Texas Freshwater Mussel Conservation and Stakeholder Summit

Hosted by the
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Saving Mussels with Proper Wastewater Treatment: The Austin Water Story

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Austin Water

City of Austin, Texas

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Presentation Outline

- Why wastewater treatment?
- Effluent Parameters of Concern
- Ammonia and Freshwater Mussels
- Water Quality Standards
- Wastewater Treatment in Austin

Wastewater Treatment

Natural Purification:

$$\text{Waste} + \text{MO} + O_2 \rightarrow \overset{\text{more}}{\text{MO}} + CO_2 + H_2O + \text{Byproducts}$$

MO = Microorganisms

Early days – small population, natural purification adequate

$$\text{Waste} + MO + O_2 \rightarrow \overset{\text{more}}{MO} + CO_2 + H_2O + \text{Byproducts} + \text{Leftover } O_2$$

Later – larger population, waterways stressed

Waste + MO + O_2 → more MO + CO_2 + H_2O

+ Byproducts + No O_2 left

+ Leftover Waste

Now – larger population, but treatment plants help nature

$$\text{Waste} + MO + O_2 \rightarrow \overset{\text{more}}{MO} + CO_2 + H_2O + \text{Byproducts}$$

+Leftover O_2

Evolution of Wastewater Treatment in the U.S.

- Early days: Night Soil, Sewage Farms, Lagoons
- 1880s – Oxidation Ponds, Trickling Filters
- 1913 – Activated Sludge
- 1911-1945 – Two World Wars slow treatment technology
- 1920s – D.O. Depletion Study – Streeter-Phelps
- 1950s-1960s – Improvements in Activated Sludge
- 1970 – U.S. Environmental Protection Agency Established
- 1970s – Secondary Treatment – BOD, TSS Limits
- 1980s – Nitrification – Ammonia Limits
- 1990s – Nutrient Removal – TN, TP Limits
- 2000s – Enhanced Nutrient Removal – Low N, P Limits
- 2010s – Emerging Contaminants – No standards yet

Clean Water Act

- Promulgated in 1972
- Discharges to surface waters prohibited except in accordance with CWA requirements
- Permits authorize certain discharges
  - ✓Technology Based Limits (TBELs): 85% removal
  - ✓Water Quality Based Limits (when TBELs insufficient)
- Pretreatment required for industries discharging to publicly owned treatment works
- Prohibit discharge of toxic pollutants in toxic amounts

Treatment Levels

- Early emphasis on organic matter removal
- Secondary Treatment Permit limits:

5-day Biochemical Oxygen Demand, BOD_5	30 mg/l
Total Suspended Solids, TSS	30 mg/l
pH	6.0 – 9.0 Standard Units

