Technical Review of Spring Creek Modeling

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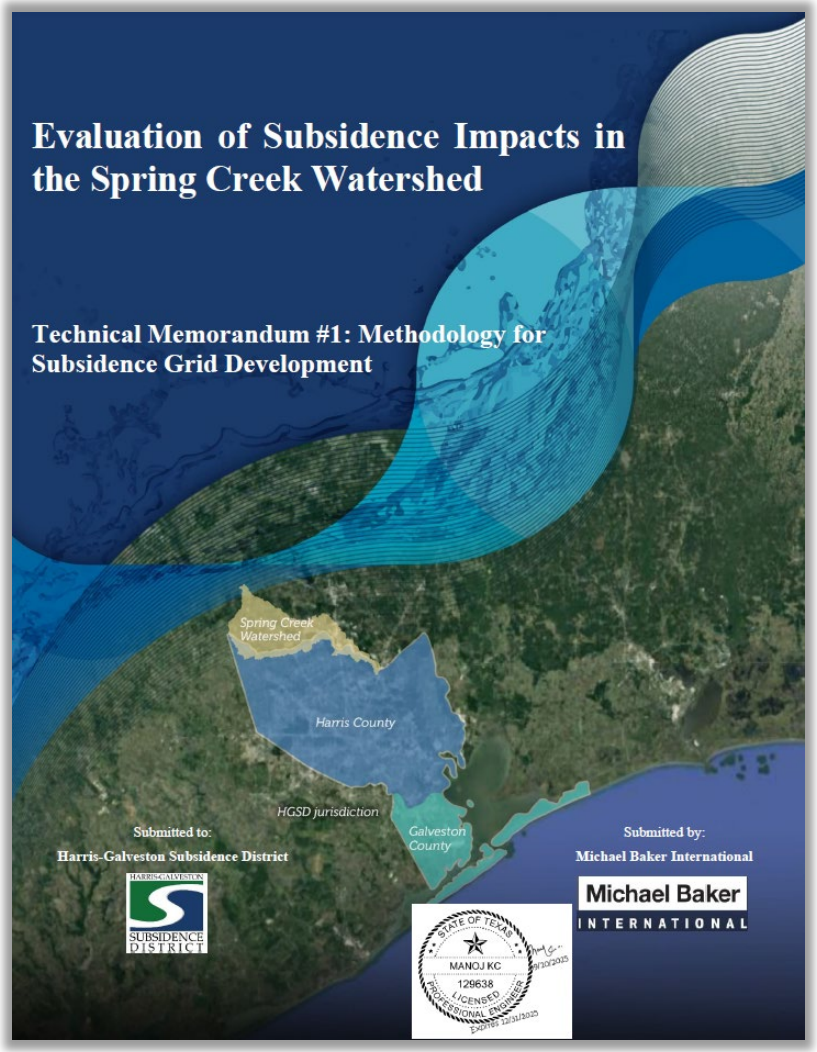
Introduction

- At Lone Star GCD's request, Spheros Environmental was commissioned to provide a technical review of the "Michael Baker Report"
  - Title: *Evaluation of Subsidence Impacts in the Spring Creek Watershed*
  - Consisted of five documents: Executive Summary, Data Collection Report, and three technical memoranda
  - Available at HGSD website
- Review focused on modeling methodology
- Reviewers were Gretchen Miller, Amir Sedaghatdoost, and Jordan Furnans



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Report Overview

- Purpose: "*evaluate subsidence impacts on flood risk within the Spring Creek Watershed*"
- Report Methods:
  - Predicted future terrain changes due to subsidence based on GULF-2023 outputs
  - Developed model in HEC-RAS software to determine watershed response to 10-year and 100-year rainfall events
  - Calibrated model against Hurricane Harvey and Beryl data
  - Estimated changes in flood inundation and associated economic impacts

