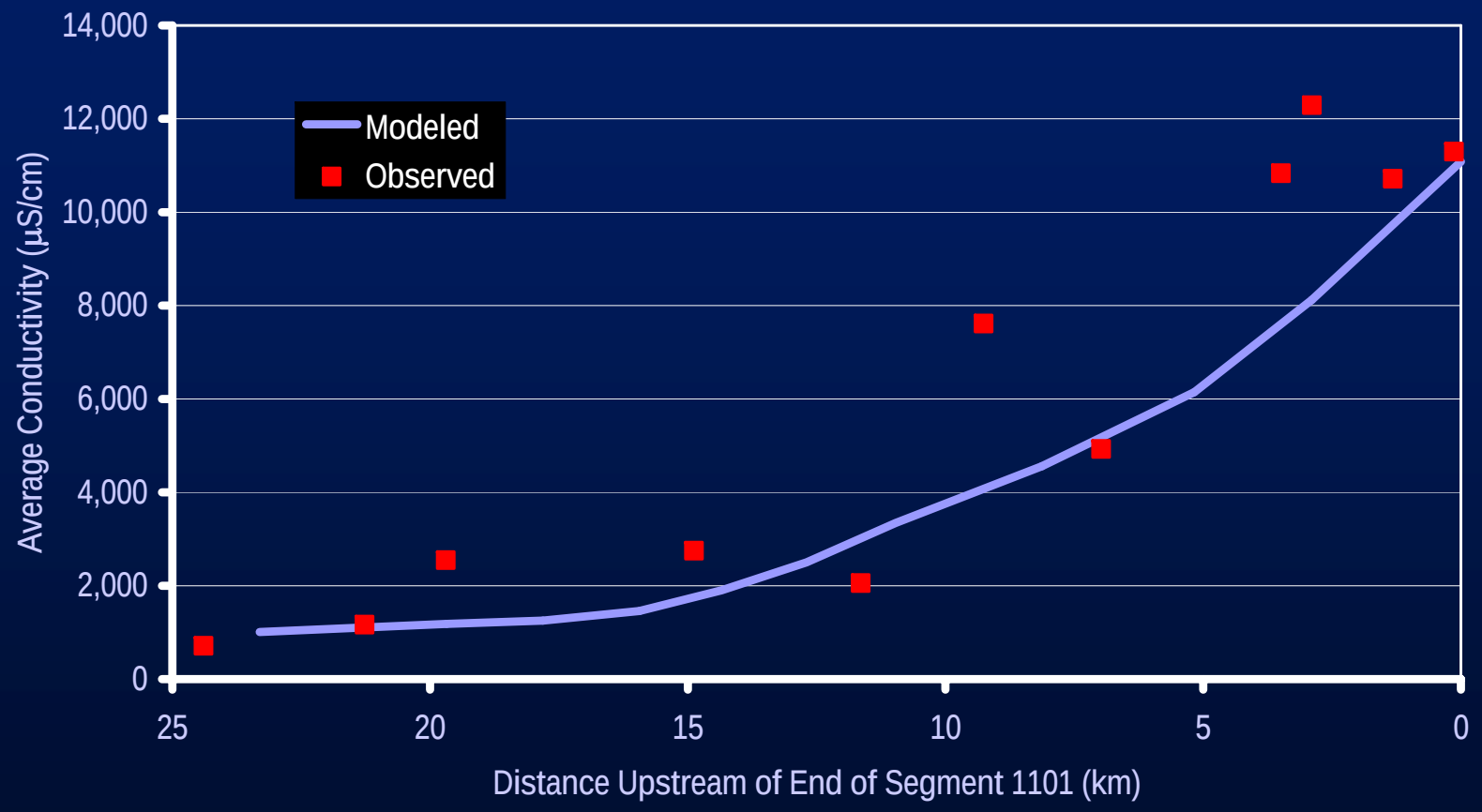
- Storm water runoff daily flows and concentrations
- WWTP daily flows and maximum 30-day geomean concentrations
- Flows and concentrations for tributaries with no reach in the model