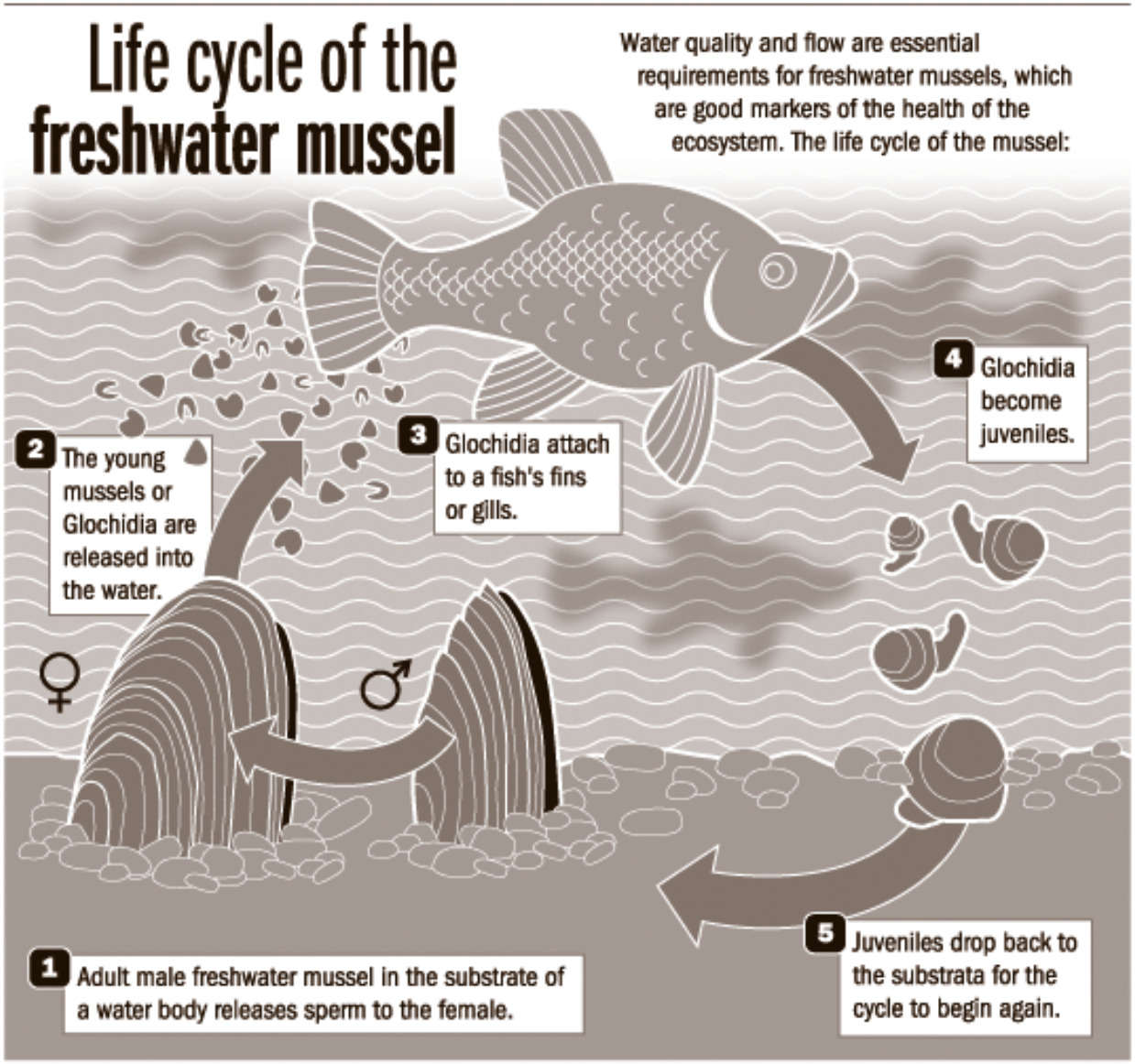
- Monthly Averages
- Ammonia limits came later
- Ammonia consumes oxygen and can also be toxic to aquatic organisms

Treatment Level Progression

	Treatment Level	Regulatory Drivers	Effluent
1970s	Secondary Treatment	Clean Water Act / EPA Grants Program	Secondary BOD / TSS < 30 mg/L
1980s	Nitrification / NH_4-N removal	Local Water Quality	NH_4-N or TKN limits seasonal (summer/winter)
1990s	Biological Nutrient Removal (BNR)	CBA / State Voluntary Grants Program (MD, VA, DC)	TN goal: 8 – 10 mg/L TP goal: 2.0 mg/L
2000	Enhanced Nutrient Removal (ENR)	Nutrient Cap Loads TMDLs / Tributaries	TN LOT*: 3.0 mg/L TP LOT*: 0.3 mg/L
2010	Water Reuse	State guidelines	"ENR" level or greater
	Personal Care Products (PCP) *Pharmaceuticals*	*Nano pollutants* *Endocrine disruptors*	*Not established*

**LOT = Limit of Technology*

Freshwater Mussels and Ammonia



Source: Texas Parks and Wildlife

James Hillston/Post-Gazettte

Ammonia Toxicity is Sensitive to pH and Temperature

Free unionized ammonia (NH_3) is more toxic than ionized ammonia (NH_4^+)

Lower pH $NH_4^+ \leftrightarrow NH_3$ Higher pH

- pH↓ → Free Ammonia↓ → Toxicity↓
- pH↑ → Free Ammonia↑ → Toxicity↑

Lower Temp. $NH_4^+ \leftrightarrow NH_3$ Higher Temp.

- Temp. ↓ → Free Ammonia↓ → Toxicity↓
- Temp. ↑ → Free Ammonia↑ → Toxicity↑

Comparison of 2009 (Draft) and 1999 Ammonia Criteria for Freshwater Mussels

	Draft 2009 Ammonia Criteria (at pH 8 and Temperature 25°C/77°F)	1999 Criteria (at pH 8 and Temperature 25°C/77°F)
Acute	2.9 mg N/L mussels present 5.0 mg N/L mussels absent	5.6 mg N/L salmon present
Chronic	0.26 mg N/L mussels present 1.8 mg N/L mussels absent	1.2 mg N/L fish early life stages present

EPA Draft Aquatic Life Chronic Toxic Criteria for Ammonia, mg/L

	T = 25°C/77°F pH = 8.0	T = 30°C/86°F pH = 8.0	T = 30°C/86°F pH = 8.5
Mussels Absent	1.8	1.33	0.6
Mussels Present	0.26	0.19	0.08

