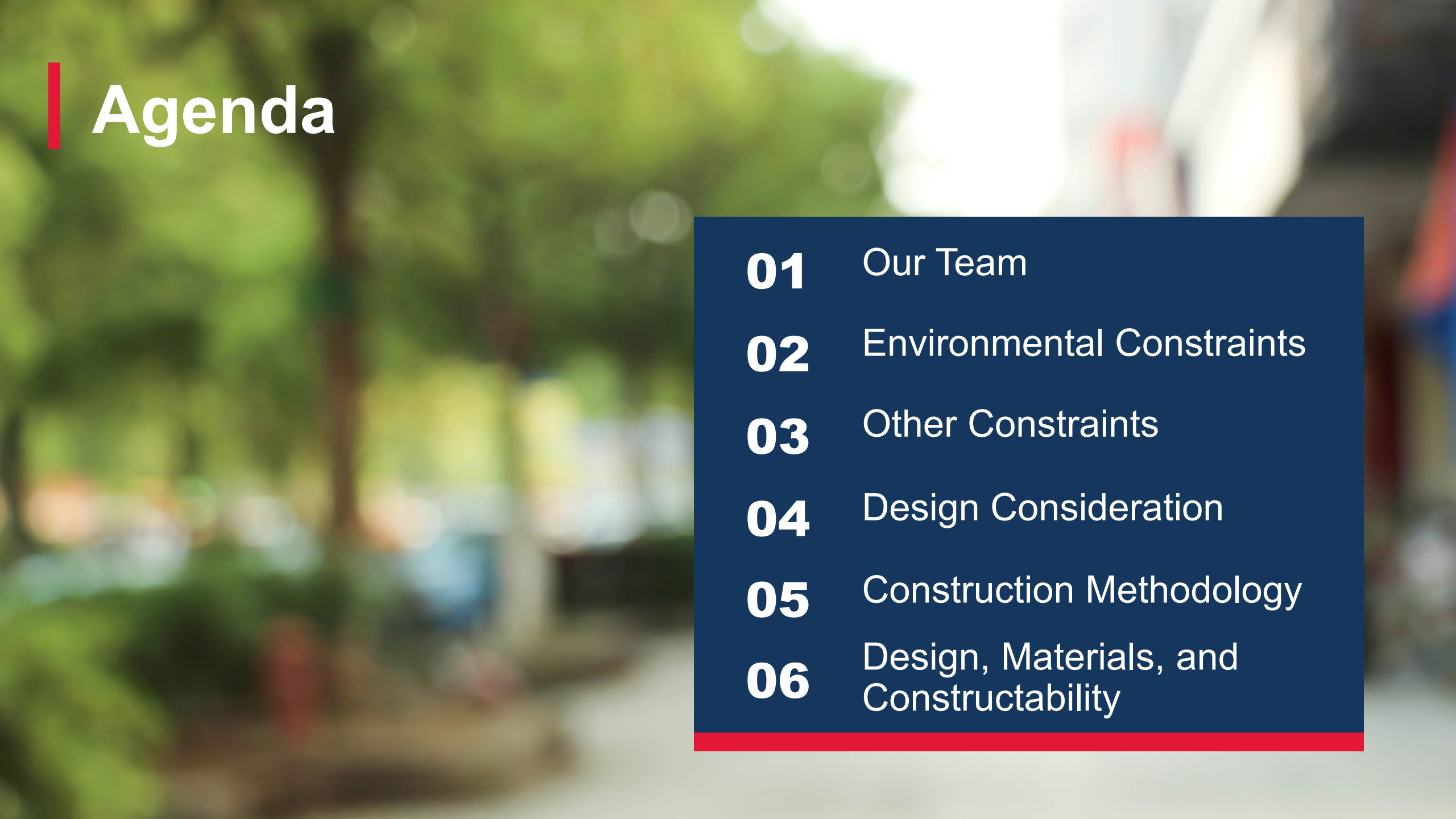
To Boardwalk or Not?

Design Challenges within Environmentally Sensitive Areas

POND

We earn the trust that sets us apart.

