Developing Improved Benefit Cost Analysis Guidance Document

Texas Water Development Board

Jenna Rao, Anne Watkins, Saul Nuccitelli

Integrating Natural Hazard Mitigation and Clean Water Act Planning and Implementation Workshop
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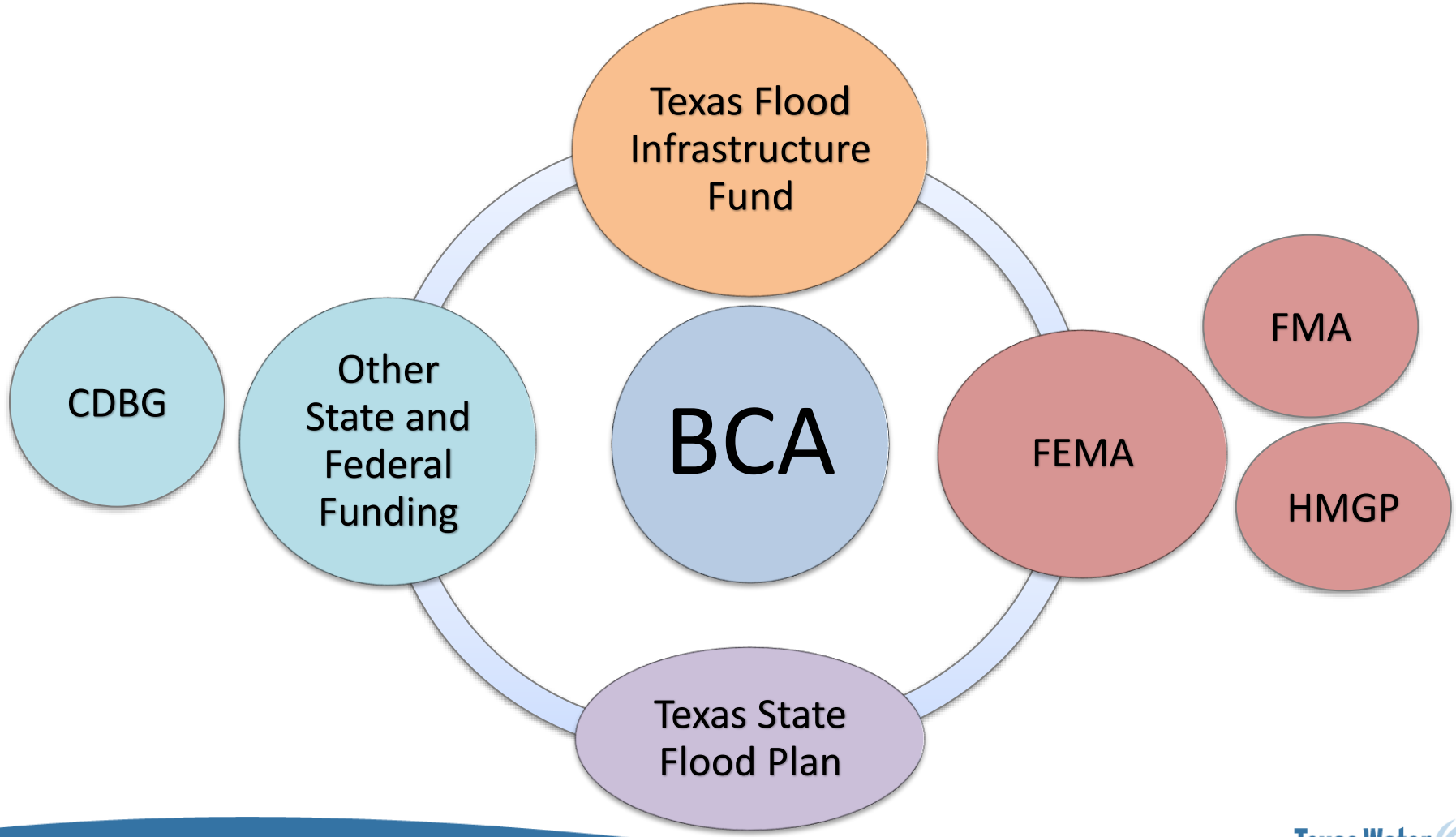
Outline

- Why is Texas trying to improve BCA guidance?
- Is the current BCA process equitable and comprehensive?
- How can equity be considered?
- How can ecosystem services be used in a BCA analysis?
- Next Steps

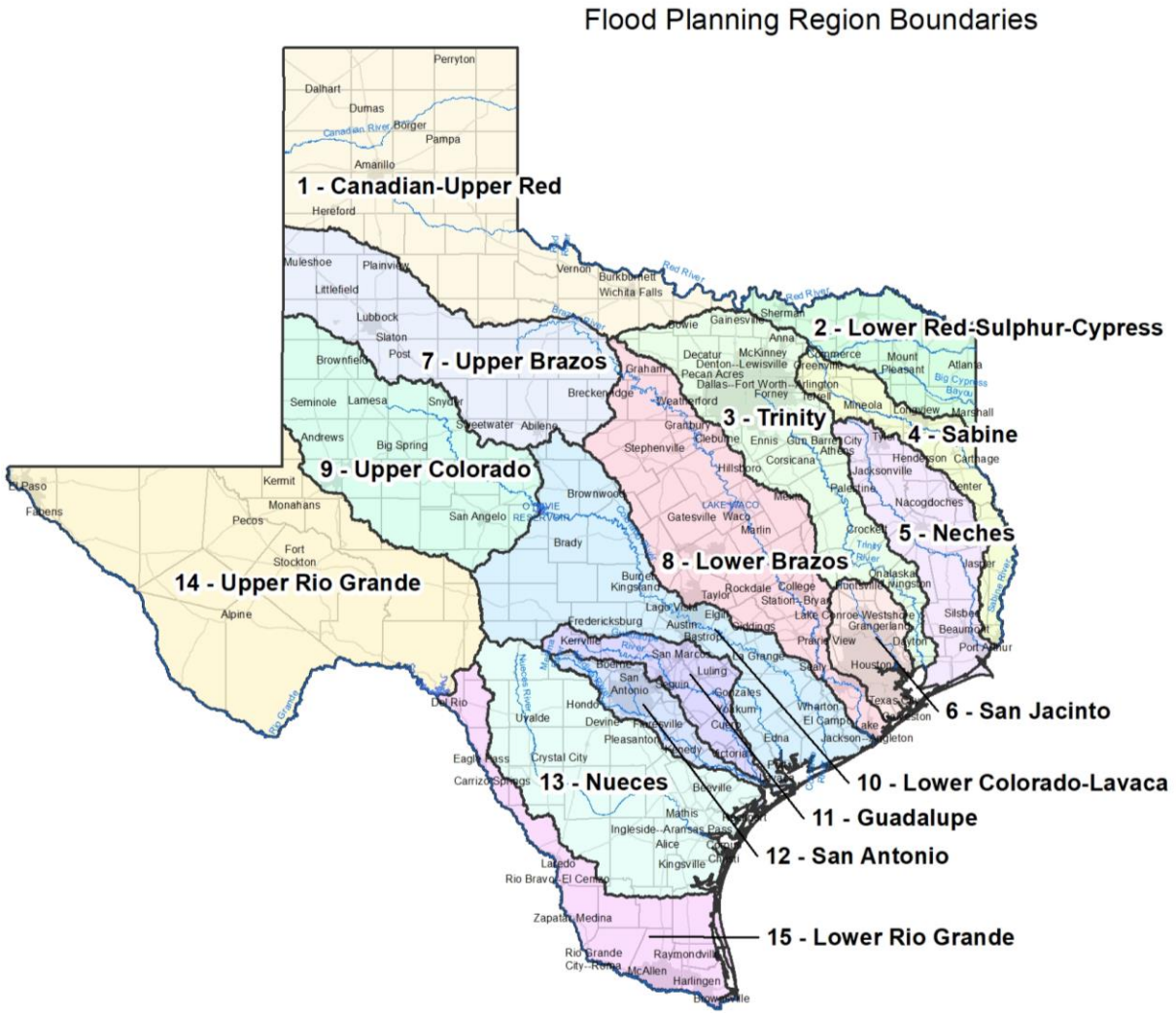
WHAT IS BCA USED FOR?