Ammonia Criteria for Freshwater Mussels

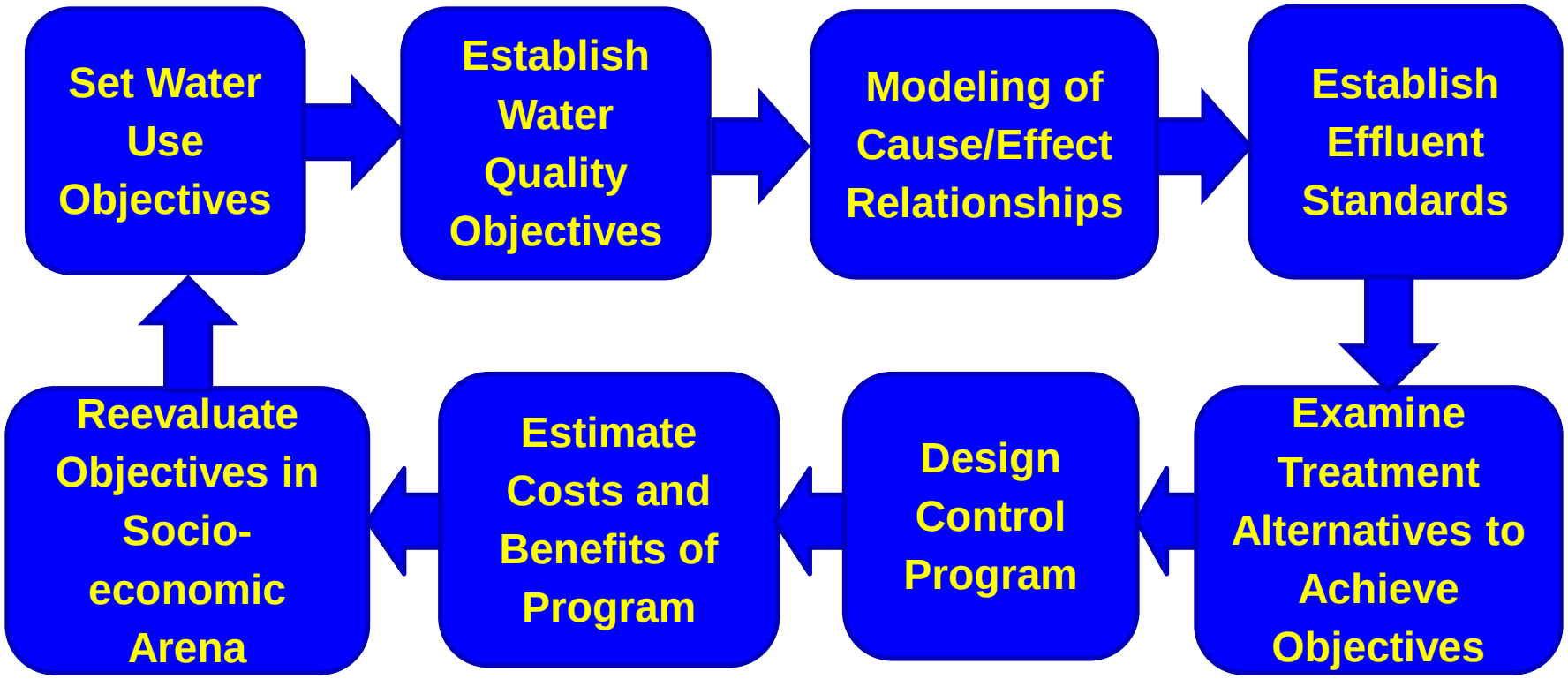
Criterion Duration	1999 AWQC Update Criteria Magnitude		2009 Draft AWQC Update Criteria[c] Magnitude		2013 AWQC Update Criteria Magnitude
	pH 8.0, (mg TAN/L)	pH 7.0, T=20°C (mg TAN/L)	pH 8.0, T=25°C (mg TAN/L)	pH 7.0, T=20°C (mg TAN/L)	pH 7.0, T=20°C (mg TAN/L)
Acute (1-hr average)	5.6[a]	24[a]	2.9	19	17[a]
Chronic (30-d rolling average)	1.2	4.5[b]	0.26	0.91	1.9*
*Not to exceed 2.5 times CCC or 4.8 mg TAN/L (at pH 7, 20°C) as a 4-day average within the 30-days, more than once in three years on average.					
Criteria frequency: Not to be exceeded more than once in three years on average.					