Agenda



01	Our Team
02	Environmental Constraints
03	Other Constraints
04	Design Consideration
05	Construction Methodology
06	Design, Materials, and Constructability

Our Team

Juan Morales, PE

Program Manager
Local Government
Pond & Company

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President
PermaTrak North America

To Boardwalk or Not?

- Project Goals
- Budget Considerations
- Land Availability

To Boardwalk or Not?

XCLT Segment 8

Common Constraints

- Environmentally Sensitive Areas (ESAs)
  - Environmental Impacts
  - Permittable Approach
  - Compensatory Mitigation
- Floodplain
- Real Estate Limitations
- Topography
- Utilities

WHAT ARE ENVIRONMENTALLY SENSITIVE AREAS?

Environmentally Sensitive Areas – Water Resources

Resources:

- Jurisdictional Wetlands
  - PFO, PSS, PEM
- Jurisdictional Streams
  - Perennial, Intermittent, Ephemeral

Regulatory Context:

- Section 404 of CWA – USACE
- Section 401 of CWA – NCDEQ/State
- State Regulations (SEPA or Others)

Environmentally Sensitive Areas – Protected Species

Resources:

- Protected Species Habitat
- Protected Species Occurrence
- USFWS Designated Critical Habitat

Regulatory Context:

- Section 7 of ESA
  - Consultation of Potential Affects
- Section 10 of ESA
  - Regulates Incidental Take
- State Regulations (SEPA or Others)

Environmentally Sensitive Areas – Cultural and Historical Resources

Resources:

- Features of Cultural, Historical, or Archeological significance
  - Eligibility for listing on the NRHP

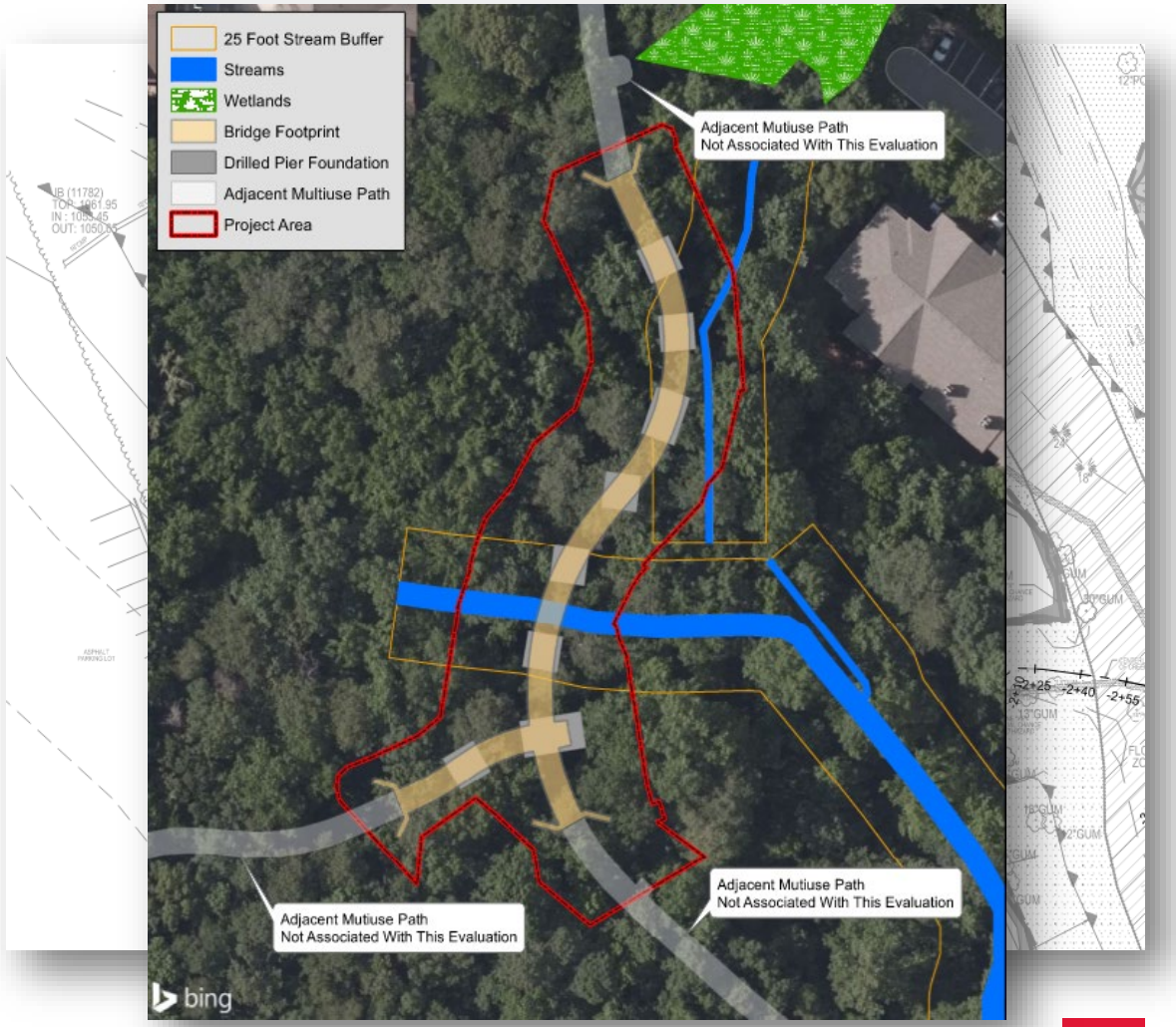
Regulatory Context:

