Comparing the Changes in Hydrology due to Different Development Regulations using Sub-Daily SWAT

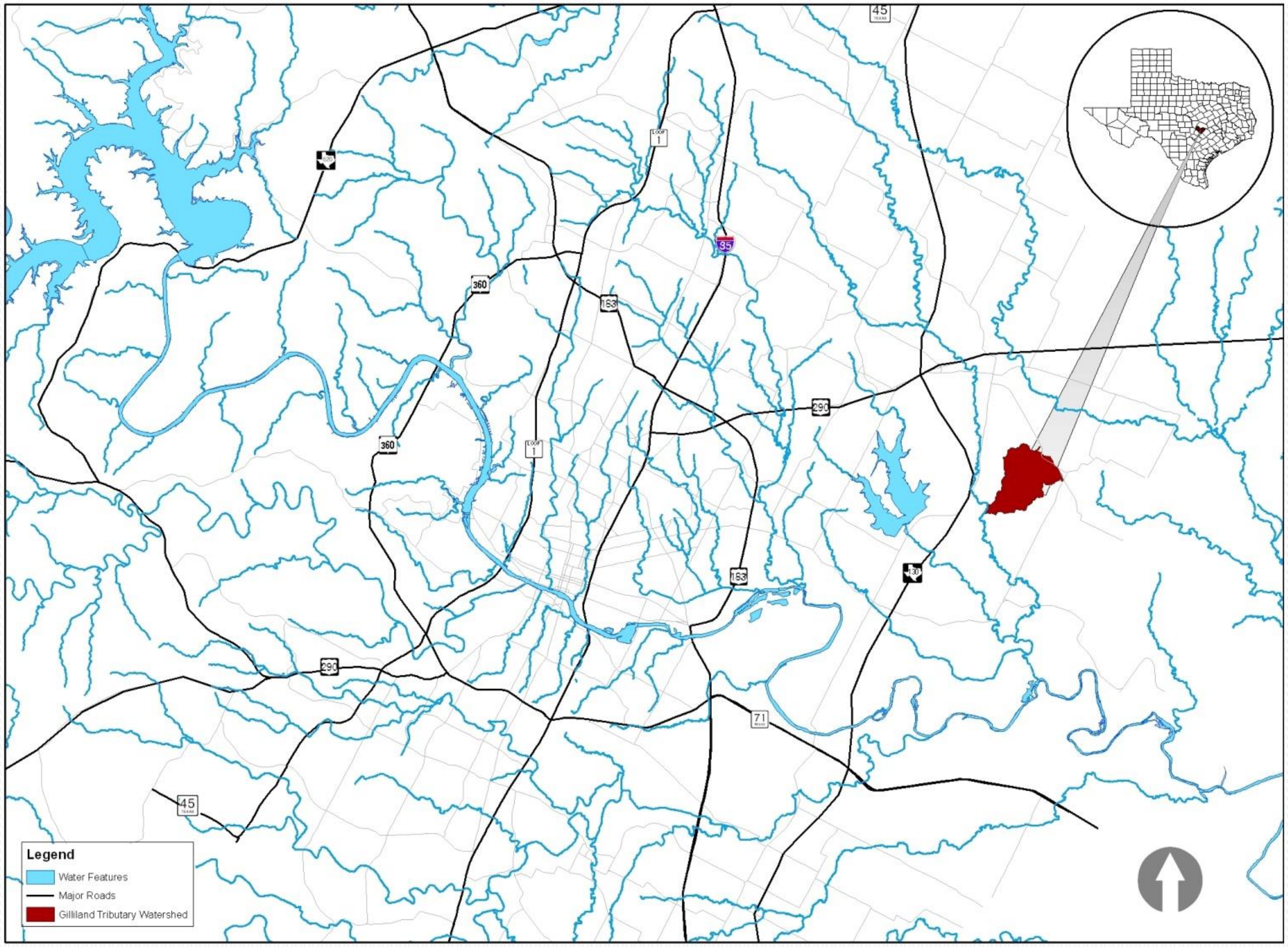
Roger H. Glick, P.E., Ph.D.
Leila Gosselink, P.E.

