North Central Texas Council of Governments

# Project Update Meeting

## Breakout Station 2: Optimization

September 2024

Funded by the Texas General Land Office, Community Development Block Grant, Disaster Recovery Program.

Also Funded by the Texas Water Development Board and Texas Department of Transportation.

# TSI Optimization Overview

- The optimization study aims to model ideal **location and sizing** for detention ponds and consider potential alternatives (e.g., GSI/NBS) **to reduce downstream flows** due to anticipated changes in imperviousness, using updated HEC-HMS models.
- The study considers input from the transportation (facilities at risk, vulnerable areas) and environmental (GSI/NBS, flood-prone areas) perspectives.
  - Specifically, the GSI and NBS suitability index helps to provide a foundation for where GSI/NBS can be proposed.

# GSI/NBS Suitability Index (GIS Stacking Model)

## Environmental

**Topographical**
Elevation, Slope, Aspect, Curvature, TWI, TRI

**Meteorological**
Rainfall intensity, Temperature

**Land use/cover**
NDVI, Curve number, NRCS BMPs

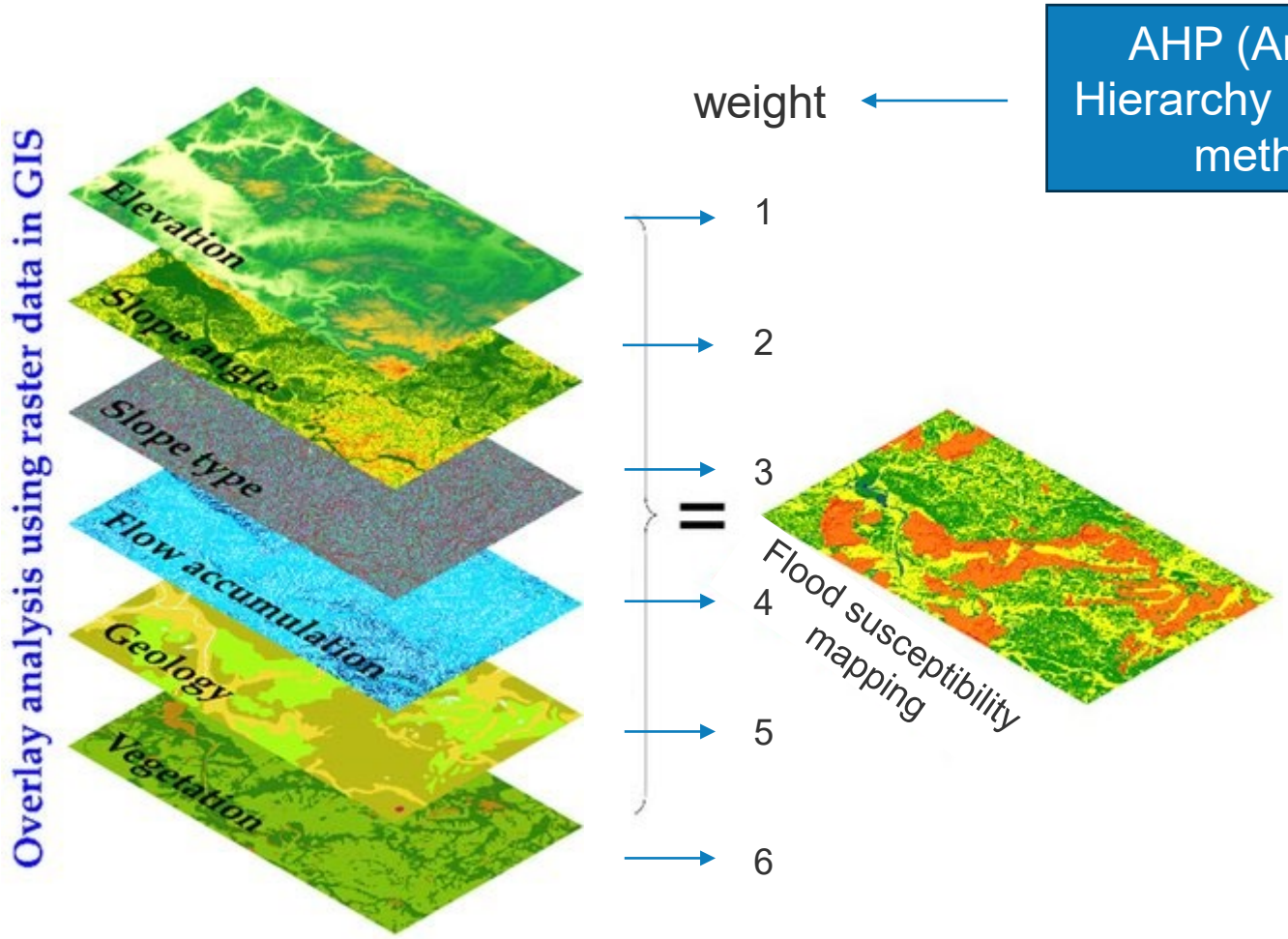
**Hydromorphological**
Distance from river, Stream density, Time of concentration

## Socio-economical

Social vulnerability index, Population density

## Infrastructural

Distance from transportation network, Distance from detention pond, Distance from USGS streamflow monitoring gauges