- Section 106 of the HPA
- State Regulations (SEPA or Others)

Environmentally Sensitive Areas – Locally Regulated Areas

Regulated State/Local Buffers

- Maintaining Diffuse Drainage Patterns and Minimizing Concentration of Stormwater
- Regional Protective Regulations



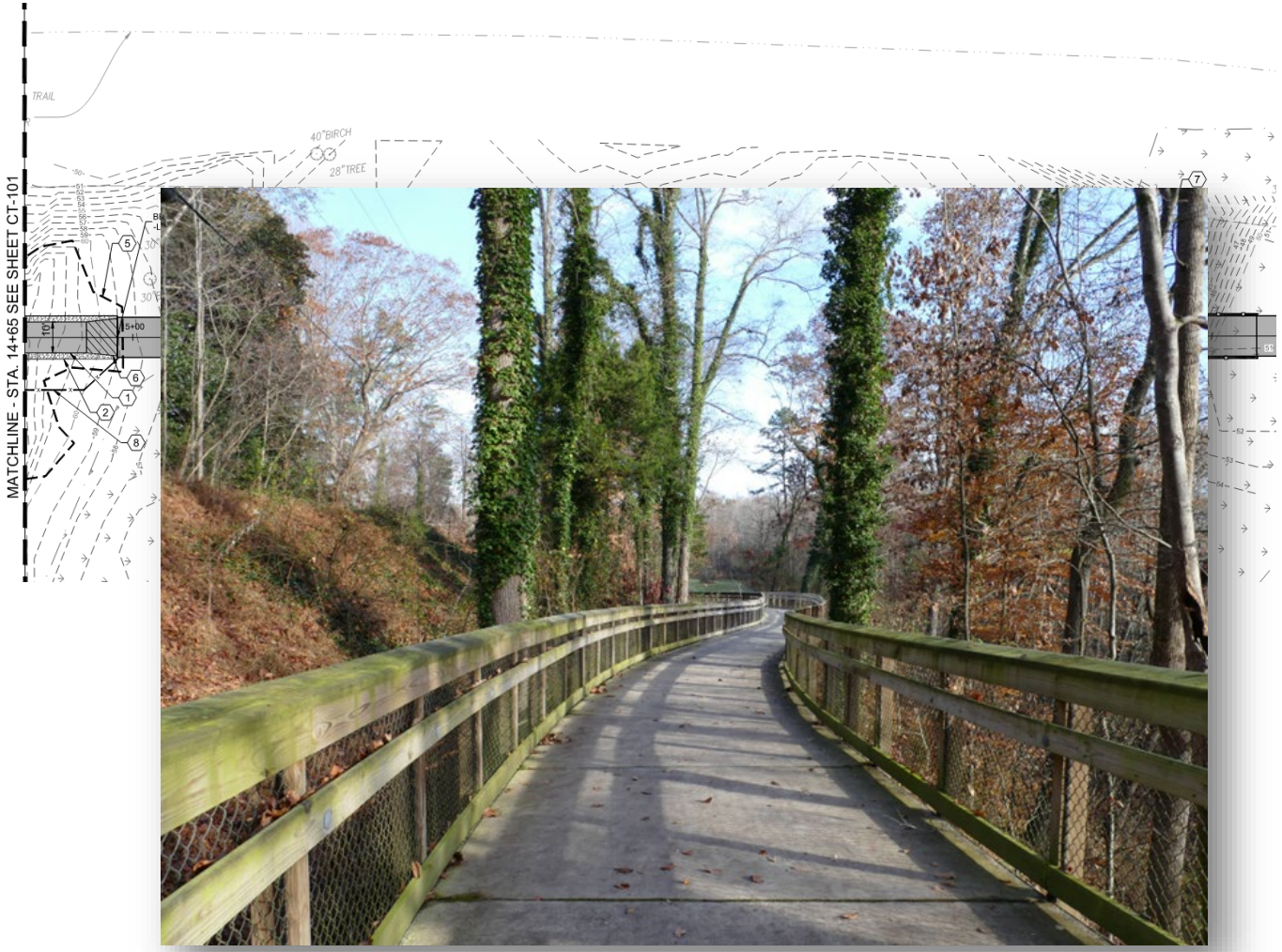
Environmentally Sensitive Areas – Locally Regulated Areas