Flows and loads to the system. Load is Q*C

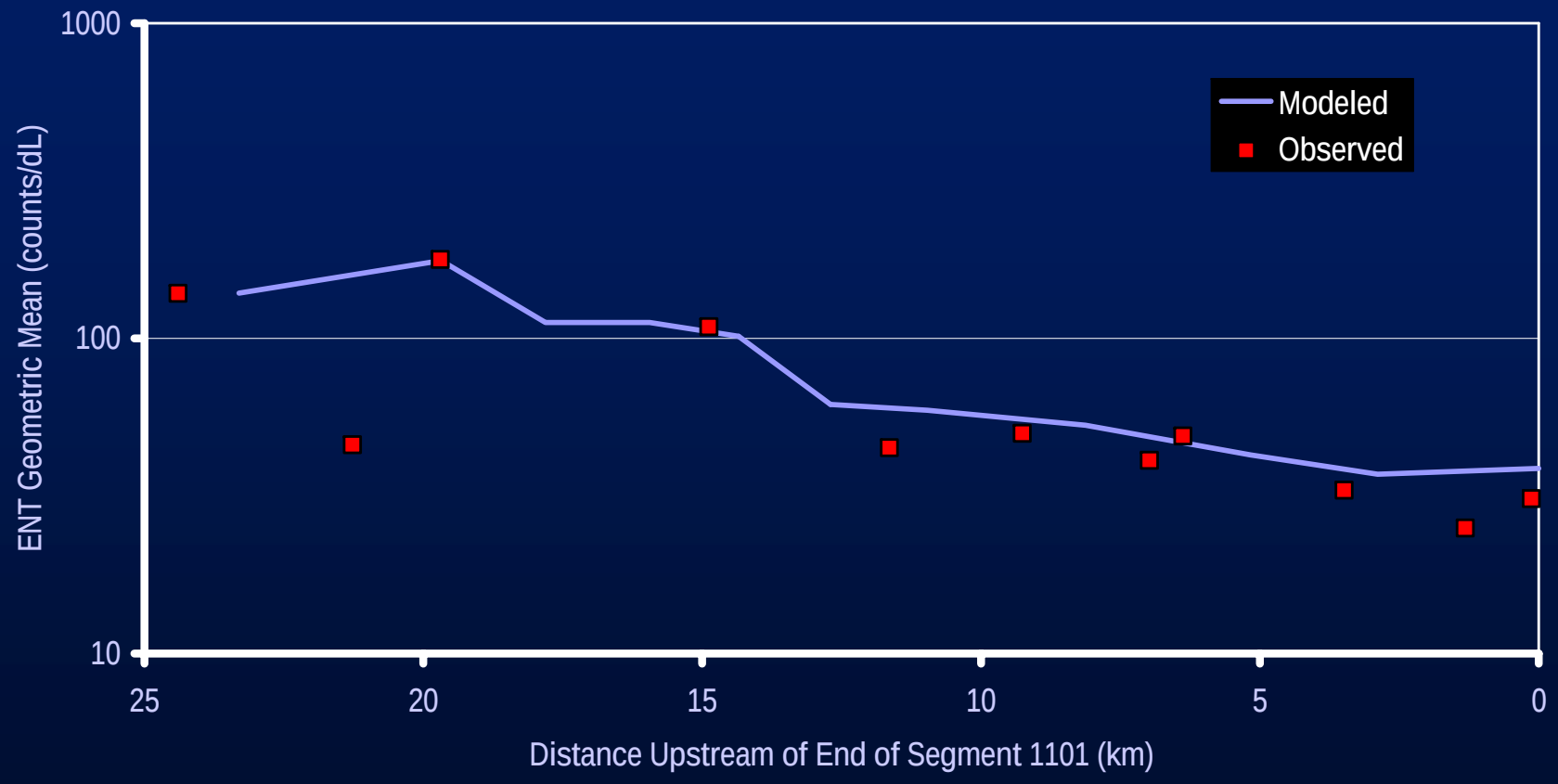
- First-order decay rate

Removal mechanism