BCA used for Cost Effectiveness of FMP



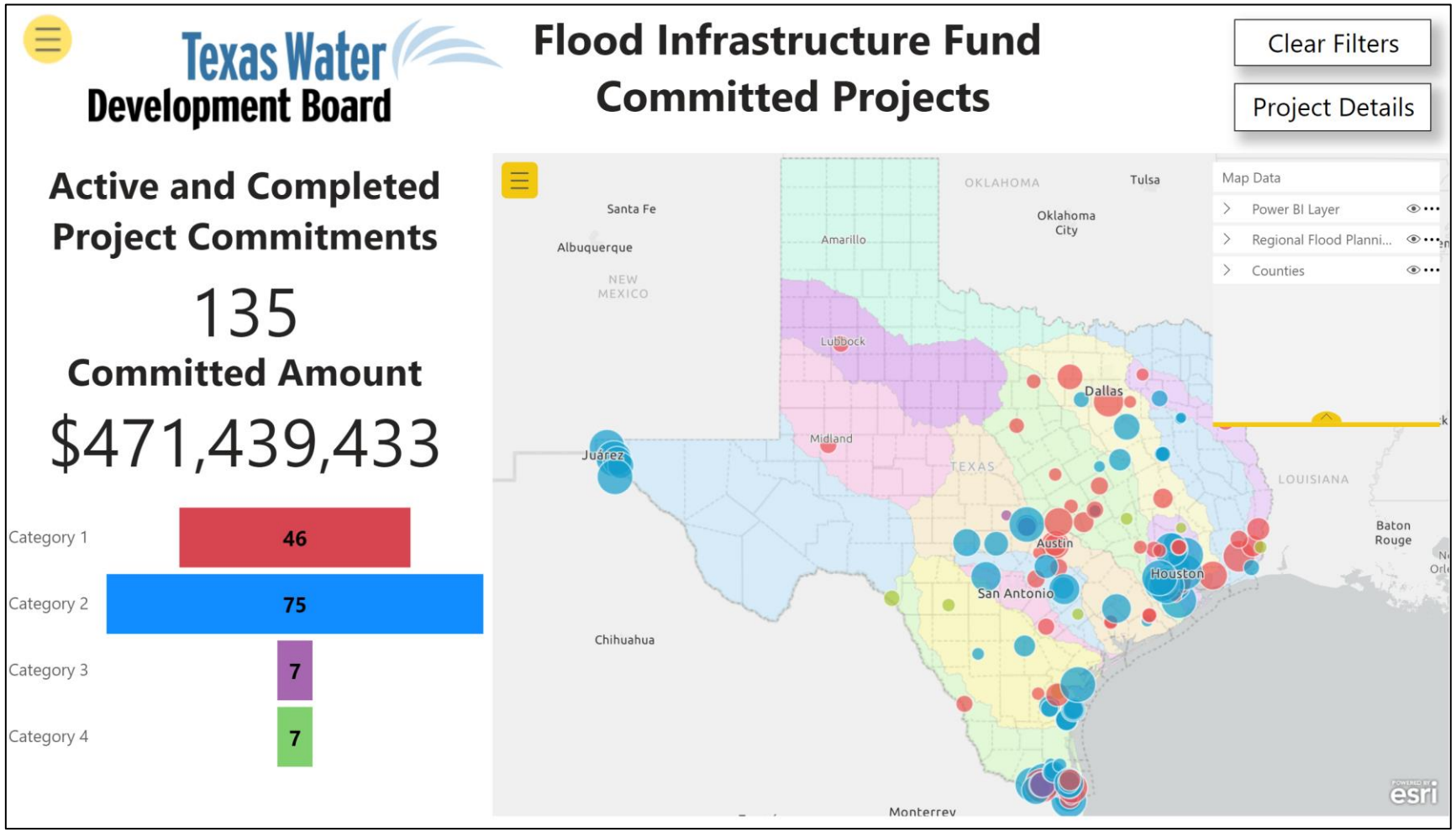
State Flood Plan

- Regional Flood Plans
  - Identify flood risk
  - Recommend strategies, evaluations (studies), and projects
- State Flood Plan
  - Combine and summarize regional plans
  - Rank all recommended strategies, evaluations (studies), and projects
  - Projects require a Benefit-Cost Ratio (BCR)
- State Financial Assistance
  - Efforts included in State Flood Plan will be eligible



Flood Infrastructure Fund (FIF)

- State Financial Assistance for studies, projects, and other activities
- Funding mix of grant and 0% loan
- 2019 - One time appropriation of $793M
- 2023 - State Legislature considering $300-400M, to supplement fund
- Construction Projects require BCR



Federal Agency BCAs

Over the past several decades, **BCAs have become an established tool for evaluating regulatory changes and other federal investments**, particularly in infrastructure and public works.

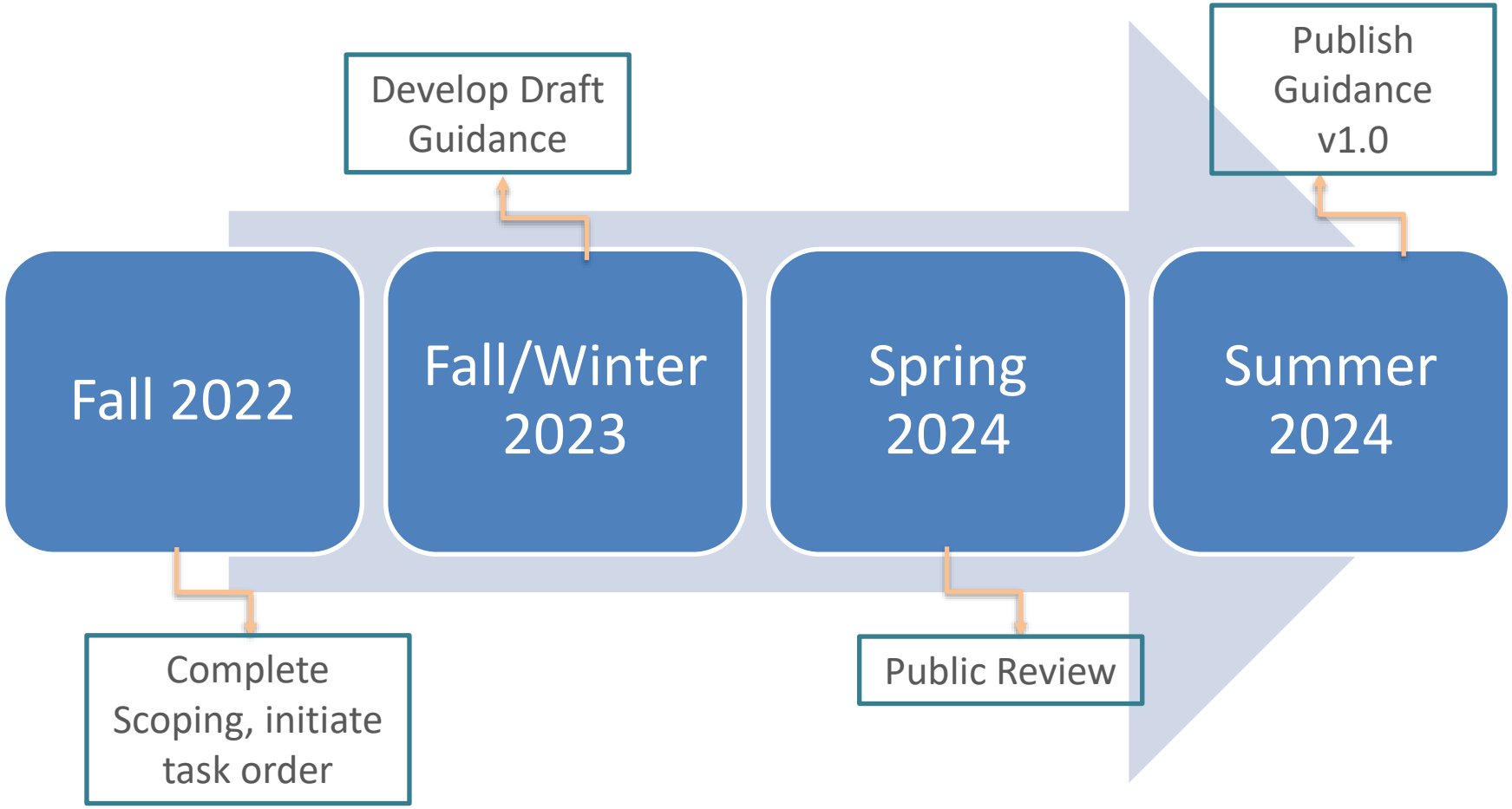
DOT	FEMA	USACE	HUD
• Expects applicants to provide BCAs and incorporate them into any relevant planning activities. • Sample benefits include safety, travel time, operating cost savings, emissions reductions, changes to operating and maintenance expenditures, residual value, and disbenefits during construction.	• Applicants must use FEMA-approved methodologies and tools—like the FEMA BCA Toolkit—to demonstrate cost-effectiveness. • FEMA's BCA methodology includes impacts to people, direct asset damage to property, and ecosystem benefits, but factors like health and safety are excluded except for in specific cases.	• BCAs have been mandated within Corps planning studies since the Flood Control Act of 1936. They play a large role in determining which projects are ultimately funded. • The P&G required recommendation of the alternative with the greatest net NED benefits. Updated PR&G strives to maximize economic, social, and environmental benefits, with no hierarchy.	• Not all HUD projects require BCAs, but projects under the CDBG-DR Rebuild By Design (RBD) program and those submitted for the National Disaster Resilience Competition (NDRC) are asked to complete them. • HUD encourages use of FEMA's BCA toolkit but allows applicants to use a range of methodologies with justification.

