HOUSTON STRONGER

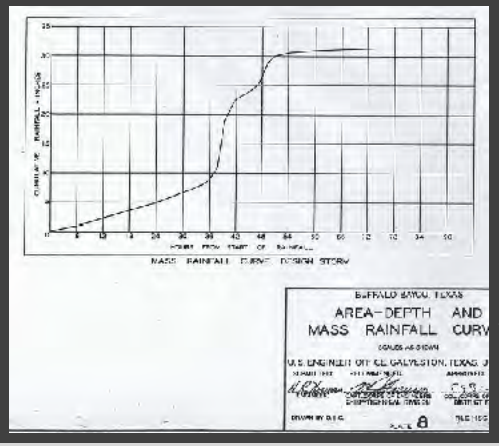
Buffalo Bayou Community Plan

Working to Increase Resiliency and Reduce Flood Risk

Presentation to North Houston Association Water Committee

June 13, 2024

- U.S. Army Corps of Engineers developed flood mitigation plan in 1940 after catastrophic flooding in 1929 and 1935.
- The region has experienced several rains of around 30” since record-keeping began.
- Harvey produced 31” of rain in west Harris County and 47” in southeast Harris County in 2017.



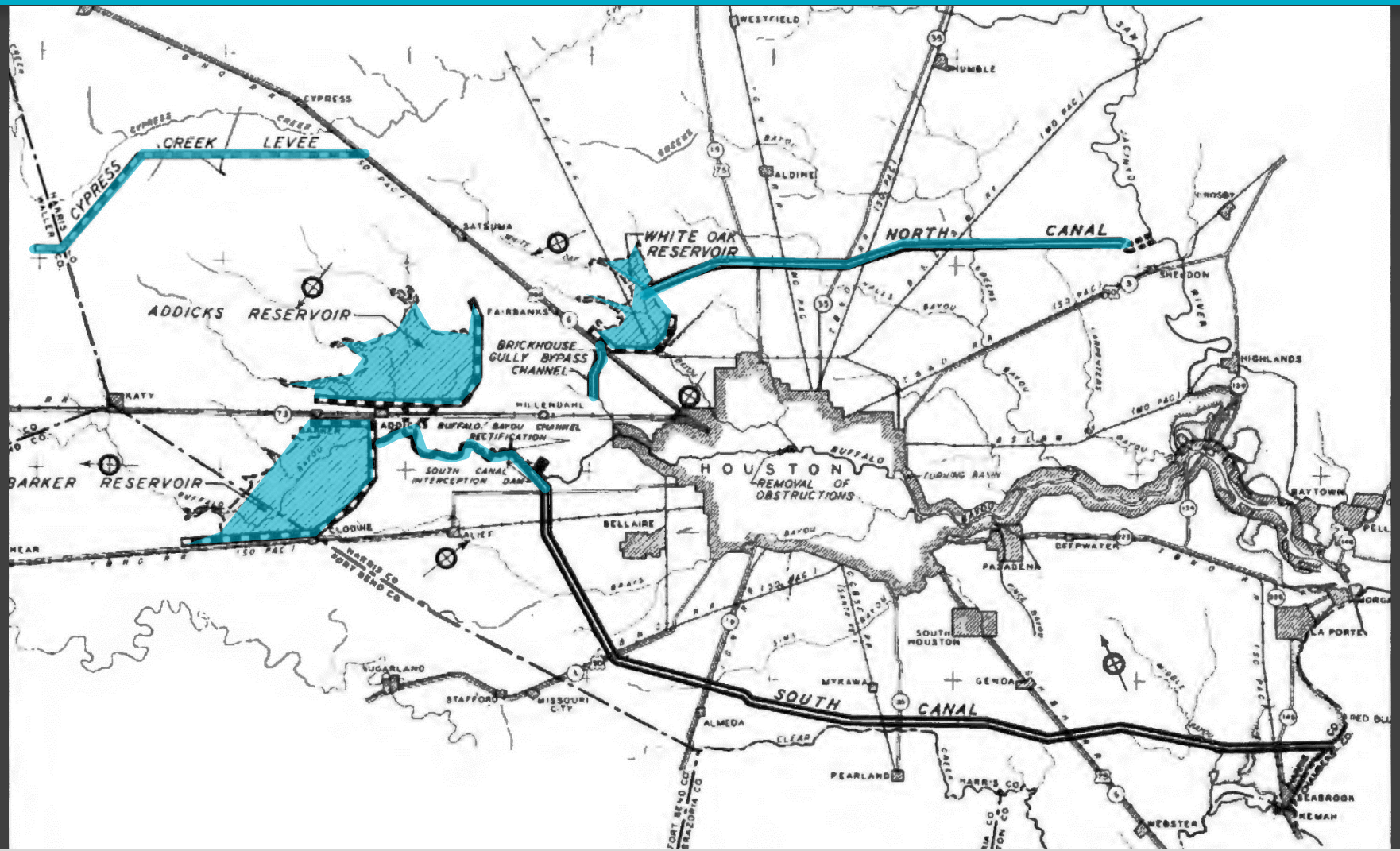
USACE’s early design storm graph for Buffalo Bayou indicating 30”+ cumulative rainfall