# GSI/NBS Suitability Index (GIS Stacking Model)

AHP (Analytic Hierarchy Process) method

Fundamental scale for pairwise comparison in AHP.

| The scale of relative importance | Definition |
|---|---|
| 1 | Equal importance |
| 3 | Moderate importance |
| 5 | Strong importance |
| 7 | Very strong importance |
| 9 | Extreme importance |
| 2,4,6,8 | Intermediate values |

Comparison matrix

Pairwise comparison of flood causative parameters.

| Parameter | *SDP* | *FA* | *DD* | *PR* | *EL* | *SL* | *NDVI* | *LUC* |
|---|---|---|---|---|---|---|---|---|
| *SDP* | 1 | 1/3 | 1/3 | 1/3 | 1/4 | 1/3 | 2 | 1/3 |
| *FA* | 3 | 1 | 2 | 1/2 | 1/3 | 1/2 | 3 | 2 |
| *DD* | 3 | 1/2 | 1 | 1/2 | 1/3 | 1/2 | 3 | 2 |
| *PR* | 3 | 2 | 2 | 1 | 1/2 | 1/2 | 3 | 2 |
| *EL* | 4 | 3 | 3 | 2 | 1 | 2 | 5 | 4 |
| *SL* | 3 | 2 | 2 | 2 | 1/2 | 1 | 3 | 3 |
| *NDVI* | 1/2 | 1/3 | 1/3 | 1/3 | 1/5 | 1/3 | 1 | 1/3 |
| *LUC* | 3 | 1/2 | 1/2 | 1/2 | 1/4 | 1/3 | 3 | 1 |
| **Sum** | **20.5** | **9.666** | **11.166** | **7.166** | **3.366** | **5.499** | **23** | **14.666** |

*SDP* = Soil Drainage Profile, *FA* = Flow Accumulation, *DD* = Drainage Density, *PR* = Proximity to a river, *EL* = Elevation, *SL* = Slope, *NDVI* = Normalized Difference Vegetation Index, *LUC* = Land use/cover

Parameter weights for weighted sum analysis.

| Parameter | Criteria Weight | Relative Weight (%) |
|---|---|---|
| Soil Drainage Profile | 0.05 | 5 |
| Flow Accumulation | 0.12 | 12 |
| Drainage Density | 0.10 | 10 |
| Proximity to a river | 0.15 | 15 |
| Elevation | 0.28 | 28 |
| Slope | 0.18 | 18 |
| Normalized Difference Vegetation Index | 0.04 | 4 |
| Land use/cover | 0.08 | 8 |
| **Sum** | **1** | **100** |

Mathematical operation

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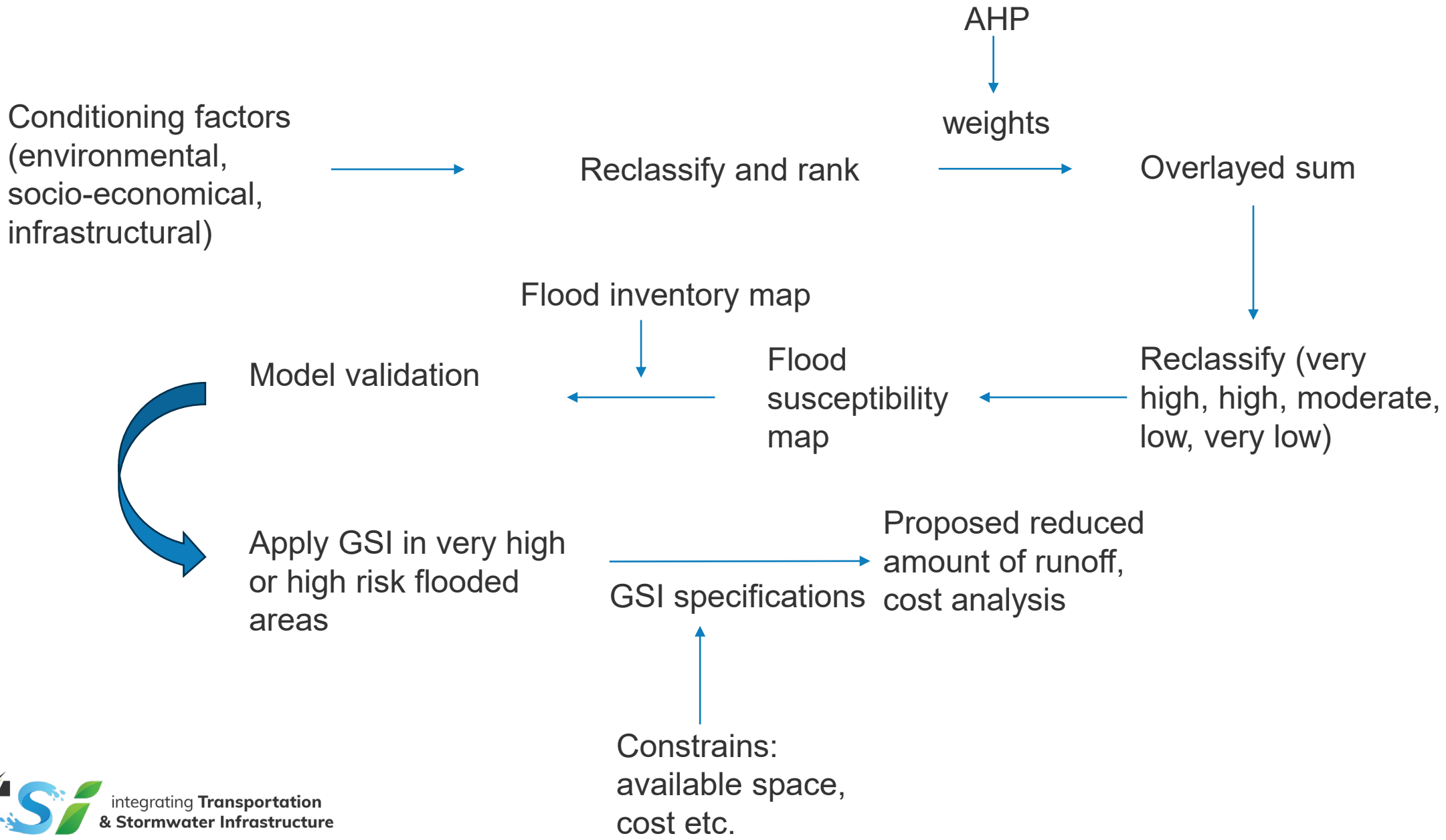
# GSI/NBS Suitability Index (GIS Stacking Model)



