Analysis of Streamflow Trends in San Jacinto River Basin, Texas

By:

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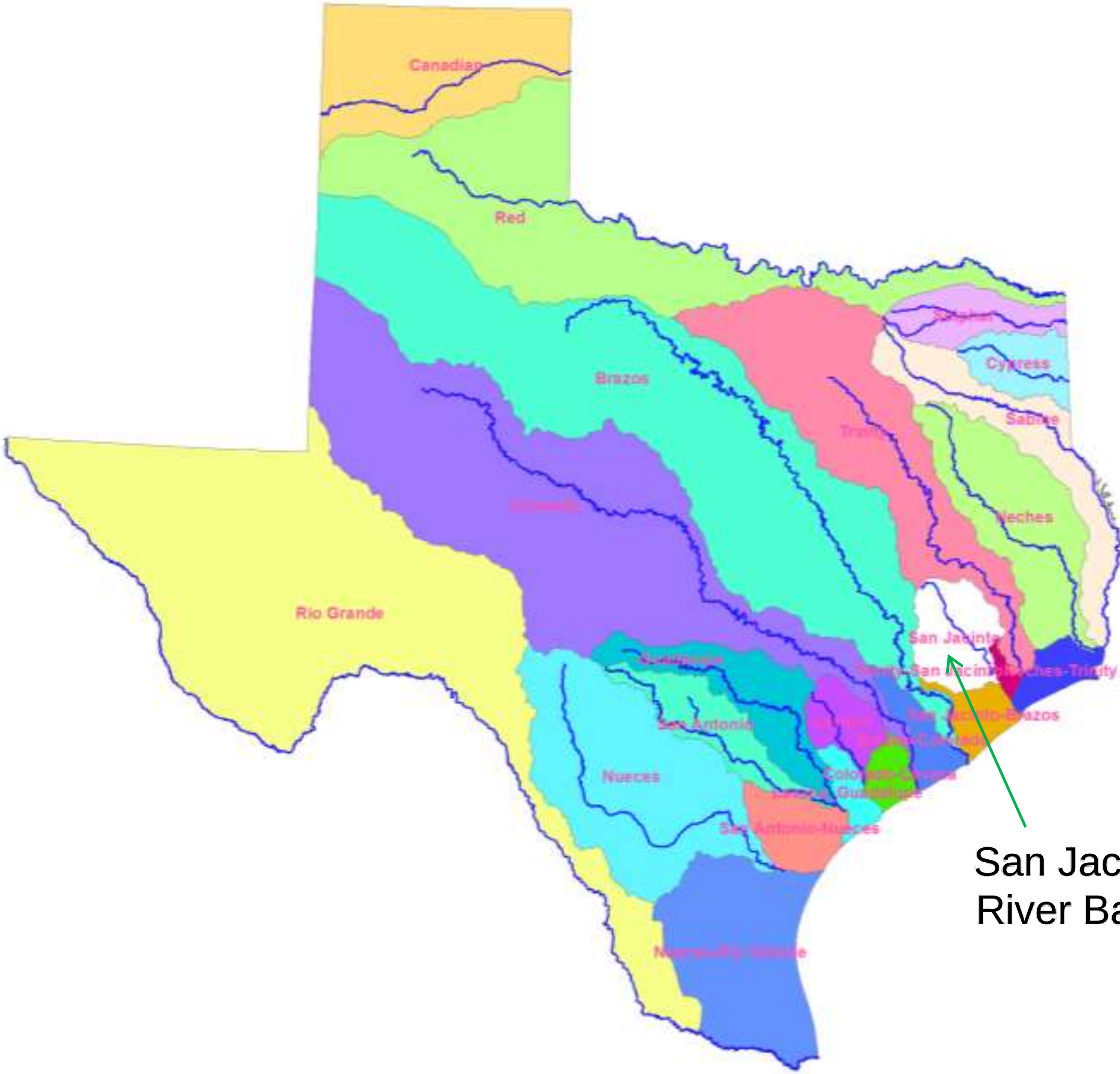
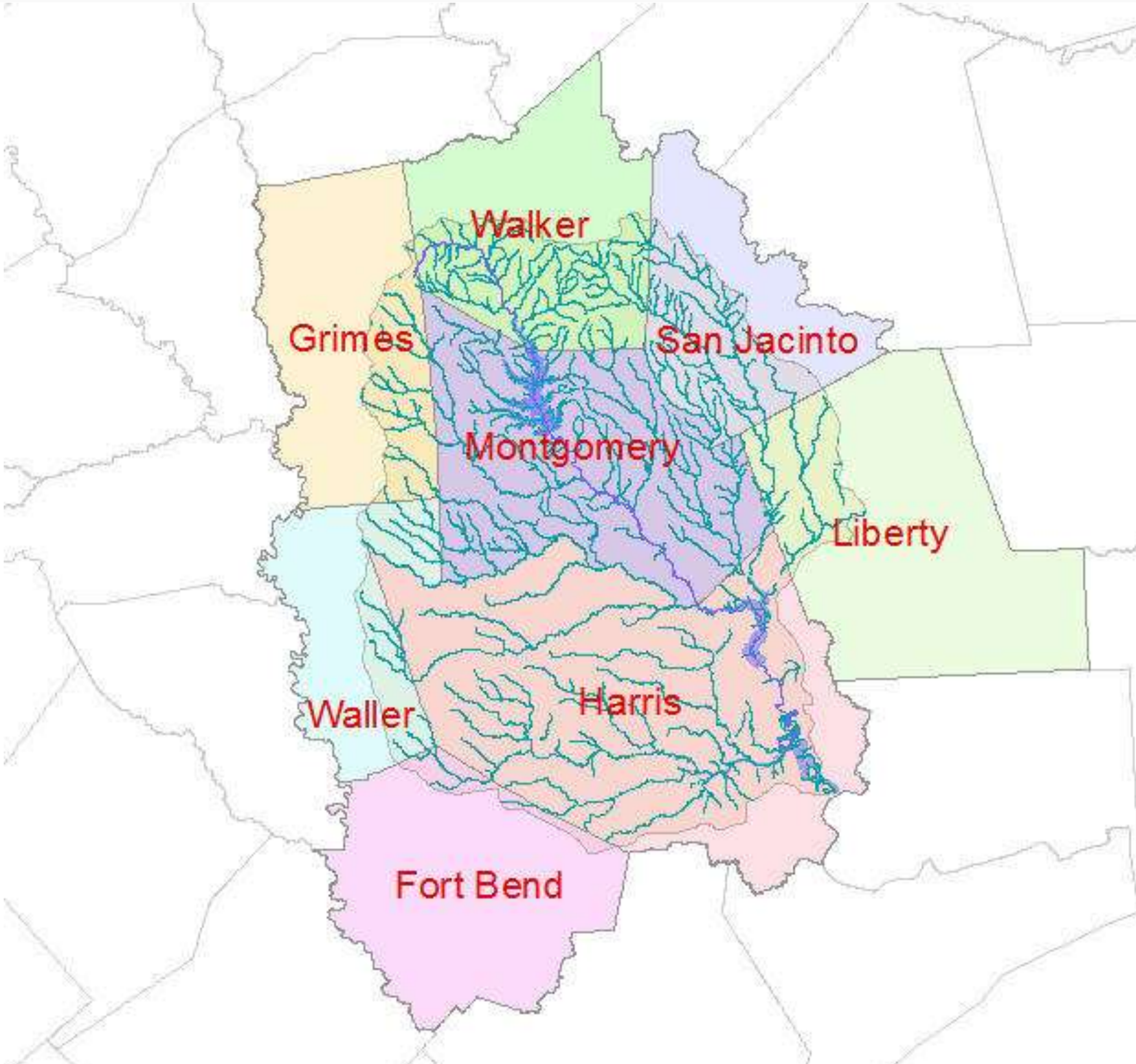
Major river basins of Texas