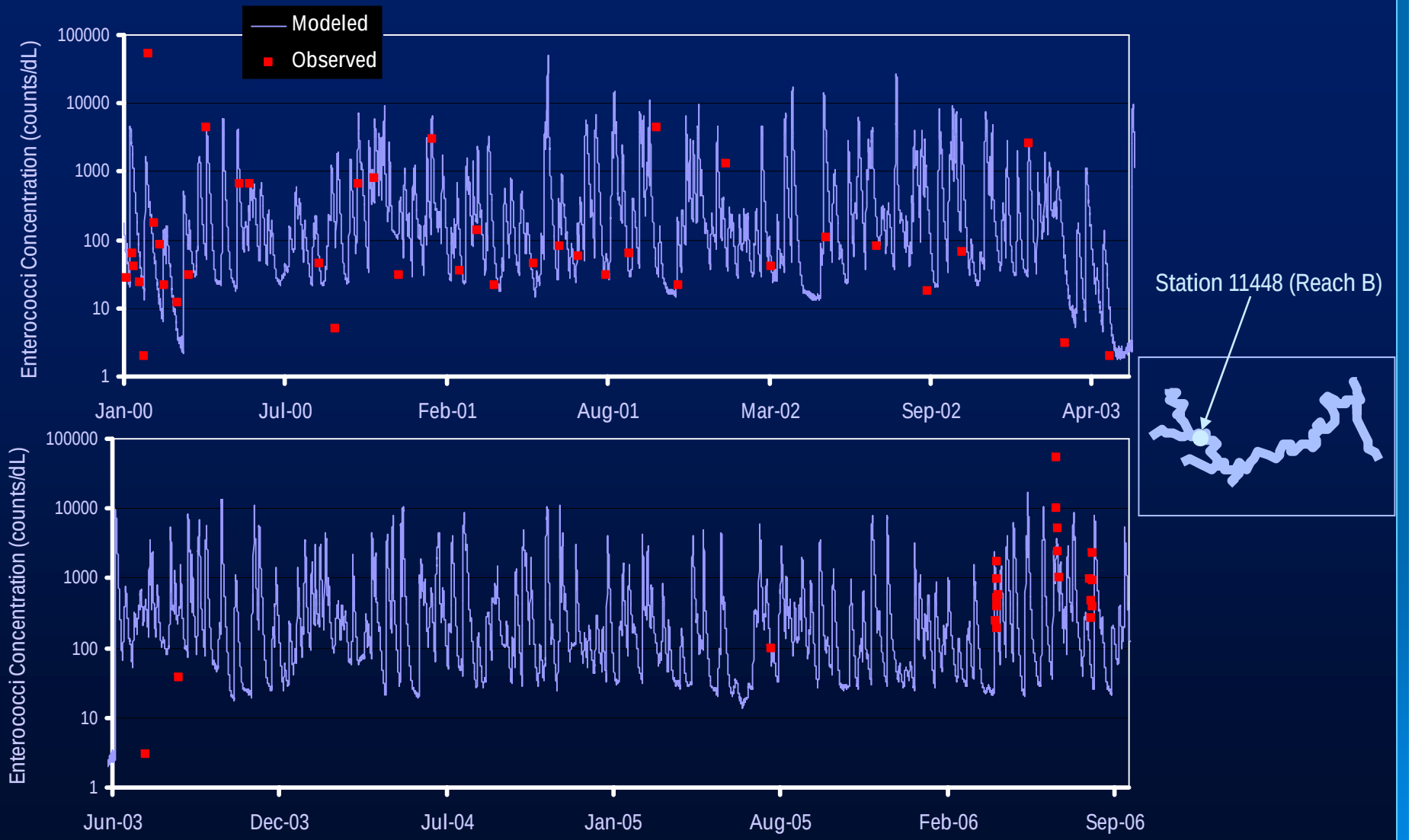
Conductivity calibration



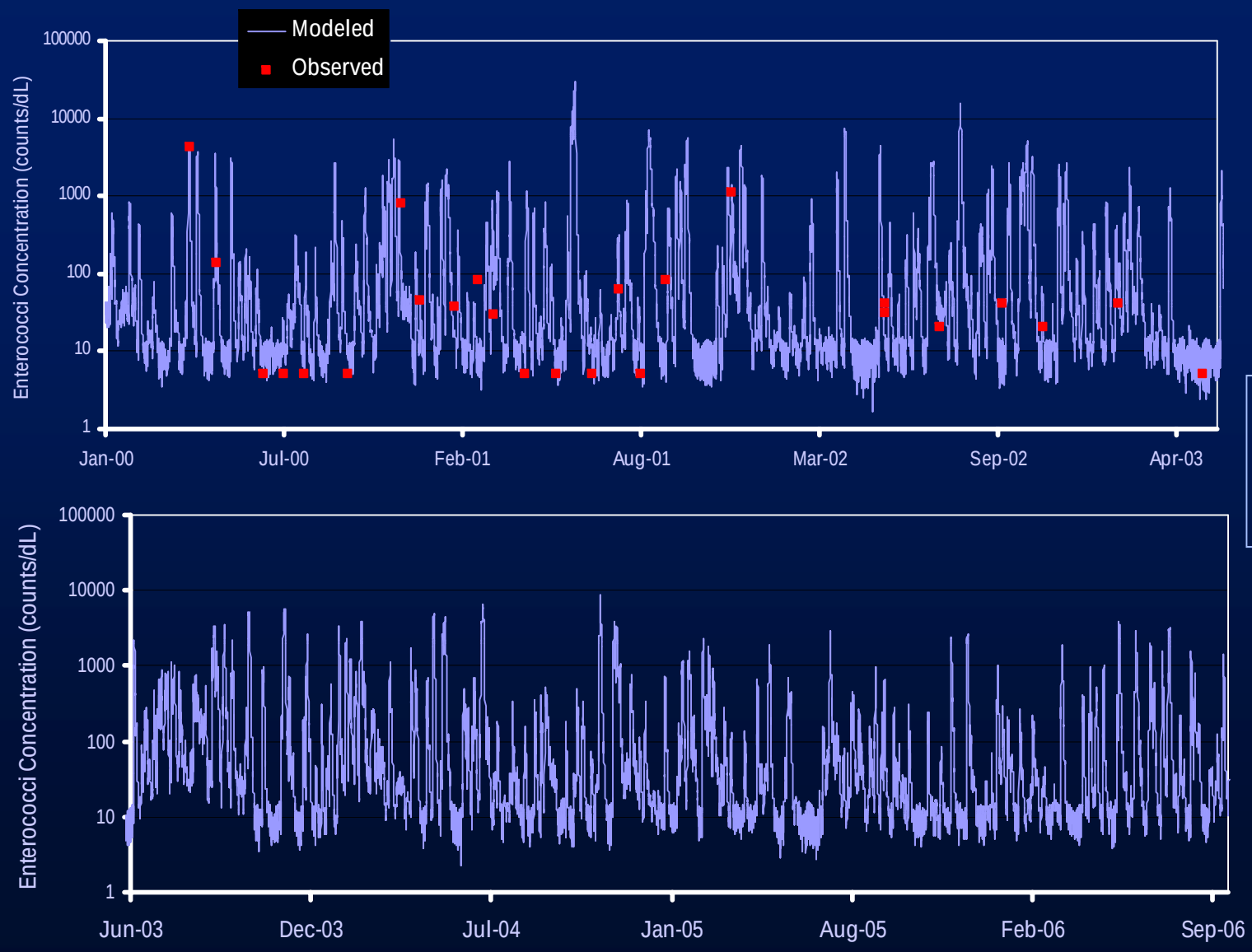
Enterococci calibration

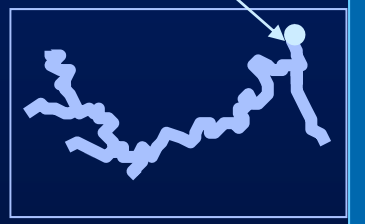