# TSI Optimization: Pilot Study Workflow

Obtain HEC-HMS models ("current conditions" and "future conditions") for all pilot study areas.

Compare results from the "current conditions" and "future conditions" HEC-HMS models to identify subbasins with significant changes in peak flow and/or volume.

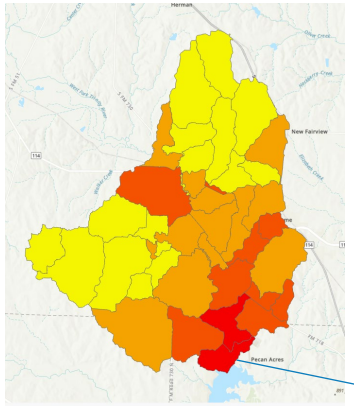
Modify the "future conditions" basin model by creating *Reservoir* elements downstream of each subbasin with associated Storage-Discharge Curves.

Develop a library of Storage-Discharge Curves (1) for detention ponds by generating per-subbasin ideal curves based on frequency storm results and (2) for GSI/NBS (from AgriLife).

Develop a python script to automate HEC-HMS and optimize, minimizing the change in peak discharge and/or volume by applying multipliers to the Storage-Discharge Curves.

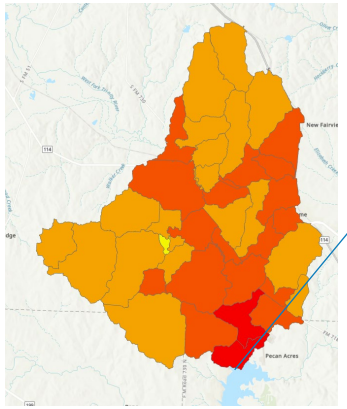
# TSI Optimization: Pilot Study Methodology