Watershed Protection Department
City of Austin

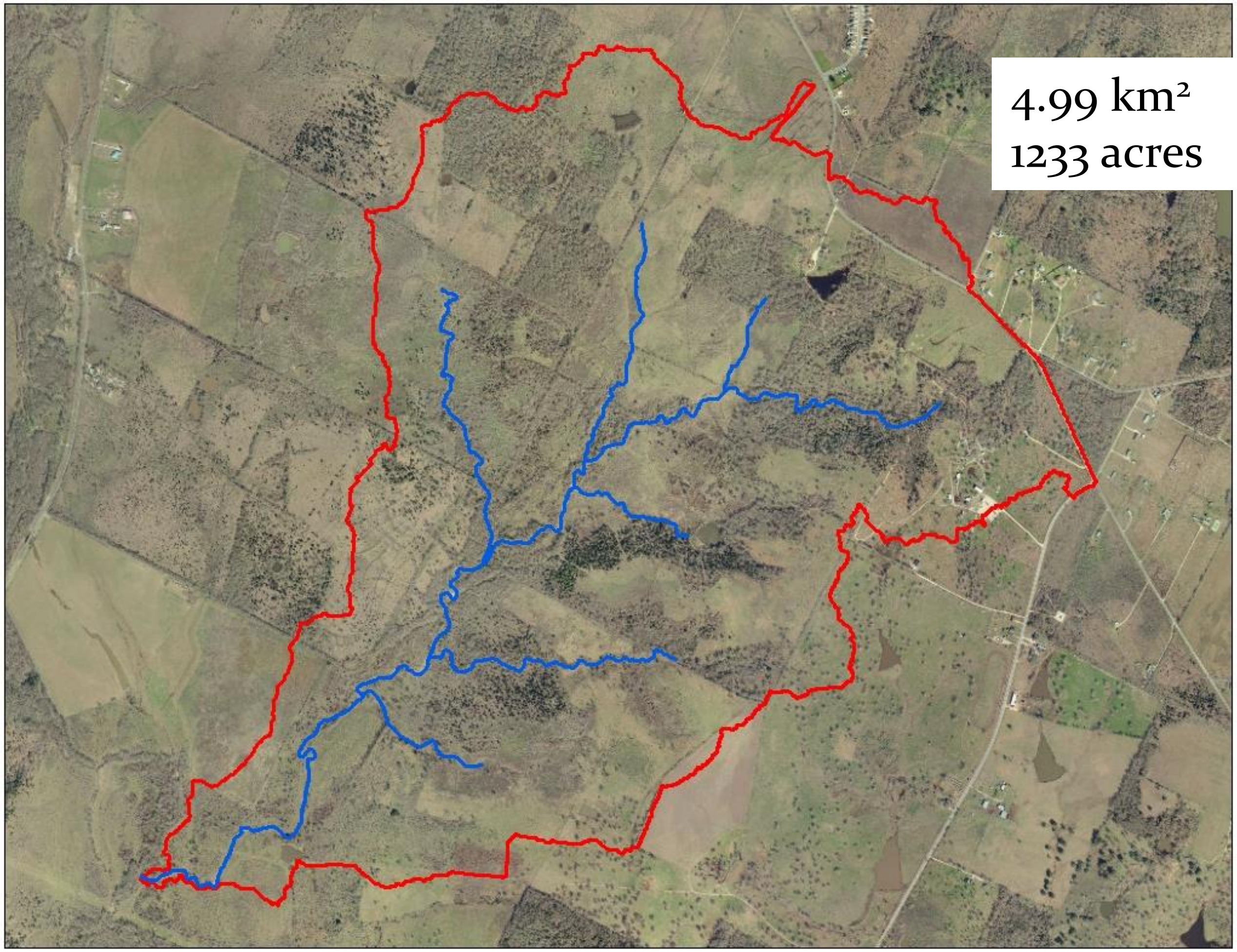
Presented at

2013 International SWAT Conference
Toulouse, France
Université Paul-Sabatier

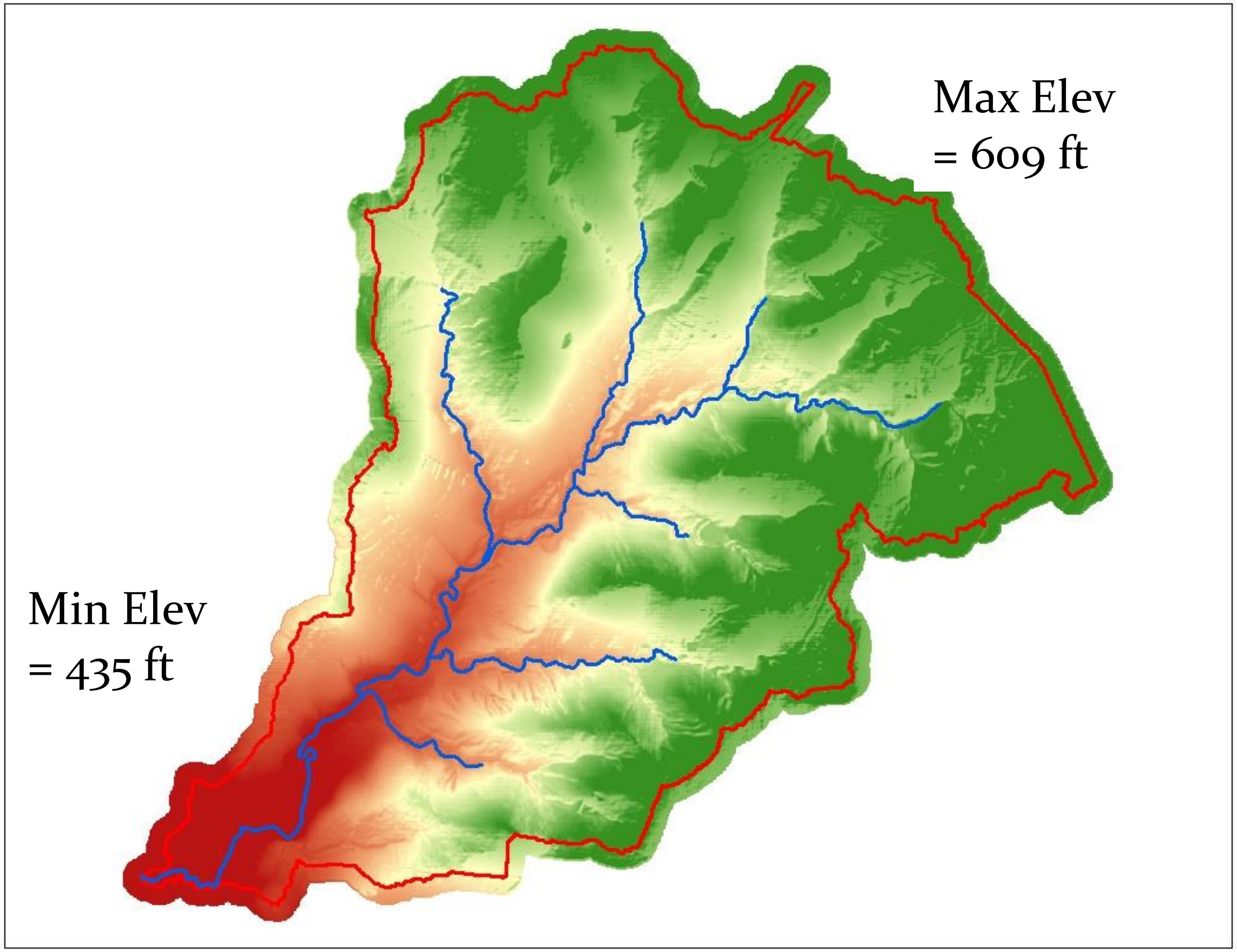
Study area


Legend
Water Features
Major Roads
Gilliland Tributary Watershed

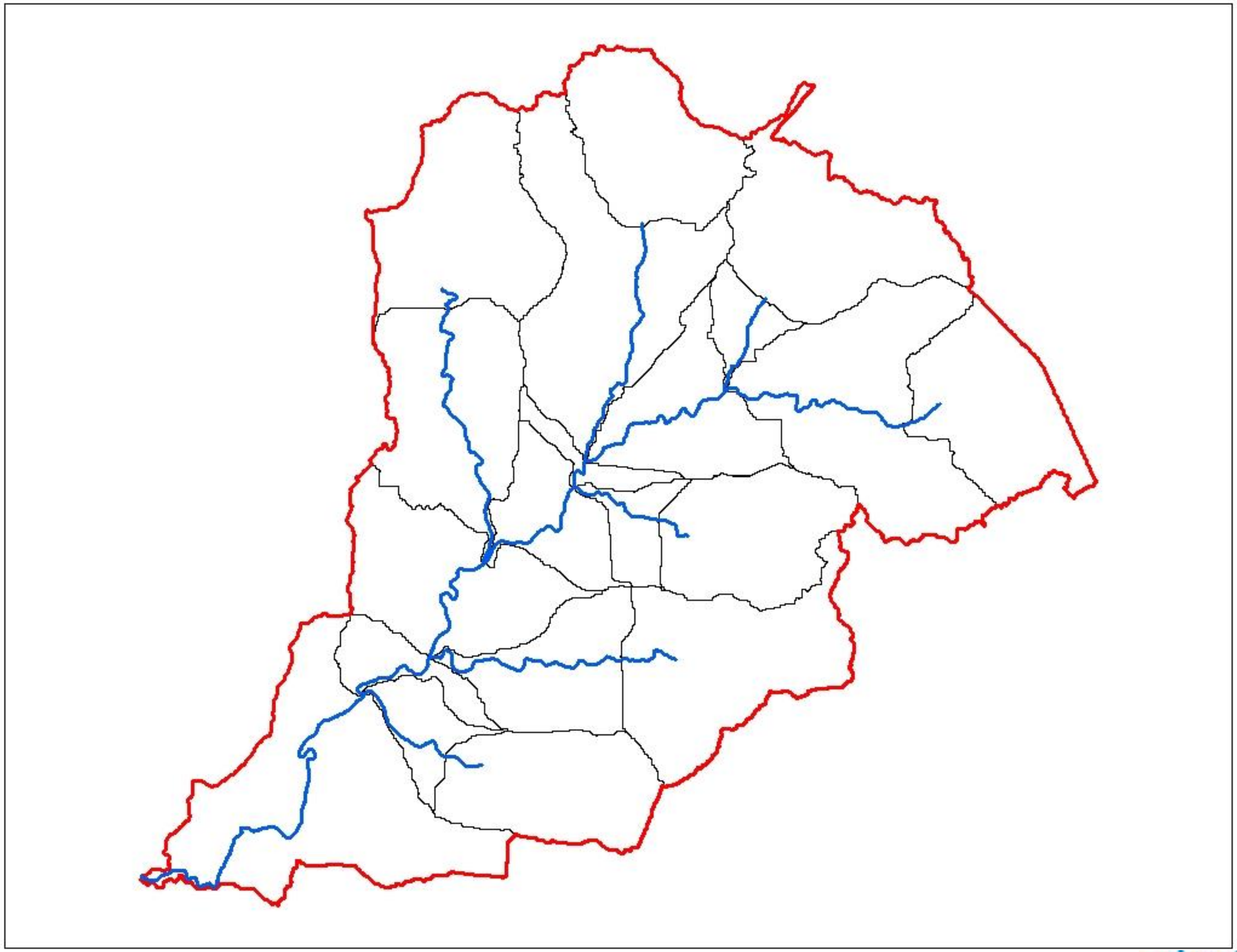
Study Watershed:
Tributary to Gilleland Creek