Enterococci calibration – time series

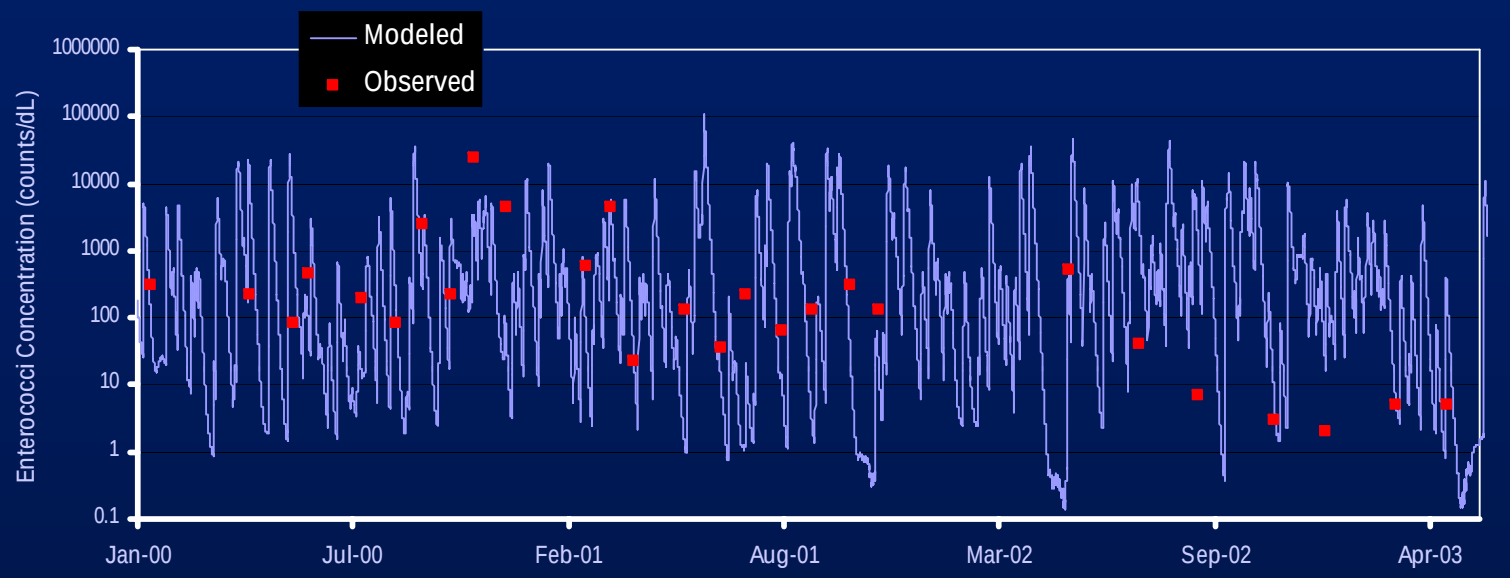


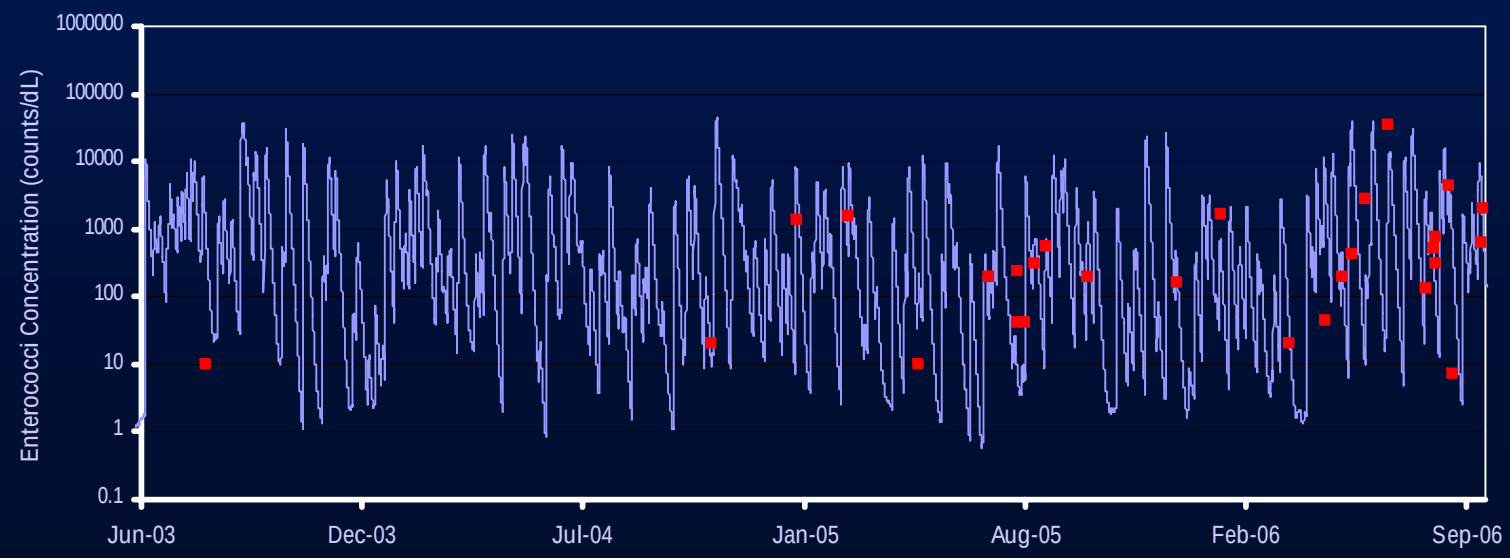
Enterococci calibration – time series –cont'd

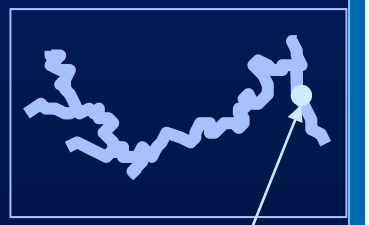




Enterococci calibration – time series –cont'd







Station 16475 (Reach O)