[a] Salmonids present
[b] Based on renormalization of data to pH 7 and 20°C
[c] Mussels present

Ammonia Criteria for Freshwater Mussels

Criterion Duration	1999 Criteria	2009 Draft Updated Criteria	2013 Final Updated Criteria
Acute (1-hour average)	24	19	17
Chronic (30-day rolling average)	4.5*	0.91*	1.9*
*Not to exceed 2.5 times the criterion continuous concentration as a 4-day average within a 30-day period.			
Criteria frequency: Not to be exceeded more than once in three years on average.			

Iterative Process for Establishing Water Quality Objectives



Ammonia-Nitrogen (NH_3-N) Removal

Nitrification: Ammonium ion (NH_4^+) oxidized in two steps – first to Nitrite (NO_2^-), then to Nitrate (NO_3^-)

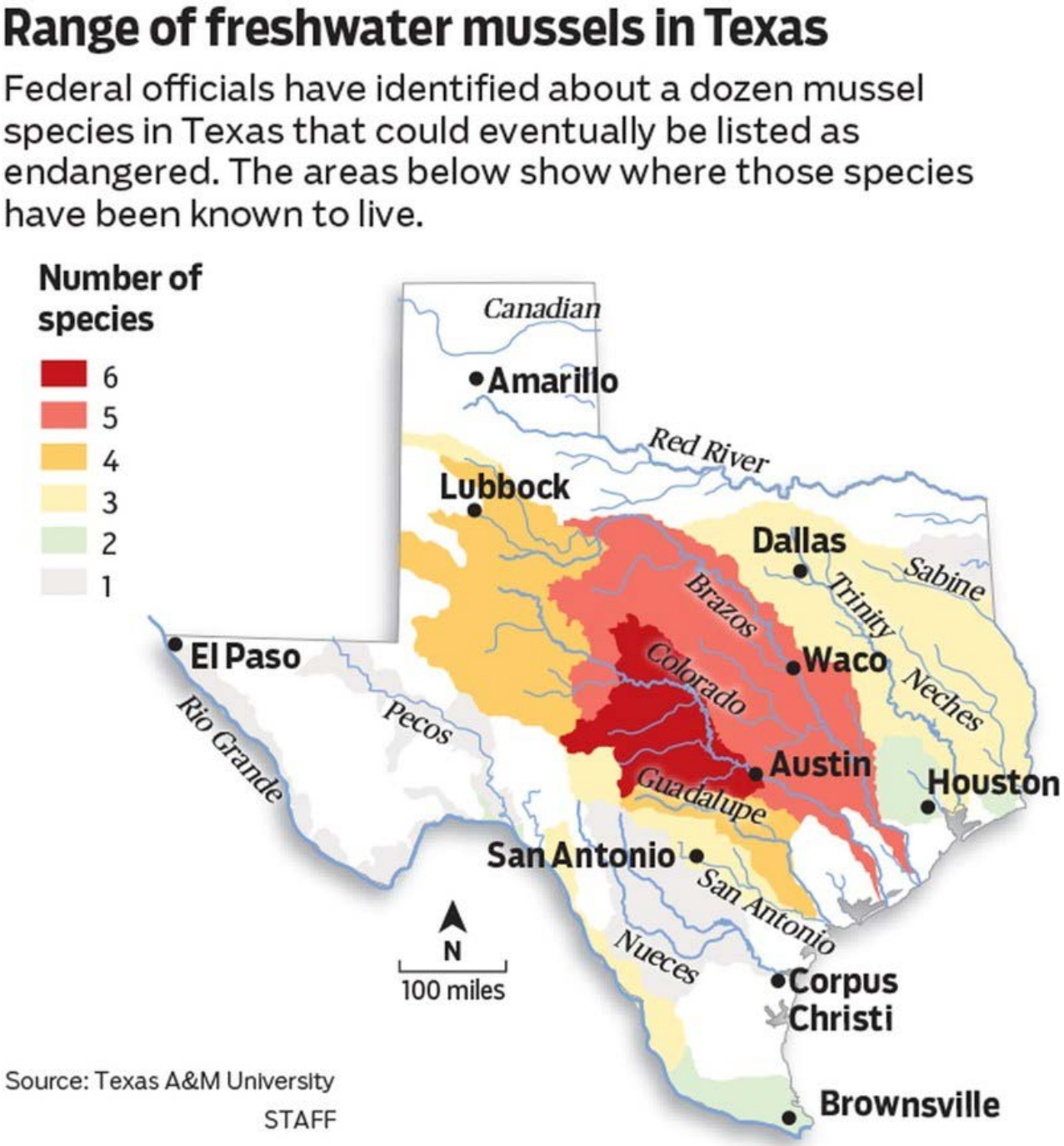
$$NH_4^+ + 1.5\ O_2 + 2\ HCO_3^- \rightarrow NO_2^- + 3\ H_2O + 2\ CO_2\uparrow \qquad \text{(AOB)}$$