Flooding in Downtown Houston

1940 US Army Corps of Engineers (USACE) Plan

Storage • Conveyance • Diversion

BUFFALO BAYOU COMMUNITY PLAN



USACE Plan – Implemented Components

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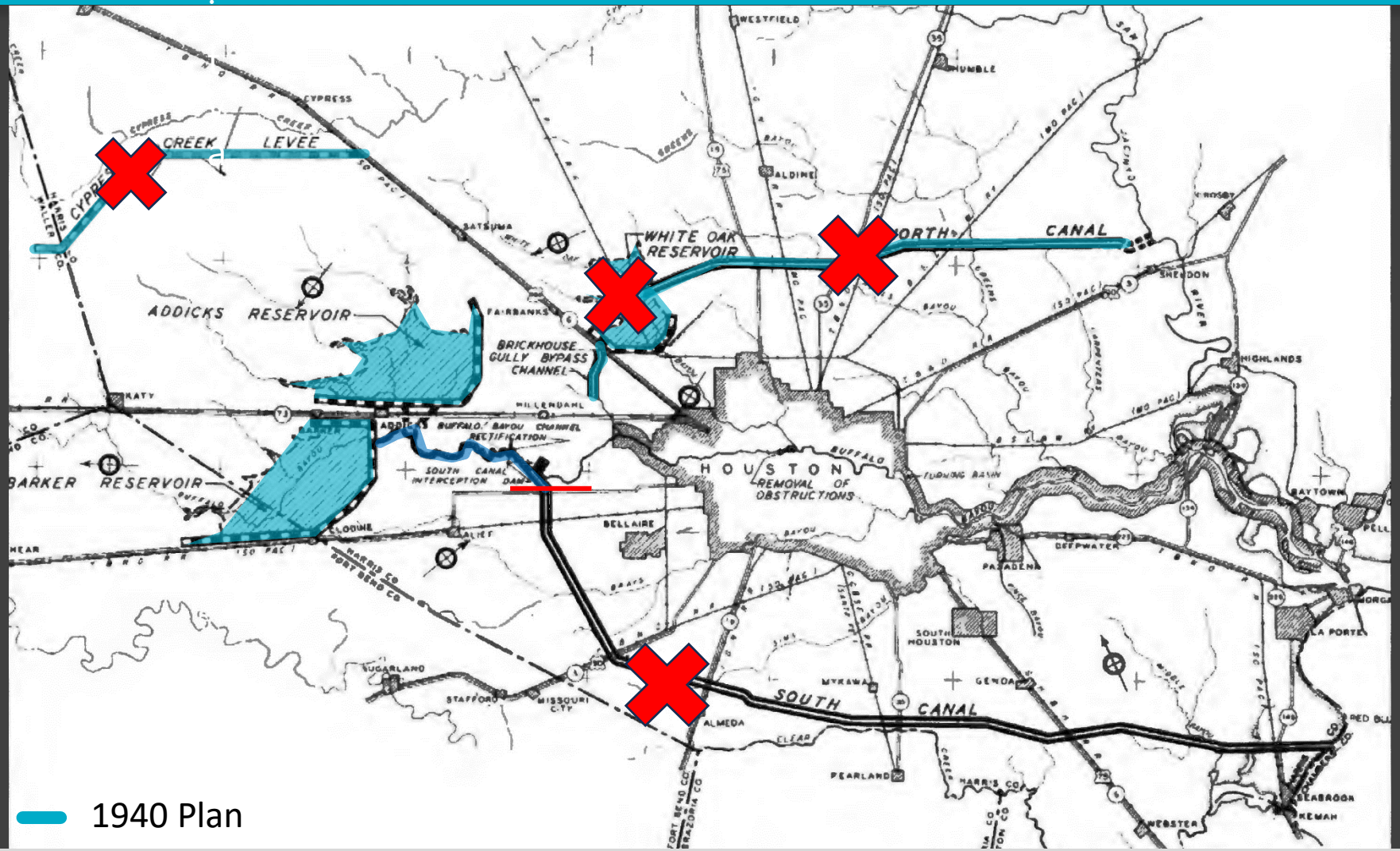
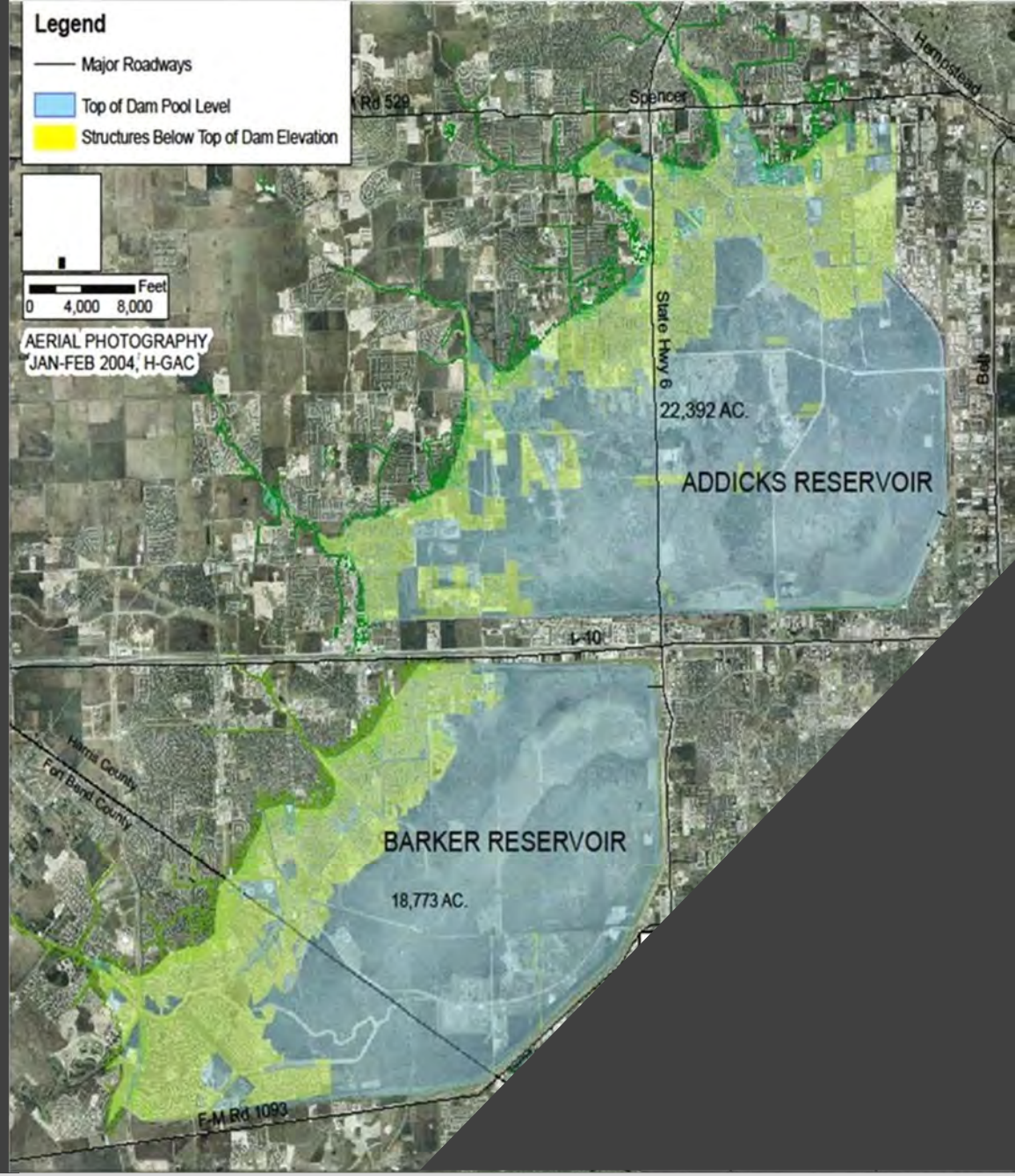