TWDB GUIDANCE DOCUMENT

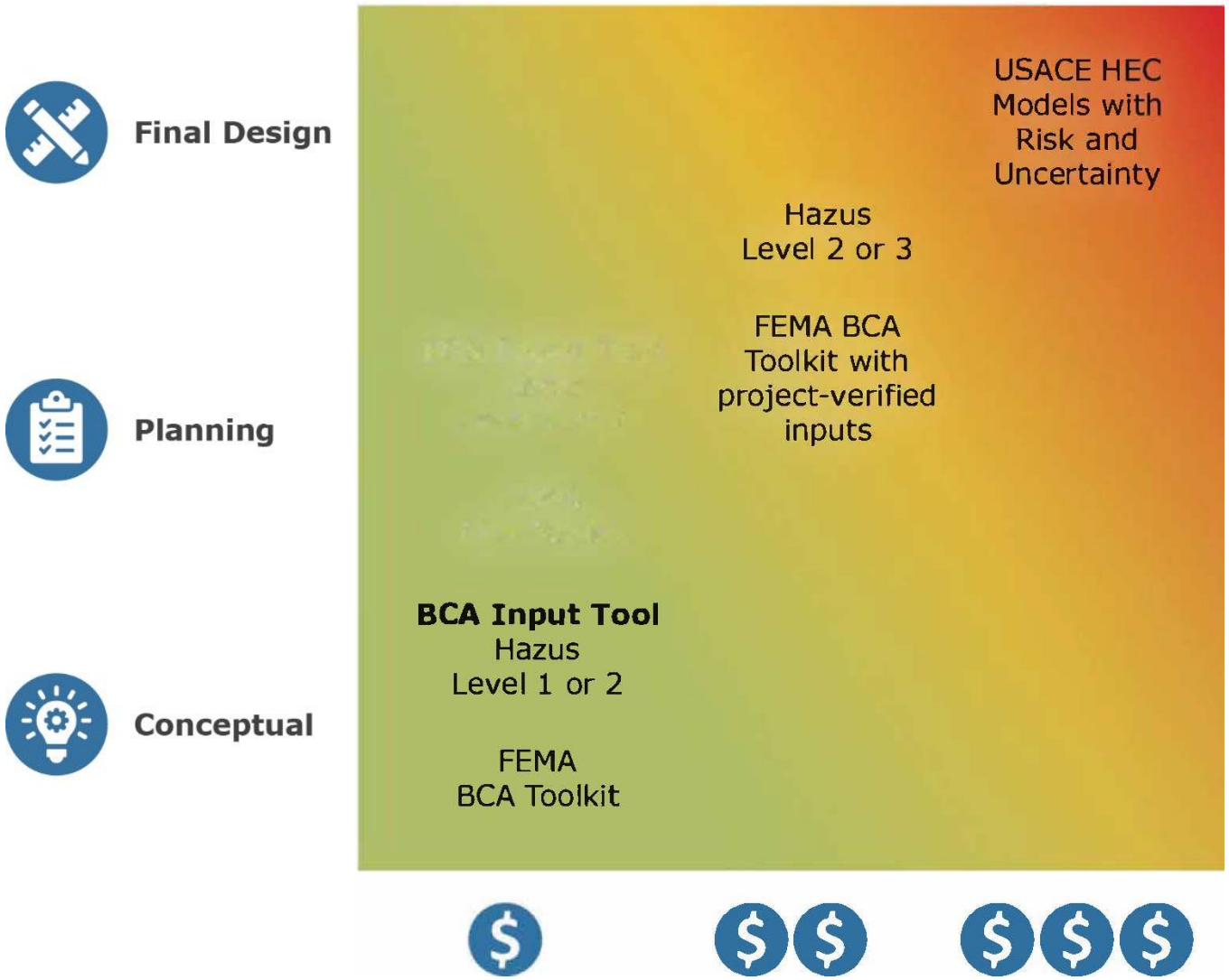
BCA Project Overview

- Current TWDB BCA Guidance Document Development
- BCA is a common measure to estimate cost effectiveness of proposed projects
- The project consisted of the following:
  - Literature Review
  - Flow Chart on Level of Analysis
  - Damage Benefit Tables References
  - Sensitivity of BCA
  - Draft Guidance and Final Guidance

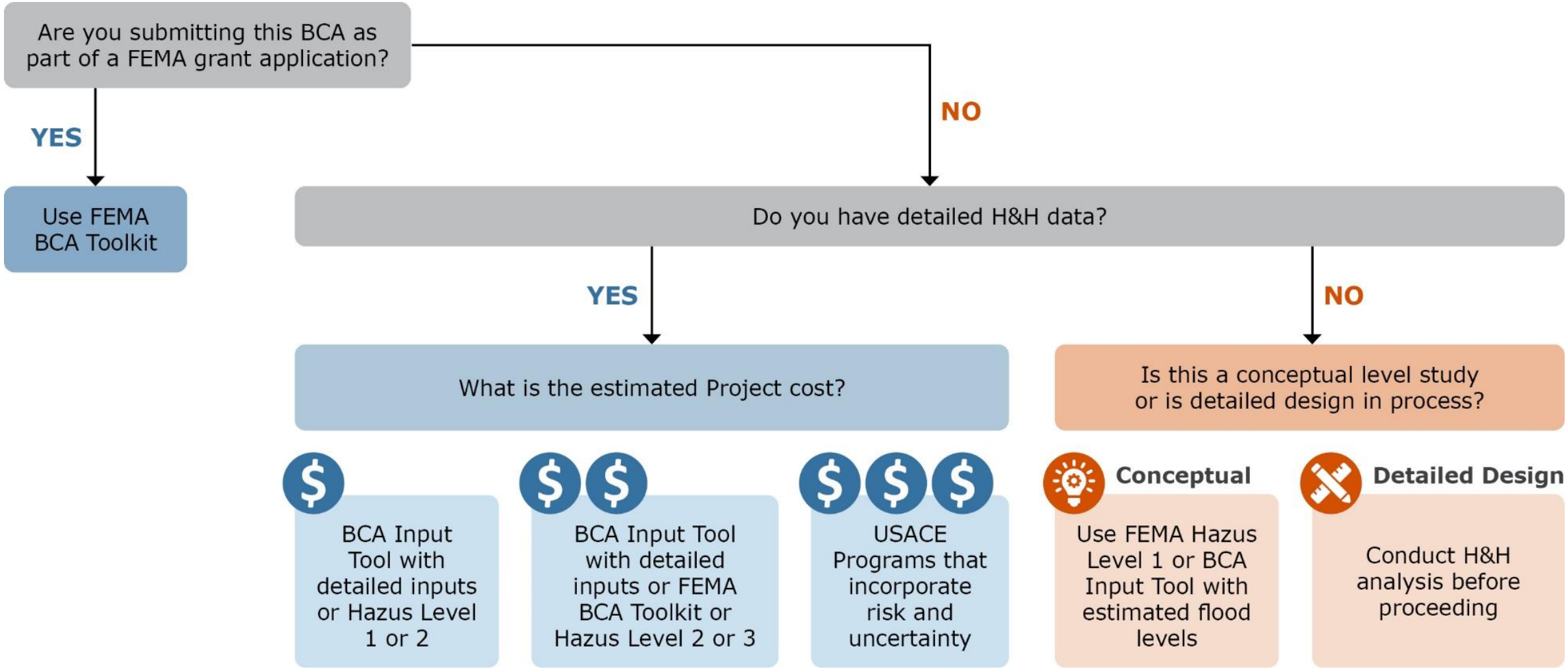
BCA Guidance Schedule



Level of Analysis for BCA Matrix



Flow Chart to Determine Appropriate BCA Model



Data Requirements for BCA

Benefit Categories	Examples of Data Requirements (For the Baseline and Project Alternative)
Flood Damages	Water elevations; number, type, value, and elevation of structures; debris totals
Loss of Function	Water elevations; number of households and businesses; impacted utilities
Life and Safety	Populations served and response times for emergency services; estimated injuries or deaths due to flooding
Environmental	Acres of habitat by type; reduction in stormwater runoff and treatment costs
Travel Savings	Traffic counts on streets that flood; detour routes
Agricultural	Land use and cropping patterns; acres of crops inundated; crop yields and expenses
Recreation	Number of recreational visitors; type of recreation; quality of experience
Water Supply	Annual or daily water supply yield; regional water costs
Residual	Construction costs; component lifespans

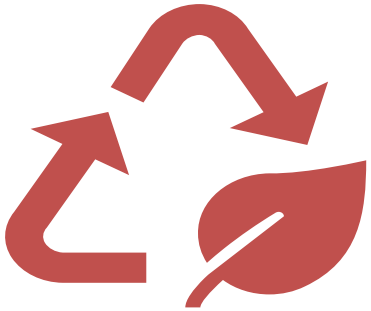
Damage Benefit Tables

Land Use Types:

Agriculture (crop/livestock),

Transportation Infrastructure,

Utility Infastructure



Impact Types:

Social Factors,

Health and Safety,

Environment and Water Quality

Sensitivity of BCA

- Impacts of property and asset values with an emphasis on residential and transportation facilities on the results of the BCA.
- Identifying ways and reducing issues surrounding inequitable BCA for residential projects, as well as characterizing uncertainties with the BCA guidance or tables:
  - Residential Sensitivity
  - Transportation Sensitivity
  - Sensitivity of Discount Rate

BCA SENSITIVITY

Critiques of the Traditional BCA

EDE

Social vulnerability in cost-benefit analysis for flood risk management

Jarl Kind,[1*] W. J. Wouter Botzen,[2,3,4] and Jeroen C. J. H. Aerts[2]

"Most of the traditional 'flood' CBAs focus narrowly on avoided asset damages…**Focusing on avoiding asset damages will steer investments in flood risk reduction to areas with people who are already relatively better off, leaving the poor exposed**."