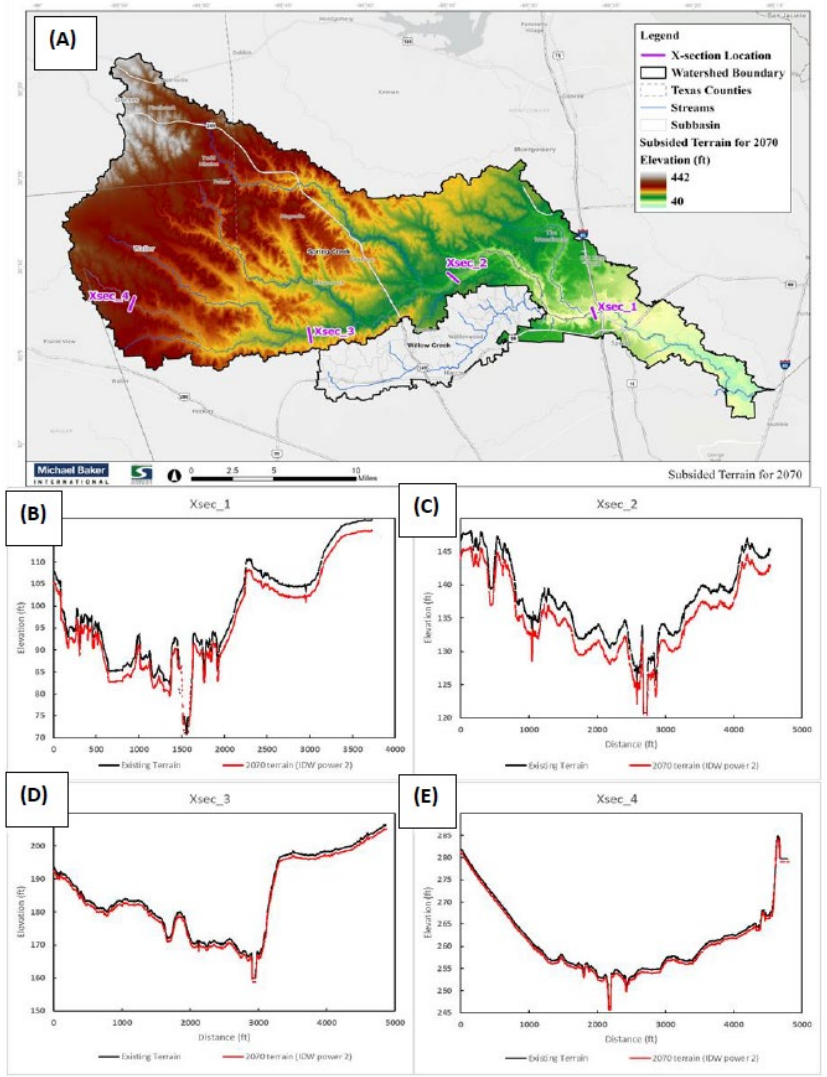

Image source: Technical Memo 1

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Report Overview

- Scenarios Modeled for Report:
  - Baseline
  - Terrain changes only (SWFD)
  - Terrain changes plus land use/land cover changes (SFD)
- Report Conclusions:
  - Subsidence across watershed ranged from 0.2 to 3.7 ft by 2070
  - In a 100-year event, subsidence could cause $43 million in total losses
  - Monetary impacts magnified more than 10-fold with land use change