- Reservoirs were built in the 1940s without gates, and 15,000 cubic feet per second (cfs) could be discharged into Buffalo Bayou.
- The south canal, White Oak reservoir, north canal and Cypress Creek levee were never built, so USACE added gates to the reservoirs.
- When gates were added in the 1960s, the maximum flood pool grew to include land that remains privately owned today. It is likely all assumed the chance of a storm so big that it would fill the reservoirs was unlikely.
- Reservoir watersheds and land in the larger flood pool are now largely developed.



Hurricane Harvey and Dam Safety

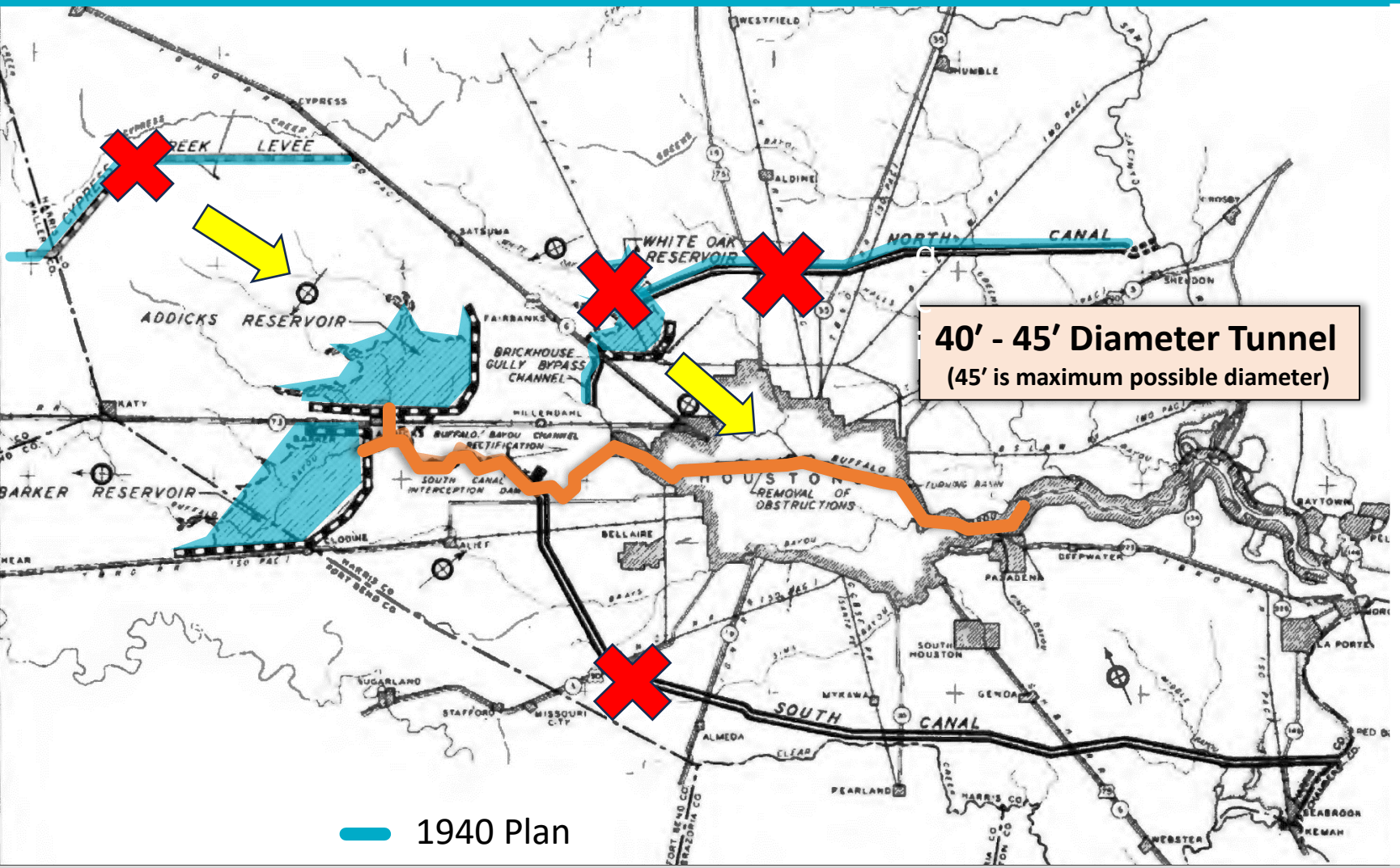
- During Harvey, 31 inches fell on the reservoirs' watersheds, and Houston's southeast side received 47 inches. About 72,000 cfs flowed into Addicks (143,000 acre-feet/day; its capacity on government-owned land is 200,800 acre-feet).
- With thousands of properties already inundated in the flood pools and water flowing uncontrolled around the north end of Addicks Reservoir, the Corps opened the gates at **12:21 a.m. on August 28, 2017**.
- If Harvey made a final turn west as predicted by the weather forecast, it could have dropped an additional 10-20 inches on the reservoirs' watersheds.
- As recently as 2020, the dams were classified as unsafe, and USACE has completed new gate structures since that time; however, no major work on the levees has occurred.