$$NO_2^- + 0.5\ O_2 \rightarrow NO_3^- \qquad \text{(NOB)}$$

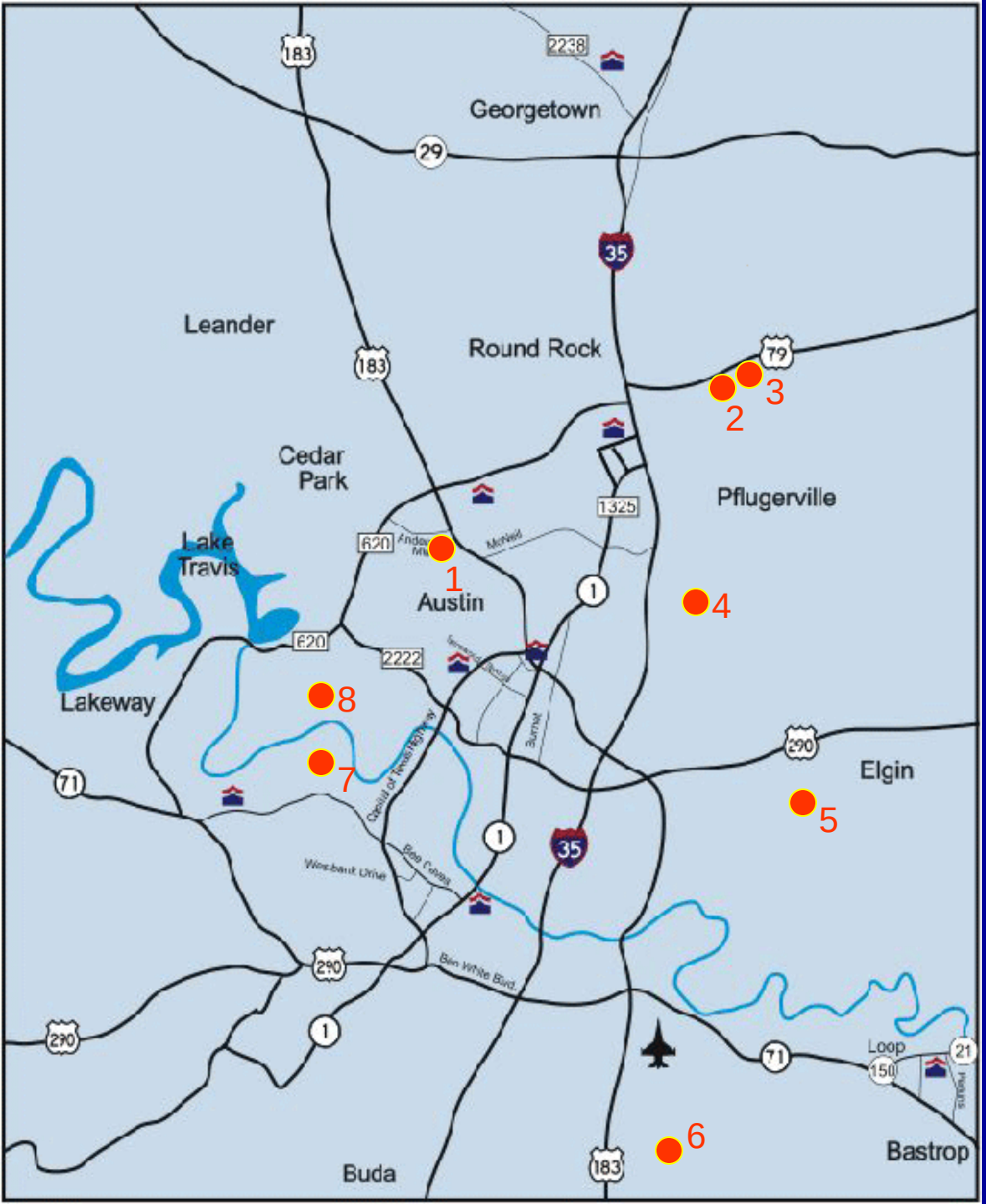
$$NH_4^+ + 2\ O_2 + 2\ HCO_3^- \rightarrow NO_3^- + 3\ H_2O + 2\ CO_2\uparrow$$