Elevation Data

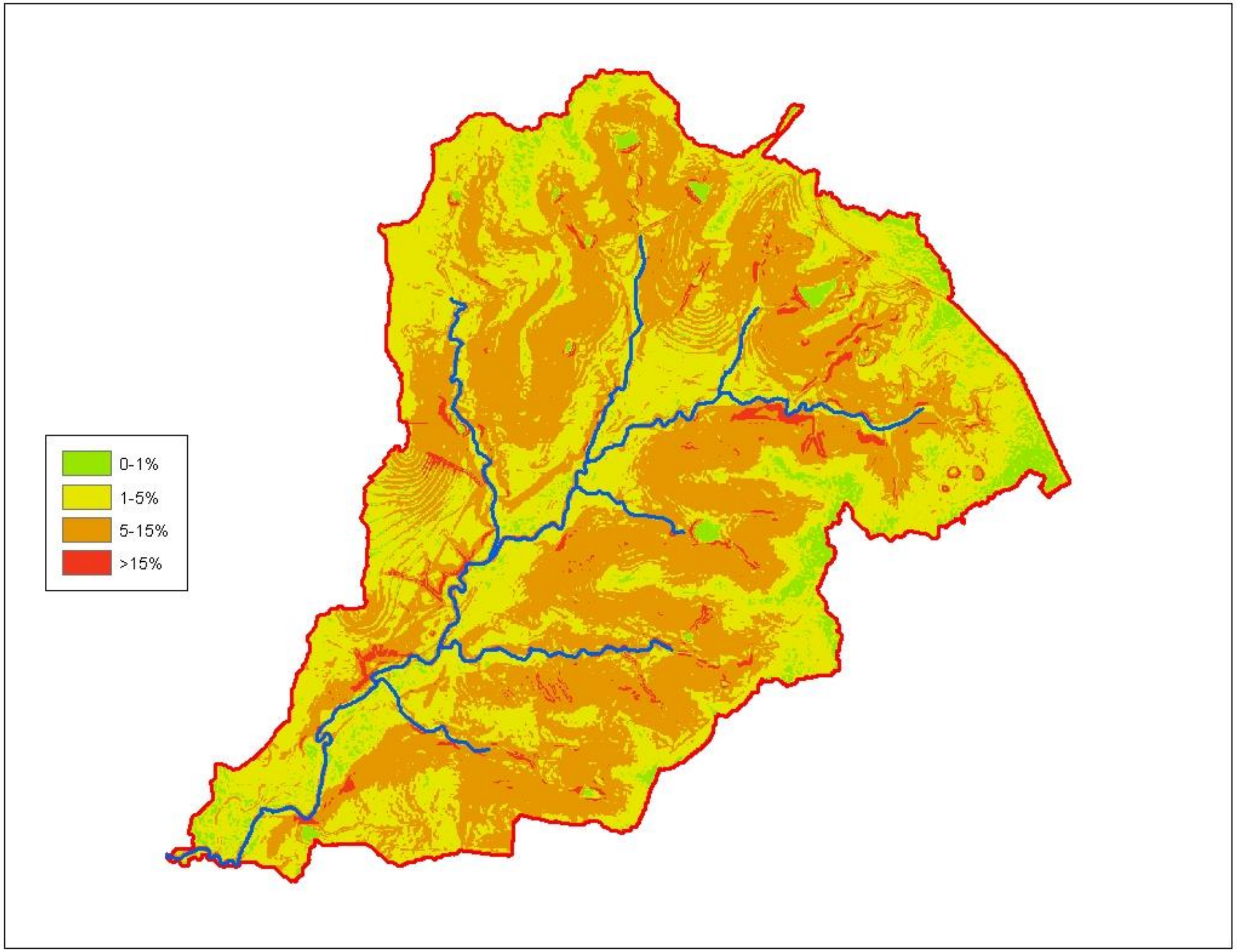


Model Sub-basins

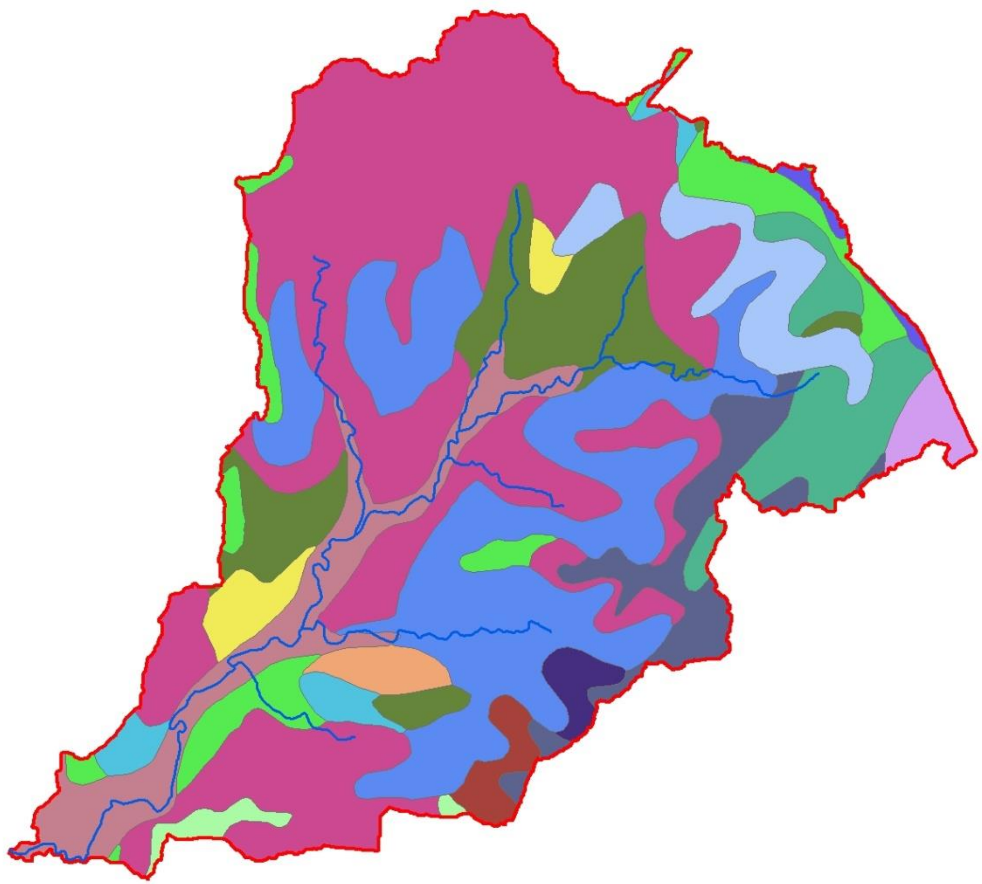


City of Austin WATERSHED PROTECTION

Site Slopes



Site Soils

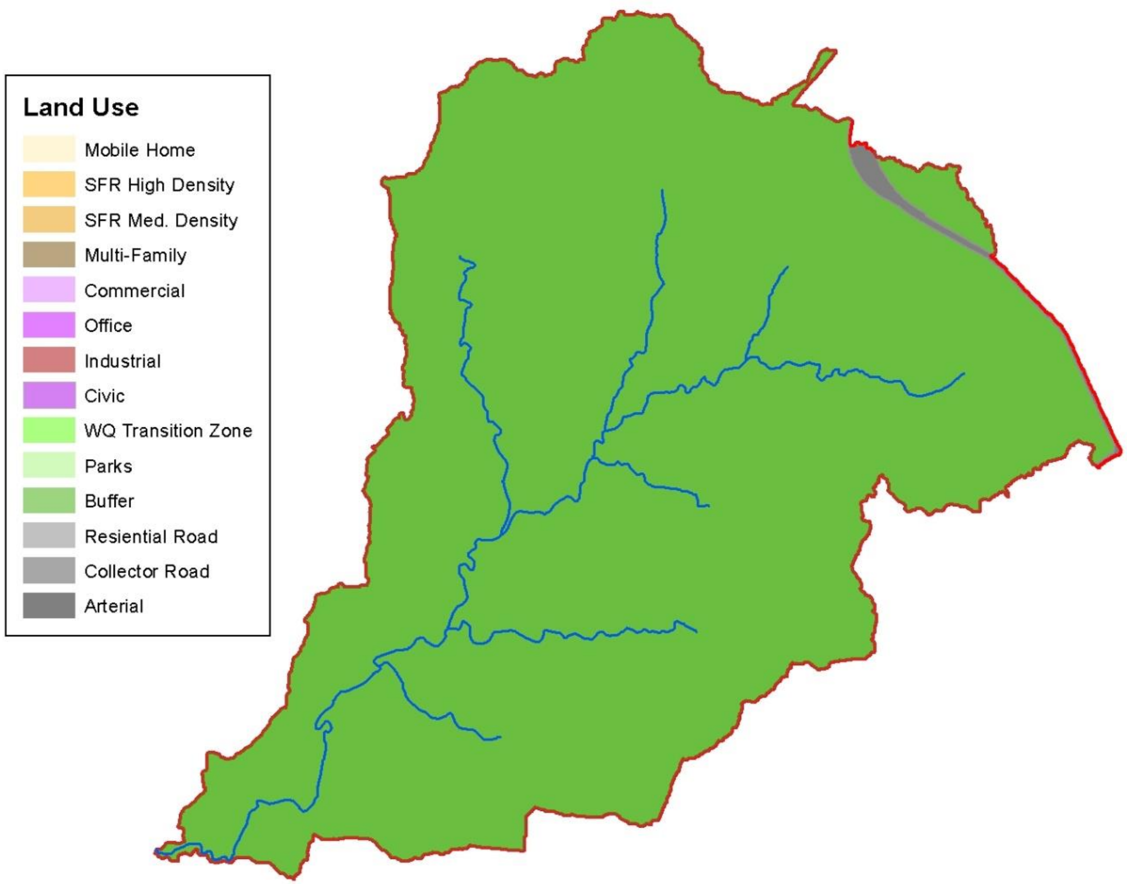


City of Austin Ordinances: Land Use & Controls

- **Undeveloped [UND]**
- **Pre-Waterways Ordinances [Pre-ORD]**, <1974
  - No controls
  - Limited creek easements, >320 ac.
- **Waterway Ordinance [WO]**, 1974-1986
  - Detention only
  - Wider easements, >320 ac
- **Comprehensive Watershed Ordinance [CWO]**, 1986-present*
  - Detention and ½”+ sed-fil
  - Creek buffer and water quality transition zone, >320 ac
- **Watershed Protection Ordinance [WPO]**, proposed
  - Detention and ½”+ sed-fil
  - Creek buffer, >64 ac (no WQTZ)

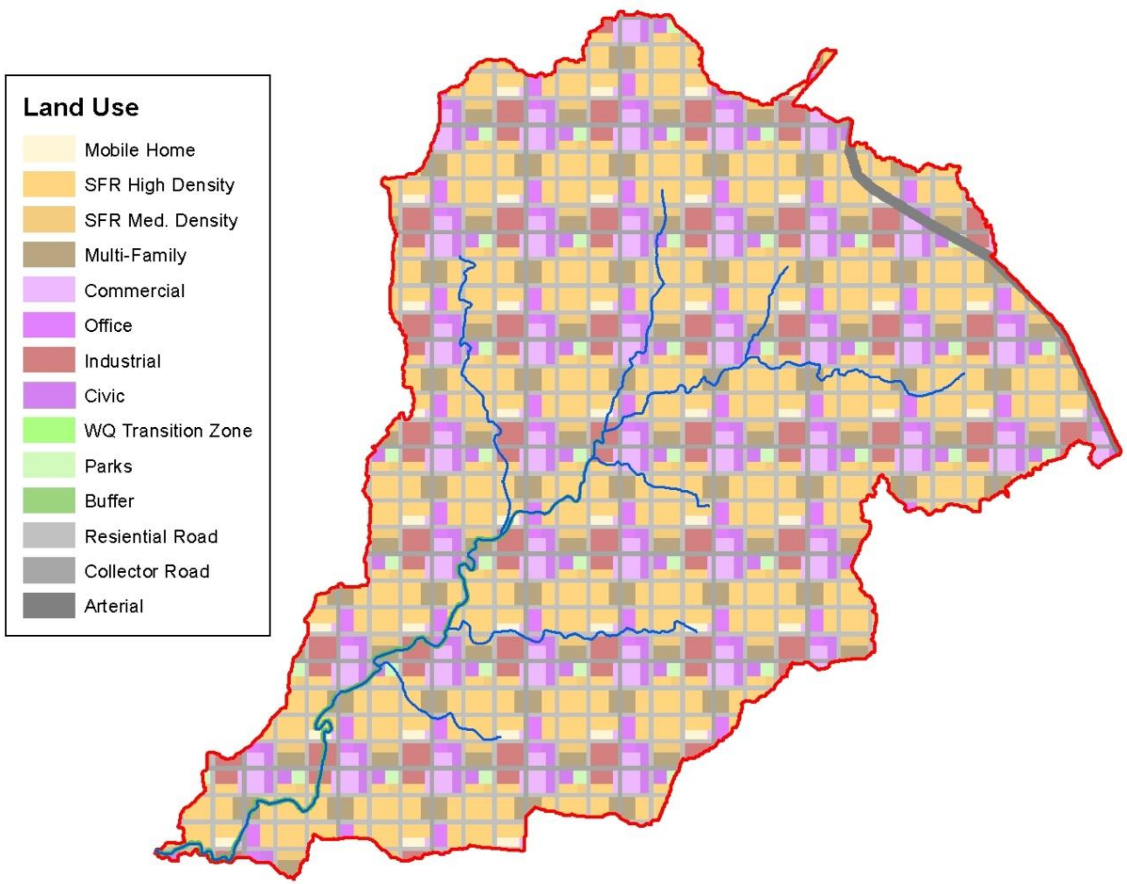
City of Austin WATERSHED PROTECTION

Undeveloped Land Use

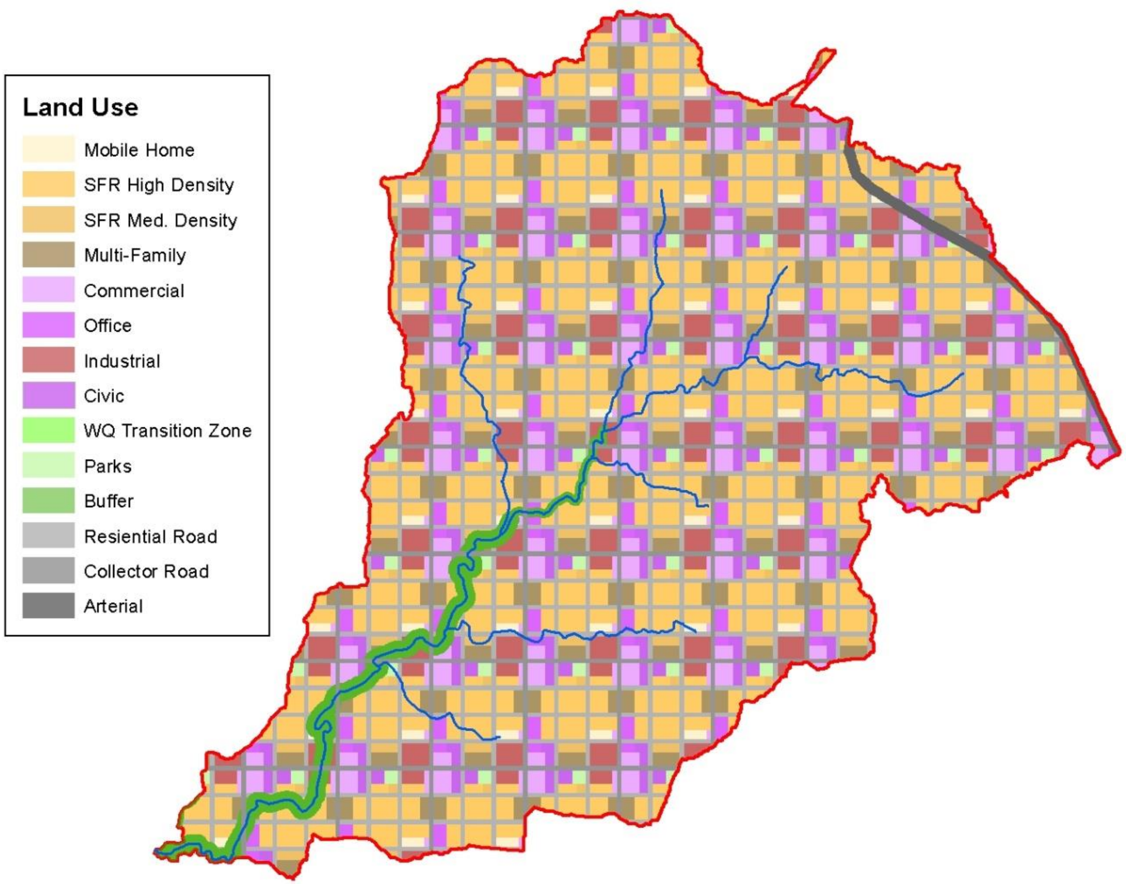


City of Austin
WATERSHED PROTECTION

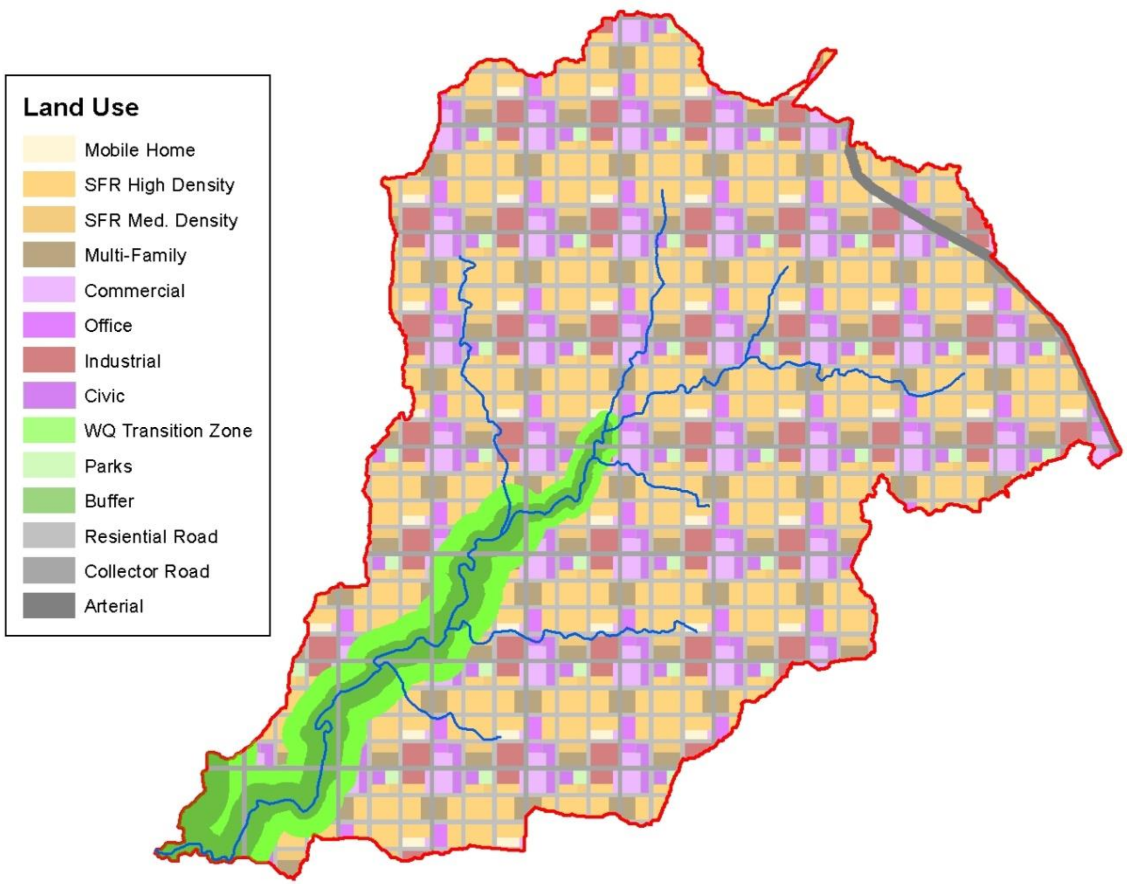
Pre-Ord Land Use (<1974)