"Nor do they consider how flood damage is distributed over people with different incomes, and the **capacities of those people to cope with, and recover from, floods**."

Critiques of the Traditional BCA

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Application Process

Regional Assistance

BCA Input Tool

Types of Project Impacts	
Residential Structure Damage Reduction	Yes
Commercial Structure Damage Reduction	Yes
Critical Facility (Police, Fire, Hospital) Loss of Function Reduction	Yes
Reduction in Street Flooding	Yes
Utility Outage Reduction	Yes
Agricultural Damage Reduction	Yes
Water Supply Benefits	Yes
Recreation Benefits	Yes
Does this project include Green Infrastructure elements?	Yes
Does this project replace a low-water crossing?	Yes

https://www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/BCA%20Workbook.zip

Triple Bottom Line BCA

Financial (Property)

- **Property damages avoided**
- Agricultural damages avoided
- Infrastructure damages avoided

Social (People)

- **Mental health and anxiety**
- **Lost productivity**
- **Recreation values**
- **Access to utilities/critical services**
- **Emergency response**
- Injuries/loss of life

Environmental (Place)

- **Ecosystem service values**
- Green infrastructure values
- Water quantity and quality

Normalize Values

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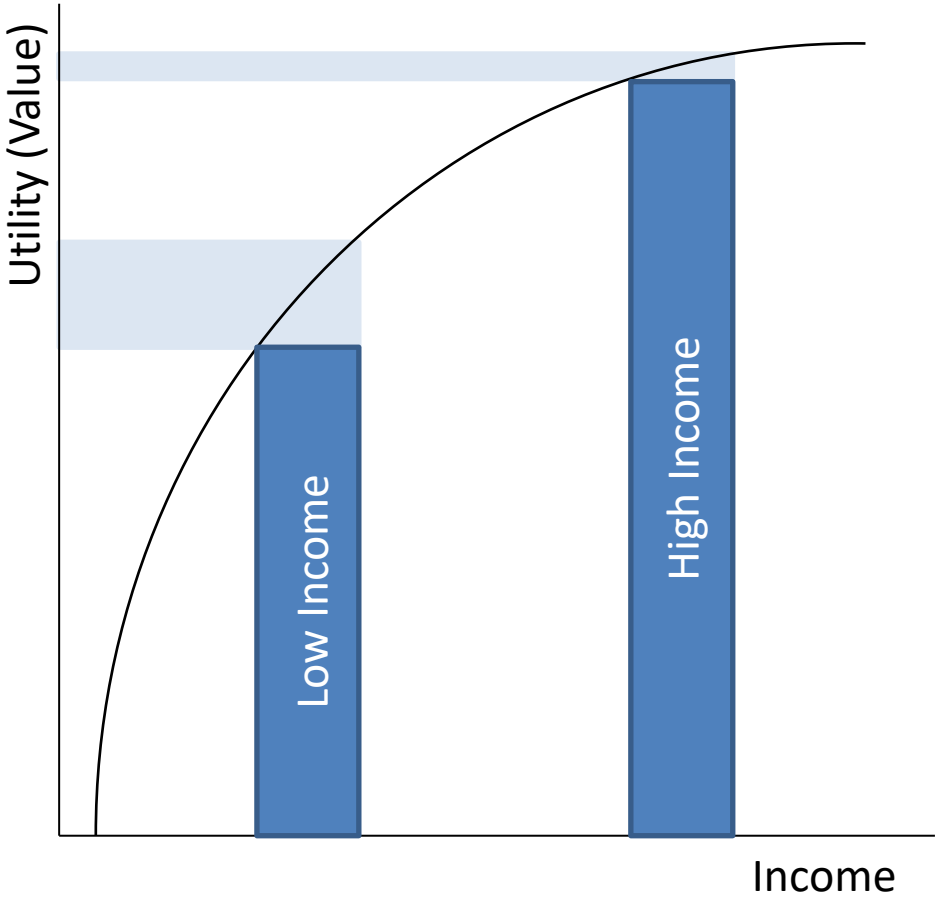
SOCIAL EQUITY WEIGHTING

Social Equity Weights



This relies on the concept of **marginal utility of the dollar** whereby a dollar held by a household with a lower income is more valuable than an identical amount held by a household with a higher income.

Marginal Utility of the Dollar

Key Concept: Marginal Utility of the Dollar
whereby a dollar held by a household with a lower income is more valuable than an identical amount held by a household with a higher income.

$$Utility = \frac{Income^{(1-Elasticity\ of\ Marginal\ Utility\ of\ Consumption)}}{(1 - Elasticity\ of\ Marginal\ Utility\ of\ Consumption)}$$

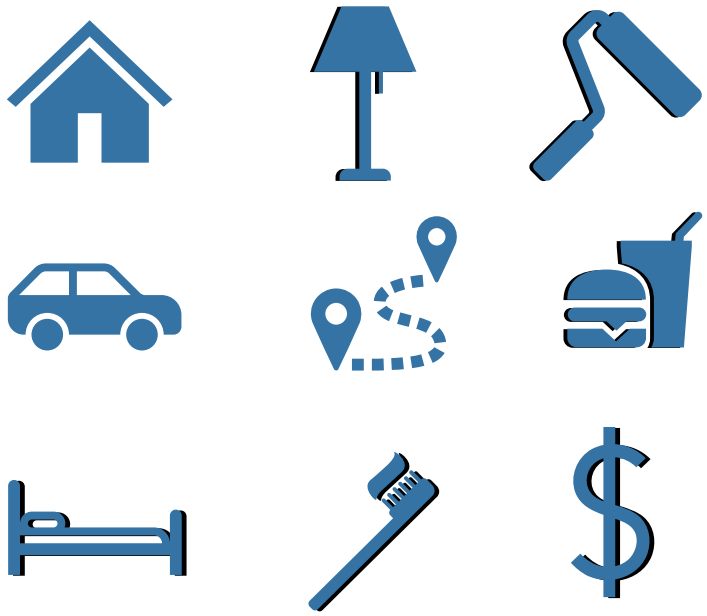
→ **The marginal utility is estimated based on the comparative utility of a given income and that income plus one additional dollar.**

Source: Kind, et al. 2019. Social Vulnerability in Cost-Benefit Analysis for Flood Risk Management.

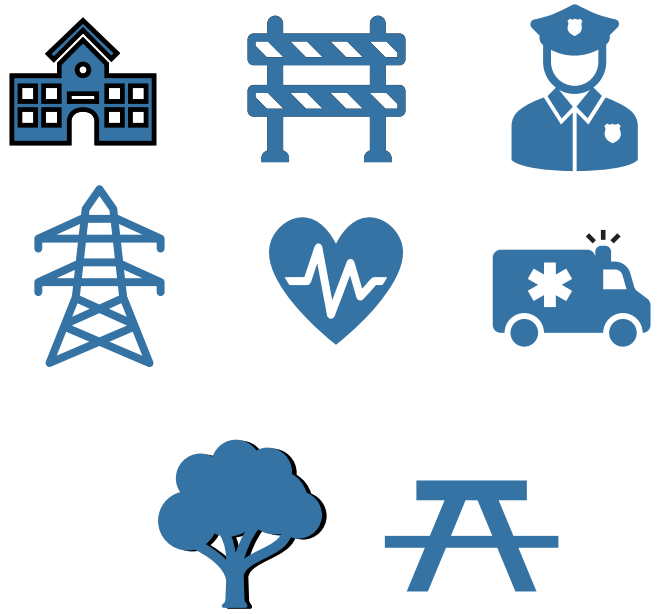
Equity Weight Application

Weights are applied only to benefits that result in an out-of-pocket expense.

Out of Pocket Expenses (Weighted)



Indirect Expenses (Not Weighted)



Equity Weight Equation for BCR

$$\left[\left(\text{Direct Benefits}\right) \times \text{Equity Weights}\right) + \text{Other benefits}\right] / \text{Costs} = \text{Equity-weighted benefit cost ratio (BCR)}$$