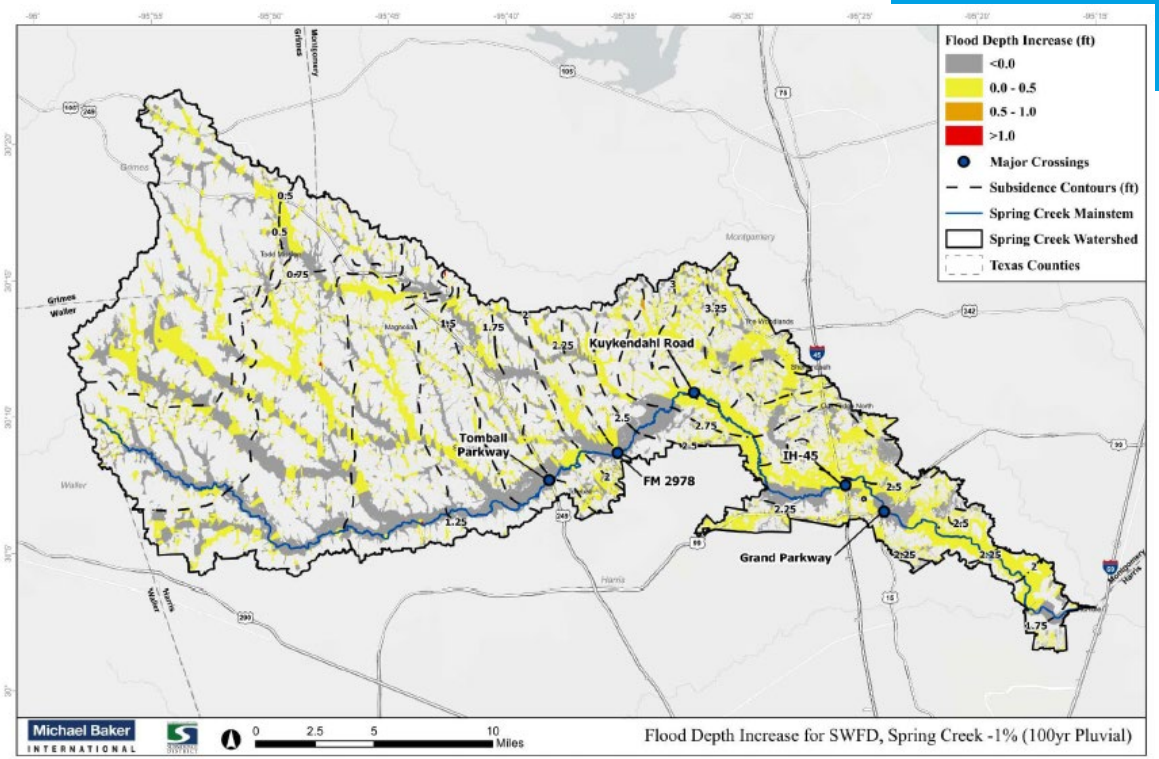

Figure 6: Flood Depth Increase Between Baseline and SWFD Scenario for 100-Year Event (Pluvial)

Table 25: Economic Impact (Additional Loss) Due to Increased Flood Hazard (Pluvial) Due to Subsidence in Spring Creek Watershed

Flood Event	Flood Economic Loss	Subsidence without future development ($ million)	Subsidence with future development GDP ($ million)
10-year	Direct Loss	12	113
	Indirect Loss	4	51
	Total Loss	**16**	**164**
100-year	Direct Loss	35	446
	Indirect Loss	8	114
	Total Loss	**43**	**560**

Image source: Technical Memo 3

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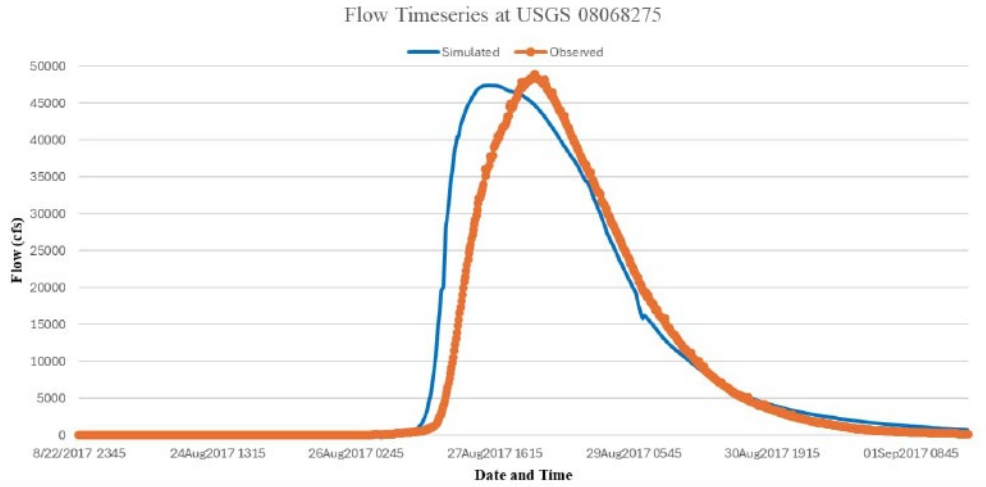
Technical Review Findings

Limited Calibration Dataset

- Hurricanes Harvey and Beryl were the only events considered
- Multi-event calibration is considered the standard of practice
- Calibrating only to extreme events can introduce bias