Interim Report and Completing the BB&TR Study

- In early 2018, Congress directed USACE to study flooding in the reservoirs and the Buffalo Bayou watershed – again. USACE issued an "Interim Report" in late 2020.
- The Corps' Interim Report for the Buffalo Bayou and Tributaries Resilience (BB&TR) Study favored two solutions:
  - **Alternative 2 Conveyance:** Channelizing Buffalo Bayou
  - **Alternative 6 Storage:** Constructing a "third reservoir" on the Katy Prairie
- There was strong community opposition to both proposals.
- Opposition meant the USACE proposal was likely to stall, so Houston Stronger began work on an alternative proposal we named the Buffalo Bayou Community Plan.

Current Plan to be Studied

BUFFALO BAYOU COMMUNITY PLAN



Today, USACE and HCFCD are poised to update the study with new modeling information, analysis based on comprehensive benefits, and a focus on a tunnel to replace the 1940 Plan’s proposed South Canal.

While very important, the tunnel will not directly address the Cypress Creek Overflow in northwest Harris County and downstream flooding along White Oak Bayou, which the 1940 Plan also sought to address.

Buffalo Bayou Community Plan Goals

GOAL 1: Contain flood waters within the boundaries of federally owned lands for Barker and Addicks Reservoirs.

GOAL 2: Mitigate flooding resulting from local rainfall in Buffalo and other bayous downstream of the reservoirs.

GOAL 3: Avoid negative environmental impacts and enhance benefits for the Katy Prairie, reservoirs, Buffalo Bayou, Houston Ship Channel, and Galveston Bay.

GOAL 4: Develop broad, diverse and prolonged community support and help secure funding for the eventual proposal.

While the tunnel is absolutely essential, it alone will not achieve these goals – if a storm the size of Hurricane Harvey were to strike again as demonstrated by the following rough modeling.

Model Assumptions for Three Scenarios

Gates can discharge 4,000 cubic feet per second (cfs) total without flooding low-lying property downstream; however, ***USACE's operating plan calls for the gates to be closed when Buffalo Bayou is in flood stage***. As a result, our models assumed closed gates.

- A 40-foot-diameter tunnel can discharge 12,000 cfs total per HCFCD study
  A 45-foot-diameter tunnel can discharge 18,000 cfs total per HCFCD study
- Both reservoirs can store a combined 210,512 acre-feet of flood water on government-owned land

The added storage needed in these scenarios:

500-Year Event with 40-foot-diameter tunnel:	+/- 72,000 acre-feet of added storage (112 square miles)
500-Year Event with 45-foot-diameter tunnel:	+/- 43,000 acre-feet of added storage (67 square miles)
Repeat of Harvey with a 45-foot-diameter tunnel:	+/-152,000 acre-feet of added storage (237 square miles)

We suggest the tunnel design be evaluated to allow "balancing" of water levels between the reservoirs, so added storage in each reservoir could vary as long as the total is achieved.

Model Results with 500-year Atlas 14 Storm (24.2”/24 hours) 40-foot Diameter Tunnel

BUFFALO BAYOU COMMUNITY PLAN

Scenario	Discharge (cfs)	Addicks WSEL	Barker WSEL
Existing System	0 (gates closed)	108.8 (<1’ ↑ north spill)	100.8 (4’ to spill)
Tunnel	12,000 (A=6k, B=6k)	105.0 (2’ above GOL)	98.1 (3’ above GOL)
Tunnel + Storage	12,000 (A=6k, B=6k)	103.0 (at GOL) +29,250 ac-ft	95.0 (at GOL) +42,400 ac-ft

Total Added Storage Required in Both Reservoirs 71,650 ac-ft

Models are based on MAAPnext for 500-year storm. This MAAPnext data is not available for Barker Reservoir, but the two reservoir watersheds are similar, so modelers used Addicks data without the Cypress Creek Overflow.

The figures included in this presentation reflect a cursory review of the performance of the reservoirs and a potential tunnel system under extreme storm events – Harvey and 500-year storms – for the purpose of evaluating the benefits and limitations of a large diameter drainage tunnel in protecting the reservoirs and property owners in the flood pool. Very simplistic modeling methods were used to be able to inform Houston Stronger about the benefits and limitations of potential flood mitigation strategies.

Model Results with 500-year Atlas 14 Storm (24.2”/24 hours) 45-Foot Diameter Tunnel

BUFFALO BAYOU COMMUNITY PLAN

Scenario	Discharge (cfs)	Addicks WSEL	Barker WSEL
Existing System	0 (gates closed)	108.8 (<1’ ↑ north spill)	100.8 (4’ to spill)
Tunnel	18,000 (A=9k, B=9k)	103.7 (< 1’ above GOL)	99.3 (2.3’ above GOL)
Tunnel + Storage	18,000 (A=9k, B=9k)	103.0 (at GOL) +11,050 ac-ft	95.0 (at GOL) +31,800 ac-ft

Total Added Storage Required in Both Reservoirs +/- 43,000 ac-ft

The figures included in this presentation reflect a cursory review of the performance of the reservoirs and a potential tunnel system under extreme storm events – Harvey and 500-year storms – for the purpose of evaluating the benefits and limitations of a large diameter drainage tunnel in protecting the reservoirs and property owners in the flood pool. Very simplistic modeling methods were used to be able to inform Houston Stronger about the benefits and limitations of potential flood mitigation strategies.