Conservation Easements

- Protect, Avoid, or Minimize ESA Impacts (Species, Waters, Buffers, etc.)

Tree Protection Ordinances

- Minimize Construction Impact and Post-Construction Compaction



Design Considerations at Stream and Wetland Crossings

- Spans
- Piles
- Scour
- Potential Utility Conflicts

XCLT Segment 8

Construction Methodology at ESAs

- Top-down construction

Shot Pouch Greenway

Toby Creek Greenway

Construction Methodology at ESAs

- Partial top-down
  - Timber Mats

West Ashley River Crossing, Charleston, SC

Environmentally Sensitive Areas – FEMA Floodplains & Drainageways

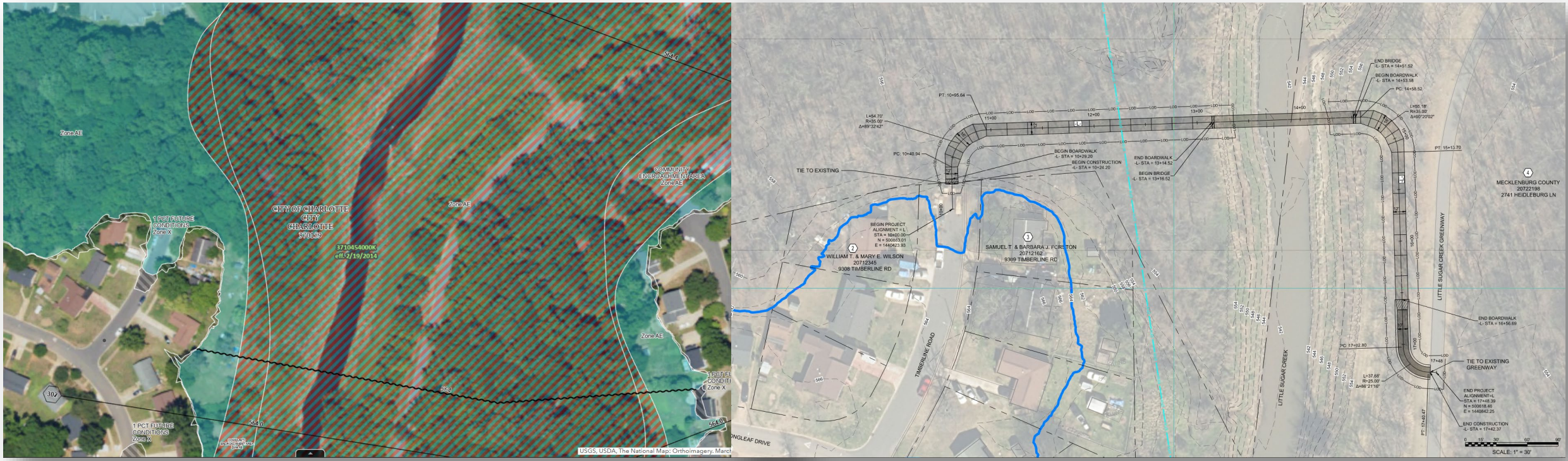
- FEMA Regulatory Floodplains & Floodways