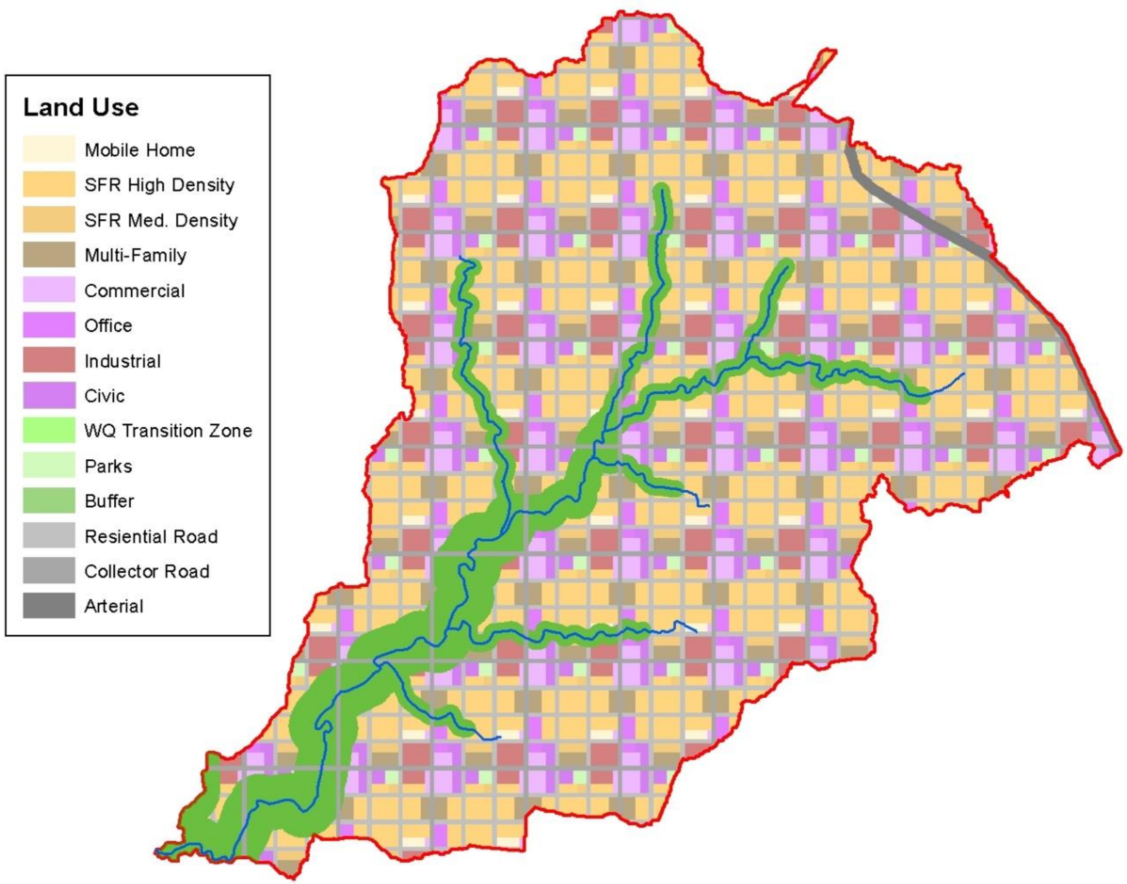
WO Land Use (~1974-86)



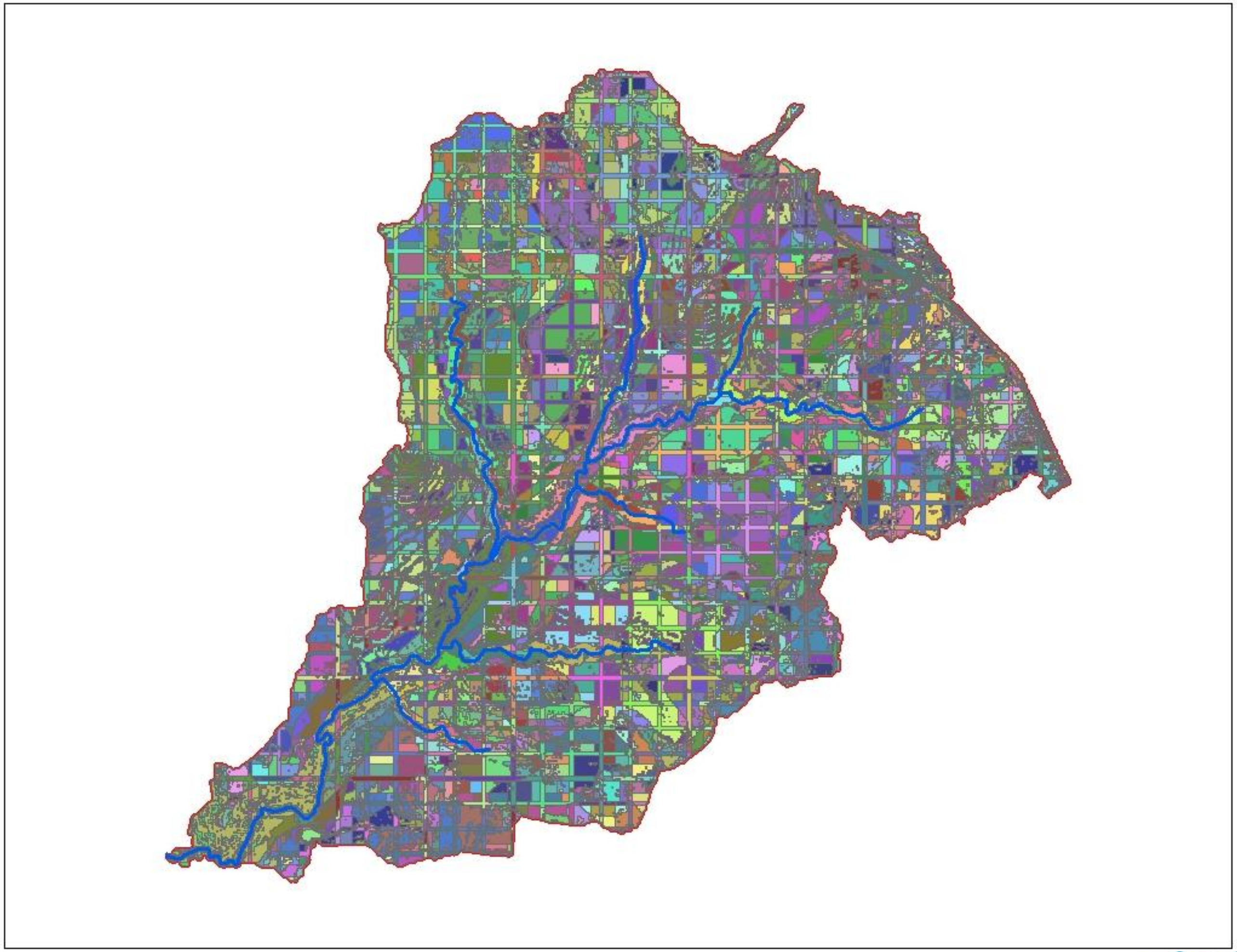
CWO Land Use (1986-present)



WPO Land Use (proposed)



HRU Distribution



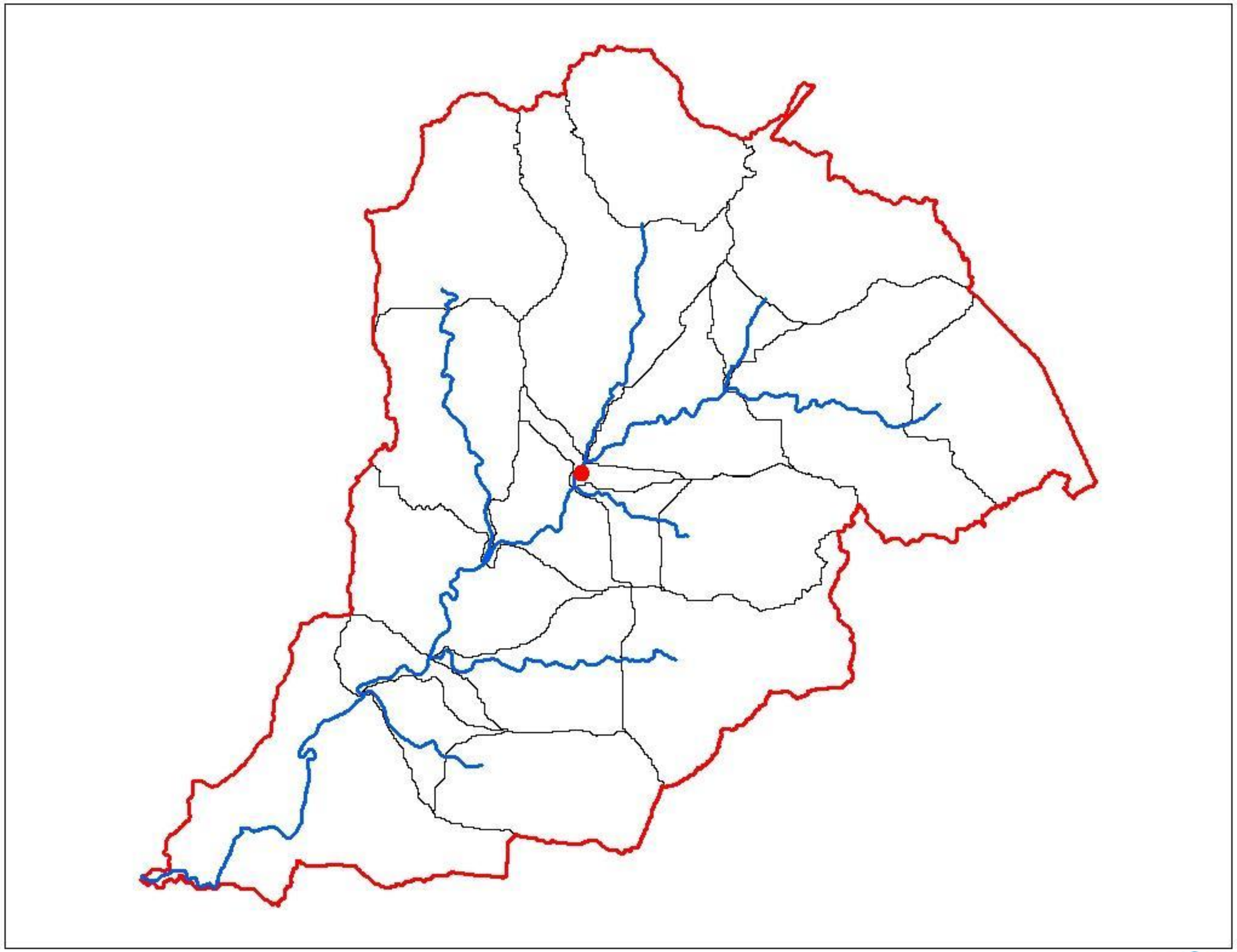
Model Scenarios

Developed Conditions

- Irrigation and fertilizer on lawns and commercial; except high slopes
- Increased roughness & conductivity in channels
- 100% of developed residential & commercial land treated by BMPs; some land uses excluded.
- One large detention basin mid-basin (reach 9)