7.14 parts of **alkalinity** and **4.57** parts of **oxygen** consumed for every part of NH_4^+ oxidized to NO_3^-

Range of Freshwater Mussels in Texas



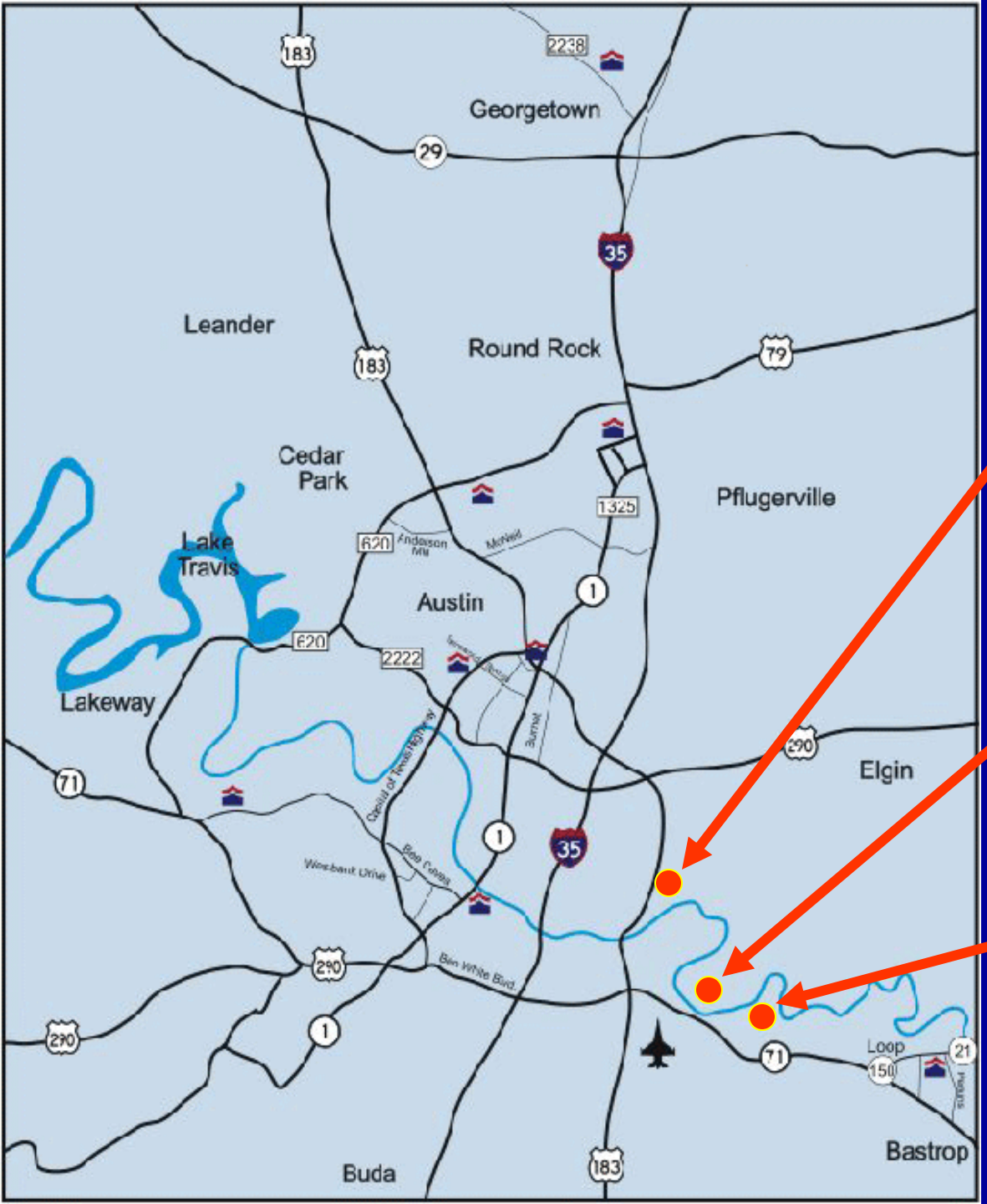
Source: Texas A&M University, and Coastal Bend Chronicle



Austin's Small Wastewater Plants

1. Balcones*
2. Brushy Creek (West)
3. Brushy Creek (East)
4. Dessau
5. Wild Horse Ranch
6. Thoroughbred Farms
7. Lost Creek*
8. River Place*