Model Results with a Repeat of Harvey (31”)
45-Foot Diameter Tunnel

BUFFALO BAYOU COMMUNITY PLAN

Scenario	Discharge (cfs)	Addicks WSEL	Barker WSEL
Existing System	0 (gates closed)	Above north spill	101.8 (3.2 to spill)
Tunnel (40’-diameter)	12,000	107.9 (at north spill)	100.9
Tunnel (45’diameter)	18,000	106.2 (3.2’ above GOL)	99.6 (4.6’ above GOL)
Discharge Only (GOL)	35,000 needed	103.0 (at GOL)	95.0 (at GOL)
Tunnel + Storage	18,000	103.0 (at GOL) +58,000 ac-ft	95.0 (at GOL) +94,000 ac-ft
Total Added Storage Required in Both Reservoirs		+/-152,000 ac-ft	

The figures included in this presentation reflect a cursory review of the performance of the reservoirs and a potential tunnel system under extreme storm events – Harvey and 500-year storms – for the purpose of evaluating the benefits and limitations of a large diameter drainage tunnel in protecting the reservoirs and property owners in the flood pool. Very simplistic modeling methods were used to be able to inform Houston Stronger about the benefits and limitations of potential flood mitigation strategies.

Reservoir Storage Conceptual Capacity Alternative

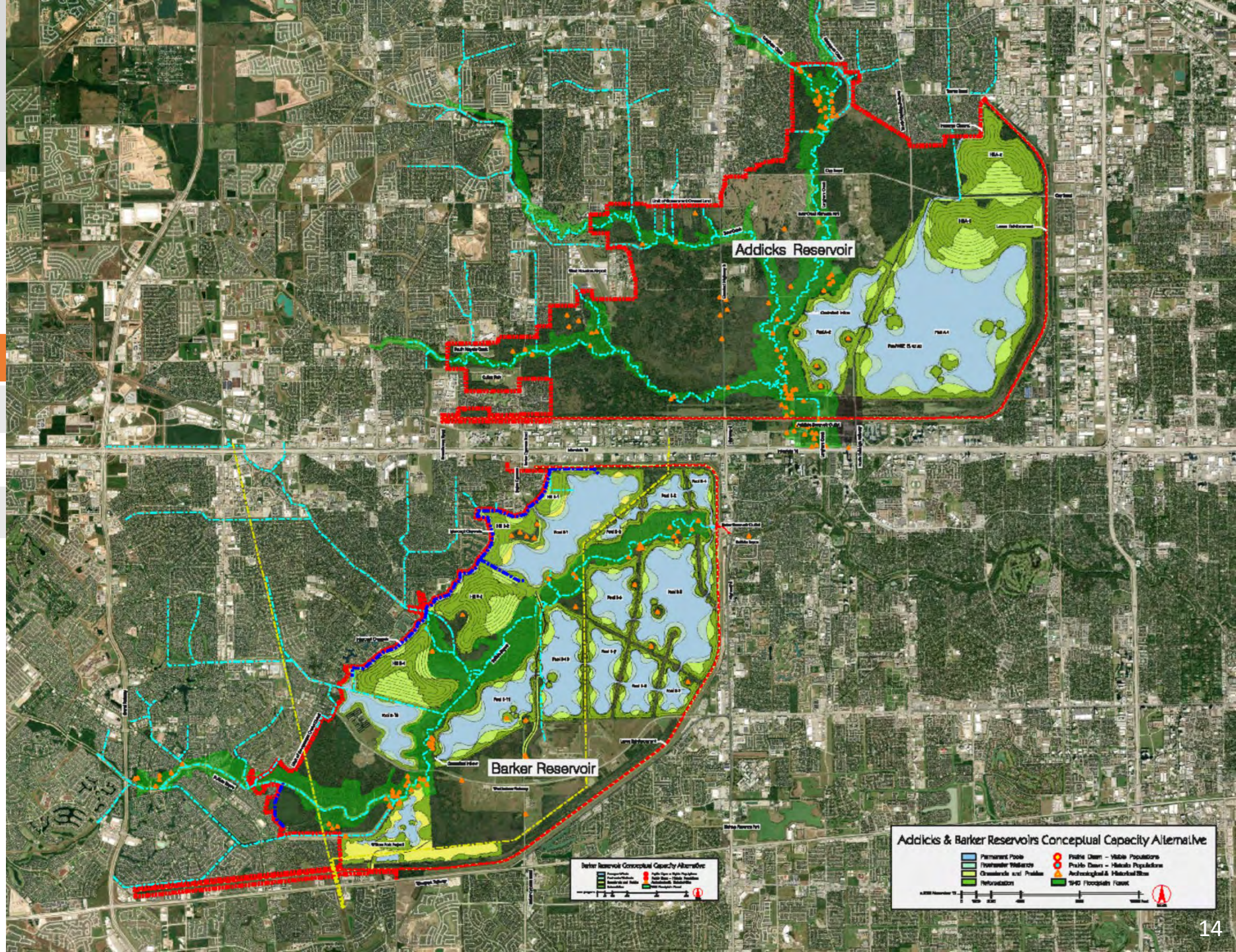
By Kevin Shanley

Acre-Feet Added

Event	Harvey	500-Year	500-Year
Tunnel	45’ dia	45’ dia	40’ dia
Addicks Reservoir	58,000	11,000	29,000
Barker Reservoir	94,000	32,000	43,000
Total	152,000	43,000	72,000

The plan illustrates 152,000 acre-feet of storage. There would be a combination of fewer and/or shallower basins for lower storage capacities.

We suggest the tunnel design be evaluated to allow “balancing” of water levels between the reservoirs, so added storage in each reservoir could vary as long as the total is achieved.