XCLT Segment 2

Little Sugar Creek Greenway

Environmentally Sensitive Areas – FEMA Floodplains & Drainageways

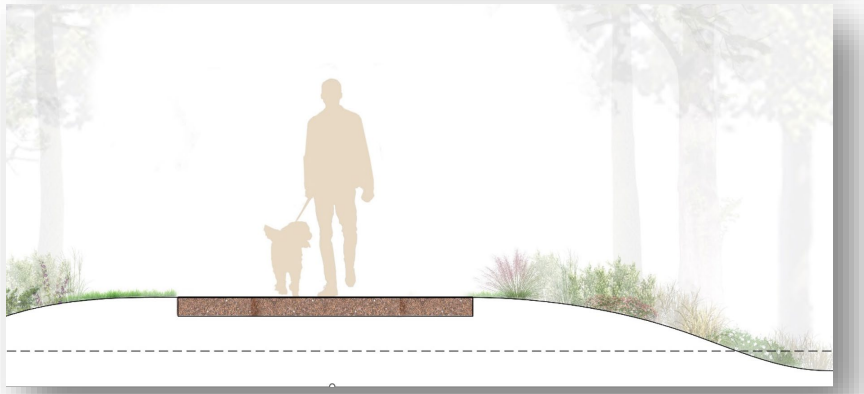
- FEMA Regulatory Floodplains & Floodways



Neighborhood Connector at LSCG

OTHER CONSTRAINTS

Property Ownership and Real Estate Impacts



XCLT – Segment 8

Navigating Difficult Terrain


XCLT – Segment 2


Clabber Creek Extension

Environmental Permitting Implications

Opportunities

- Resource Avoidance/Minimization
- Minimal Construction Disturbance
- Terrestrial Species Passage
- Minimize Concentrated Drainage
- Minimize Floodplain Impacts
- Access to Otherwise Inaccessible Areas
  - Recreation Diversity