San Jacinto River Basin

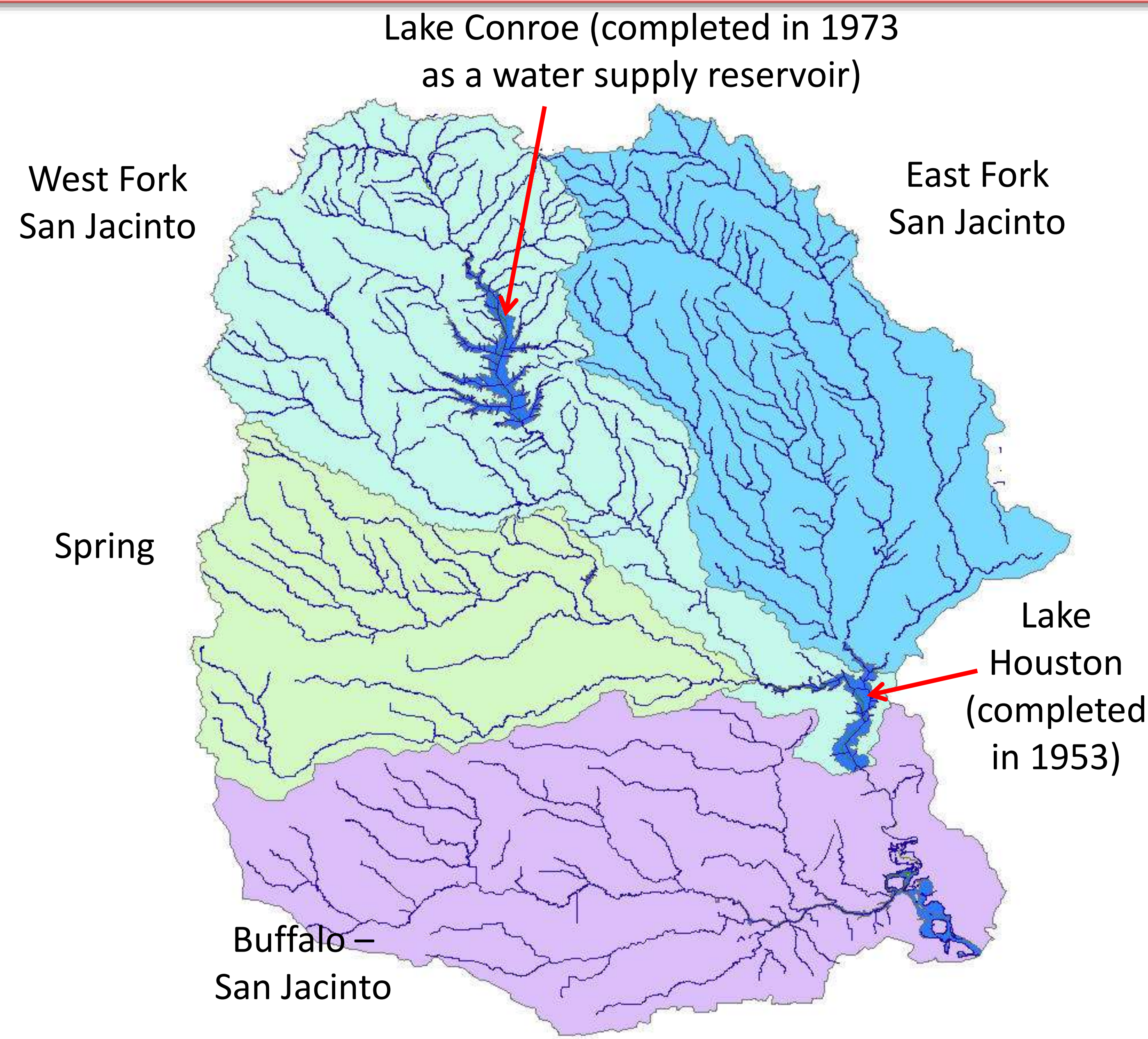
San Jacinto river basin is the second most populous basin in Texas.

San Jacinto river basin - Counties



San Jacinto river basin covers 8 counties including Harris county.

San Jacinto river basin – Major sub-basins



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Objective of the study

The information of trend of streamflow in the past several decades and future potential trends is essential for the planning of water resources in a basin scale.

The main objective of this study is to carry out trend analyses in San Jacinto river basin, Texas using the Mann-Kendall trend test for the streamflow of following time scales:

i) Annual mean daily discharge

ii) Seasonal mean daily discharge (winter, spring, summer and fall)

iii) Annual instantaneous peak discharge.

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Trend analysis of streamflow

- Data: Streamflow data from USGS, rainfall data from NOAA's NCDC, National Land Cover Data (1992 – 2011), Houston-Galveston Area Council's Regional Growth Forecast data (Population and Land use)

- Trend analyses were conducted using the Mann-Kendall trend test for the different variables:

S. No.	Variable		Number of stations
1	Annual mean daily discharge		29
2	Seasonal mean daily discharge		
		Winter (Dec - Feb)	30
		Spring (March - May)	30
		Summer (June - August)	30
		Fall (Sept - Nov)	30
3	Annual instantaneous peak discharge		43

Mann-Kendall trend test

Mann-Kendall statistic

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} Sign\left(x_j - x_i\right)$$

Variance of S

$$Var\left(S\right) = \frac{n\left(n-1\right)\left(2n+5\right)}{18}$$

Kendall’s rank correlation coefficient $\tau = \frac{S}{D}$ where, $D = \frac{n\left(n-1\right)}{2}$

(These relationships are further modified to take into account any ties presents in data)