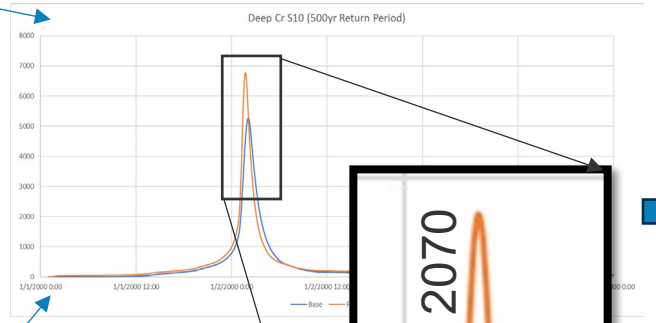
2020

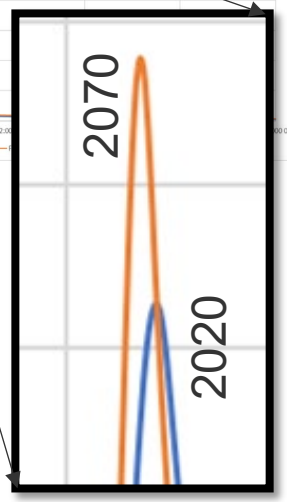


Increased Imperviousness

2070

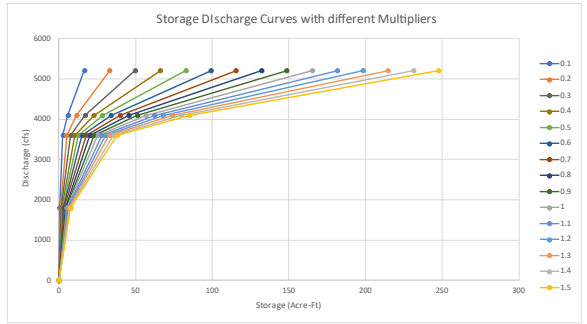




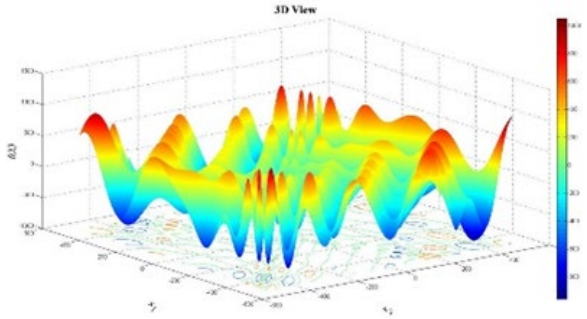

Increase in Flow

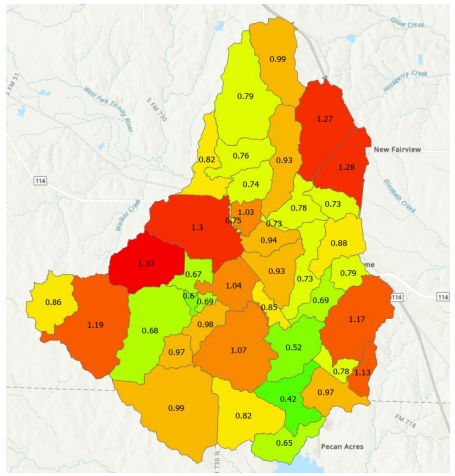
Setting Up HEC HMS Model with Reservoirs at Each Subbasin




Varying Storage Values to Best Reduce the Peak Flow

Optimized Storage Values generated from HMS Runs

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# TSI Optimization: Eagle Mountain HEC-HMS Model

No. of Subbasins : 41

No. of Reach : 42

Outlet (Sink) : 1

Total Area: 75.17 sq mi.

Avg. Increase in Imperviousness: +24.89% (max: 46.88%)

Avg. Decrease in Lag Time : -0.41 hrs (max: -0.67 hrs)