Excavation and Fill Placement Strategy

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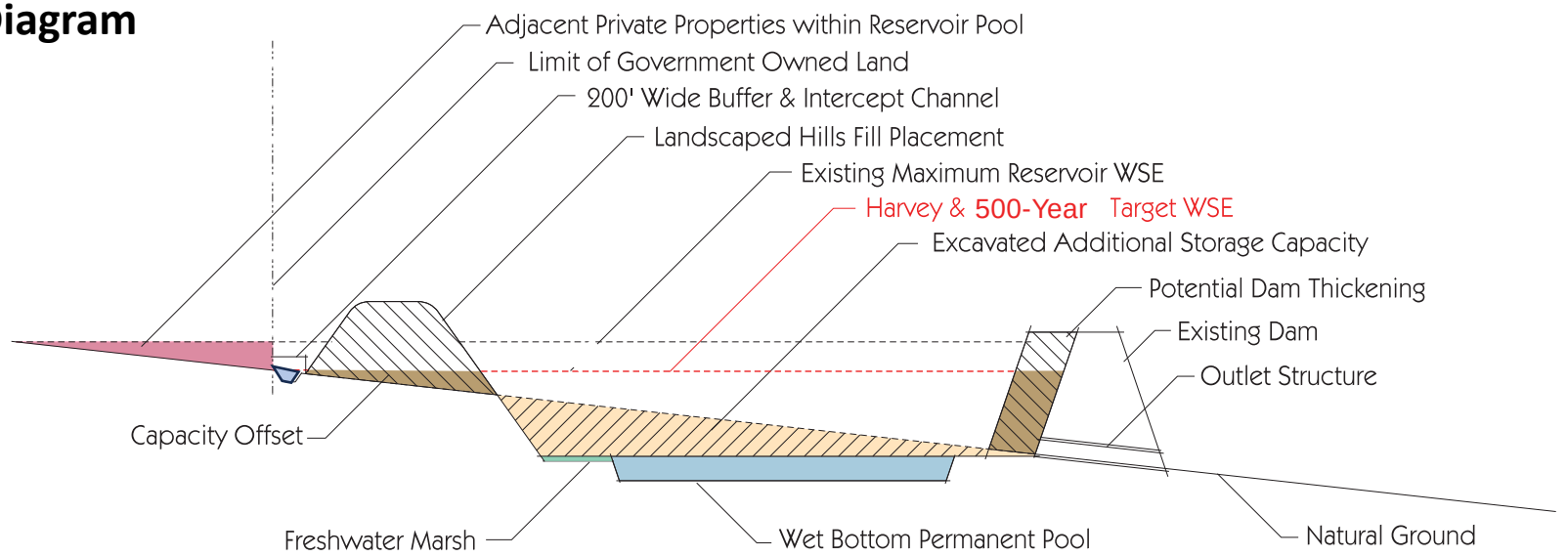
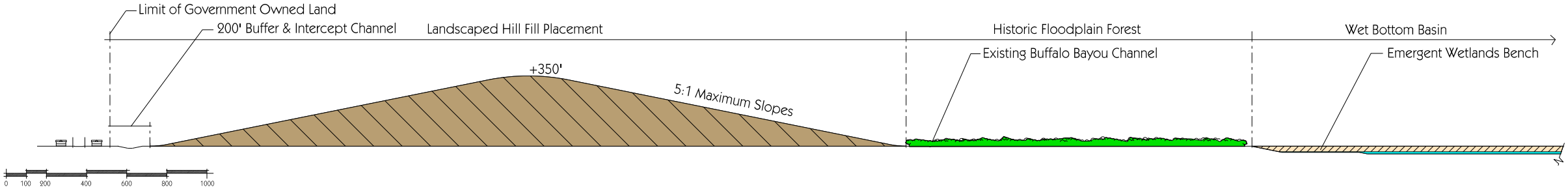
Reservoir Capacity Alternative Diagram



Typical Section at Maximum Hill (Barker BH-2)



Not to Scale
v. 2023 March 25

HOUSTON STRONGER

Excavation/Restoration Using Large-Scale Equipment

EFFICIENT: Excavation can employ large-scale, highly-efficient practices because all work will occur on government-owned land.

FAST: Using large-scale equipment and proven practices, work can proceed 10 – 100x faster than conventional excavation used in urban settings on smaller sites. With no off-site impacts, work can occur 24/7.

LESS EXPENSIVE: Economies of scale and elimination of long hauls of excavated material save money.

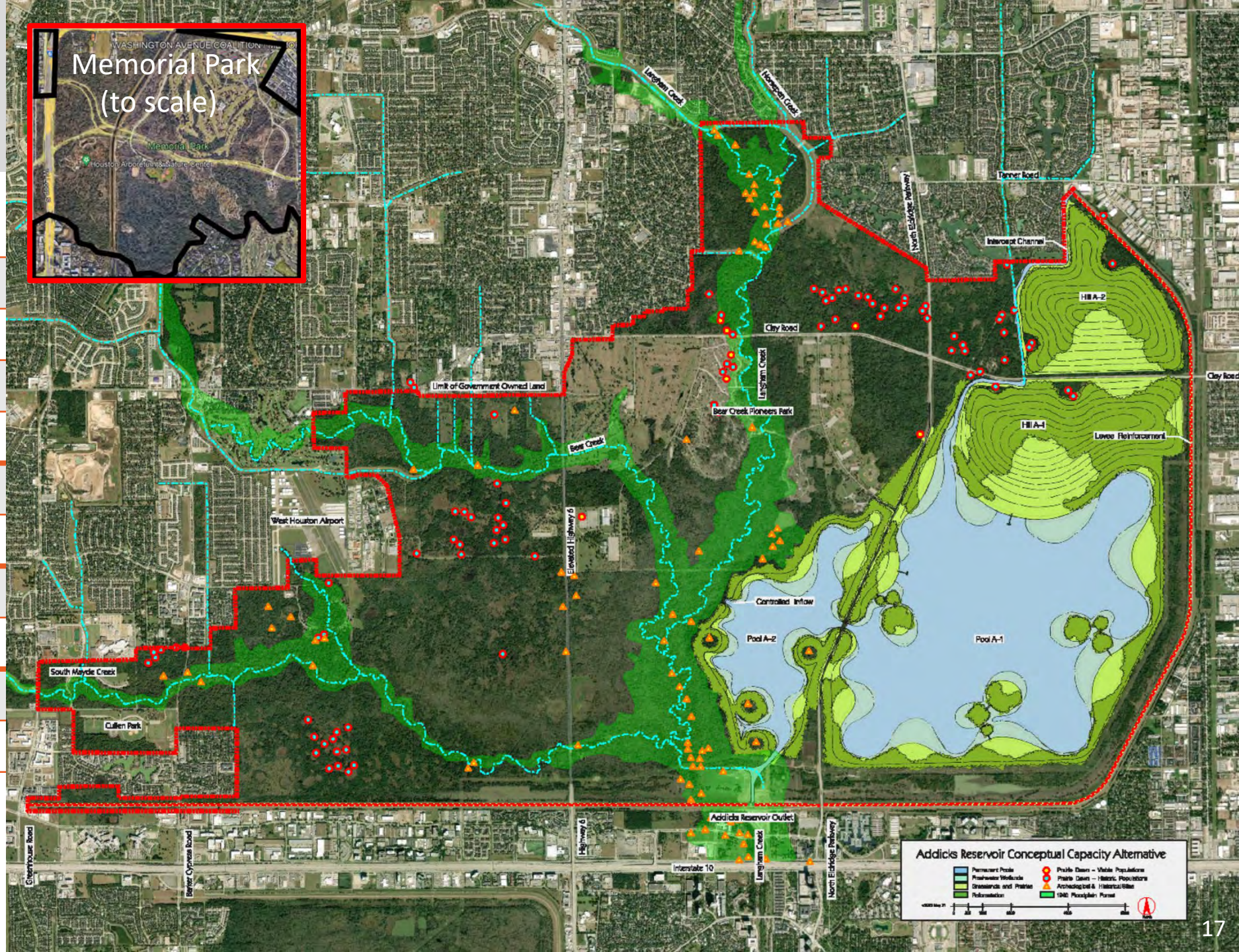
In addition to the equipment shown, dragline buckets also may be an option in shallow-water conditions.