Test statistic

$$Z = \frac{S-1}{\left[Var\left(S\right)\right]^{1/2}} \quad if \quad S > 0$$

$$Z = 0 \quad if \quad S = 0$$

$$Z = \frac{S+1}{\left[Var\left(S\right)\right]^{1/2}} \quad if \quad S < 0$$

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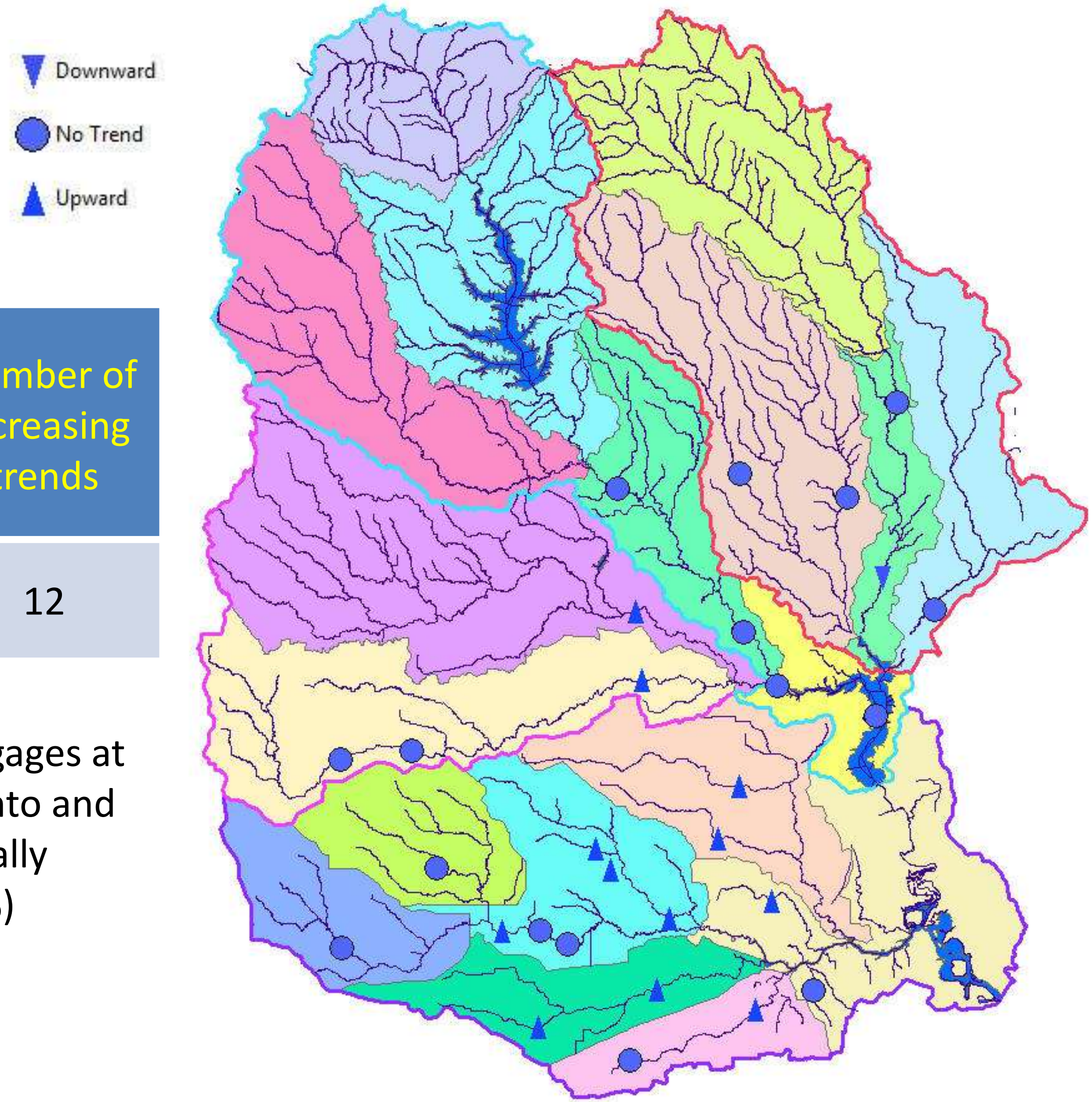
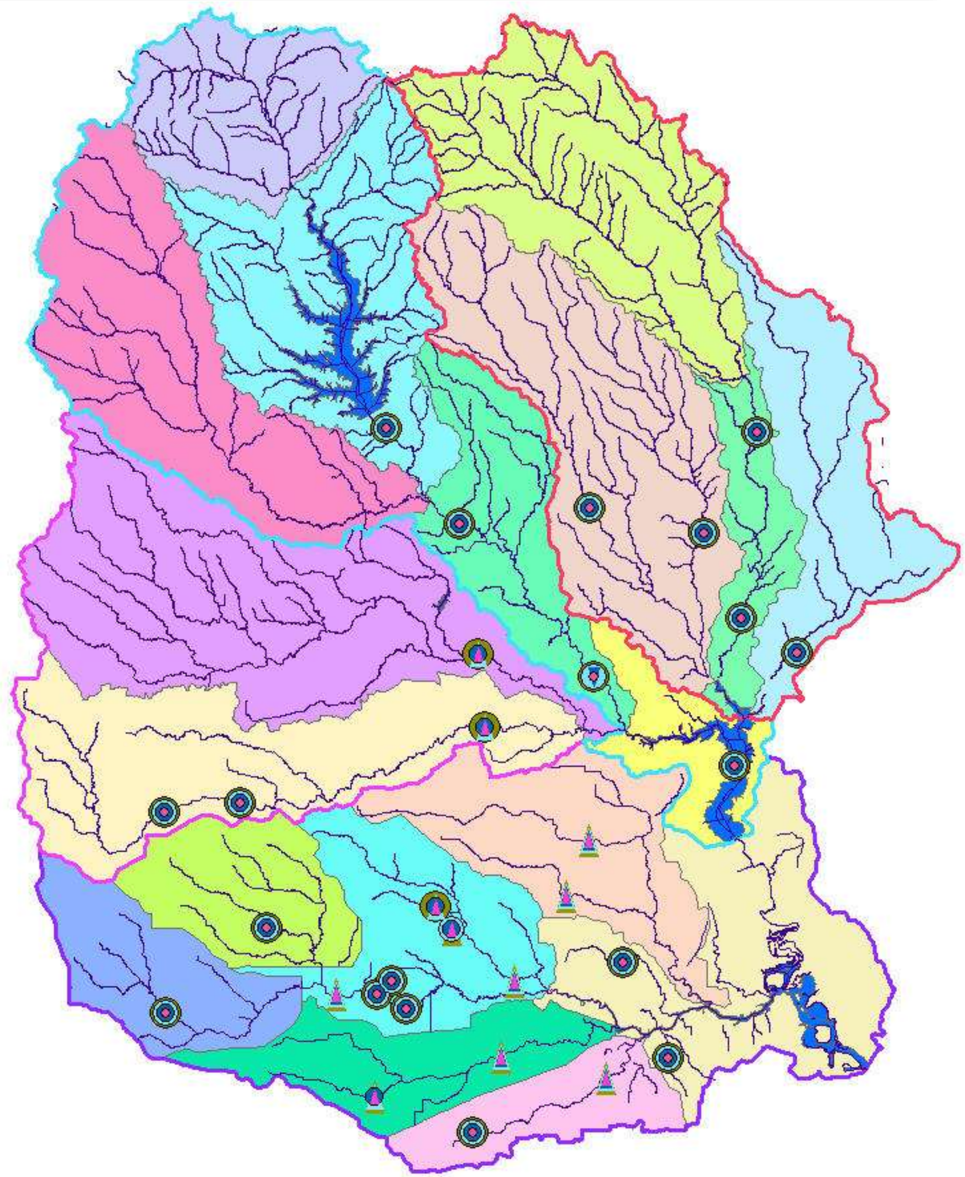
Trend analysis of annual mean daily discharge



Number of stations	Number of decreasing trends	Number of increasing trends
29	1	12

Ten and two of the streamflow gages at the urbanized Buffalo - San Jacinto and Spring sub-basins show statistically significant (significant level = 5%) upward trends.