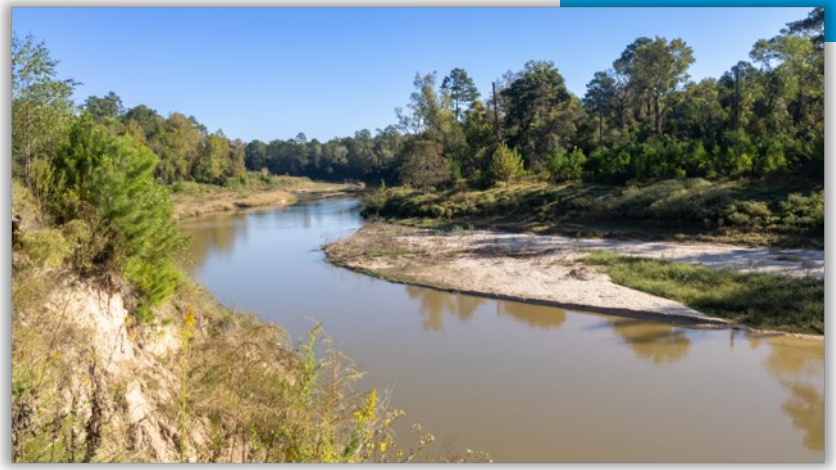


Time to Peak Difference Summary Table

Gage Number	Location	Storm Event				Error Percentage	
		Harvey 2017		Beryl 2024		Storm Event	
		Measured	Modeled	Measured	Modeled	Harvey 2017	Beryl 2024
USGS 8068390	Bear Br at Research Blvd, The	28Aug2017 0045	27Aug2017 1645	08Jul2024 1030	08Jul2024 1445	8.0	4.3
USGS 8068400	Panther Br at Gosling Rd, The	28Aug2017 0045	27Aug2017 1730	08Jul2024 1200	08Jul2024 1645	7.3	4.8
USGS 8068500	Spring Ck nr Spring, TX	28Aug2017 2015	28Aug2017 0830	08Jul2024 1215	9Jul2024 0915	11.8	9.0
USGS 8068275	Spring Ck nr Tomball, TX	28Aug2017 0300	27Aug2017 1815	09Jul2024 0230	09Jul2024 2315	8.8	20.8
USGS 8068450	Panther Br nr Spring, TX	28Aug2017 1845	28Aug2017 0515	08Jul2024 1045	09Jul2024 0430	13.6	17.8
HCFCD 1086	Threemile Creek at FM 362	27Aug2017 0537	26Aug2017 2200	08Jul2024 2116	08Jul2024 1215	7.5	9.0
HCFCD 1084	Threemile Creek at Joseph Road	27Aug2017 0958	27Aug2017 0330	08Jul2024 1400	08Jul2024 2215	6.5	8.3
HCFCD 1076	Birch Creek at Riley Road	27Aug2017 0259	27Aug2017 0245	08Jul2024 1146	08Jul2024 1115	0.3	0.5
HCFCD 1060	Spring Creek at Kuykendahl Road	28Aug2017 1016	28Aug2017 0115	10Jul2024 0546	10Jul2024 1345	9.0	8.0
HCFCD 1050	Spring Creek at I-45	28Aug2017 1950	28Aug2017 0830	08Jul2024 1216	8Jul2024 2100	11.3	8.8
HCFCD 1040	Spring Creek at FM 2978	28Aug2017 0430	27Aug2017 2315	09Jul2024 1442	10Jul2024 0515	4.8	9.3
HCFCD 1070	Spring Creek at SH 249	28Aug2017 0311	27Aug2017 1815	09Jul2024 0230	09Jul2024 2315	8.8	20.8
Total Gages	12		Within 6 hrs			21%	
Total Storms	2		Within 9 hrs			71%	
No Data	0		Within 12 hrs			83%	
Data Points	24		Greater than 12 hrs			17%	