Addicks Reservoir Conceptual Capacity Alternative

By Kevin Shanley

Open Water		1,660 acres
Wetlands		600 acres
Wet Prairie		610 acres
Shoreline		14 miles
Excavation	68,000 ac-ft	109,500,000 cy
Tallest Hill		350 feet
Bear Creek Park		No Change
West of SH 6 (Cullen Park)		No Change
SH 6		Elevated
Eldridge Parkway		Elevated

Excavation exceeds that required for storage to create permanent wet bottom pools and to account for excavated fill placed below the maximum flood pool elevation.

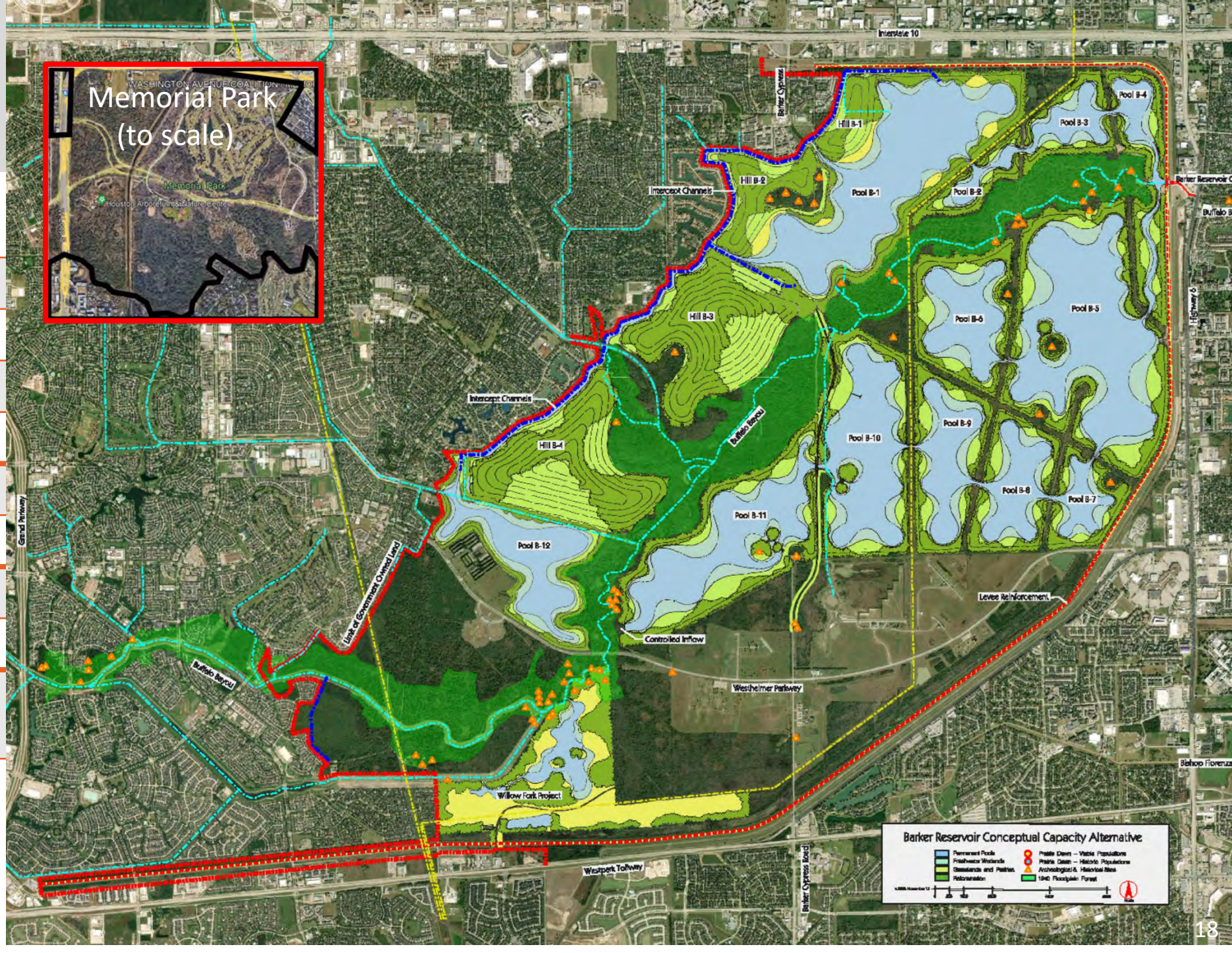


Barker Reservoir Conceptual Capacity Alternative

By Kevin Shanley

Open Water		2,254 acres
Wetlands		844 acres
Wet Prairie		1,223 acres
Shoreline		44 miles
Excavation	110,000 ac-ft	177,000,000 cy
Tallest Hill		350 feet
George Bush Park		No Change
Project Barker		No Change
Westheimer Parkway		NOT Elevated (to avoid Bush Park impacts)