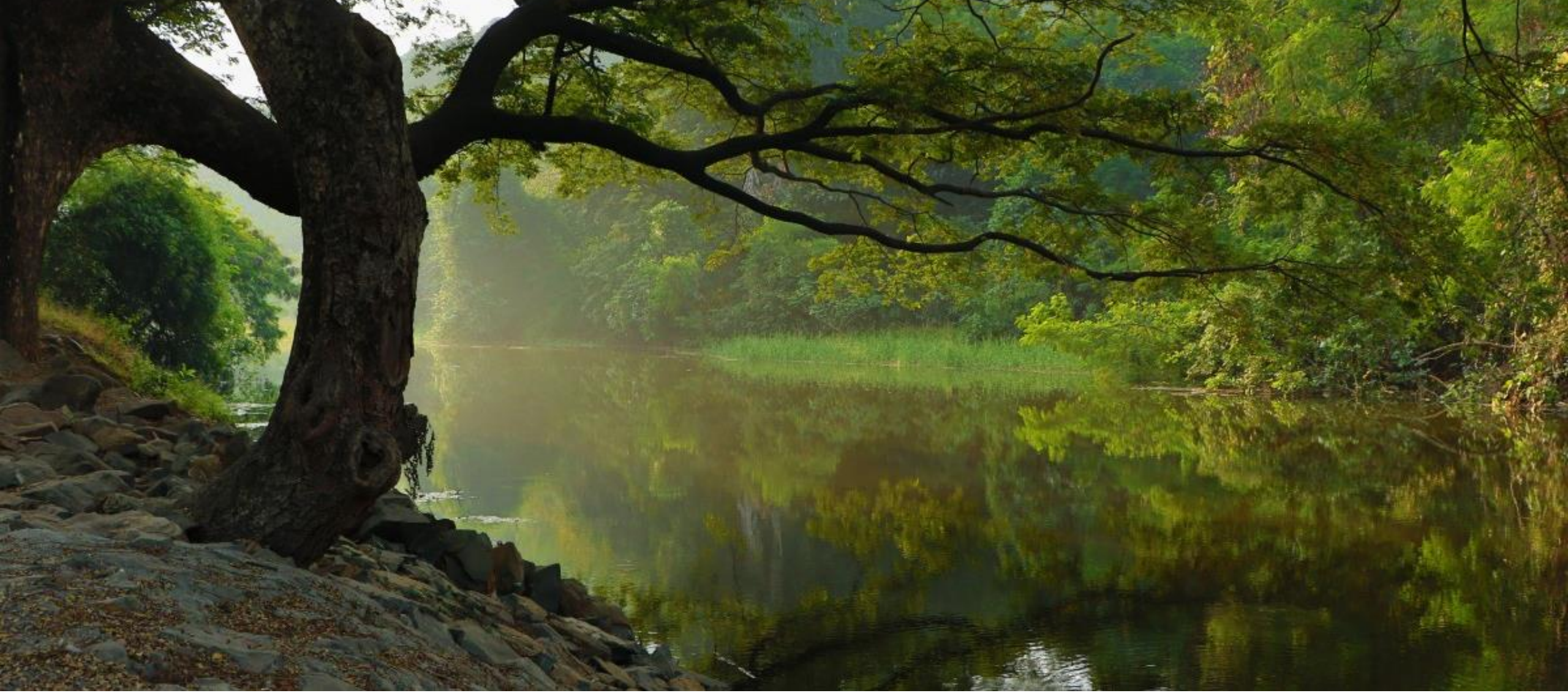
multiply *add* *divide*

(avoided out-of-pocket expenses)

(derived from the marginal utility of a dollar)

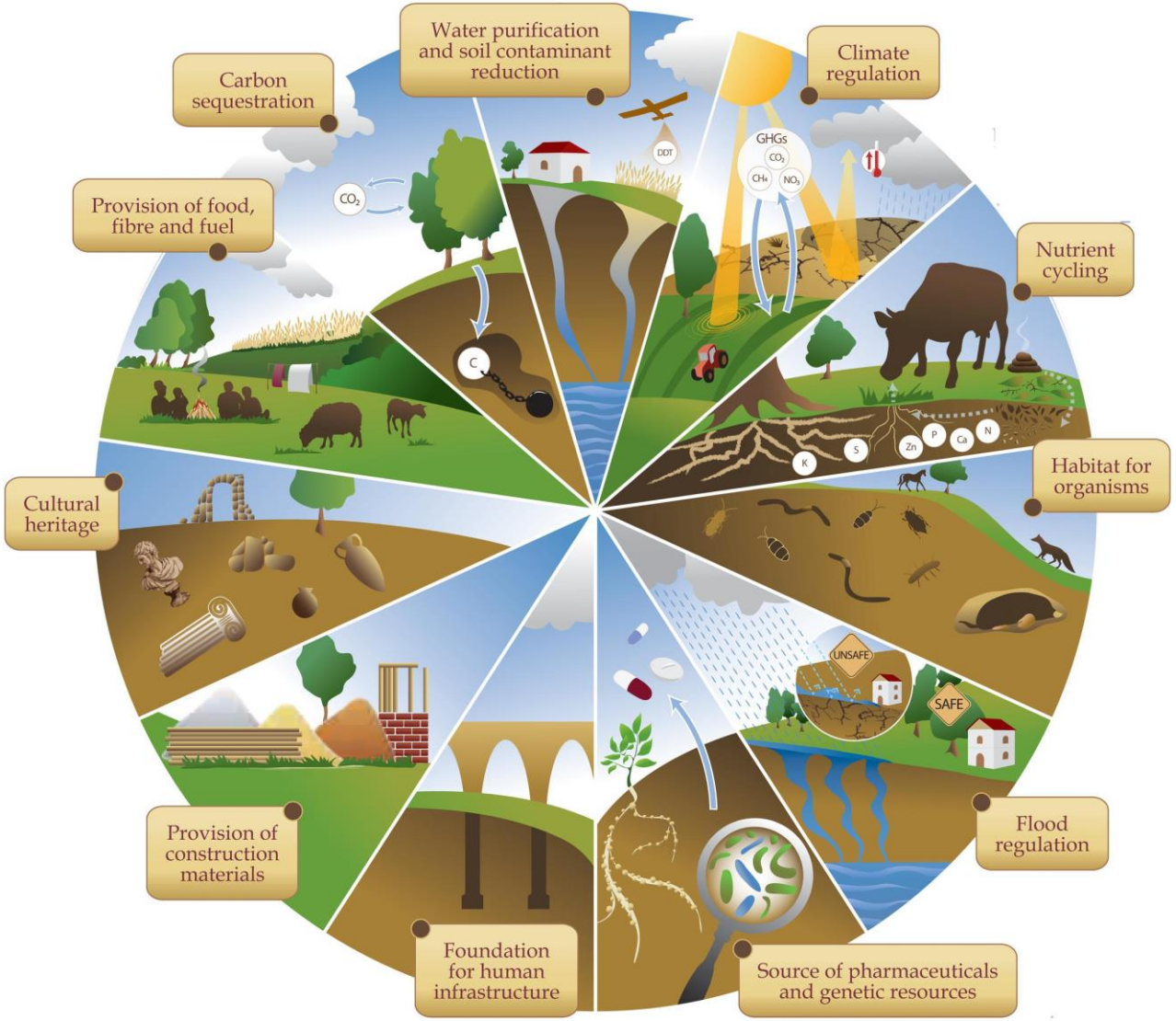
(other benefits that do not directly impact household spending)

(capital and operations & maintenance)