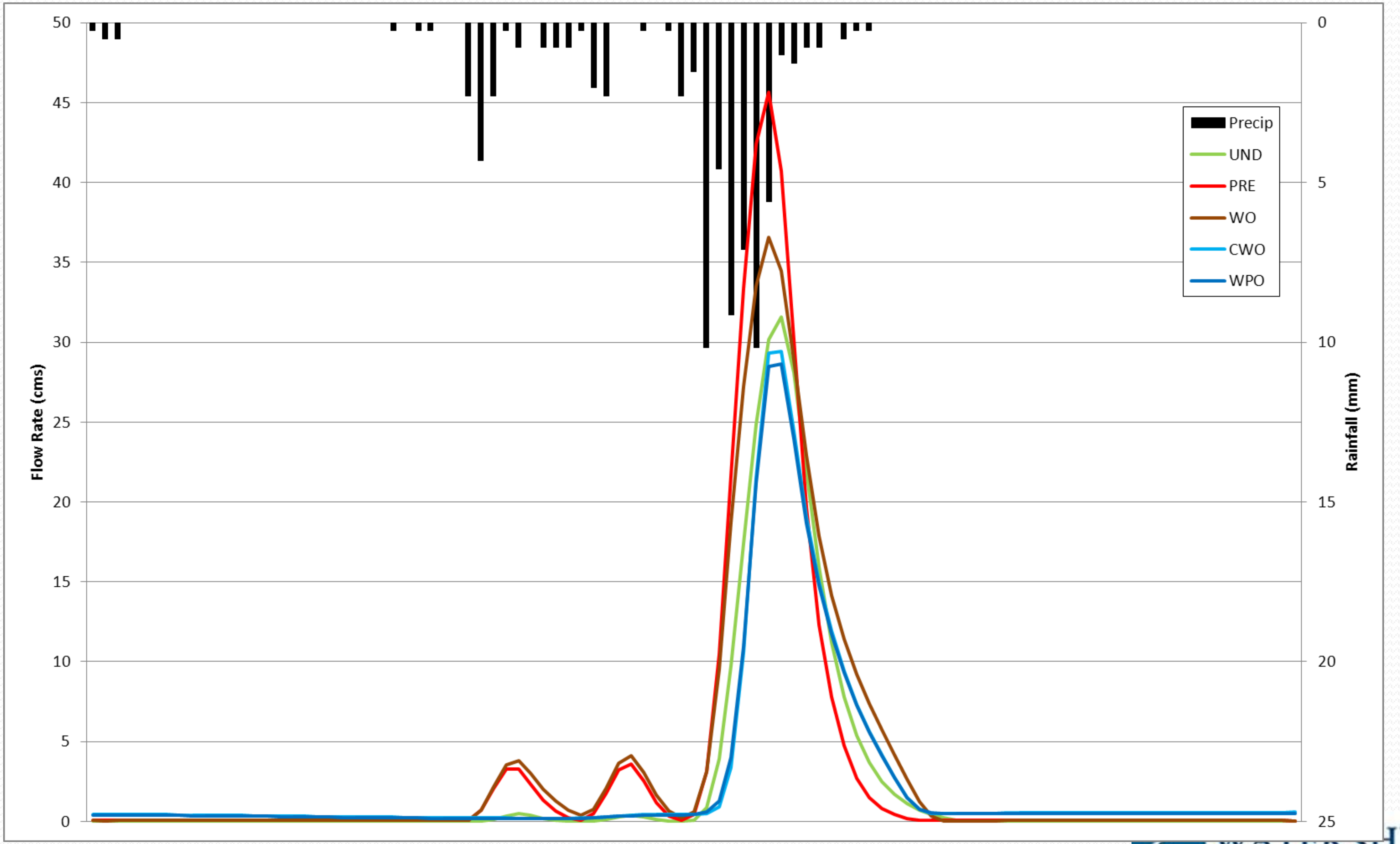
City of Austin WATERSHED PROTECTION

Detention Pond Location



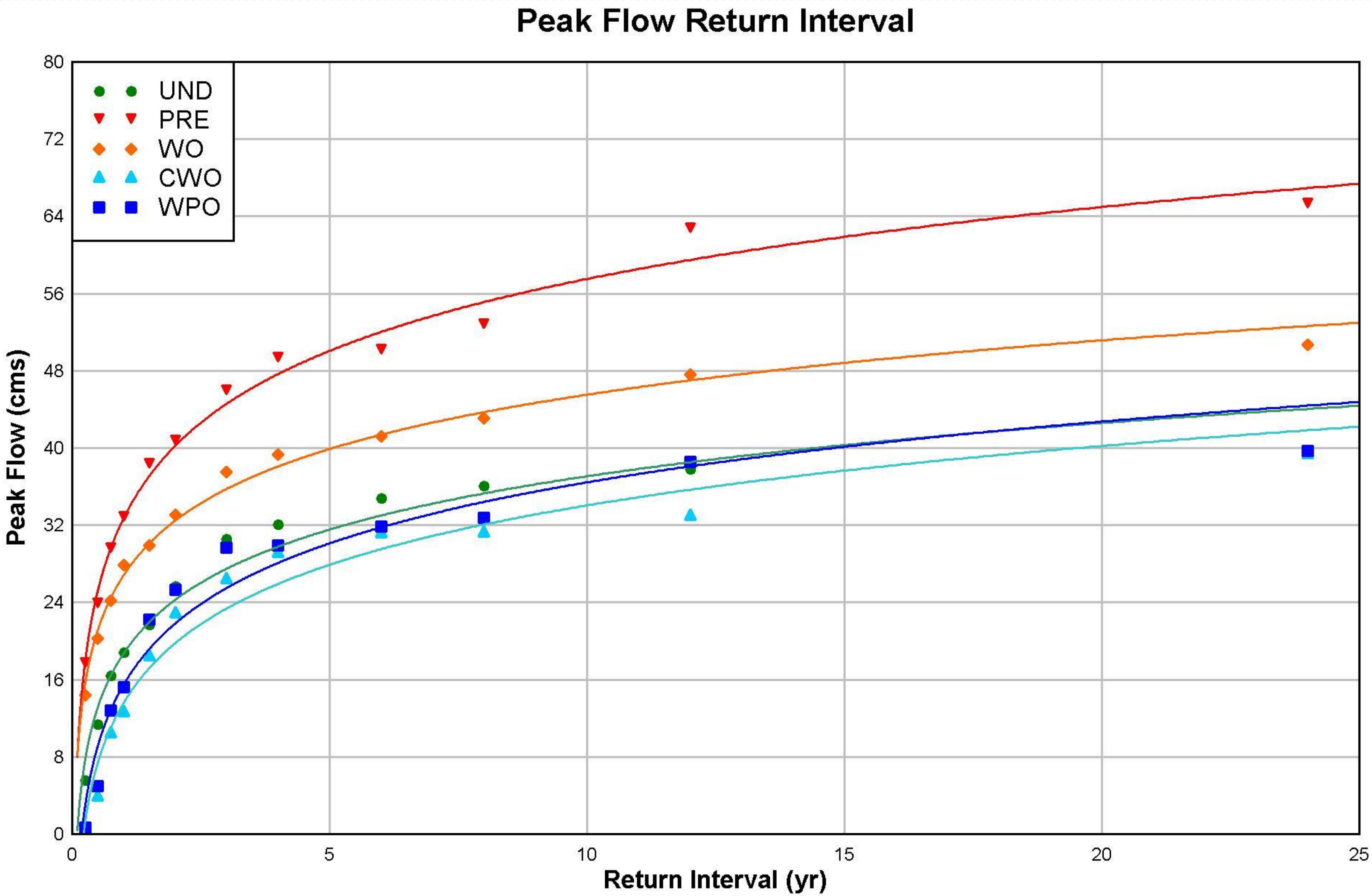
City of Austin WATERSHED PROTECTION

Effects of Ordinances



WATERSHED PROTECTION

Impacts on Flooding



Computation of shear

$$\tau = \gamma_w \cdot D_H \cdot S_w$$

where,

τ = shear (Pa)

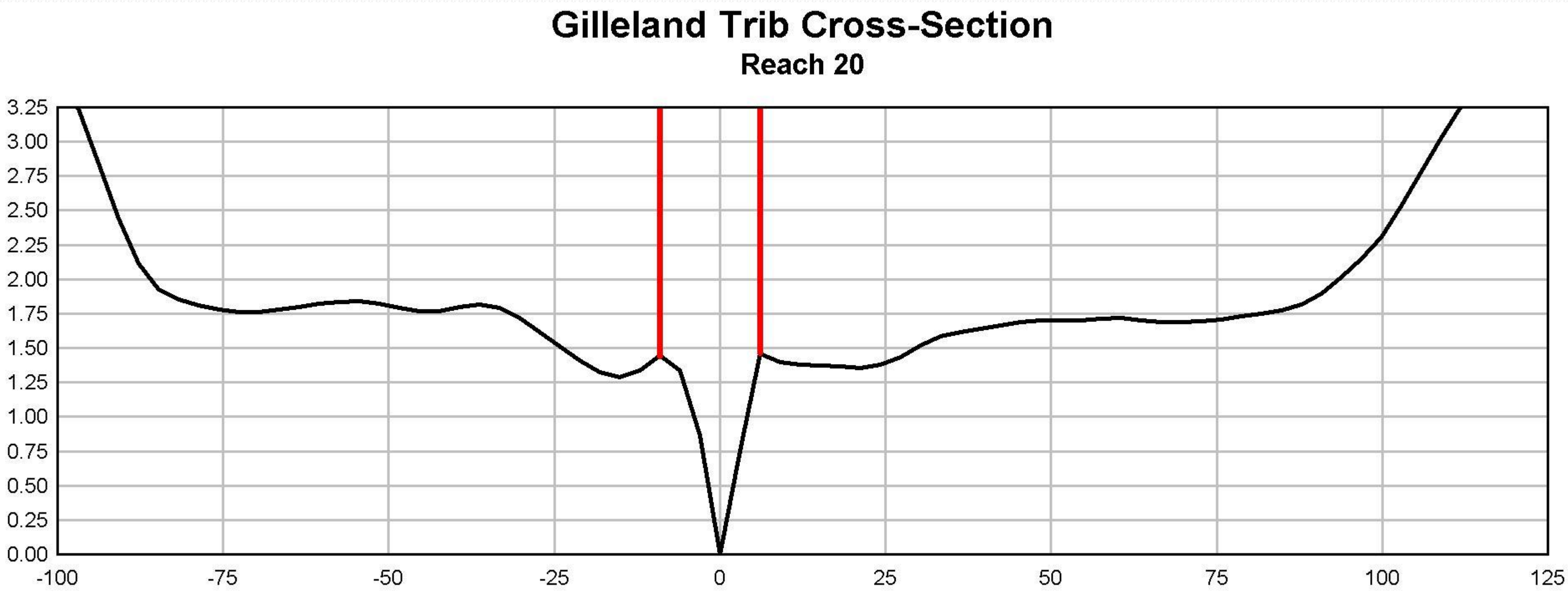
γ_w = density of water (kg/m^3)

D_H = depth of water (m)