*No discharge

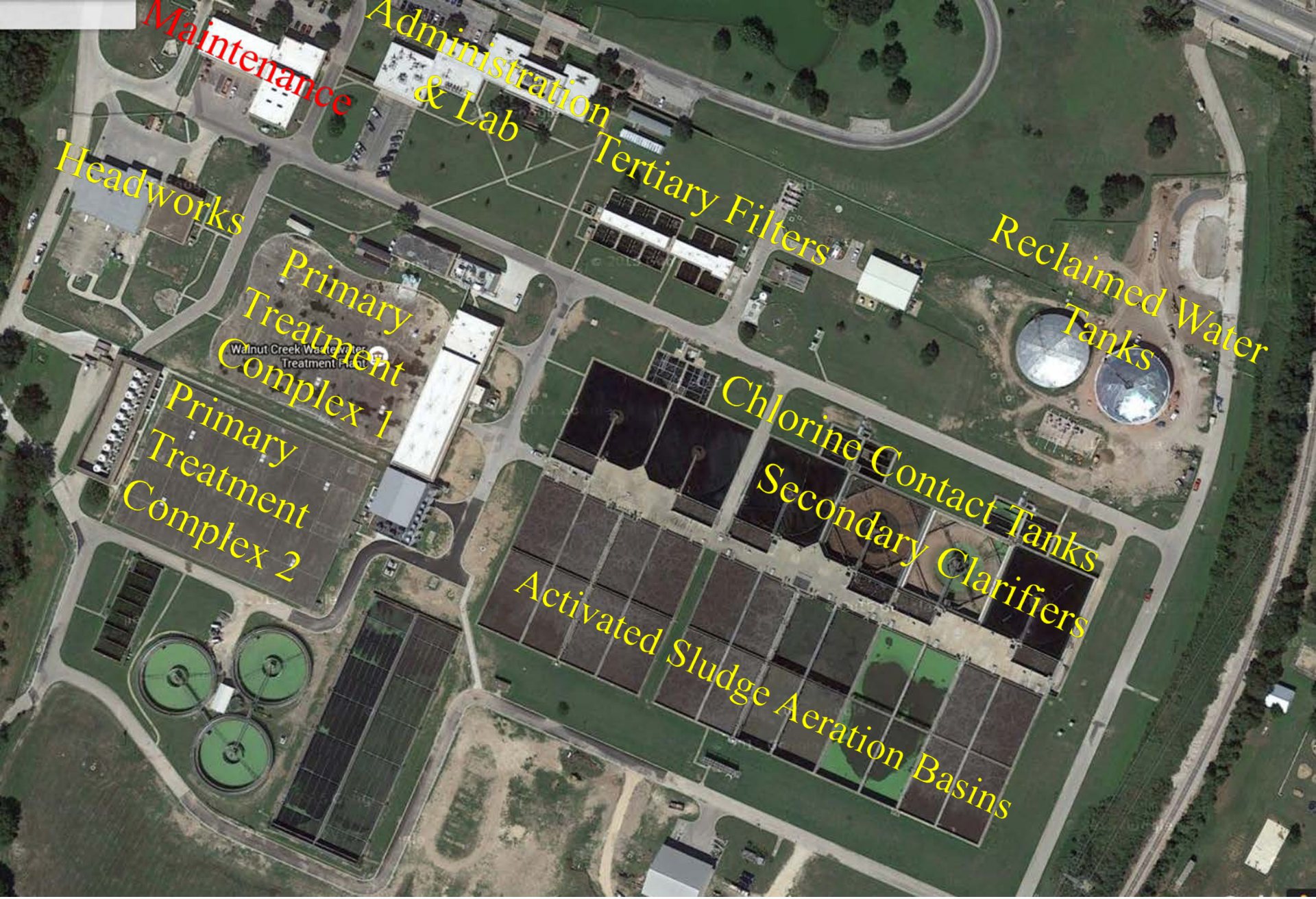


Walnut Creek Wastewater Plant (1977)

Hornsby Bend Biosolids Plant* (1956)

South Austin Regional Wastewater Plant (1986)

*No discharge



Walnut Creek Wastewater Treatment Plant, Austin, Texas

Austin's Permit Limits

Parameter	TCEQ / EPA (Monthly Averages)
5-day Carbonaceous Biochemical Oxygen Demand, mg/l	10
Total Suspended Solids, mg/l	15
Ammonia-Nitrogen, mg/l	2
pH	6 – 9
Dissolved Oxygen, mg/l	6