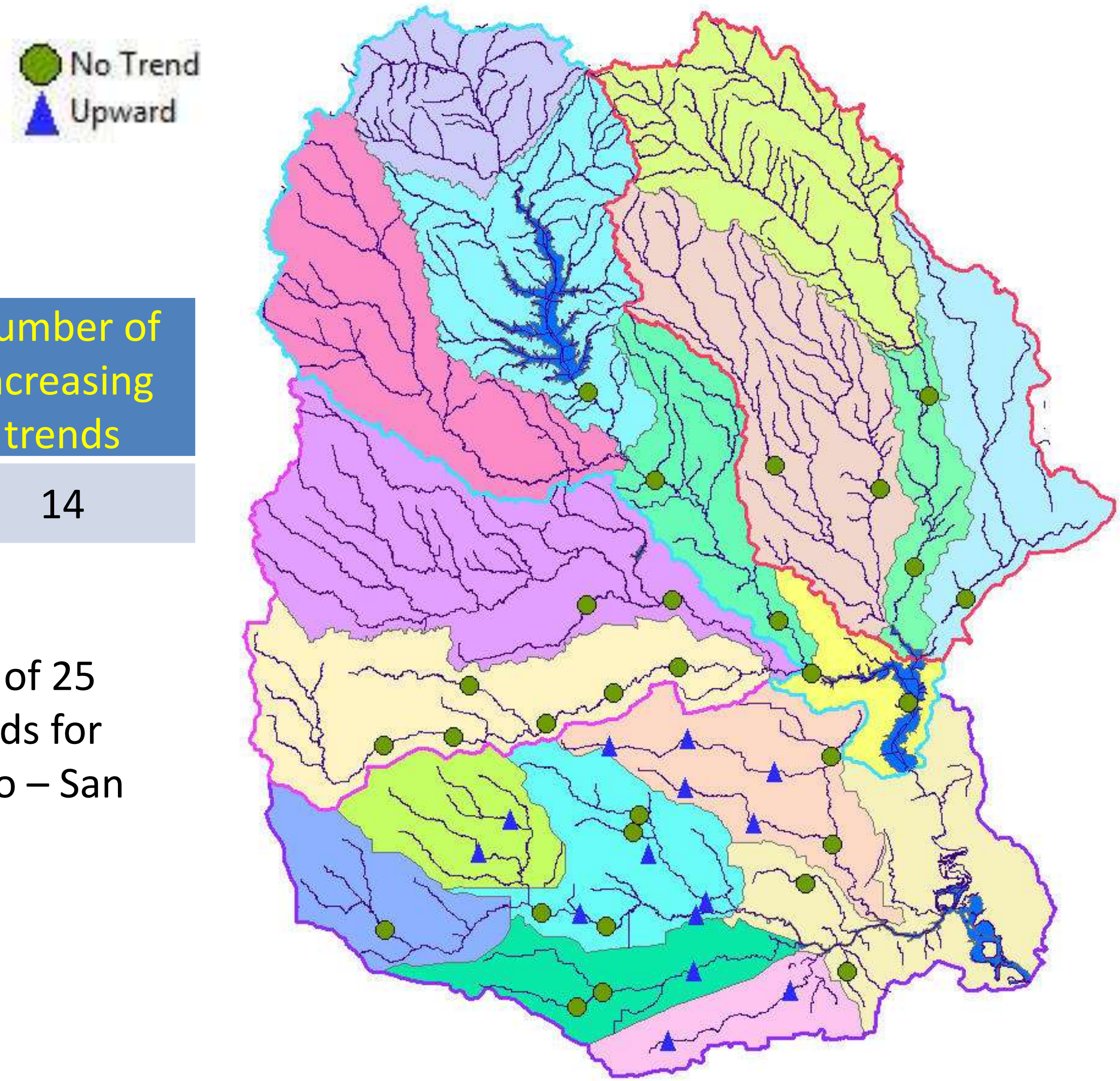
Trend analysis of seasonal mean daily discharge



Variable	No. of stations	No. of decreasing trends	No. increasing trends
Winter (Dec - Feb)	30	0	8
Spring (March - May)	30	1	6
Summer (June - August)	30	0	10
Fall (Sept - Nov)	30	0	11

Trend analysis of annual instantaneous peak discharge

Number of stations	Number of decreasing trends	Number of increasing trends
43	0	14



Fourteen streamflow gages out of 25 showed significant upward trends for annual peak discharge in Buffalo – San Jacinto sub-basin.

Summary of trend analysis

Variable	Number of stations	Number of decreasing trends	Number of increasing trends	Percent significant trends
Annual mean daily discharge	29	1	12	44.8
Seasonal mean daily discharge				
Winter (Dec - Feb)	30	0	8	26.7
Spring (March - May)	30	1	6	23.3
Summer (June - August)	30	0	10	33.3
Fall (Sept - Nov)	30	0	11	36.7
Annual instantaneous peak discharge	43	0	14	32.6

Among different analyzed variables, "annual mean daily discharge" has highest percentage of significant trends (44.8%) and "Seasonal mean daily discharge – Spring" has lowest percentage of significant trends (23.3%).

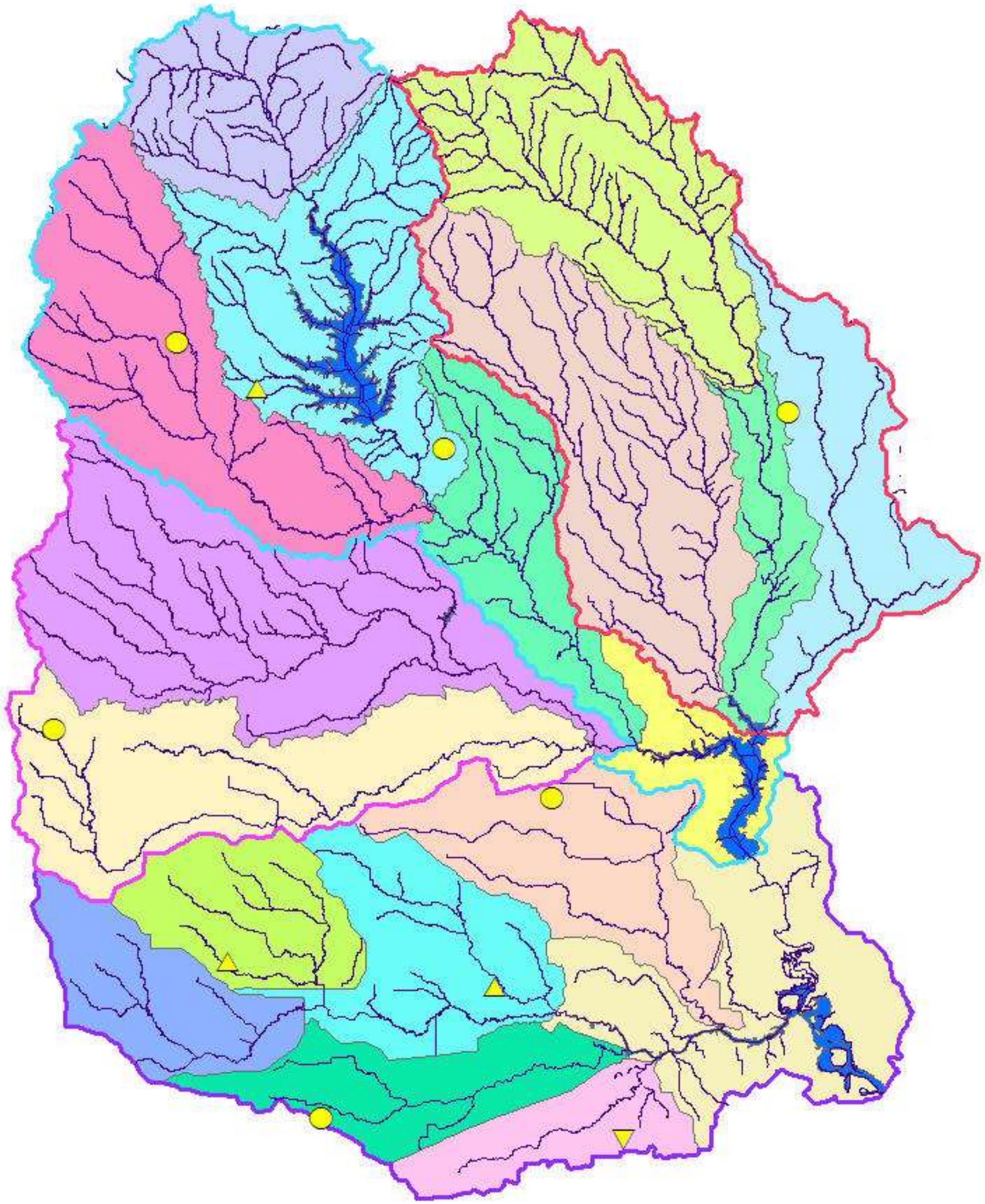
Potential factors for trends in streamflow

The trends in these streamflow data could be due to one or more of the following potential factors:

- changes in precipitation
- landuse change
- groundwater use
- inter-basin water transfer etc.