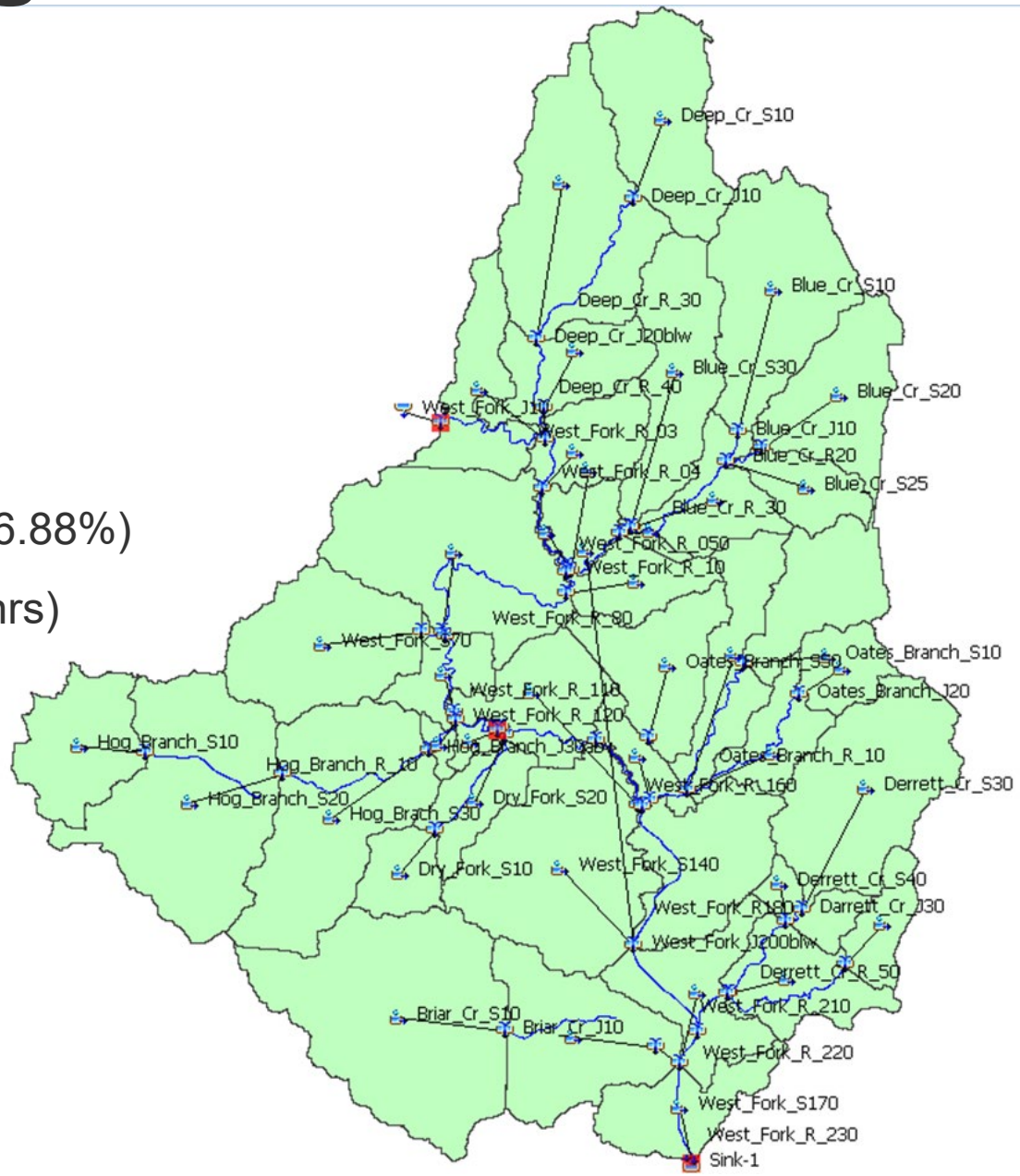
Without Inflow

Sink Discharge (2020): 40251.9 cfs

Sink Discharge (2070): 51143.3 cfs

10891 cfs increase

Theoretical Storage Required = 6210.63 acre-ft

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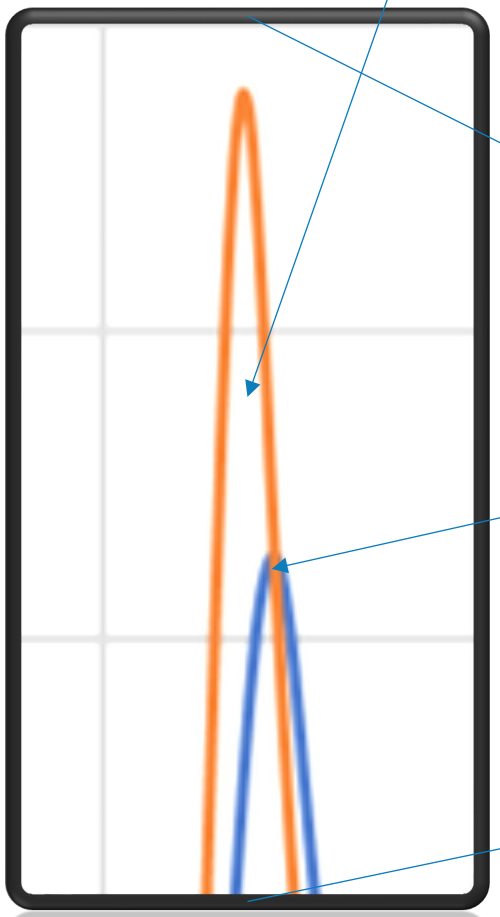
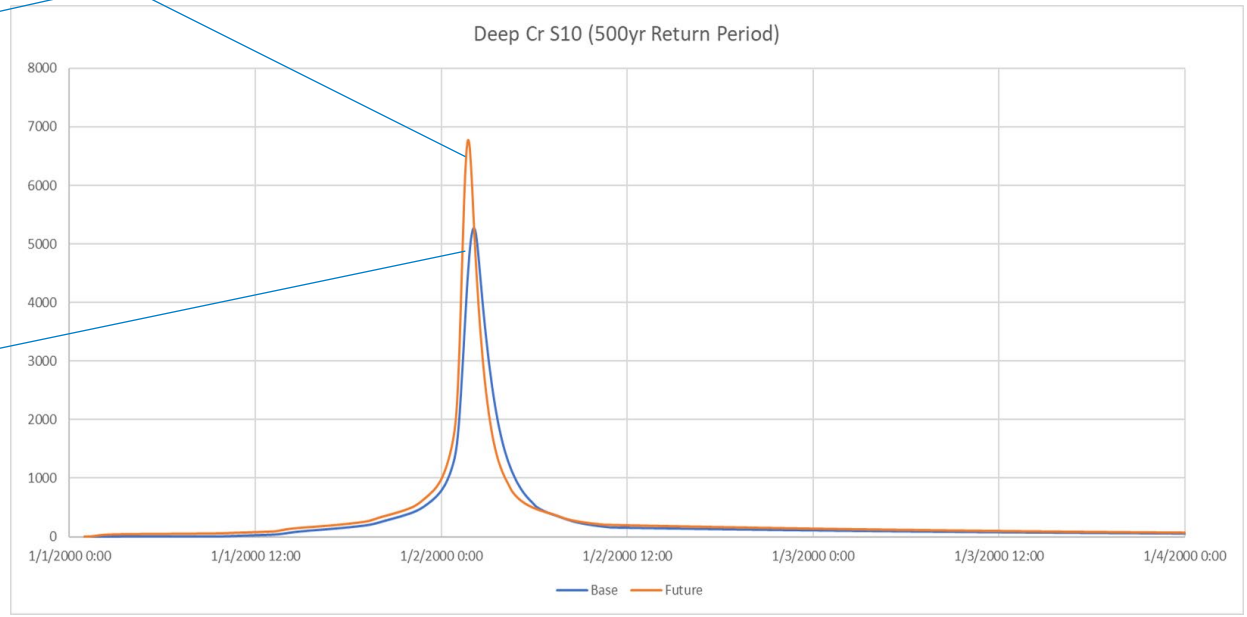
# TSI Optimization: Storage-Discharge Curve