Image source: Technical Memo 2

Technical Review Findings



Model Parameters Out of Recommended Ranges

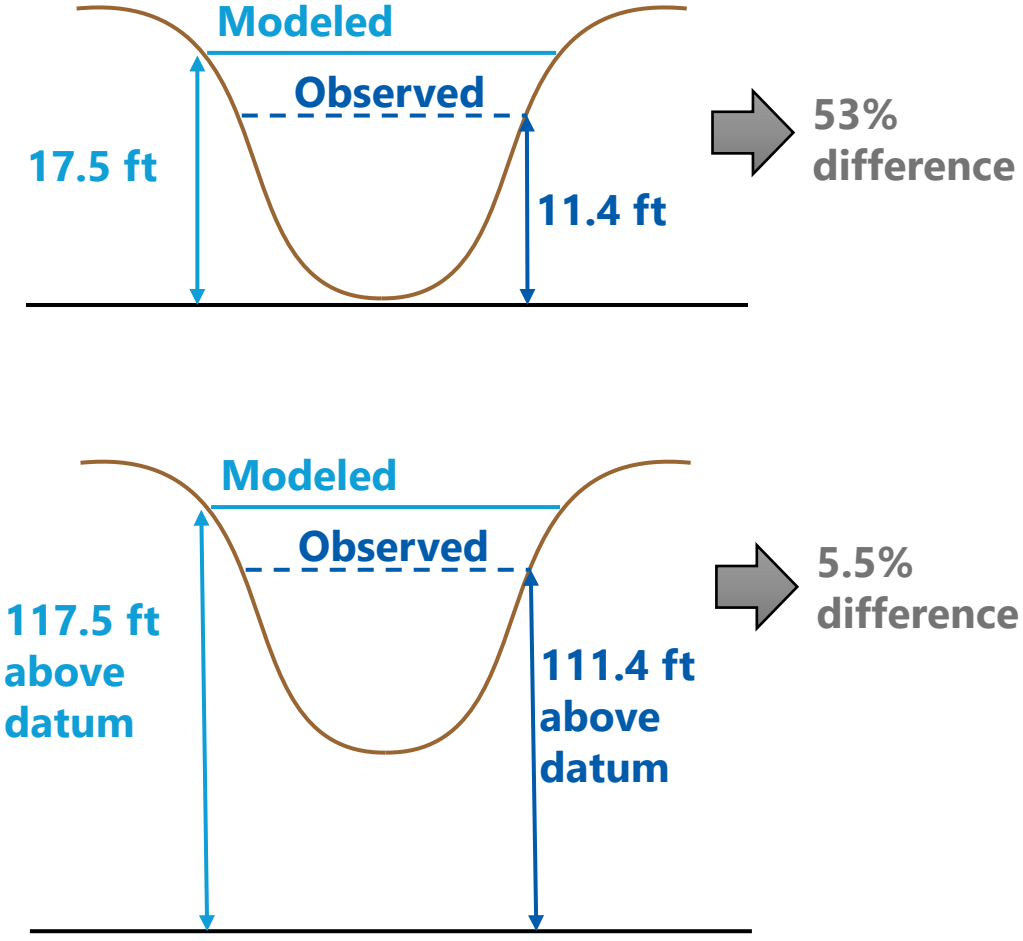
- Manning's n coefficient represents frictional resistance to water flow
  - Related to land use/land cover type
  - Rougher surfaces slow water down
  - Higher value = rougher surface
- Use of values outside range can be acceptable but should be justified

Land Classification	Report	HEC-RAS Manual
Developed – High Intensity	0.12	0.12-0.20
Developed Low-Intensity	0.1	0.06-0.12
Developed – Open Space	0.05	0.03-0.05
Cultivated Crops	0.08	0.02-0.05
Pasture-Hay	0.08	0.025-0.05
Grassland-Herbaceous	0.08	0.025-0.05
Deciduous Forest	0.15	0.1-0.2
Evergreen Forest	0.2	0.08-0.16
Mixed Forest	0.2	0.08-0.20
Scrub-Shrub	0.1	0.07-0.16
Palustrine Forested Wetland	0.2	0.05-0.085
Palustrine Scrub-Shrub Wetland	0.2	0.05-0.085
Palustrine Emergent Wetlands	0.2	0.05-0.085
Barren Land	0.03	0.023-0.030
Open Water	0.15	0.025-0.05

Technical Review Findings

Error Metrics Problematic and Incomplete

- Calculation method for percent error understates differences
  - Uses elevation datum instead of gage or bank reference
- Calibration relied on percent error only, missing standard metrics:
  - Nash-Sutcliffe efficiency
  - Root mean square error



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Technical Review Findings

Insufficiently Fine Spatial Resolution

- Mesh size telescoped based on priority of area
- Mesh selection impacts flood pathways, ponding depths, runoff timing, and inundation connectivity
- Subsidence-driven changes may be relatively subtle
- Sensitivity analysis justifying size selection should be documented