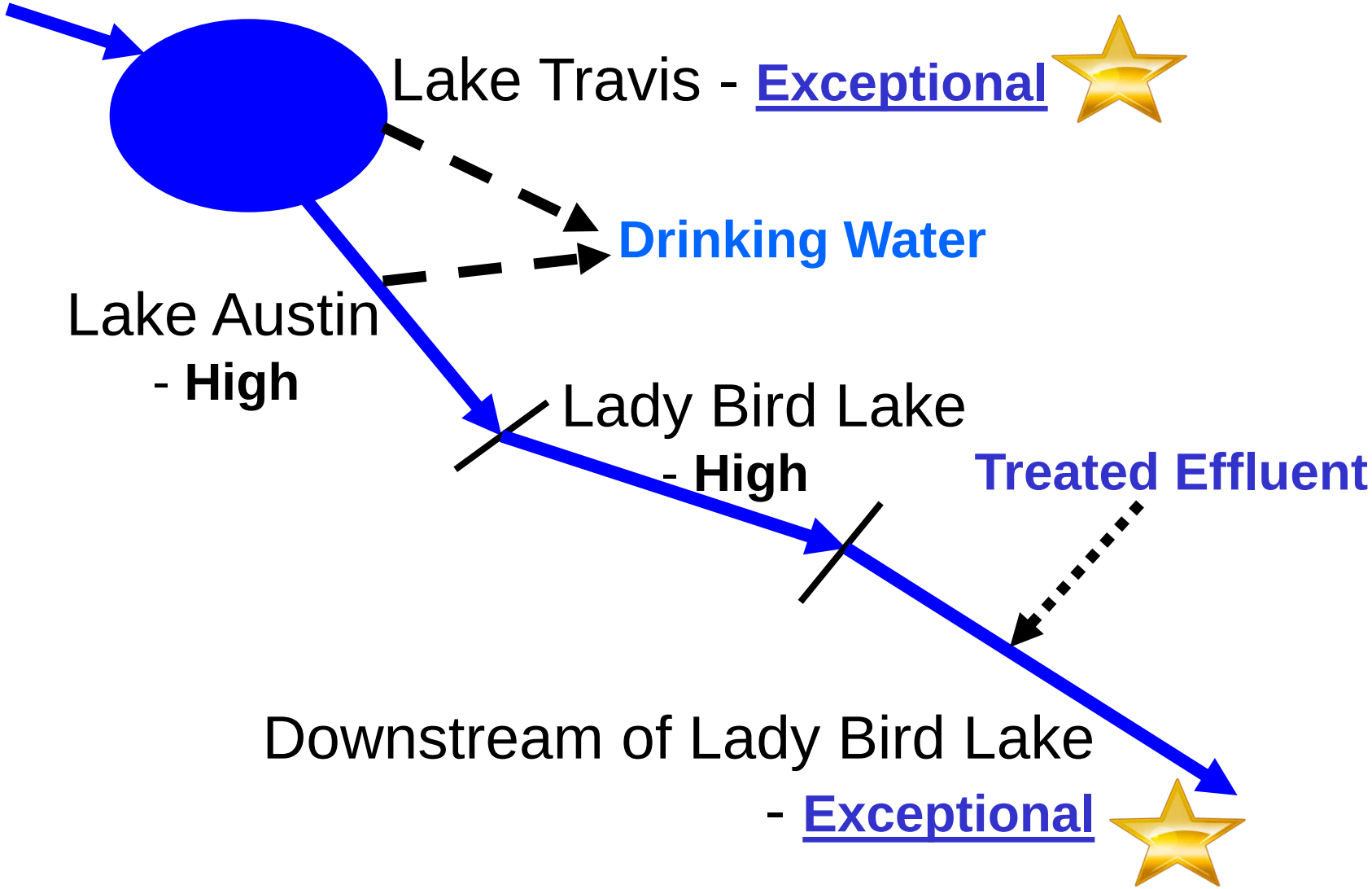
Austin's Permit Limits

Parameter	TCEQ / EPA (Monthly Averages)	Volunteered by Austin (Annual Averages)
5-day Carbonaceous Biochemical Oxygen Demand, mg/l	10	5
Total Suspended Solids, mg/l	15	5
Ammonia-Nitrogen, mg/l	2	2
pH	6 – 9	-
Dissolved Oxygen, mg/l	6	-

Texas Surface Water Quality Standards

- Promulgated by TCEQ and approved by EPA
- Lake Travis – **Exceptional Quality**
- Lake Austin – High Quality
- Lady Bird Lake – High Quality
- Colorado River downstream of Lady Bird Lake – **Exceptional Quality** (segment into which we discharge our treated effluent)

Water Quality of Various Segments of the Colorado River near Austin



Questions, Comments?

Tom Toro, *The New Yorker*, May 12, 2012