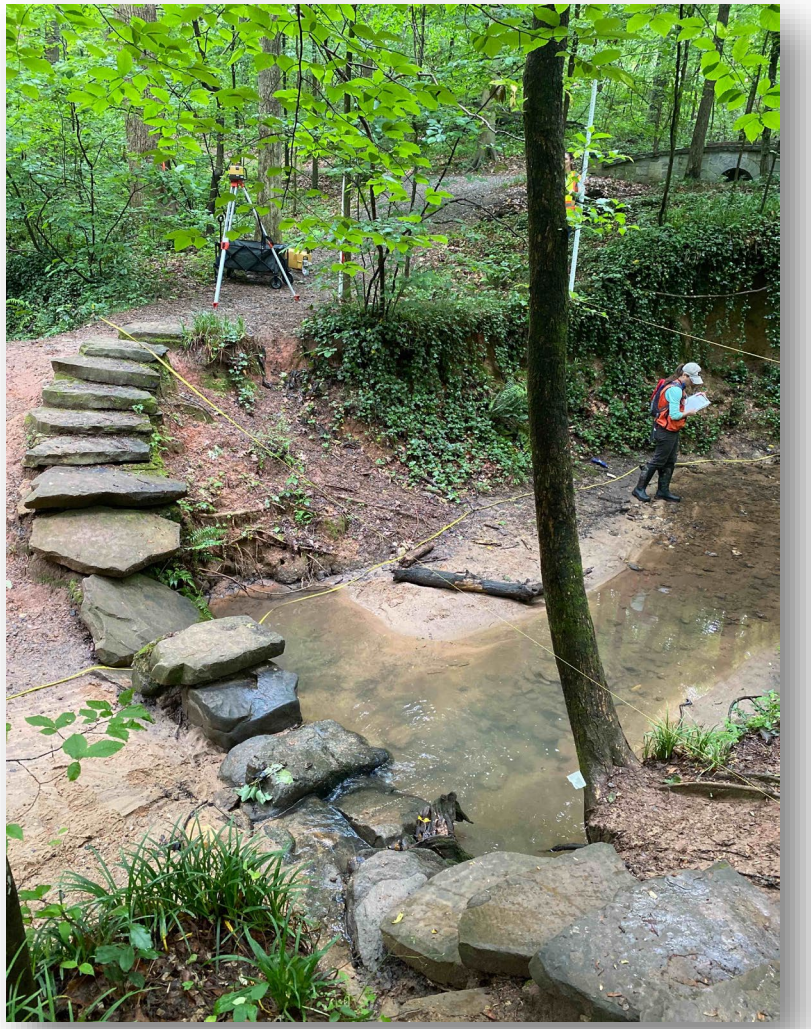
Environmental Permitting Implications

Risks

When Boardwalks Are Not an Option and Constraints Remain:

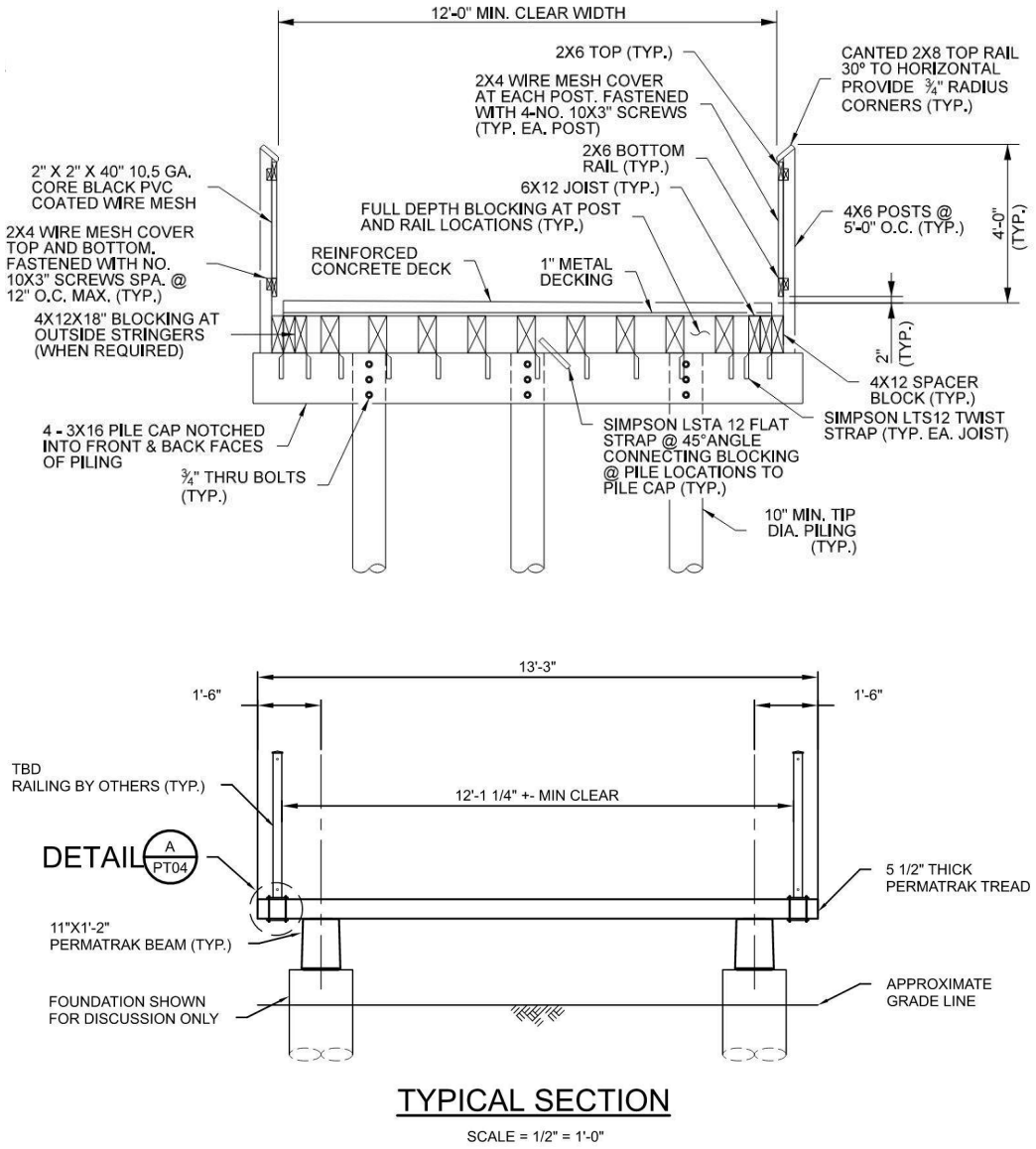
- Significant Mitigation Costs
- Complex and Extensive Permitting Efforts and Timelines
  - USACE, USFWS, SHPO, FEMA