Outline

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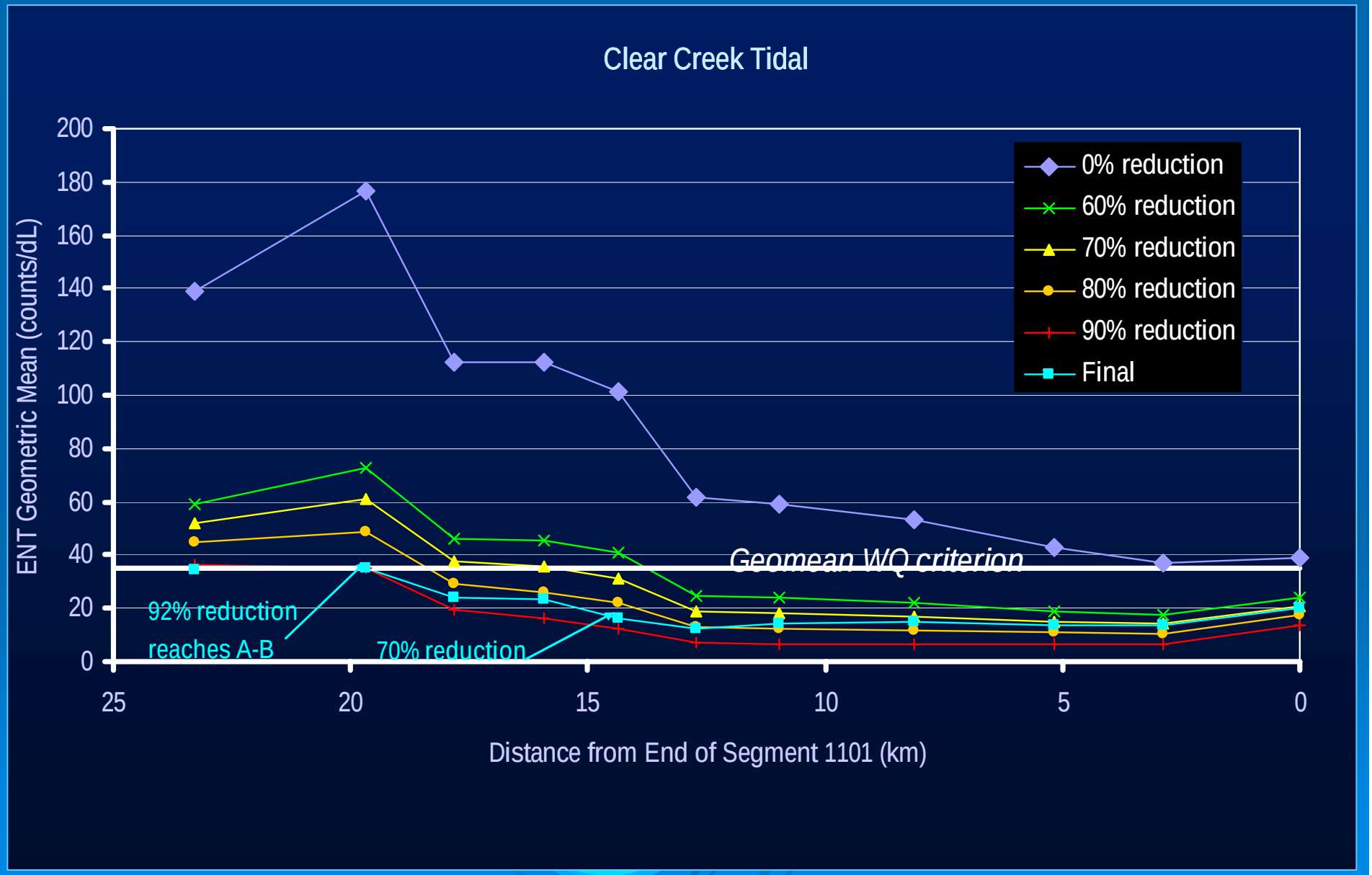