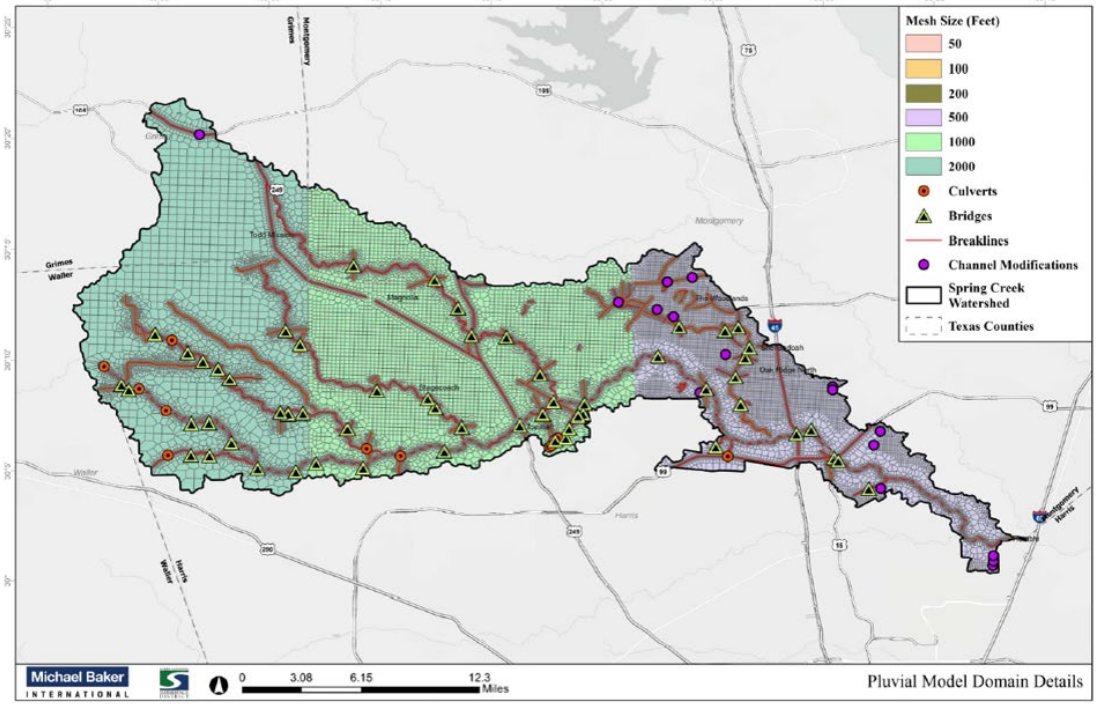

Image source: Technical Memo 3

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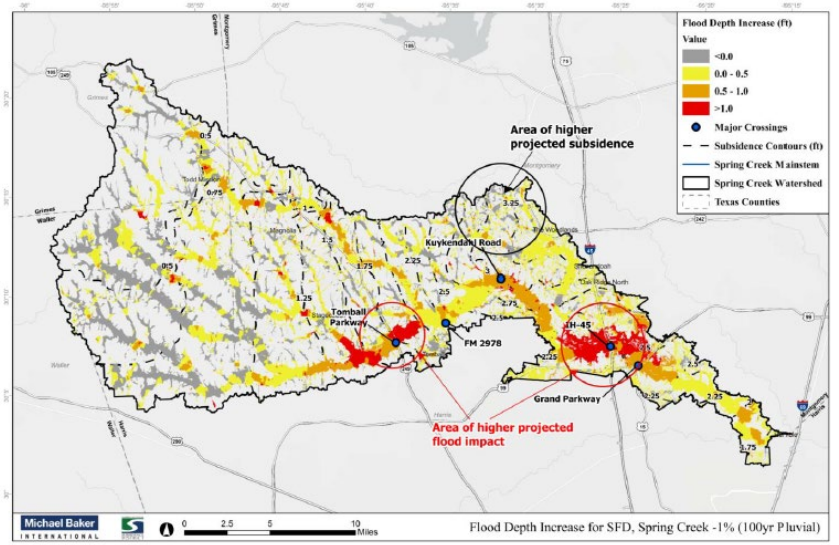
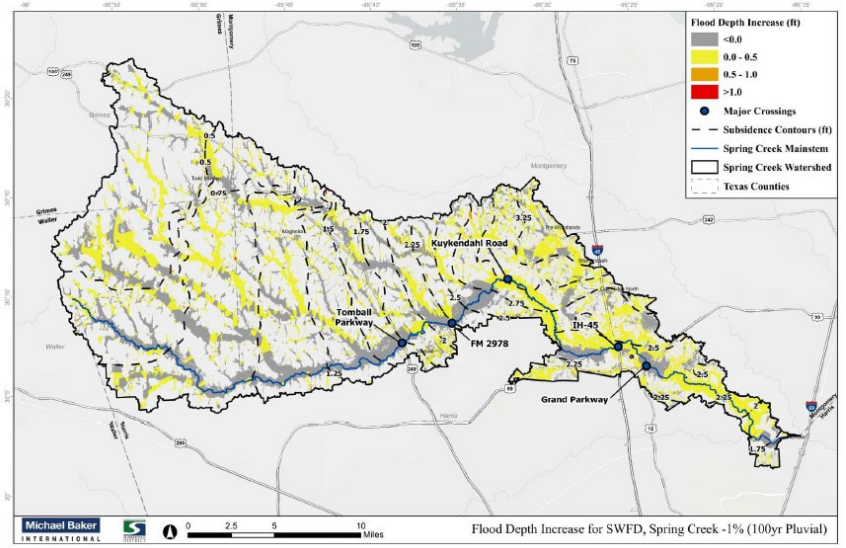
Technical Review Findings