Trend analysis of annual rainfall

Number of stations	Number of decreasing trends	Number of increasing trends
10	1	3



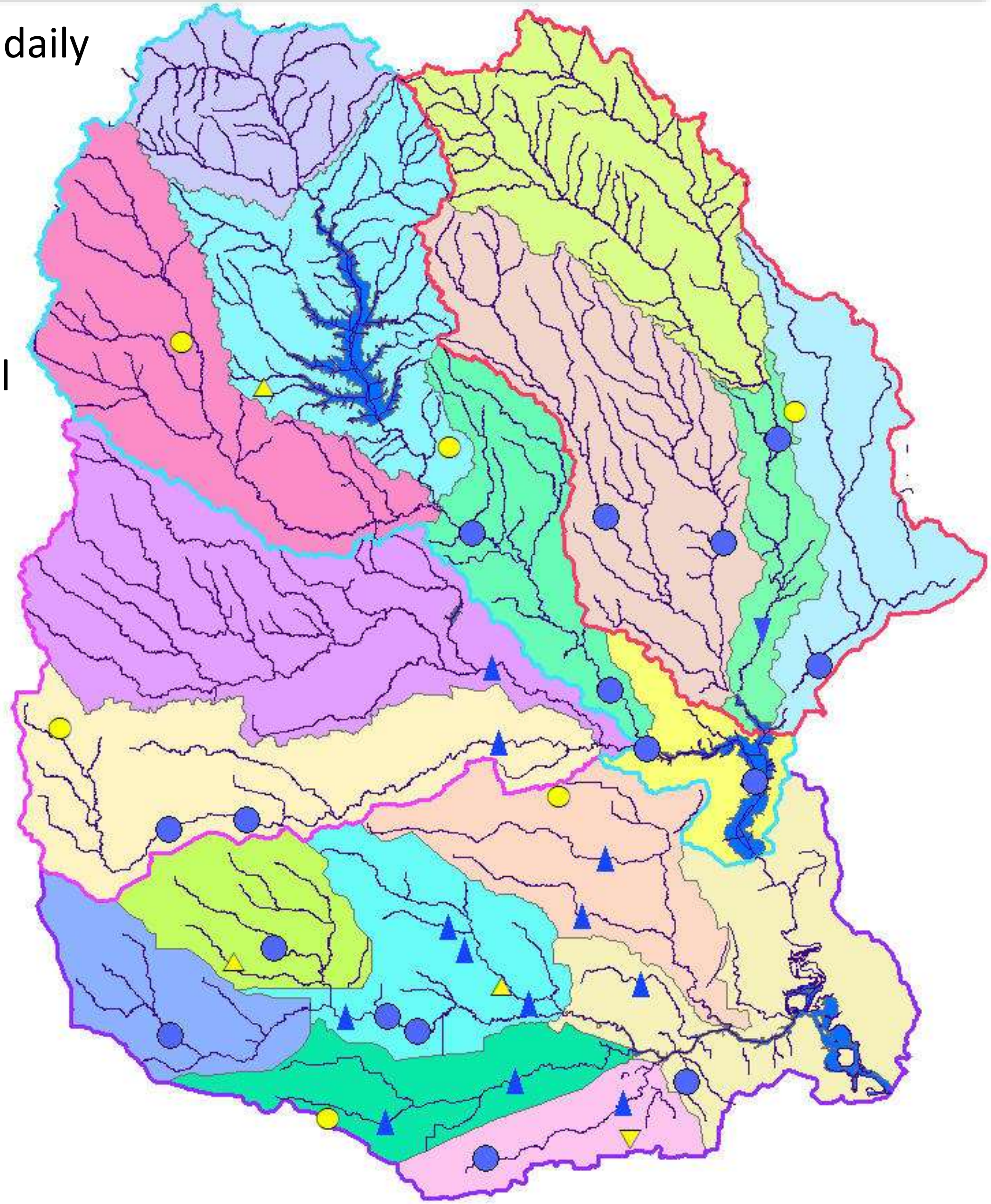
Trend analysis of annual mean daily discharge & annual rainfall