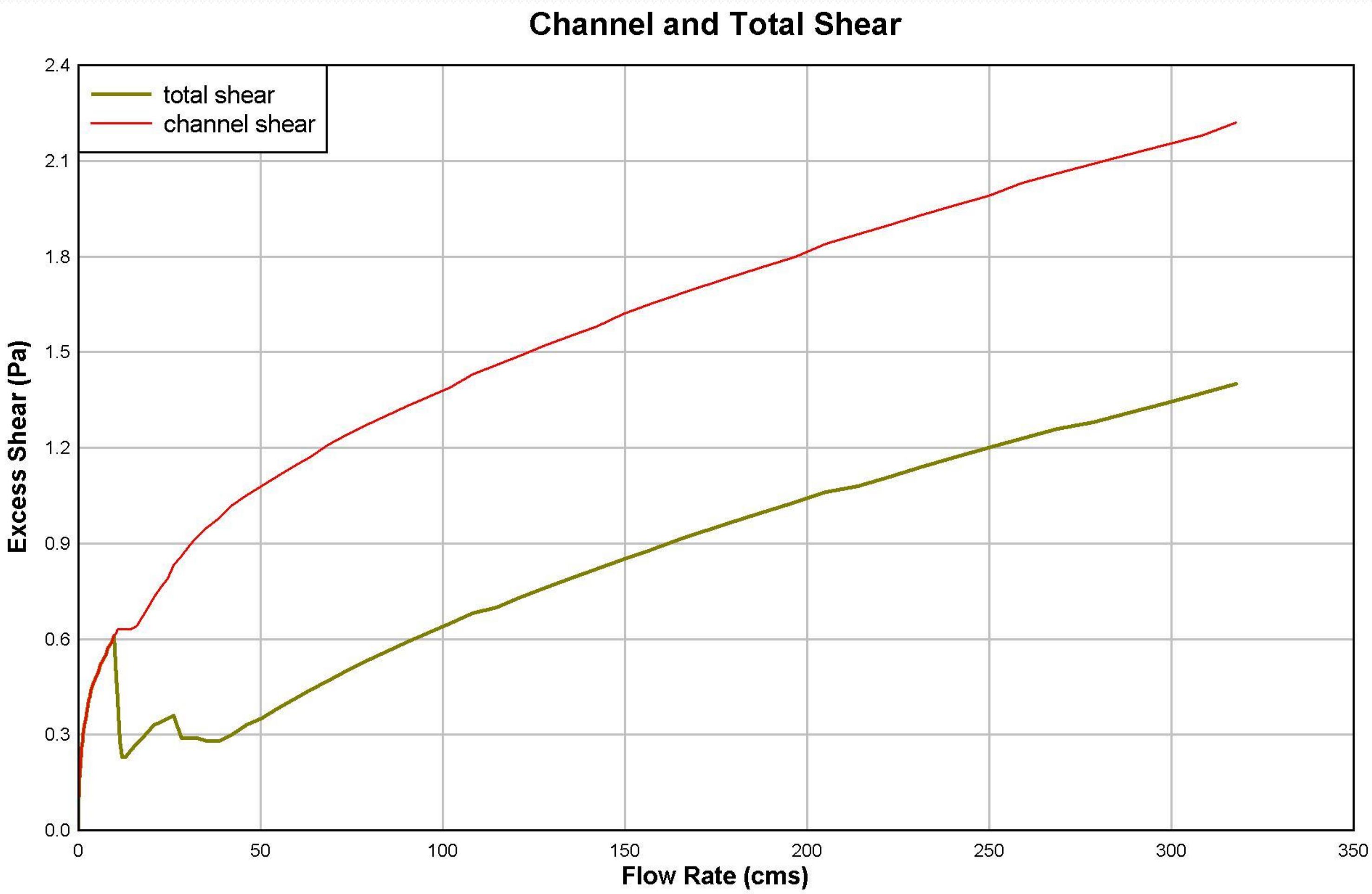
S_w = channel slope (m/m)

City of Austin WATERSHED PROTECTION

Impacts on Erosion Potential



Impacts on Erosion Potential



City of Austin WATERSHED PROTECTION

Computation of critical shear

$$\tau_c = \Theta_c(S_g - 1) \cdot \gamma_w \cdot d_{50}$$

where,

τ_c = critical shear (Pa)

γ_w = density of water (kg/m^3)

S_g = specific gravity of soil, 2.65

d_{50} = median particle diameter (m)

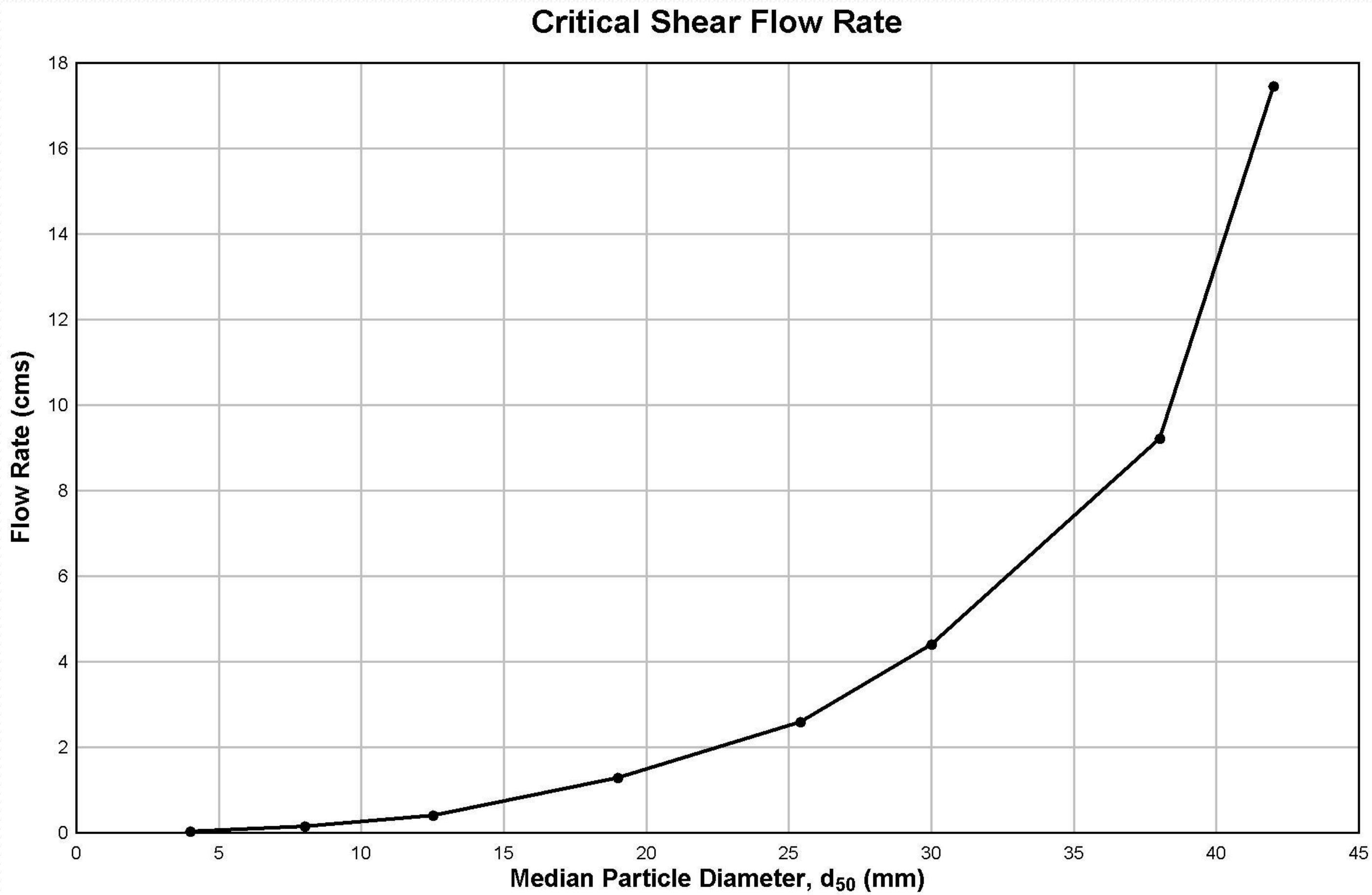
θ_c = critical Shield's parameter, 0.047

ES was defined as:

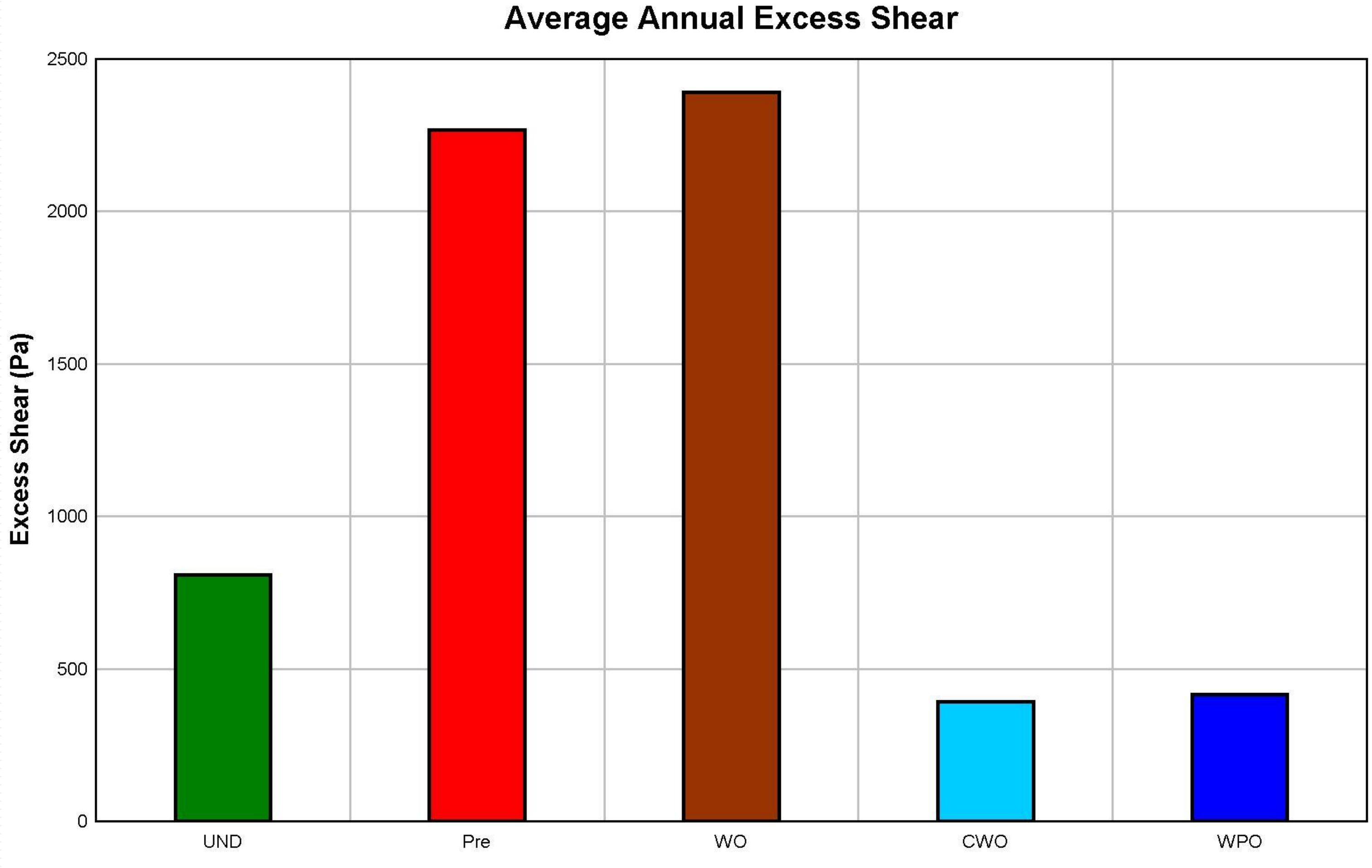
$$ES = \sum(\tau - \tau_c) \text{ for all } \tau > \tau_c$$