Positive Storage Difference



| Storage (Acre-Ft) | Discharge (CFS) | Return Period |
|---|---|---|
| 0 | 0 | |
| 557.14 | 60.01 | 2yr |
| 562.17 | 1859.4 | 10yr |
| 582.41 | 3665.8 | 50yr |
| 613.83 | 4155.4 | 100yr |
| 722.19 | 5266.8 | 500yr |

Peak Base Discharge

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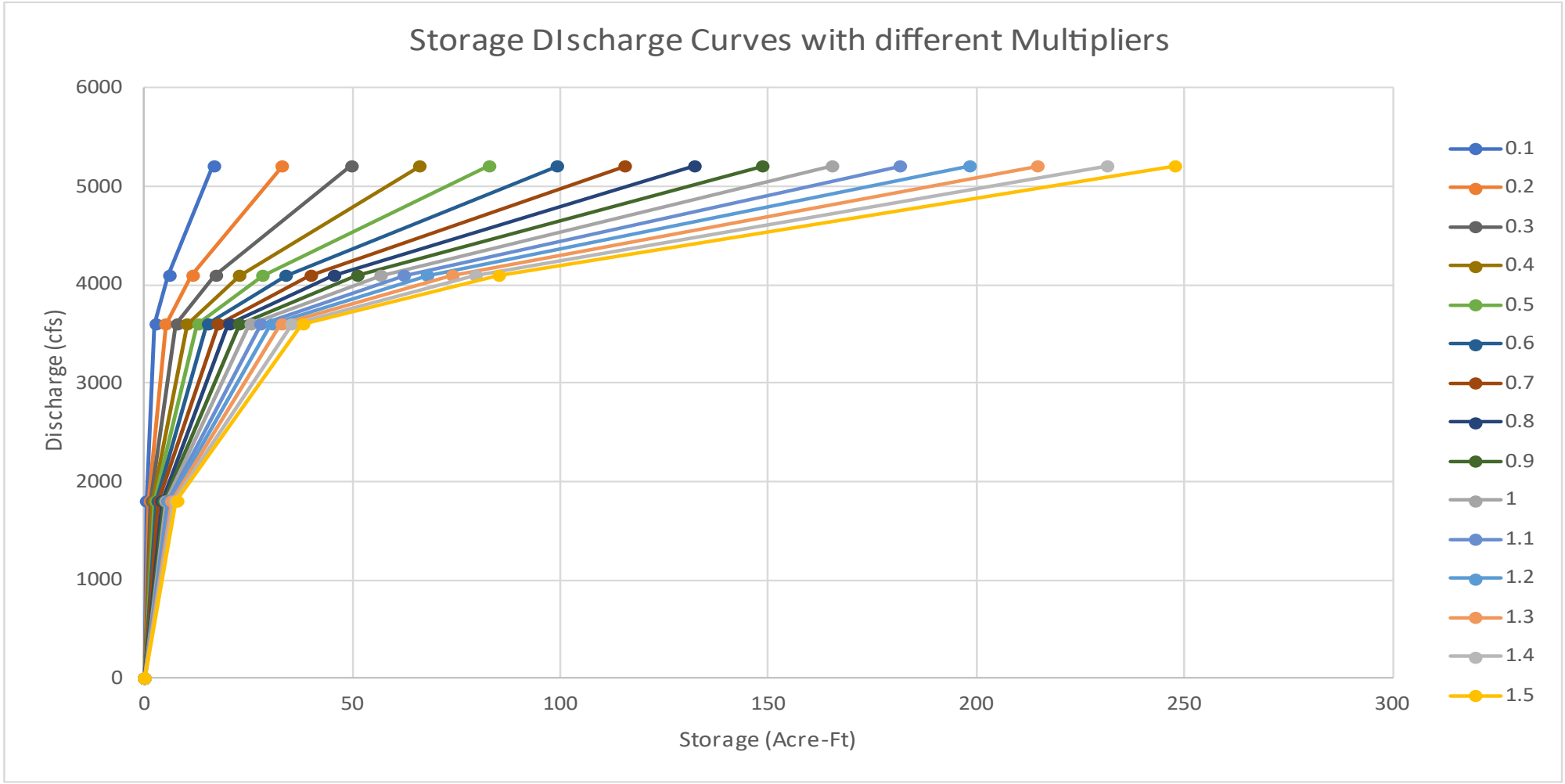
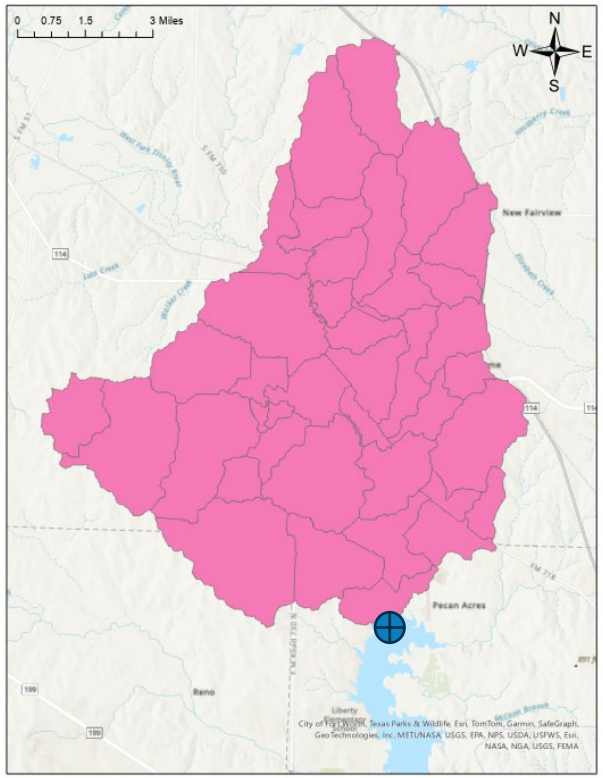
# TSI Optimization: Storage-Discharge Curve Multipliers