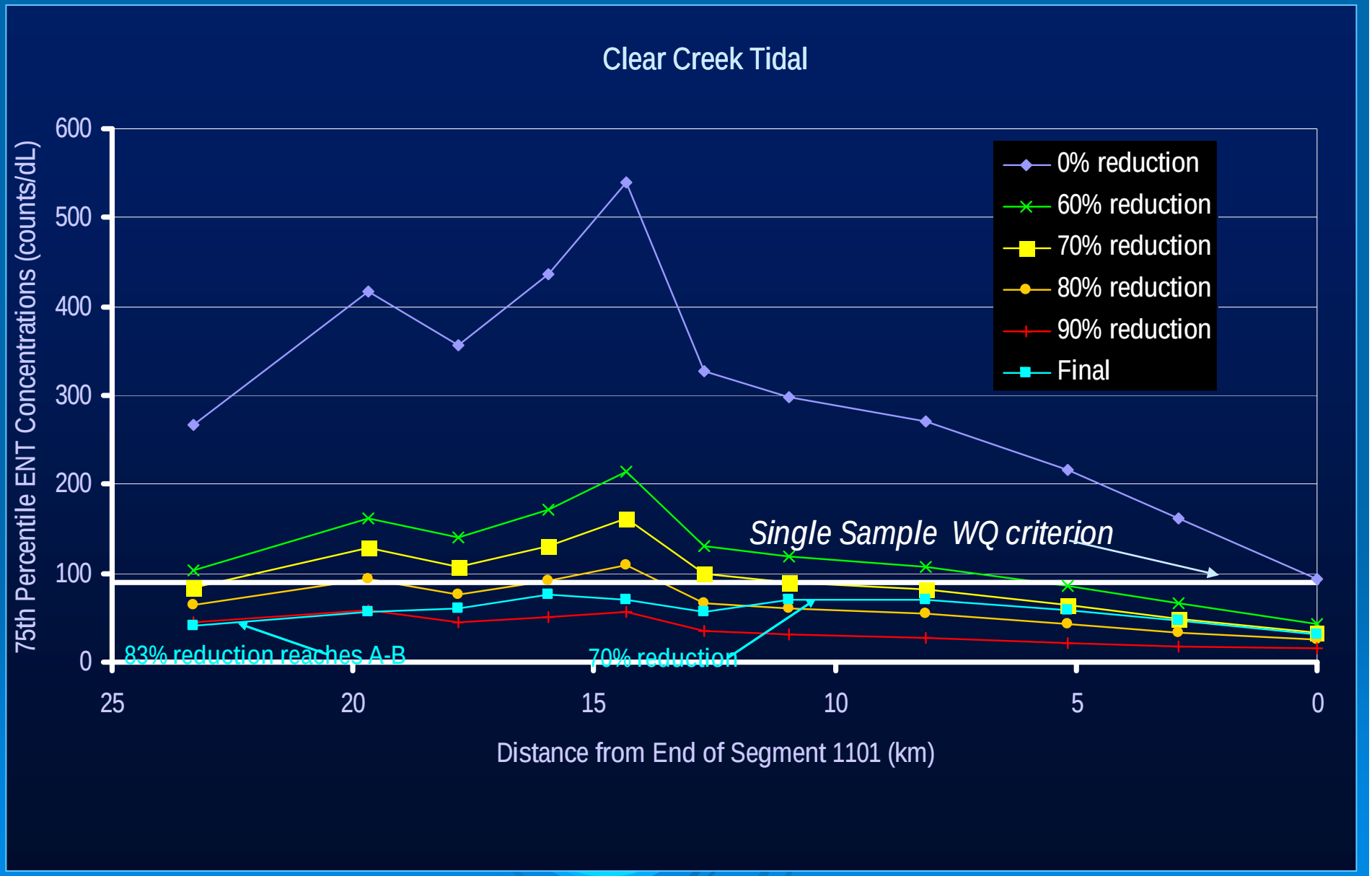
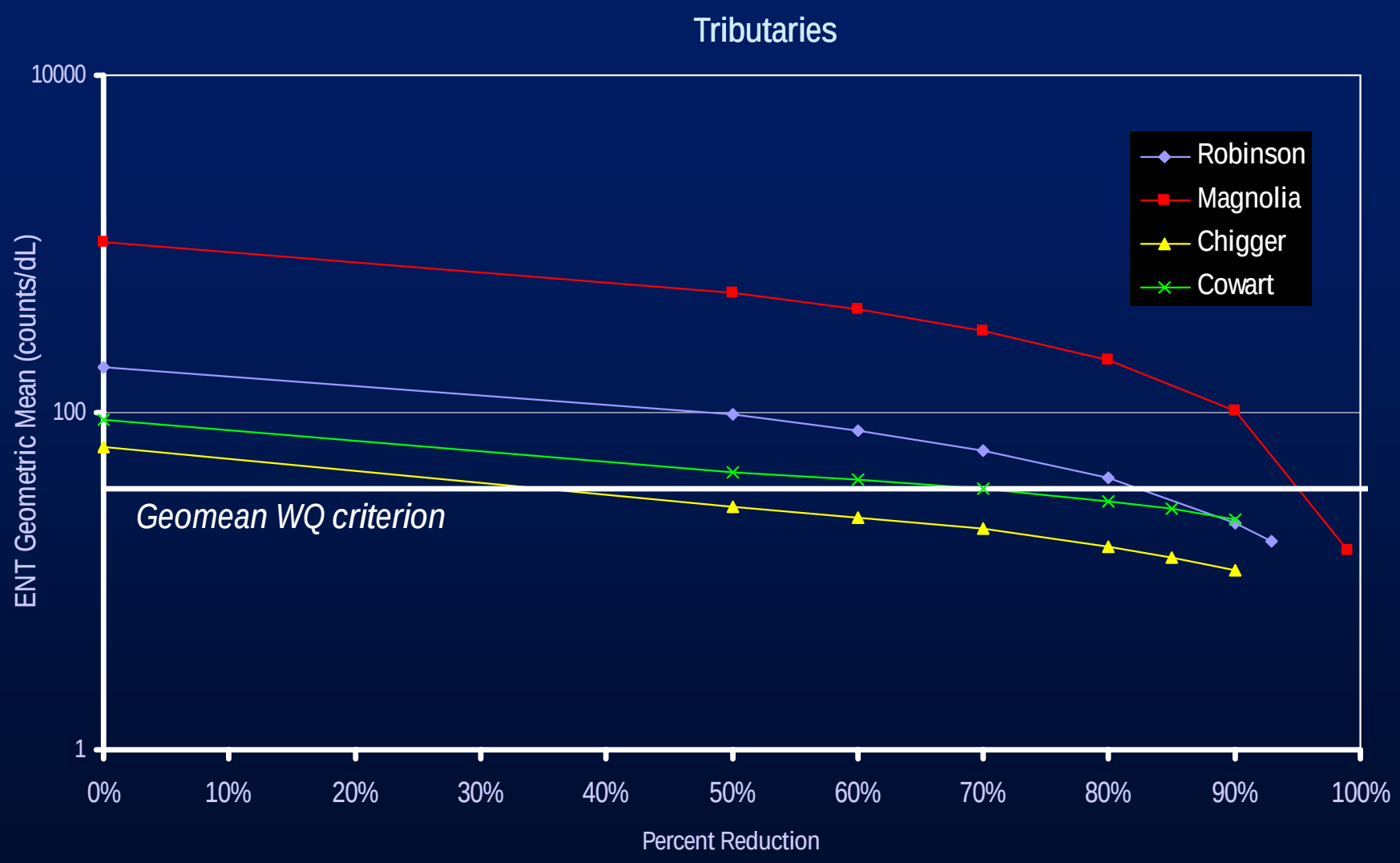
Required reductions – geometric mean