City of Austin WATERSHED PROTECTION

Impacts on Erosion Potential



Impacts on Erosion Potential



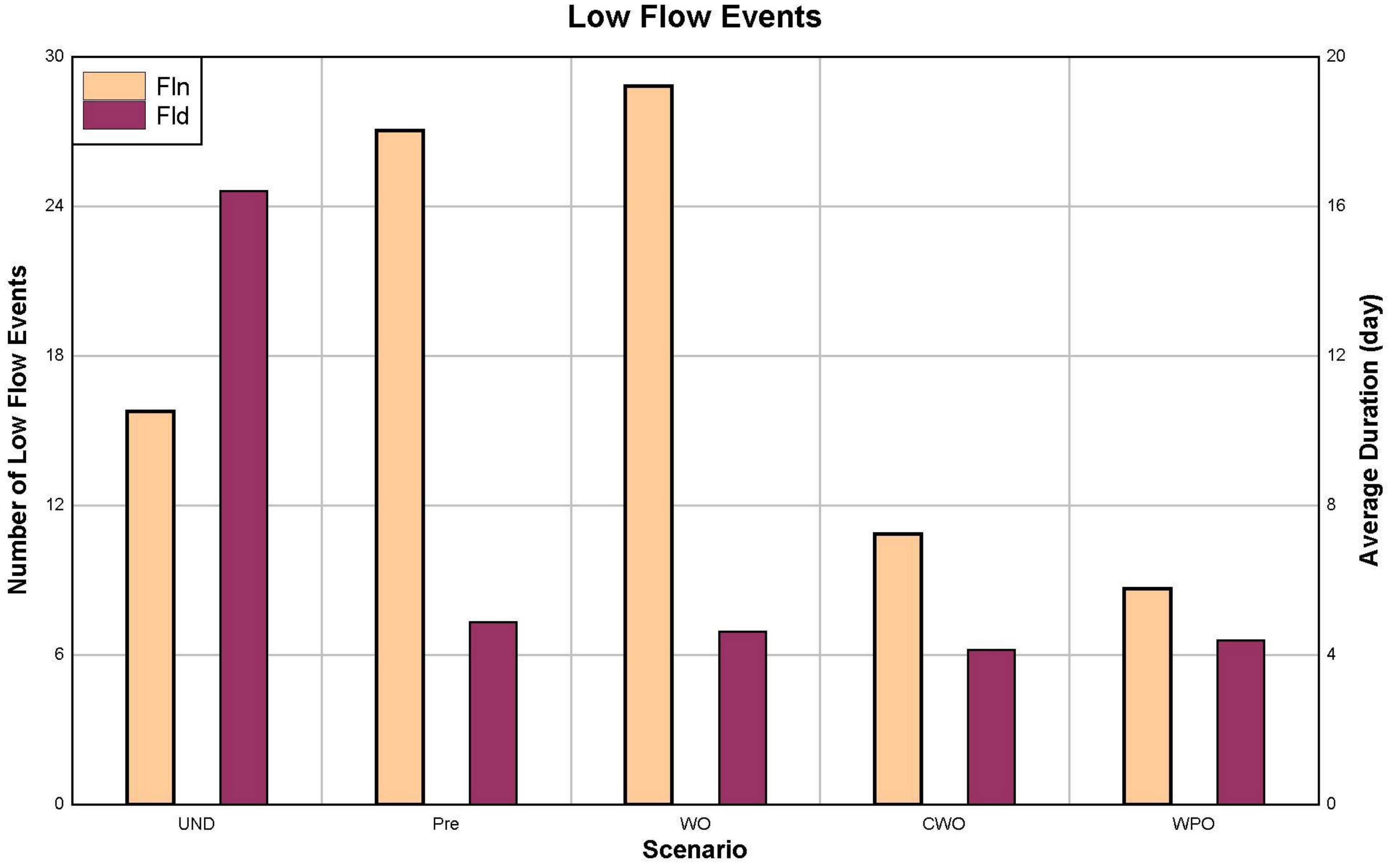
Impacts on Aquatic Life

Changes in hydrology affect aquatic live in two ways

- Changes in the wet-dry cycle interrupting species life cycles
- Increased variability affecting habitat

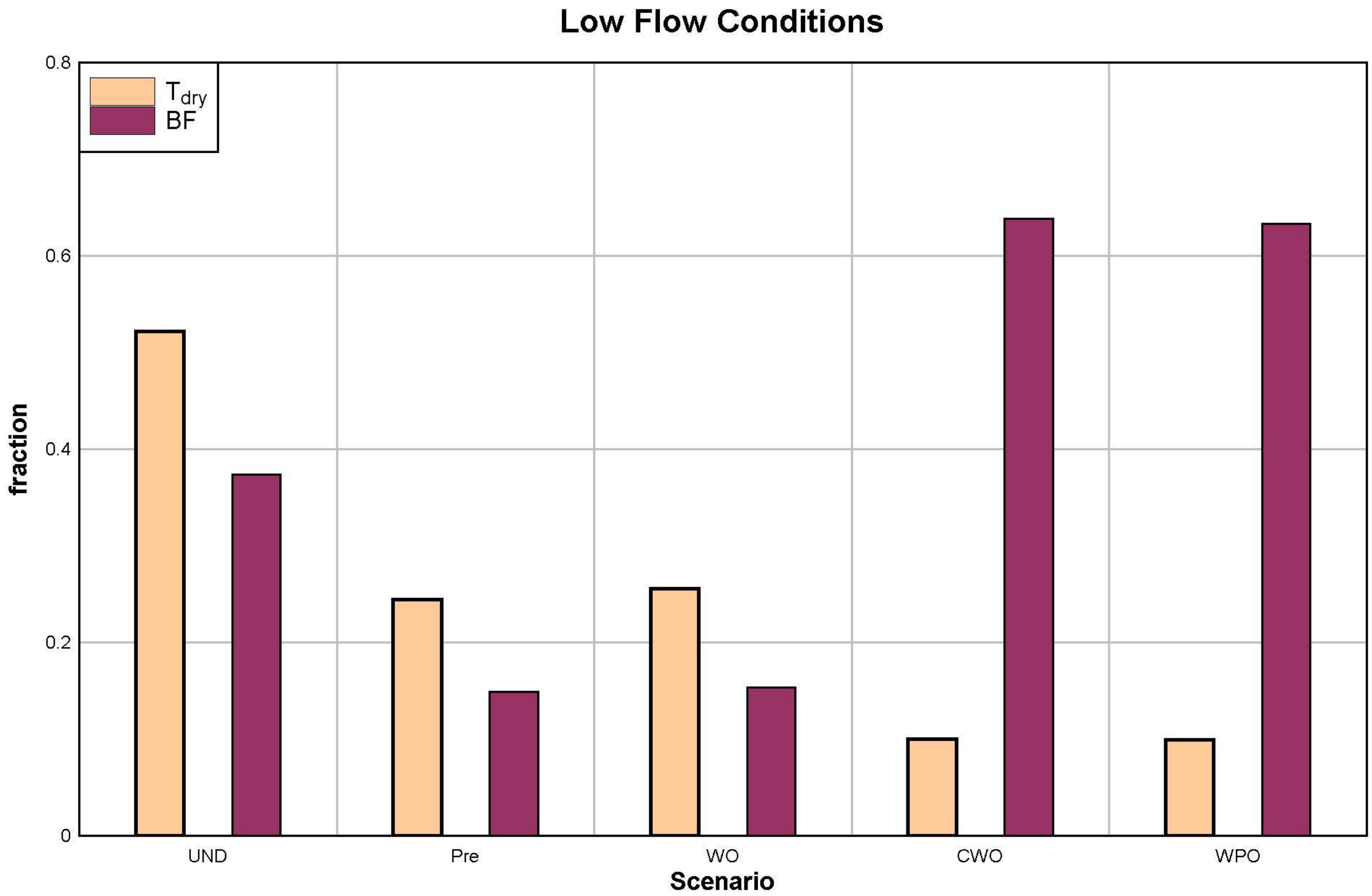
City of Austin WATERSHED PROTECTION

Impacts on Aquatic Life

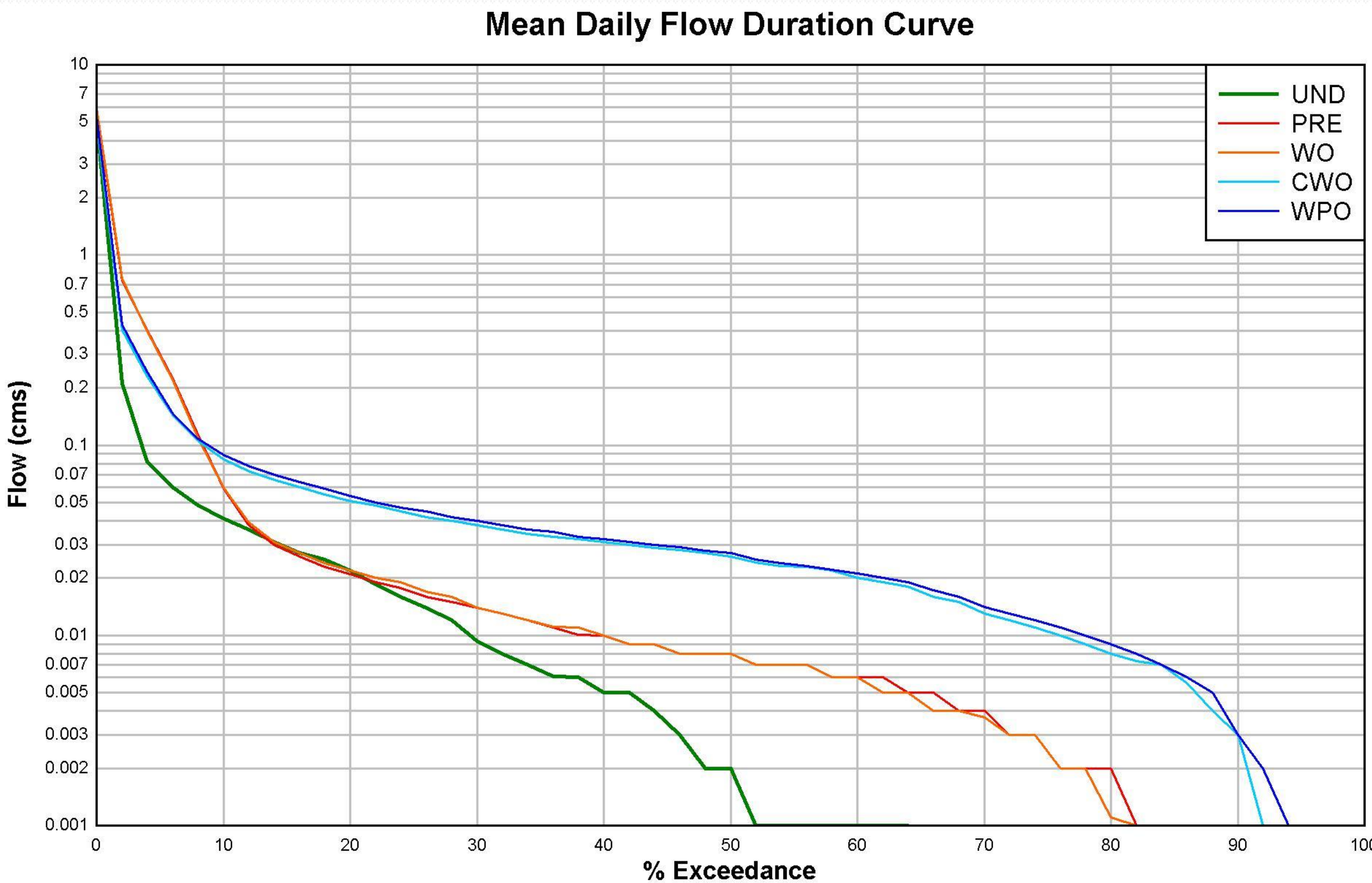


City of Austin WATERSHED PROTECTION

Impacts on Aquatic Life (cont.)