Annual mean daily discharge

- Downward
- No Trend
- Upward

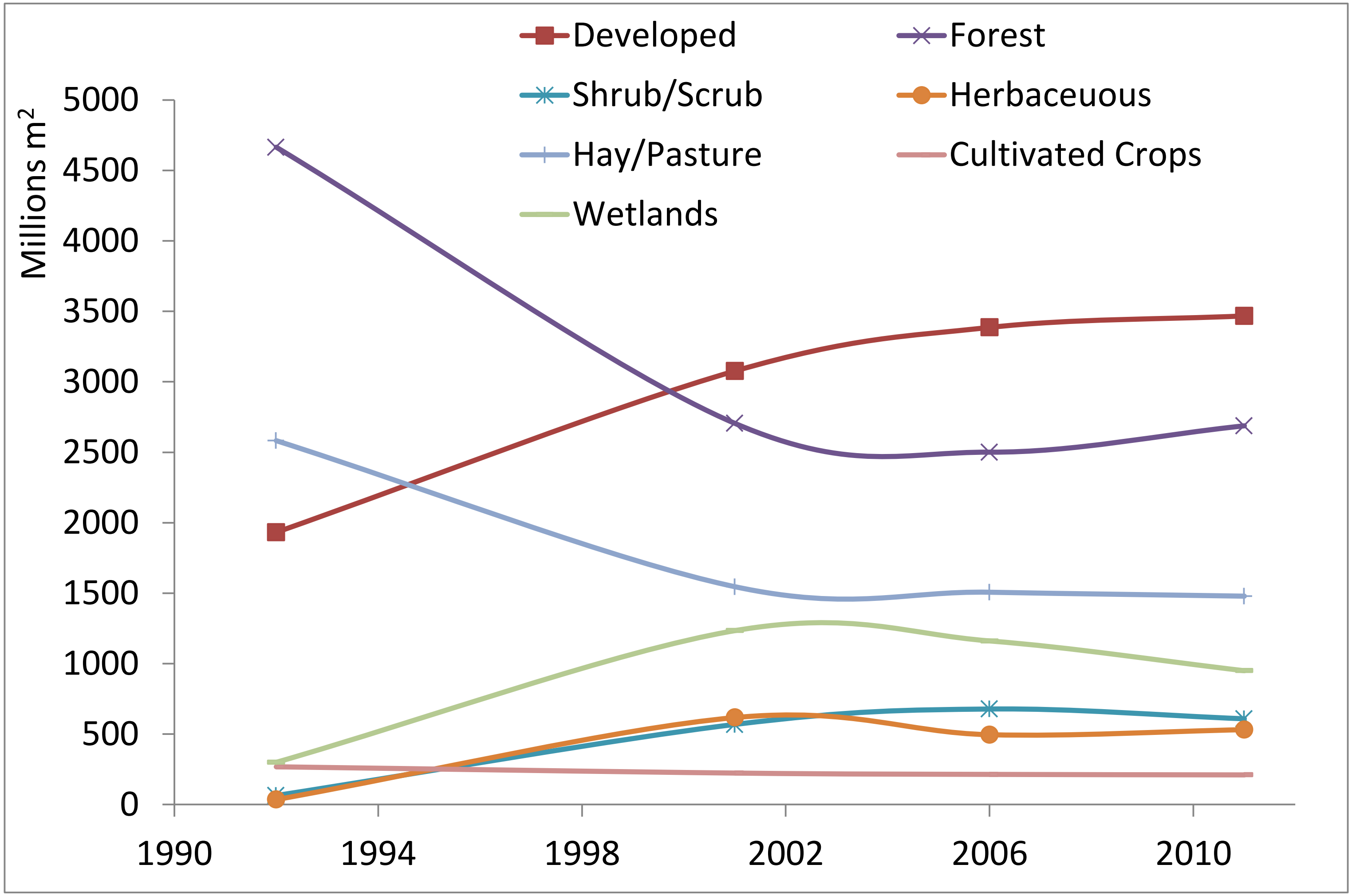
Annual Rainfall

- Downward
- No trend
- Upward



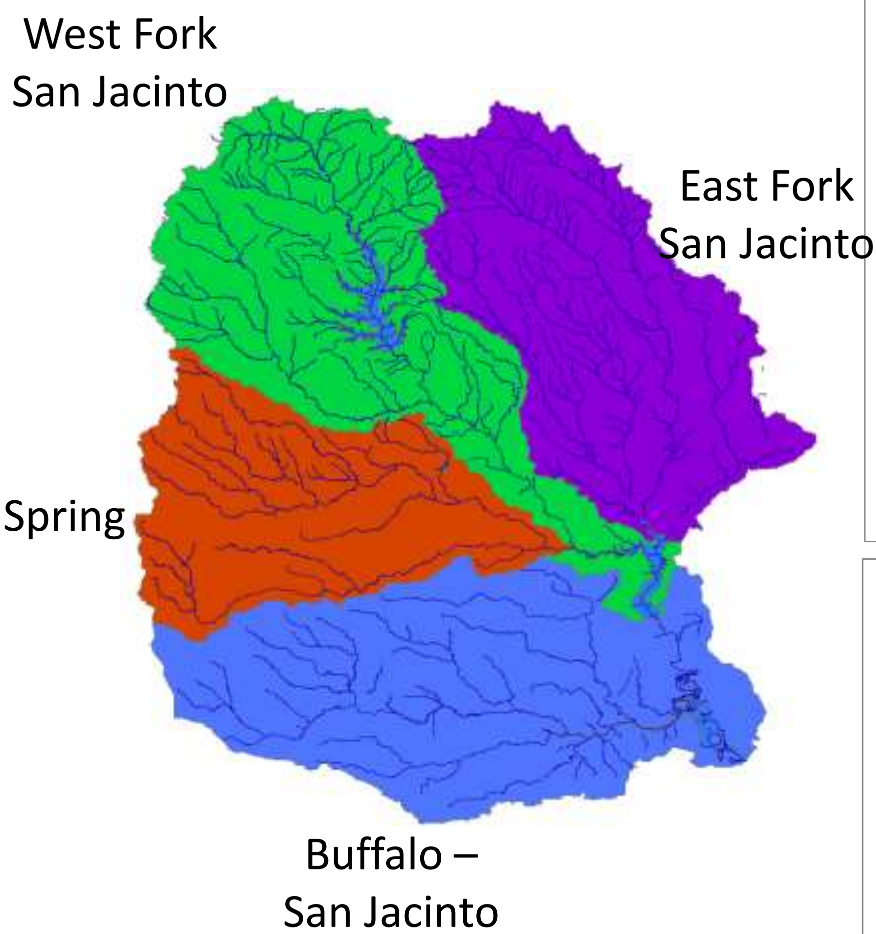
➢ There is no consistent trend in "annual mean daily discharge" and "annual rainfall" in most of the analyzed stations.

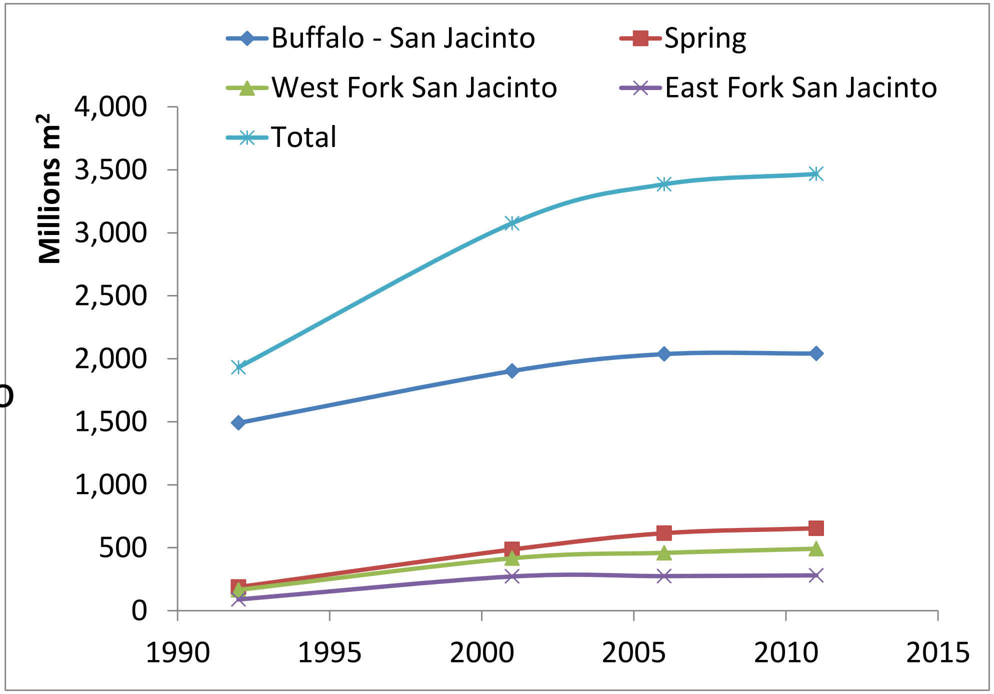
Changes in land cover based on National Land Cover Data (1992 – 2011)

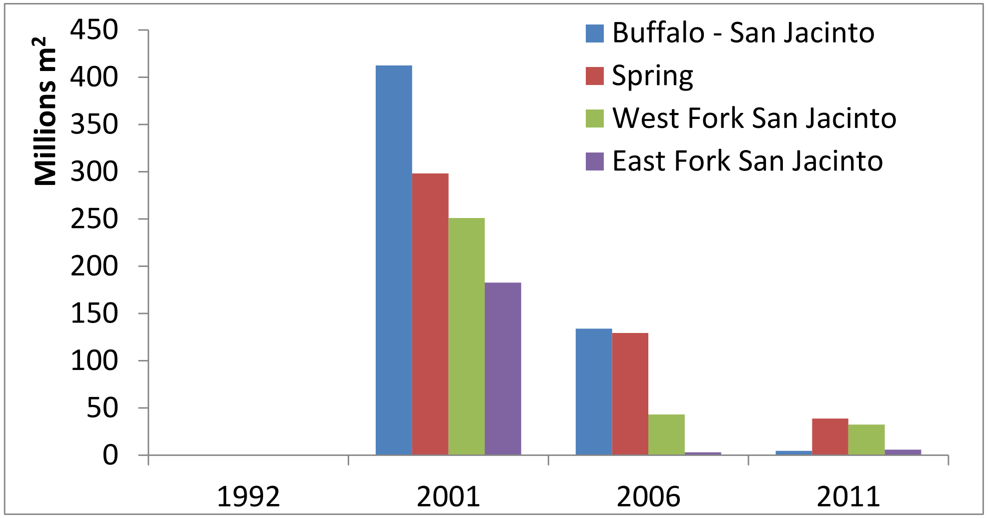


Developed areas are increasing; however, there is a significant decrease in the forested and hay/pasture areas across the basin