Storage values are multiplied with different multipliers while the discharge values are kept constant resulting in different variants of the original storage-discharge curves with different slopes.

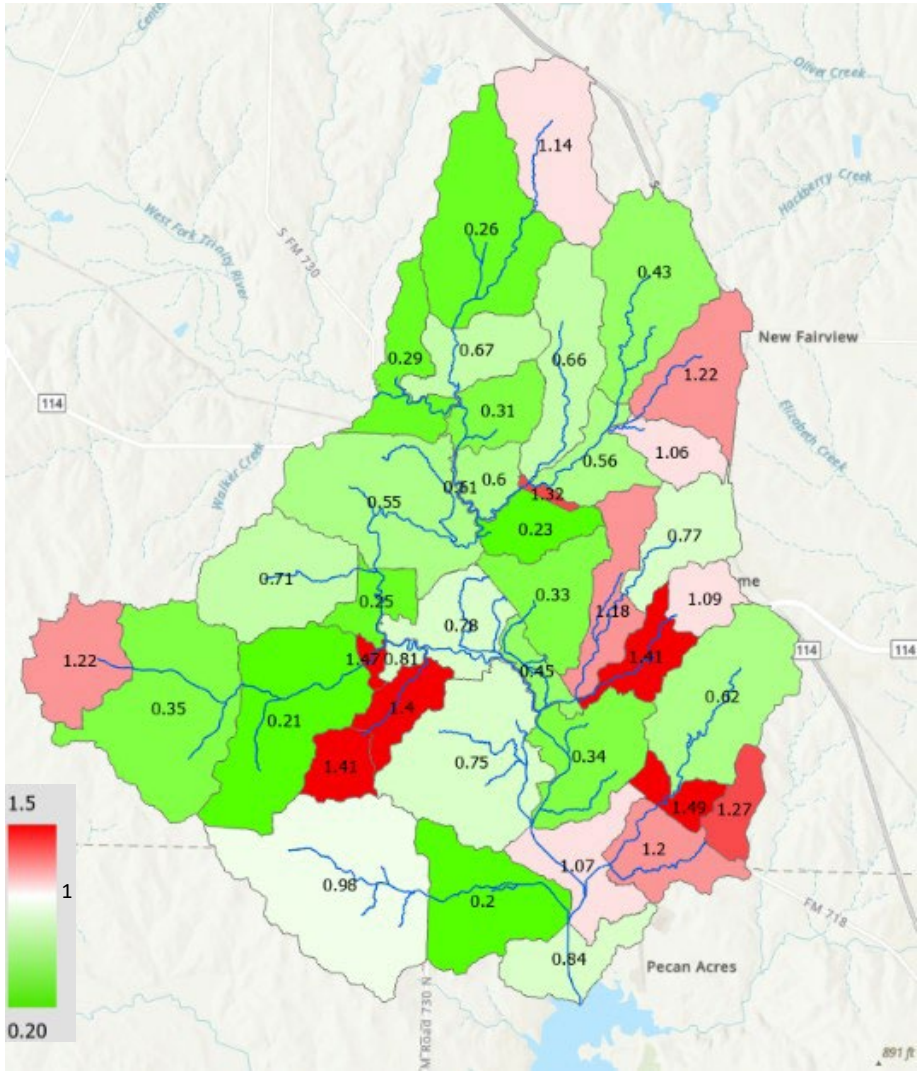


# TSI Optimization: Most Optimal Solution
## (1 Discharge Limit)

| Junctions | Description | Limiting Discharge (cfs) |
|---|---|---|
| **Sink** | **Outlet of the Basin** | **40251.9** |