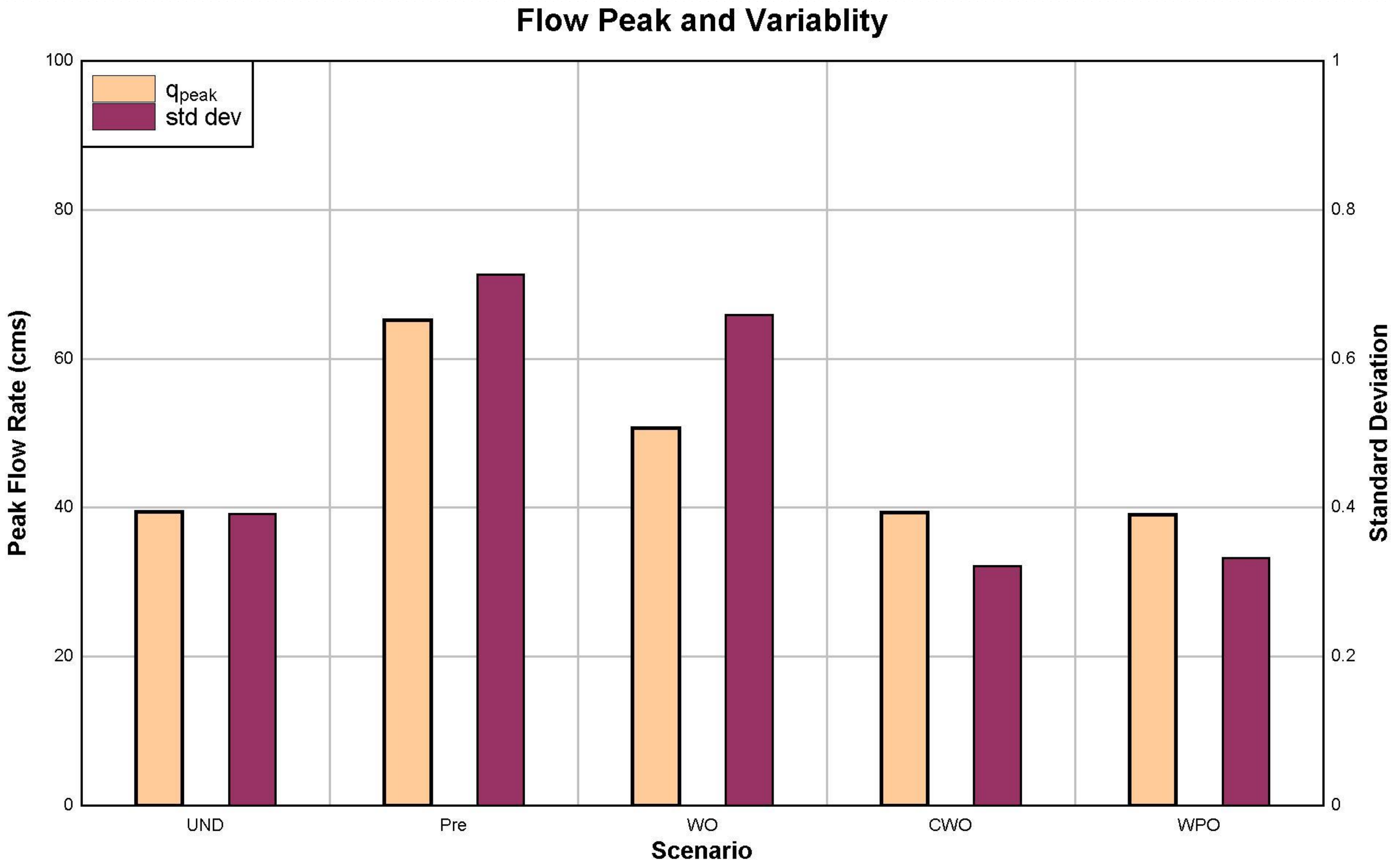


Impacts on Aquatic Life (cont.)

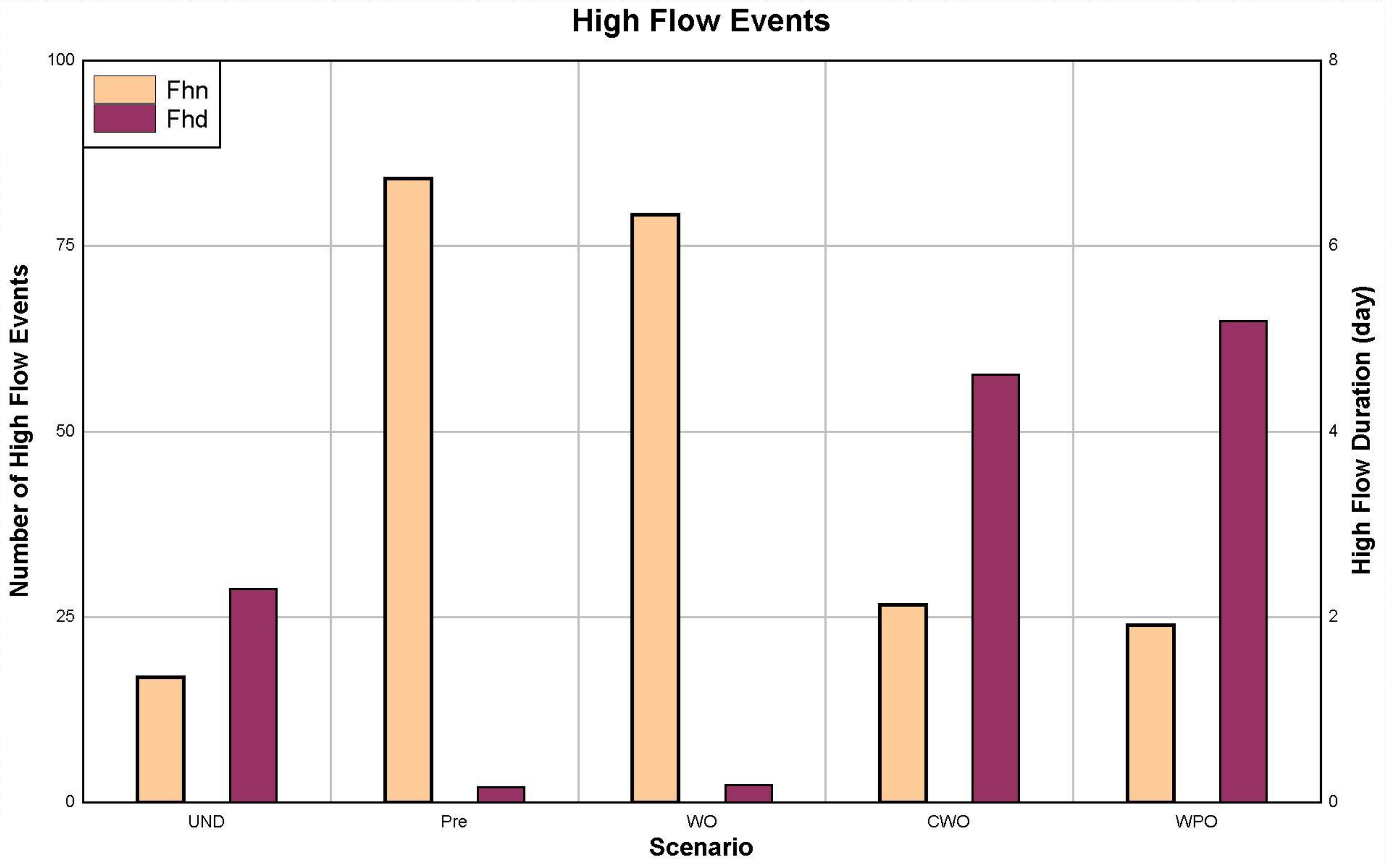


City of Austin WATERSHED PROTECTION

Impacts on Aquatic Life (cont.)

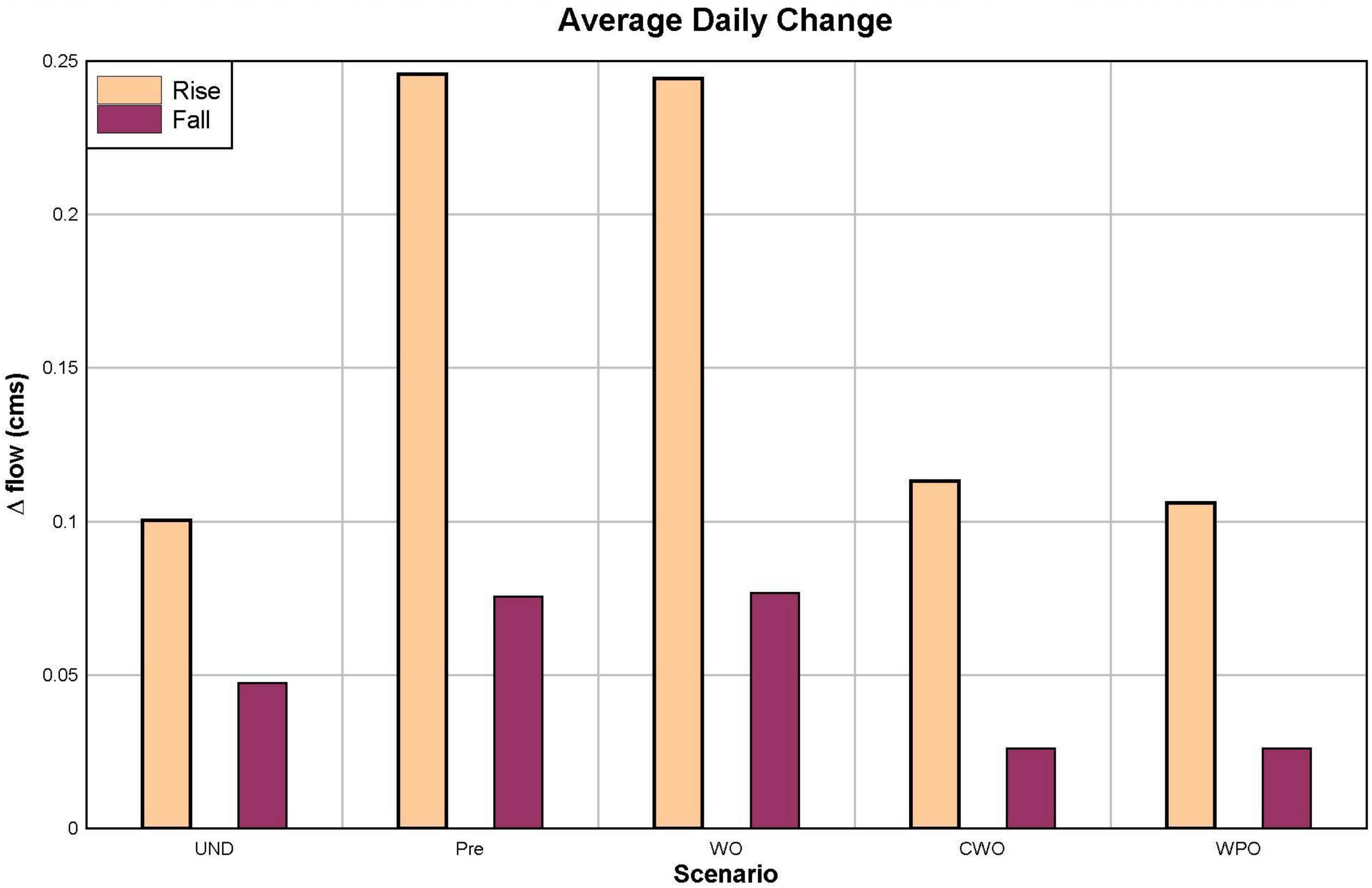


Impacts on Aquatic Life (cont.)



City of Austin WATERSHED PROTECTION

Impacts on Aquatic Life (cont.)



Conclusions

- Development prior to regulations had negative impacts on flooding, erosion and aquatic life potential.
- Detention designed for large design rainfall events will not address the increased frequency of higher flow rates.
- Flood detention alone will not address issues of erosion and aquatic life (and my be detrimental).
- Austin regulations since CWO implementation have been beneficial with respect to flooding, erosion and aquatic life potential.