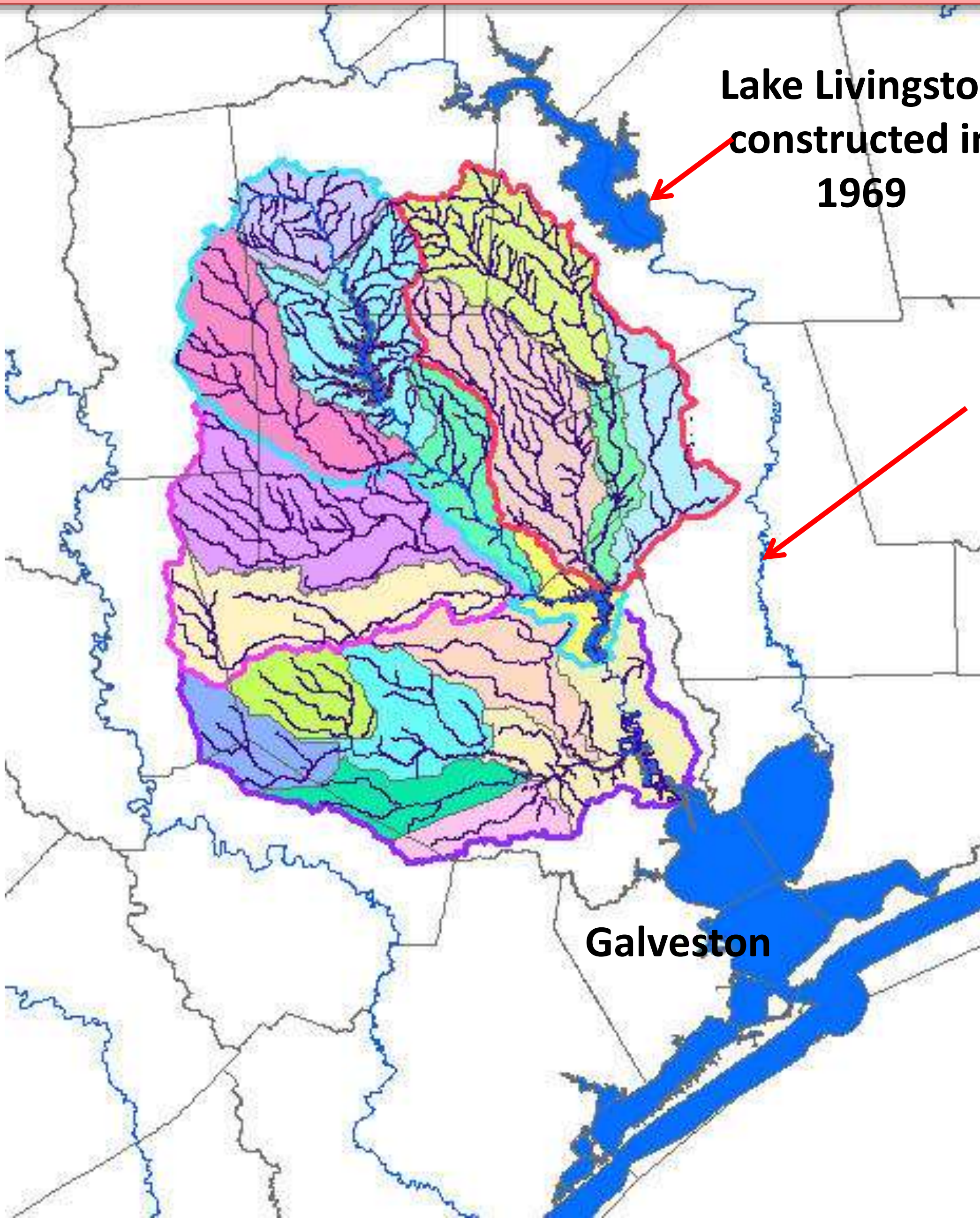
Changes in developed area based on National Land Cover Data (1992 – 2011)







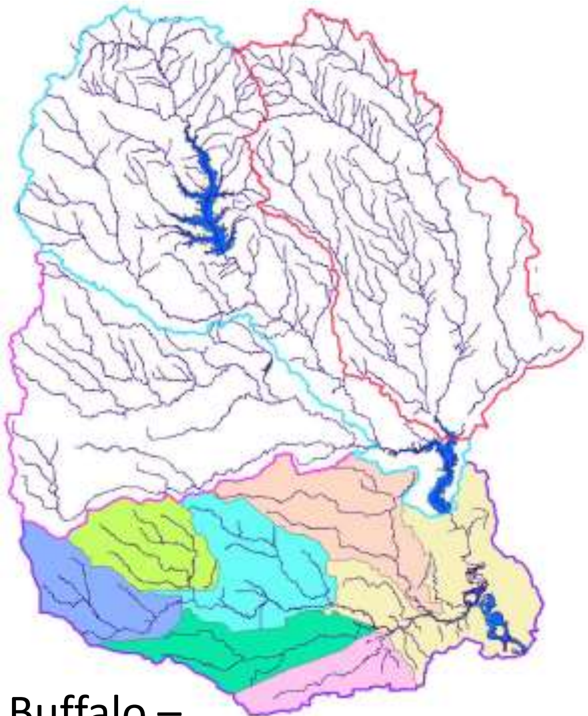
Inter-basin water transfer from Lake Livingston



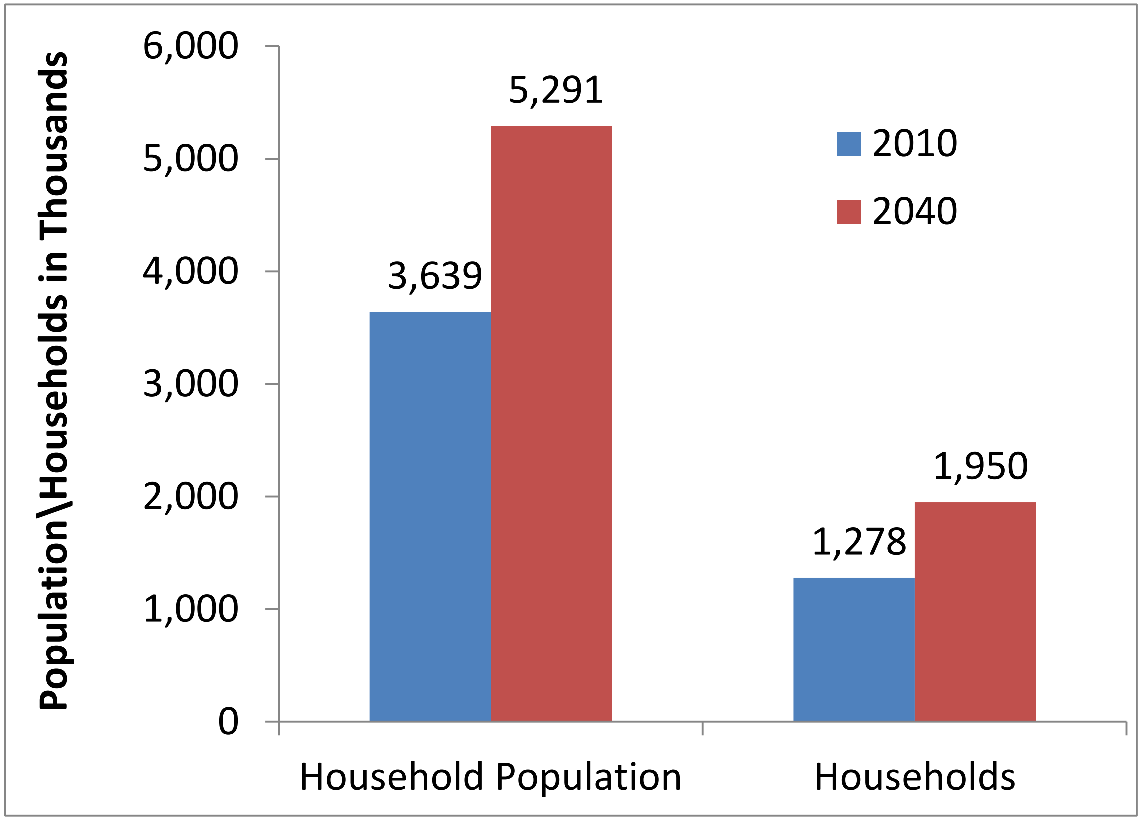
Water stored in the lake Livingston is used to supply industrial, municipal and agricultural needs in the lower Trinity River Basin and the Houston/Galveston metropolitan area.