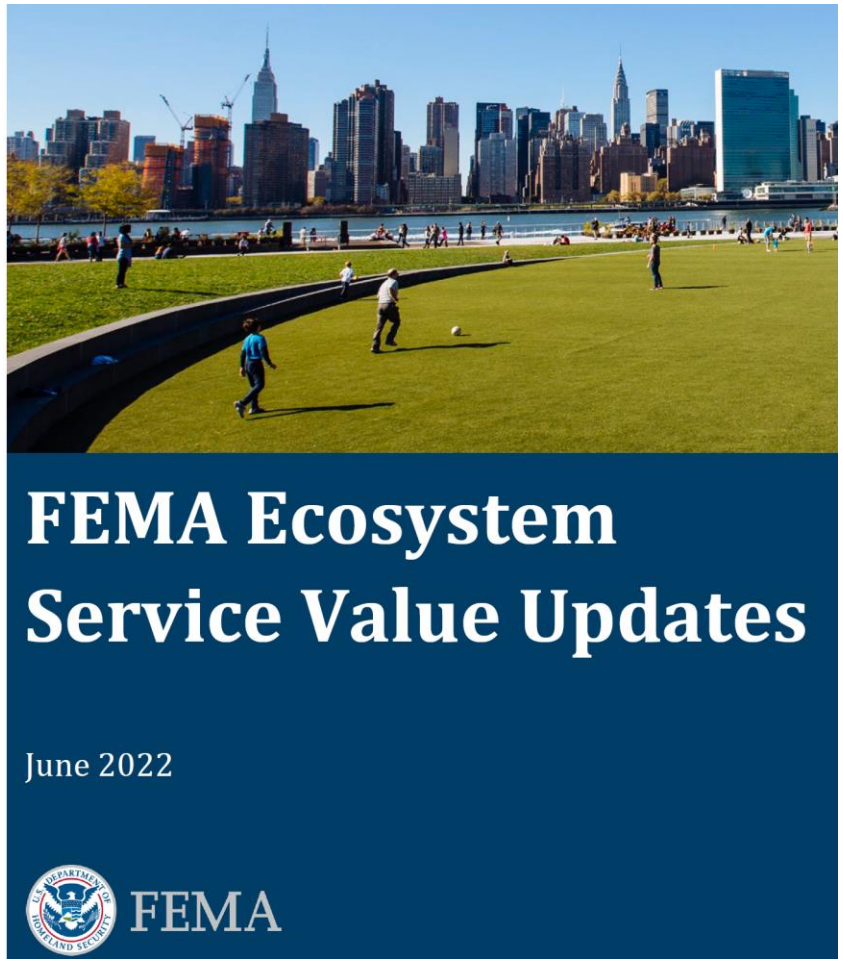


BCA IN ECOSYSTEM SERVICES

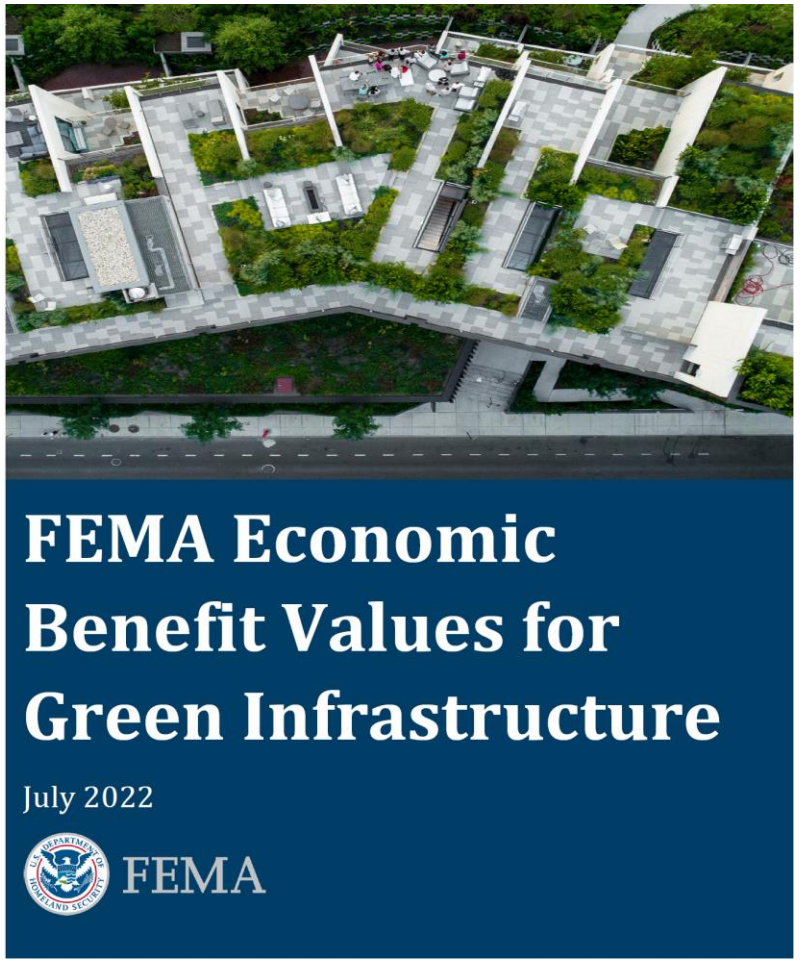
Accounting for Ecosystem Services in BCA



FEMA Updates to Ecosystem Services



https://www.fema.gov/sites/default/files/documents/fema_ecosystem-service-value-updates_2022.pdf



https://www.fema.gov/sites/default/files/documents/fema_economic-benefit-values-green-infrastructure.pdf

FEMA Green Infrastructure Updates

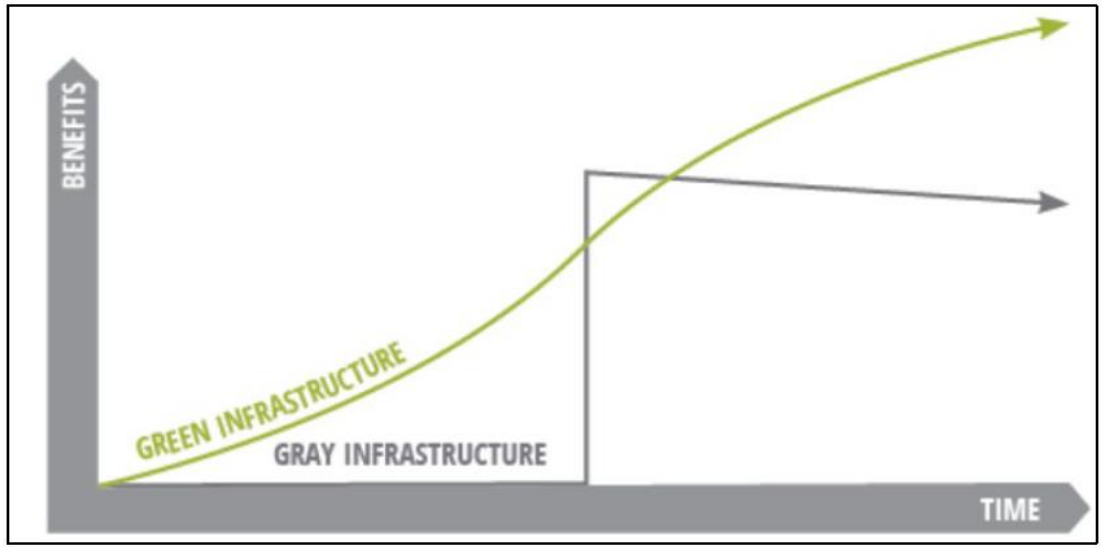


Figure 1. Benefits Realized Over Time: Green versus Gray Infrastructure

(Tables from FEMA Economic Benefit Values for Green Infrastructure)

Table 1. Categories of Green Infrastructure Benefits

Benefit	Definition
Avoided carbon emissions	Energy savings provided by green infrastructure reduces carbon emissions produced by equivalent gray infrastructure
Building energy cost savings	Reduction in energy use for heating and cooling by insulating buildings from large changes in temperature
Carbon sequestration	Process of removing and storing carbon dioxide (CO_2) from the atmosphere
Drought risk reduction	Mitigating drought risk by increasing water supply through groundwater infiltration
Habitat	Providing shelter and refugia to maintain biological diversity

Benefit	Definition
Heat risk reduction	Reducing the risk of human heat-related illness by reducing local temperatures through shade and evapotranspiration
Property value improvement	Increase in home sales price because of proximity to green infrastructure
Removal of air pollutants	Removing air pollutants, such as particulate matter or ozone, from the atmosphere
Stormwater volume and quality	Reducing the quantity of stormwater runoff and pollutant loading through increased infiltration

FEMA Green Infrastructure Updates

Table 2. Economic Benefit Valuation Methods

Method	Description	Example
Direct Market Valuation		
Market price	Valuations are directly obtained from the prices paid for the good or service in markets	Price of energy sold on open markets
Replacement cost	Cost of replacing a given benefit provided by functioning green infrastructure with a built solution	Cost of replacing a raingarden's natural filtration capacity with a water filtration plant
Avoided cost	Economic losses that would be incurred if a particular form of green infrastructure were removed or its function significantly impaired	Costs related to flooding (e.g., life losses, building and road damages, missed workdays) that would be mitigated by green infrastructure that reduces flood extents
Revealed Preference Approaches		
Travel cost	Costs incurred in the traveling required to consume or enjoy a benefit provided by green infrastructure	People who travel to visit an urban park must value that experience at least as much as the cost of traveling there
Hedonic pricing	Benefits (or costs) of green infrastructure manifested through the	Property values near lakes and parks tend to exceed similar

Table 3. Summary of Proposed Green Infrastructure Categories and Benefits

Benefit	Green Roofs ($/ft²/year)	Permeable Pavement ($/ft²/year)	Bioretention ($/ft²/year)	Urban Trees ($/tree/year)
Building energy cost savings	$0.05			$17.05
Carbon sequestration and avoided emissions	$0.01	$0.003	$0.02	$6.33
Drought risk reduction		$0.13	$0.52	$5.53
Habitat	$0.05		$0.11	$40.18
Heat risk reduction				$910.28
Property value improvement	$0.19		$0.40	$53.15
Removal of air pollutants	$0.001		$0.004	$2.50
Stormwater volume and quality	$0.09	$0.51	$1.80	$20.17
Total ($/ft²/year)	**$0.40**	**$0.64**	**$2.84**	**$1,055.19**
Total ($/acre/year)	$17,616.66	$27,949.13	$123,598.82	*

$/ft²/year = dollars per square foot per year

*values could not be converted to $/acre/year

(Tables from FEMA Economic Benefit Values for Green Infrastructure)

FEMA Ecosystem Services Updates

Table 3. Summary of Changes to Land Cover Categories and Ecosystem Service Values

2016 Adopted Values		2022 Proposed Values	
Land Cover Category	Value (2014 USD/acre/year)	Land Cover Category	Value (2021 USD/acre/year)
Forest	554	Forest	12,589
Green Open Space	8,308	Urban Green Open Space	15,541
		Rural Green Open Space	10,632
Riparian	39,545	Riparian	37,199
Wetland	6,010	Coastal Wetland	8,955
		Inland Wetland	8,171
Marine and Estuary	1,799	n/a*	n/a
n/a	n/a	Coral Reefs	7,120
n/a	n/a	Shellfish Reefs	2,757
n/a	n/a	Beaches and Dunes	300,649