No "Land Development Only" Scenario

- Substantial differences in inundation between scenarios
- Best practice would be to include it as an alternate
  - Rule out synergistic impacts
  - Provide fair comparison of causal factors
- Executive Summary only presents subsidence plus development scenario
  - Conflates impact of independent management decisions



Subsidence and Development



Subsidence Only

Image source: Technical Memo 3, Executive Summary

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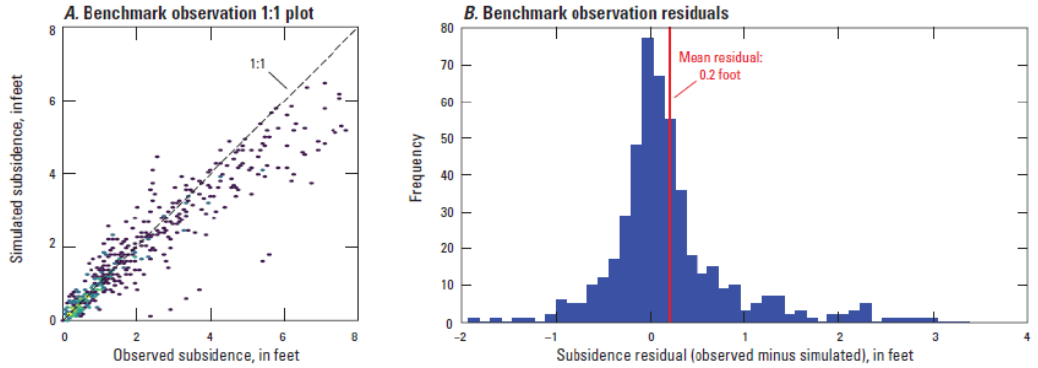
Technical Review Findings

Uncertainty in Subsidence Not Addressed

- Uncertainty due to groundwater model
  - Mean residuals range from -0.02 to 0.3 ft for USGS GULF-2023 model
- New GMA-14 model shows better agreement with data than GULF-2023
- Small subsidence errors can lead to large differences in economic impact
  - 0.3 ft -> $9 million subsidence alone, $115 million combined



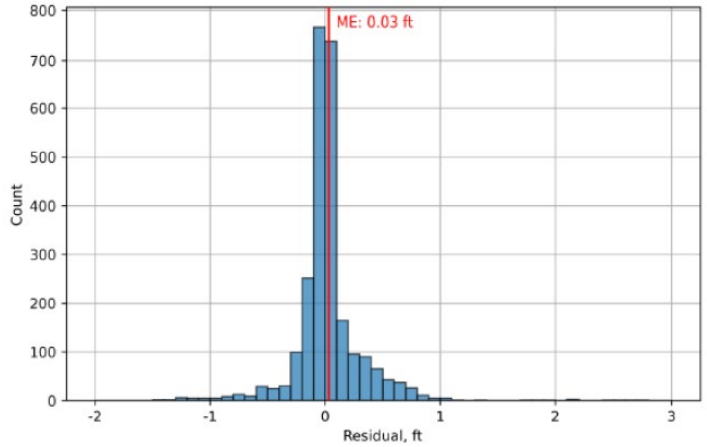


Image source: USGS Gulf-2023 Report (top), GMA-14 Model Report (bottom)

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Summary of Findings

Conclusions of the Study are Problematic

- Modeling issues lower confidence in results
- Subsidence and land development are separate, but interacting, management problems
- Recommendations:
    - Recalibrate model with wider dataset, attention to parameter ranges
    - Perform uncertainty analysis
    - Use subsidence values from updated GMA-14 model
    - Run “land development only” scenario

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