2040 Regional Growth Forecast: Population

[Based on Houston-Galveston Area Council's (H-GAC) Regional Growth Forecast]



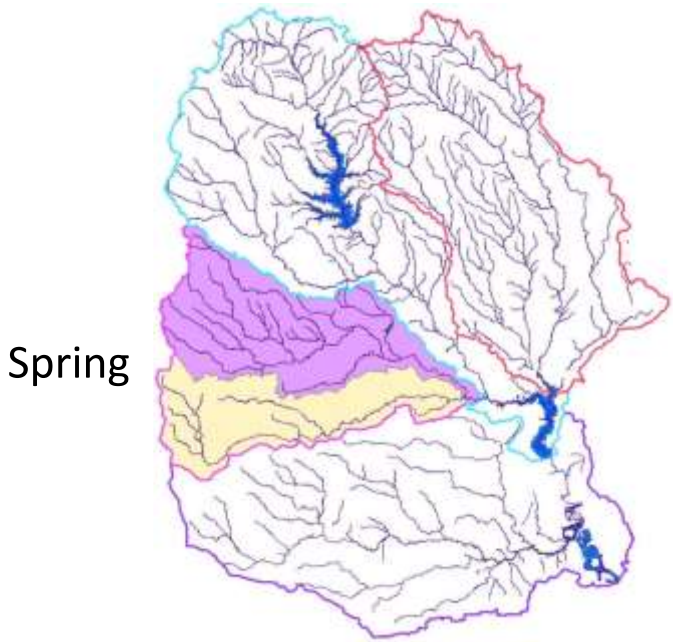
Buffalo – San Jacinto

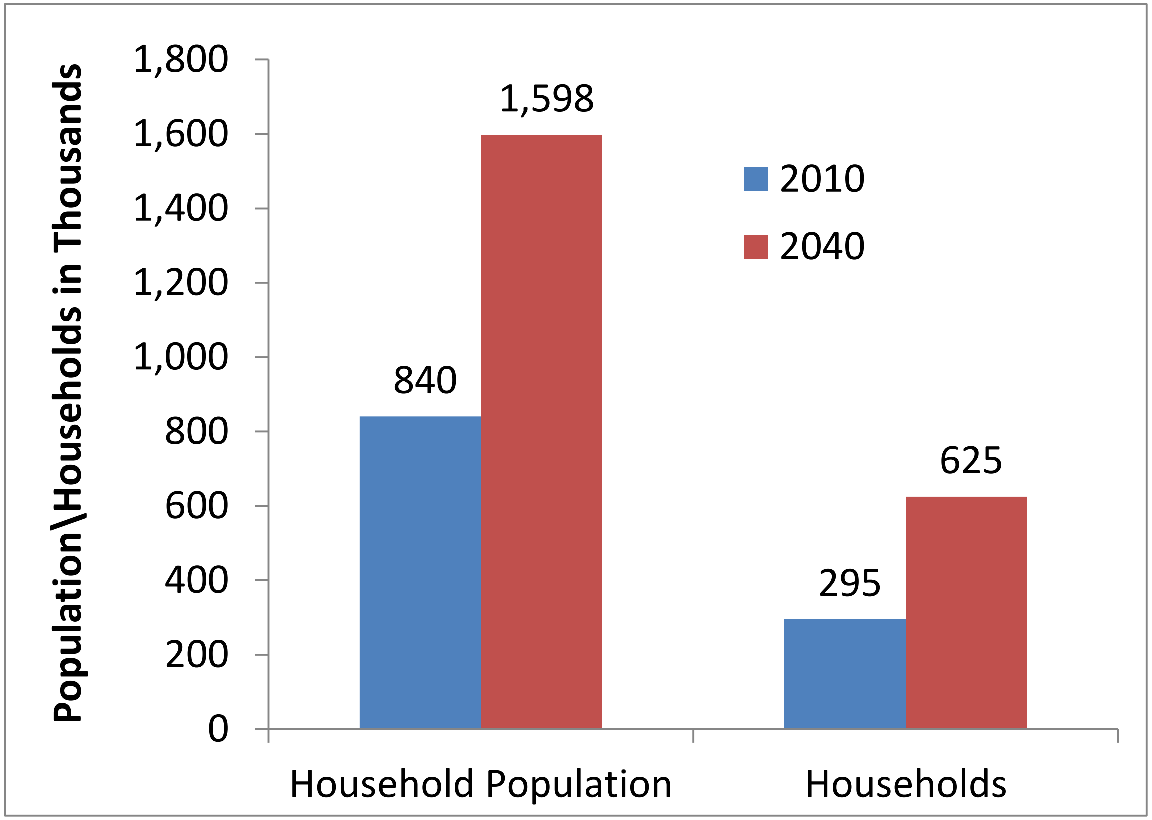


Forecasted population growth in Buffalo – San Jacinto sub-basin : 45% increase

2040 Regional Growth Forecast: Population

[Based on Houston-Galveston Area Council's (H-GAC) Regional Growth Forecast]





Forecasted population growth in Spring sub-basin: 90% increase

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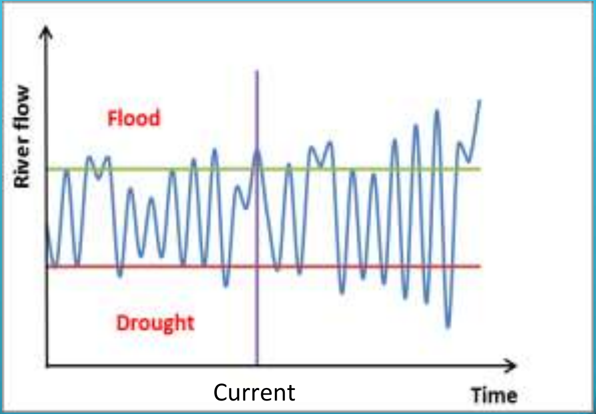
Summary

- This study presents results of basin wide streamflow trend detection in San Jacinto River basin, the second most populous basin in Texas.
- Among different analyzed variables, "annual mean daily discharge" has highest percentage of significant trends (44.8%) and "Seasonal mean daily discharge – Spring" has lowest percentage of significant trends (23.3%).
- There is no consistent trend in "annual mean daily discharge" and "annual rainfall" in most of the analyzed stations.
- The analysis of changes in land cover using National Land Cover Data (1992 – 2011) showed that the urbanized areas are increasing; however, there is a significant decrease in the forested and hay/pasture areas across the basin.

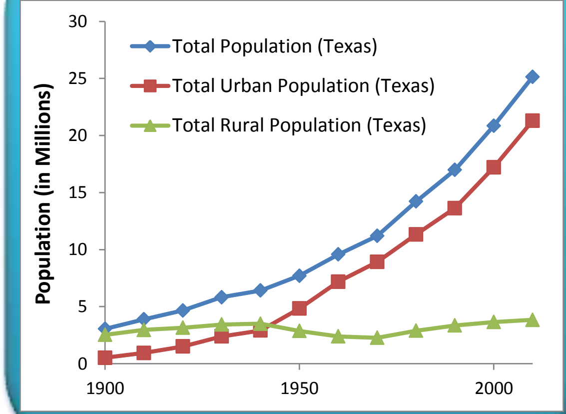
Future works

➢ Further analysis is required to determine the effect of other factors.

Climate change

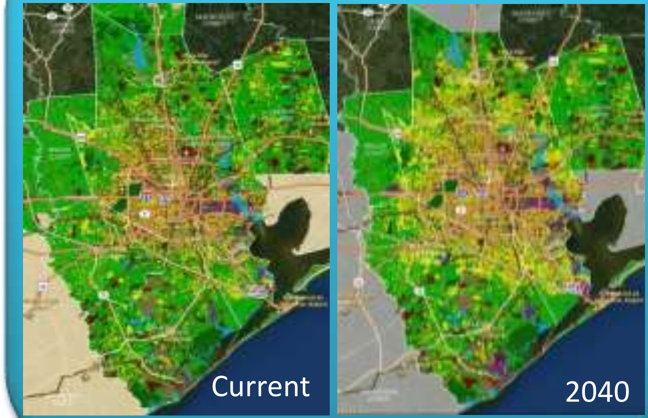


Anthropogenic change



(Data Source: US Census Bureau)

Land use change



(Source: http://arcgis02.h-gac.com/RLUIS/)

- Hydrological modeling to predict future potential trends in streamflow across the basin
- Estimation of streamflow, sediment and nutrient loading to the lakes
- Analysis of impact on hydrological processes, water resources and environment

Acknowledgements

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USDA NIFA

United States Department of Agriculture
National Institute of Food and Agriculture