Required reductions – single sample criterion



Required reductions – geometric mean



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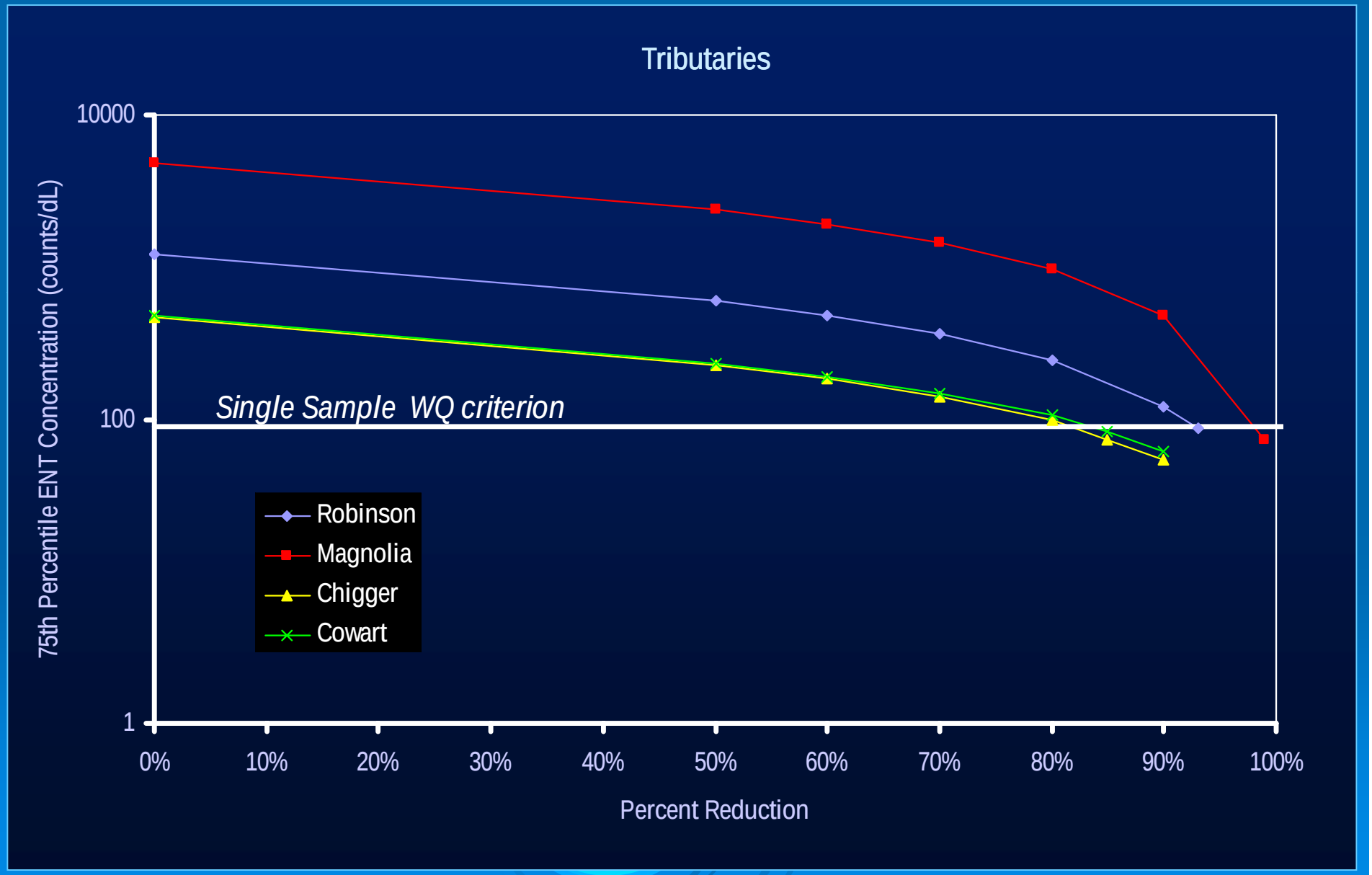

Summary required percent reductions

WQ Segment	WQ Station	Stream Name	% Reduction Required	
			Instantaneous	Geomean
1101	16572	Clear Creek Tidal[a]	71%[b]	72%[b]
1102A	11425	Cowart Creek[a]	85%	74%
1101A	16472	Chigger Creek[a]	86%	36%
1101	16611	Magnolia Creek	99%	94%
1101D	16475	Robinson Bayou	93%	83%

[a] Reductions are calculated assuming that the upstream freshwater segment (addressed using LDC) meet the WQS of 35 counts/dL

[b] Overall reduction for the entire main stem

The bacteria indicator in tidal segments is Enterococci

TMDL calculations for tidal segments

WQ Segment	Stream Name	Loads (counts/day)				
		TMDL[a]	MOS[b]	WWTP WLA[c]	MS4 WLA[d]	LA[e]
1101	Clear Creek Tidal	5.26E+12	2.63E+11	3.60E+10	3.67E+12	1.29E+12
1102A	Cowart Creek	1.33E+11	6.65E+09	0	1.26E+11	0
1101A	Chigger Creek	1.39E+11	6.96E+09	0	1.32E+11	0
1101	Magnolia Creek	4.09E+10	2.05E+09	8.74E+08	3.80E+10	0
1101D	Robinson Bayou	6.28E+10	3.14E+09	0	3.94E+10	2.03E+10

[a] Sum of WWTP, stormwater runoff, and tributary loads discharging directly to the WQ segment that result in attainment of the WQ criteria

[b] TMDL*0.05

[c] Sum of loads from the WWTP discharging to the segment. Individual loads are calculated as permitted flow*35 cfu/dL*conversion factor

[d] MS4 WLA = (TMDL – MOS – WWTP WLA)*percent of drainage area covered by MS4 permits

[e] LA = TMDL – MOS – WWTP WLA – MS4 WLA