Excavation exceeds that required for storage to create permanent wet bottom pools and to account for excavated fill placed below the maximum flood pool elevation.



The Result: Equivalent to a State or National Park

Concerns About Reservoir Excavation and Restoration

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We have adjusted our proposal based on these comments received about our earlier draft plan:

- Plan will avoid areas within reservoirs with archeological sites and/or Prairie Dawn
- Reduce chance of bird concentrations near West Houston Airport by avoiding excavation or open water in the western areas of Addicks Reservoir
- The proposed scope of work includes intercept channels along the edge of government-owned land to still allow sheet flow to drain into the reservoirs
- Address flooding due to conveyance constraints and poor roadway and bridge design, such as the Clay Road bridge at Langham Creek and Westheimer Parkway at Buffalo Bayou

- Regarding any potential geotechnical/land settlement related to the man-made hills, Frank Ong, a geotechnical engineer involved in the Memorial Park land bridge, stated: “Review of the provided soil boring logs (up to 100-feet deep) show that the subsoils in Addicks and Barker Reservoirs areas generally consist of stiff to very stiff clays interbedded with layers of medium dense to dense sands/silts. We expect similar soil conditions exist for the soils deeper than 100 feet. With the detailed site-specific geotechnical study and construction monitoring, the proposed 350-ft tall hills can be safely constructed to satisfy the stability and settlement requirements over these soil foundations”

Cost of Reservoir Excavation and Restoration

Rough Cost Estimates (table based on Harvey and 45' diameter tunnel scenario)

Storage in Acre-Feet	Addicks (58,000)	Barker (94,000)	Total (152,000)
Creation of Storage	$ 420,000,000	$ 683,000,000	$ 1,103,000,000
Elevate Roadways	$ 28,000,000	$ 0	$ 28,000,000
Parks and Trails	$ 57,000,000	$ 84,000,000	$ 141,000,000
Contingency (30%)	$ 151,000,000	$ 230,000,000	$ 381,000,000
Other Costs/Project Management	$ 230,000,000	$ 348,000,000	$ 578,000,000
TOTAL: 152,000 acre-feet	**$ 886,000,000**	**$ 1,345,000,000**	**$ 2,231,000,000**

Rough cost to address a 24" / 500-Year Event with 40-foot Tunnel: *+/- $1,437,000,000 (less efficient)*

Rough cost to address a 24" / 500-Year Event with 45-foot Tunnel: *+/- $1,150,000,000 (much less efficient)*

Summary of Storage Options

With a tunnel, these storage options can help protect Houston from likely storms:

Storage Option	Storage Created (acre-feet)	Estimated Cost	Cost per Acre-Foot
Barker Reservoir (with recreation amenities)	94,000	$1,345,000,000	$14,308
Addicks Reservoir (with recreation amenities)	58,000	$886,000,000	$15,275
Upper Addicks Watershed - Retention	60,000	$891,000,000	$14,850
Addicks Watershed Creekside Retention	43,000	$606,000,000	$14,093
Cypress Watershed Conservation/Restoration	17,000	$300,000,000	$17,647
Potential Total of Added Storage	272,000	NA	Average of $14,800
Storm Scenario	**Storage Required (acre-feet)**	**Estimated Cost**	**Based on Average**
500-Year Storm with 45' Diameter Tunnel	43,000	$636,000,000	excludes tunnel
500-Year Storm with 40' Diameter Tunnel	72,000	$1,066,000,000	excludes tunnel
Repeat of Harvey with 45' Tunnel	152,000	$2,250,000,000	excludes tunnel

The Cost of Doing Something versus Doing Nothing

Cost of Doing Something

• Tunnel	$6,500,000,000 - $7,000,000,000
• Additional Storage (incl. Reservoir Excavation)	$ 636,000,000 - $2,250,000,000
TOTAL*	$7,136,000,000 - $9,250,000,000

** Lower flood insurance premiums could offset some costs*

Cost of Doing Nothing

• FEMA Formula	$1 of mitigation results in $6 of avoided damages
• Hurricane Harvey	$125,000,000,000 of damages in Harris County**

*** Argues for $21 billion investment county-wide*

Next Steps

BUFFALO BAYOU COMMUNITY PLAN

BBCP

- Present to interested stakeholders

1

- Support USACE and HCFCD BB&TRS Tunnel Feasibility Study

2

- Seek Congressional appropriation for Section 7001 Proposal Feasibility Study following approval of the 2024 Water Resources Development Act
- Identify local match funding (estimated at 25% of $3 million or $750,000)

3

- Partner with HCFCD, other public agencies, developers and landowners on detention/retention projects

4

- Partner with government agencies on land acquisition and restoration in Cypress Creek watershed

Buffalo Bayou Community Plan

Questions?

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Please Note

The Buffalo Bayou Community Plan, as developed by Houston Stronger, is a series of proposals that serve as alternatives to the USACE's Buffalo Bayou and Tributary Resiliency Study Interim Report released October 2, 2020. This is a "living document" that has and will continue to evolve as Houston Stronger receives input on projects and plans that are ongoing across the region.

Houston Stronger greatly appreciates the contributions of its Technical Committee members and Expert Advisors in developing these concepts. They are listed on the following slide.