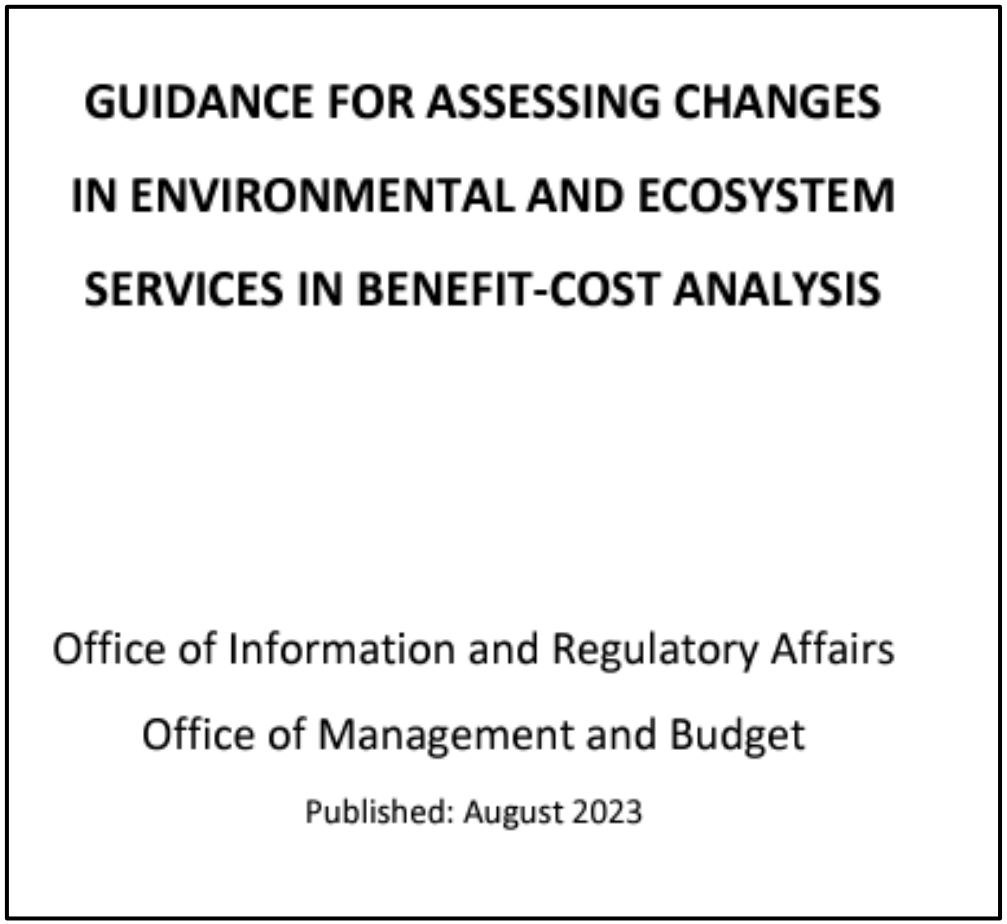
*The Marine and Estuary category (and most of its associated values) was merged with the Coastal Wetland category

Table 8. Conceptual Examples of Mitigation Projects that Include Land Cover Categories

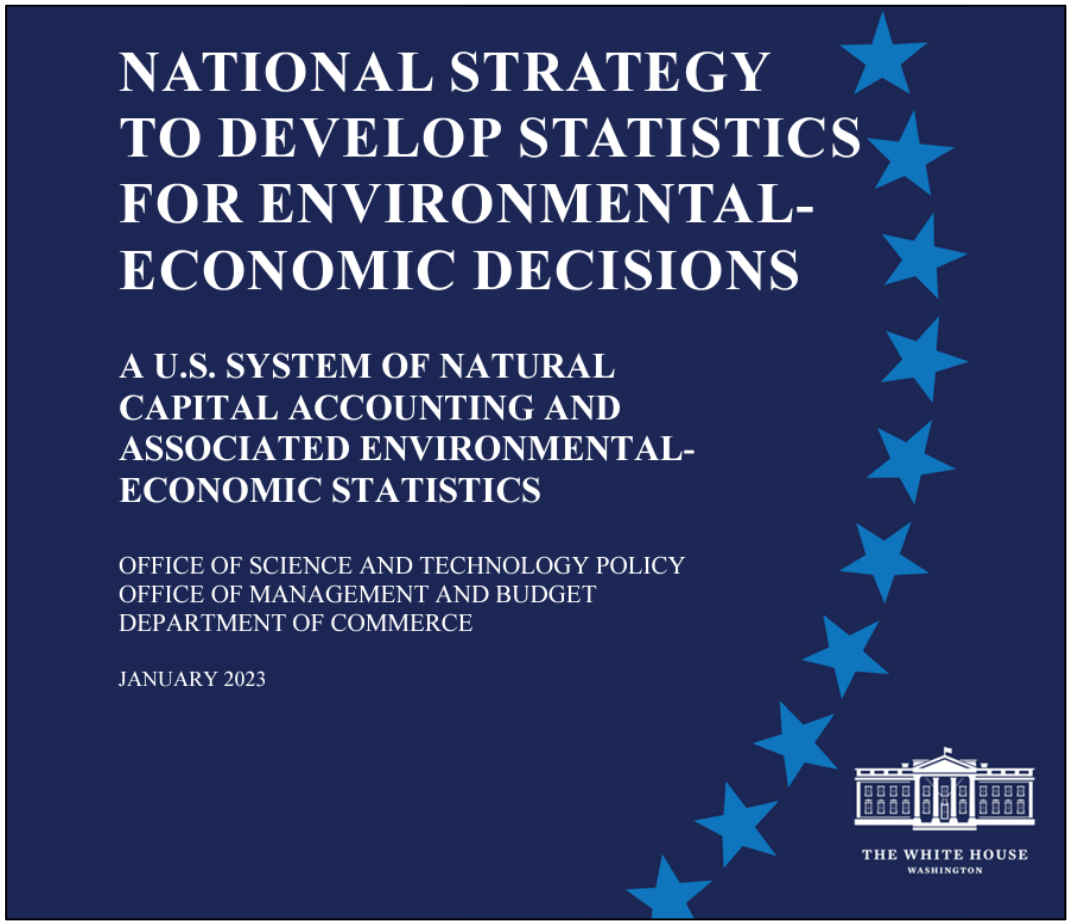
Land Cover Category	Conceptual Example	Link to Detailed Guidance
Forest	Reforestation of urban areas (e.g., as a component of an Acquisition and Relocation/Demolition project or other eligible mitigation project) to mitigate natural hazards such as heat and pluvial flooding, while generating other ecosystem services (e.g., aesthetic value, air quality, recreation).	Appendix A
Coastal Wetland	Restoration, creation, enhancement or protection of coastal wetland as part of a mitigation project to support erosion reduction, sediment trapping and building, wave attenuation, surge attenuation, and/or flood storage.[11]	Appendix B
Inland Wetland	Restoration, creation, enhancement or protection of an existing inland wetland area or creation of a new inland wetland area as a component of a Flood Diversion and Storage (FDS) or Floodplain and Stream Restoration (FSR) project to increase flood storage capacity on the land/floodplain, reduce runoff and decrease flood risk to downstream, upstream or adjacent people and structures. This example would apply to forested areas within an FDS or FSR project that are not defined as "riparian."	Appendix C

(Tables from FEMA Ecosystem Service Value Updates

Federal Updates to Ecosystem Services

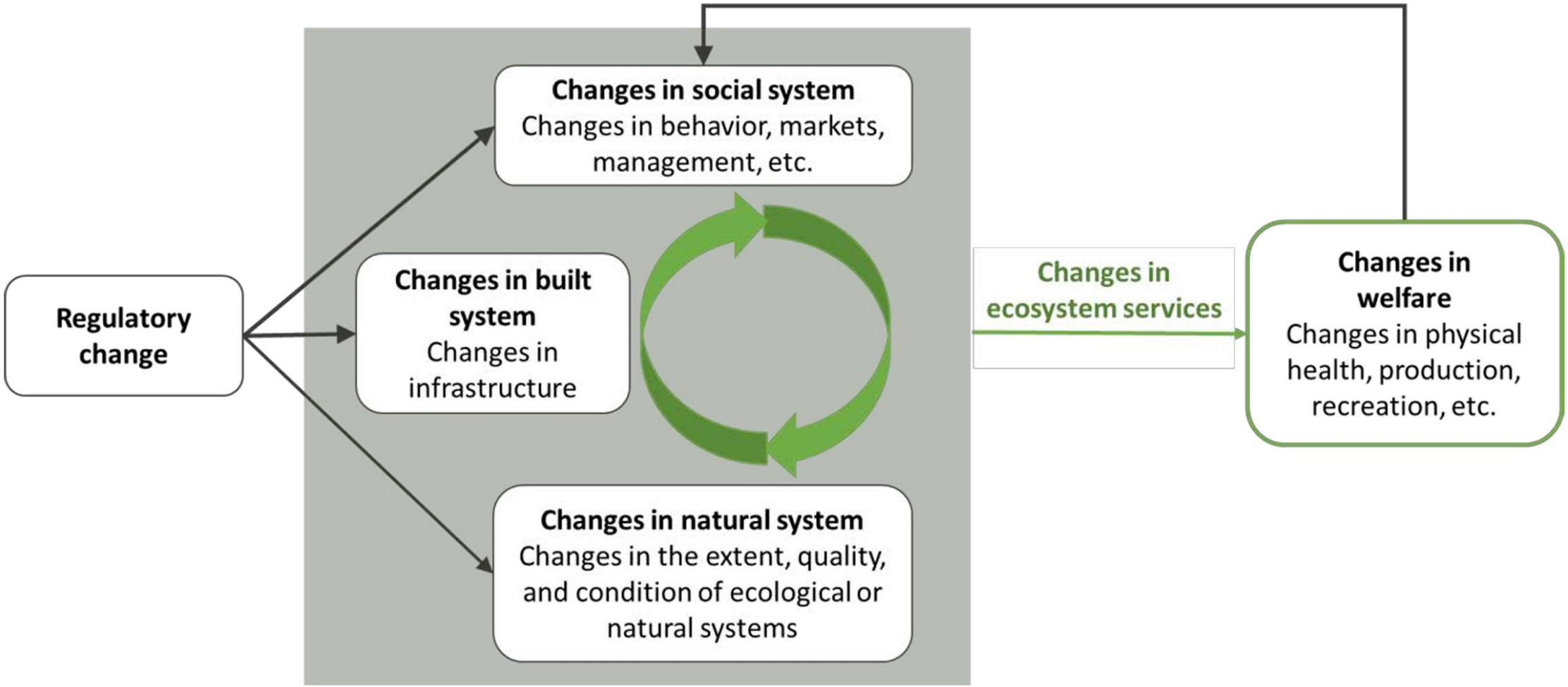


https://www.whitehouse.gov/wp-content/uploads/2023/08/DraftESGuidance.pdf



https://www.whitehouse.gov/wp-content/uploads/2023/01/Natural-Capital-Accounting-Strategy-final.pdf