Peak Discharge at Sink: 40187.56 cfs
Total Storage: 4122.94 Acre ft




**Reference**

Sink Discharge (2020): 40251.9 cfs

Sink Discharge (2070): 51143.3 cfs

Theoretical Storage Required = 6210.63 Acre-ft

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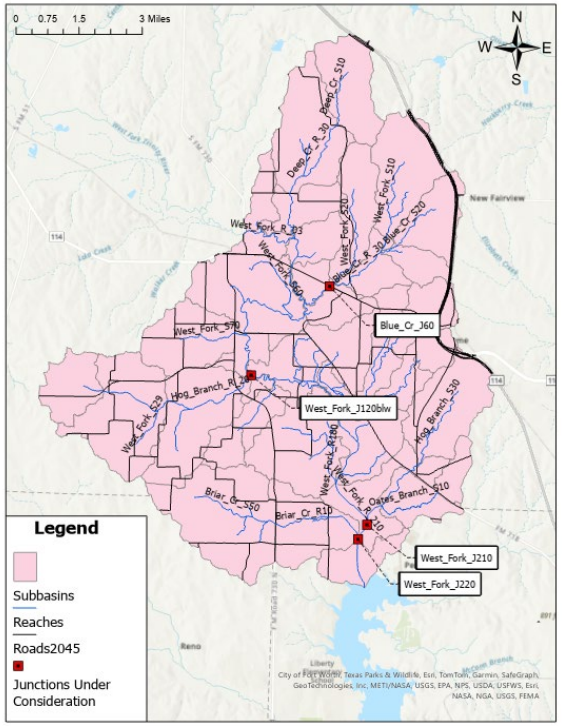
# TSI Optimization: Most Optimal Solution
## (5 Discharge Limits)

| Junctions | Description | Limiting Discharge (cfs) |
|---|---|---|
| Blue_Cr_J60 | Crosses SH114 | 11085.1 |
| West_Fork_J120blw | Merges with Hog Branch | 20648.3 |
| West_Fork_J210 | Merges with Darrett Creek | 27049.7 |
| West_Fork_J220 | Merges with Briar Creek | 38865.8 |
| Sink | Outlet of the Basin | 40251.9 |



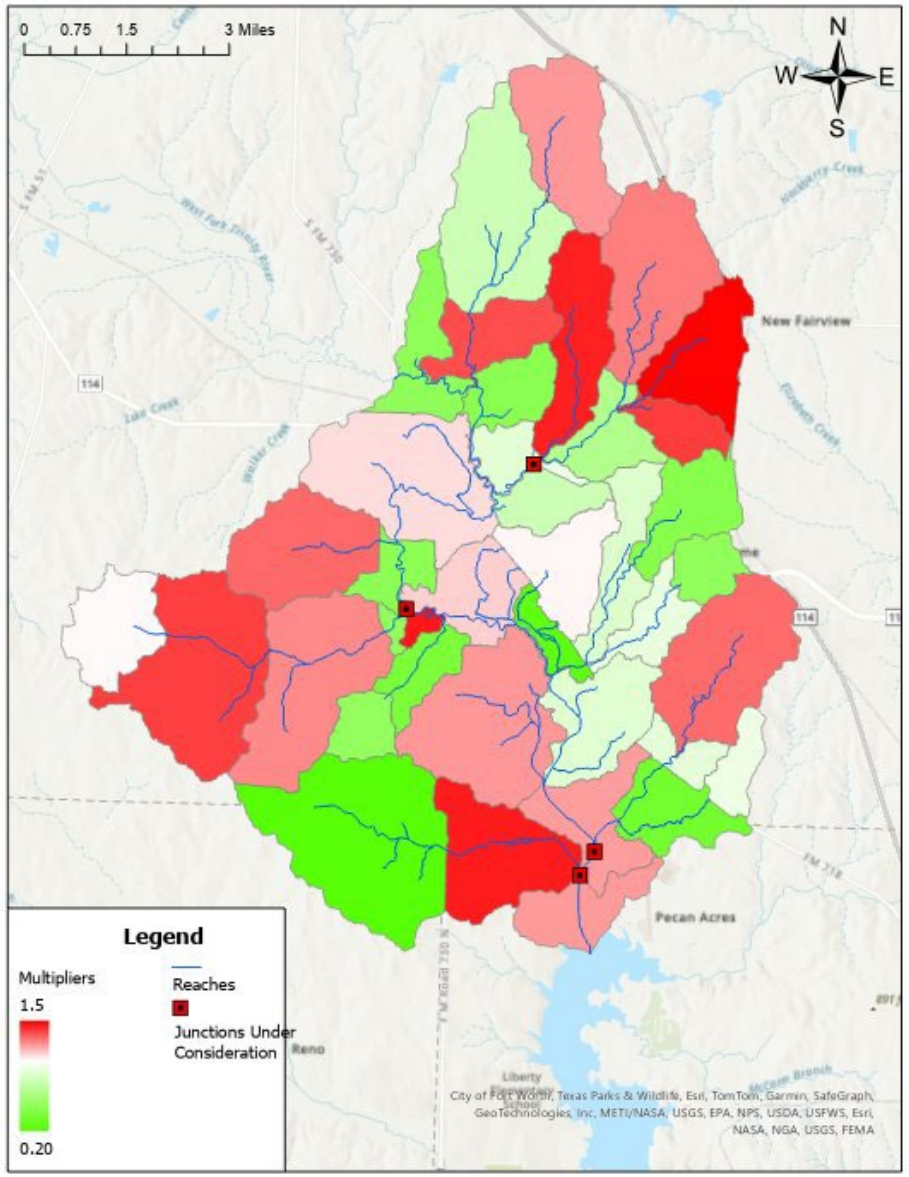

Peak Discharge at Sink: 38742.5 cfs
Total Storage: 5672.73 Acre ft

**Reference**

Sink Discharge (2020): 40251.9 cfs

Sink Discharge (2070): 51143.3 cfs

Theoretical Storage Required = 6210.63 Acre-ft



# Today's Presenter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