Conceptual Framework



(Figure from GUIDANCE FOR ASSESSING CHANGES IN ENVIRONMENTAL AND ECOSYSTEM SERVICES IN BENEFIT-COST ANALYSIS)

Recommended Steps for Analysis: *Iterative*

- **Step 1**. **Scope** and (i.e., time and spatial scale) level of the analysis is sufficiently broad to reflect important ecosystem services in the baseline and across alternatives.
- **Step 2**. **Describe links** between regulatory alternatives and likely changes to ecosystem services, and preliminarily determine which ecosystem services should be included in the analysis.
- **Step 3**. To the extent feasible and appropriate, **monetize, quantify, or qualitatively describe** the important effects of the regulatory alternatives on ecosystem services, and address uncertainty.
- **Step 4**. **Aggregate** estimated ecosystem-service changes and report them in a table, along with other benefits, costs, and transfers.
- **Step 5**. Incorporate monetized, quantified, and qualitatively described ecosystem-service benefits and costs into a **narrative describing all benefits, costs, and transfers**.

(Text from GUIDANCE FOR ASSESSING CHANGES IN ENVIRONMENTAL AND ECOSYSTEM SERVICES IN BENEFIT-COST ANALYSIS)

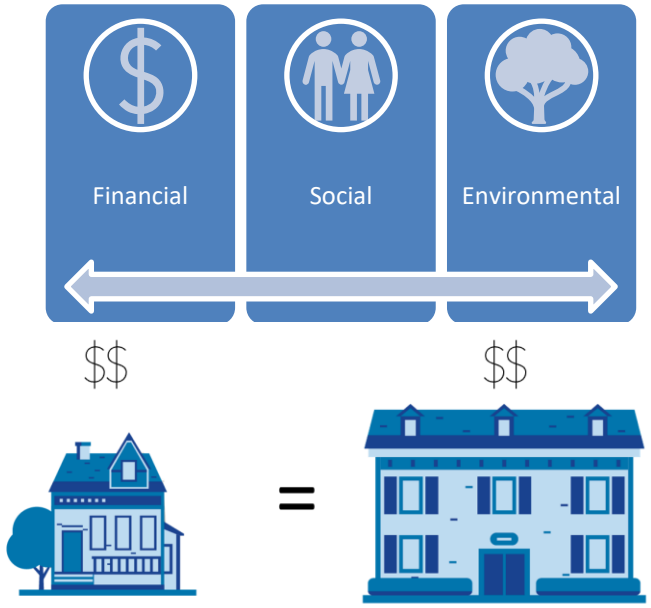
NEXT STEPS AT TWDB

What are we doing at TWDB?

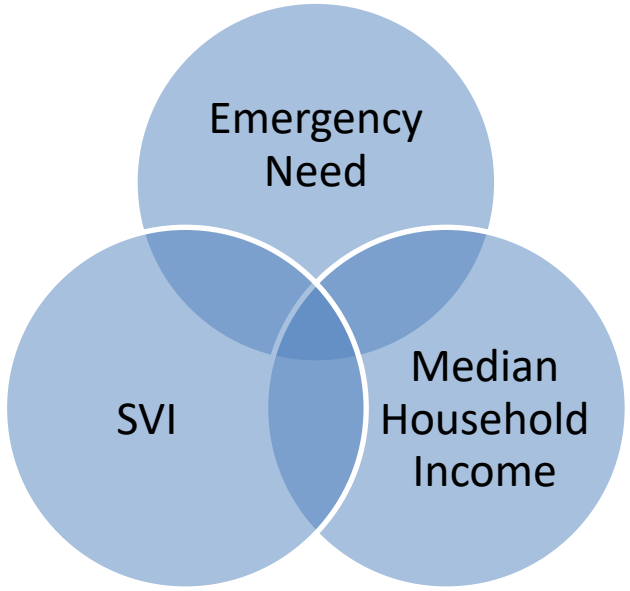
Additional Benefit Types

- Health & Safety
- Infrastructure
- Agricultural

BCA Input Tool



Scoring for Flood Infrastructure Fund



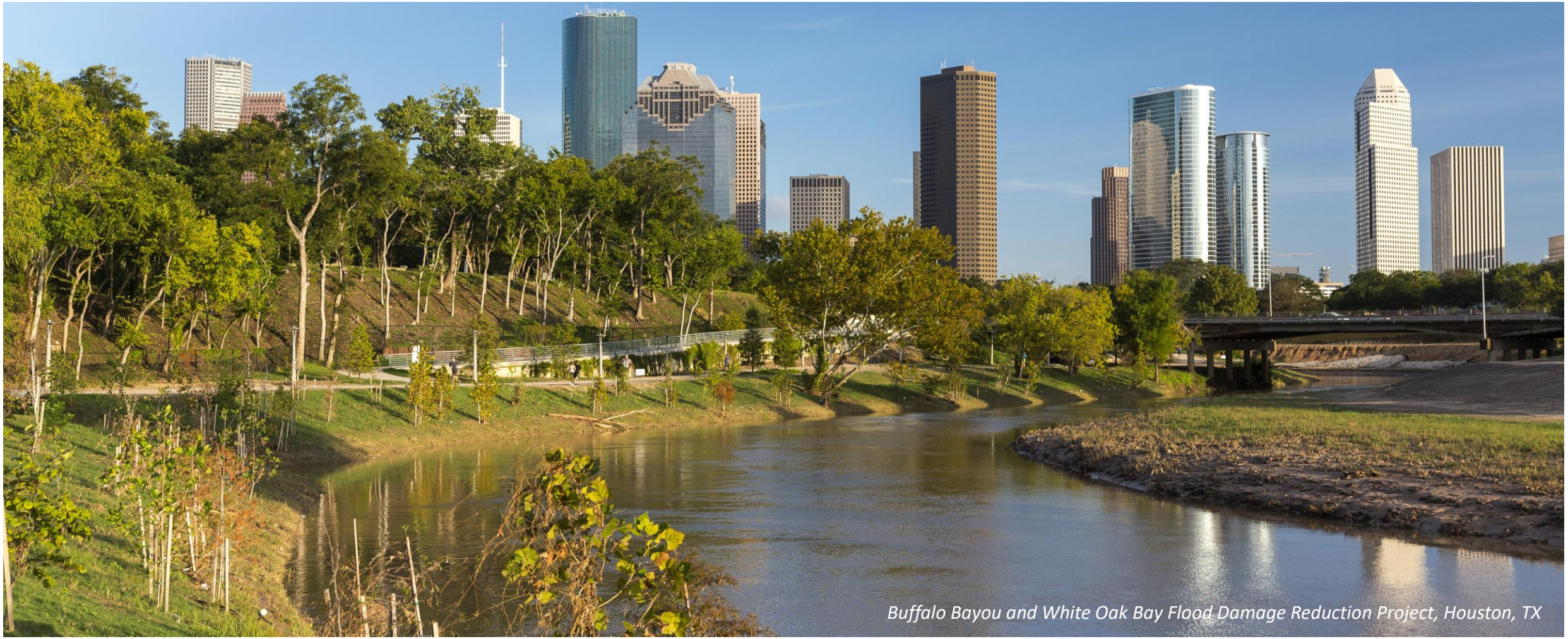
BCA – Minimum Standard

UPDATES ON FEMA BCA

Future BCA Updates from FEMA

- From Manny Perotin:
  - Discount rate still being worked on with OMB – A94 draft is not yet final
  - FEMA is looking at updating precalculated benefits possibly on an annual basis – related to/because of cost construction and inflation
  - Effort is ongoing around the marginal utility of the dollar / adding a factor to get to incoprate social vulnerability – some way to adjust value for infrastructure or buildings in more socially vulnerable areas
  - From BRIC standpoint FEMA uses scoring and one of the scores that matters is a nature based solutions score – more communities need to make sure to not leave those points on the table – it gives application leverage – points are important

Questions



Buffalo Bayou and White Oak Bay Flood Damage Reduction Project, Houston, TX