Community Involvement and Perception



What now?

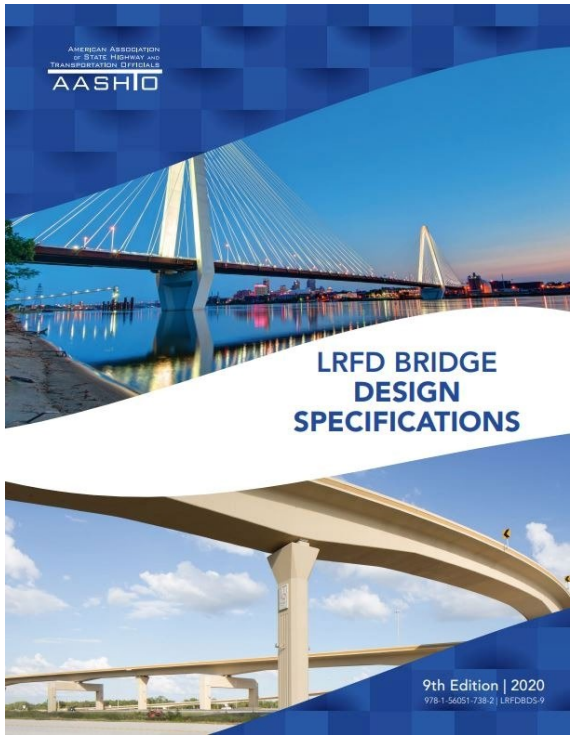
- After Reviewing
  - Project Goals
  - Project Constraints
    - Environmental
    - Budget
    - Topography
  - Potential Conflicts
    - Utilities
    - Easement Conditions
  - Permitting Requirements
- …if your team concludes that a boardwalk system is needed..



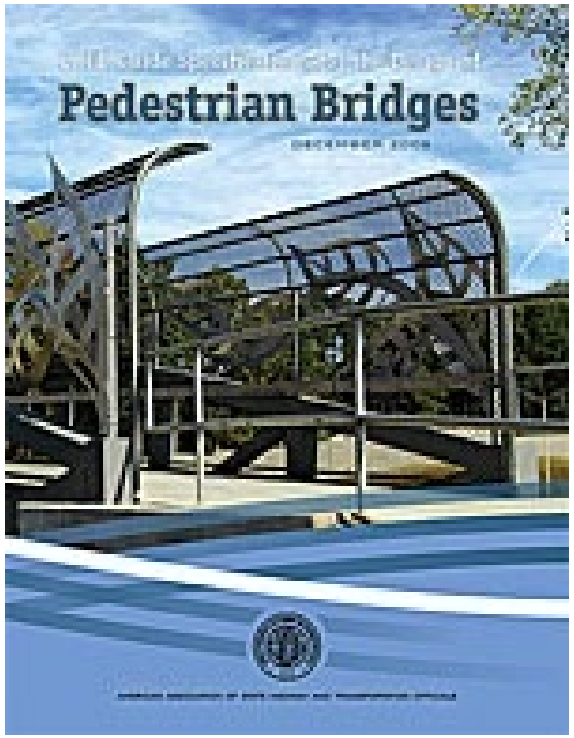
DESIGN, MATERIALS, AND CONSTRUCTABILITY

Define Clear Width

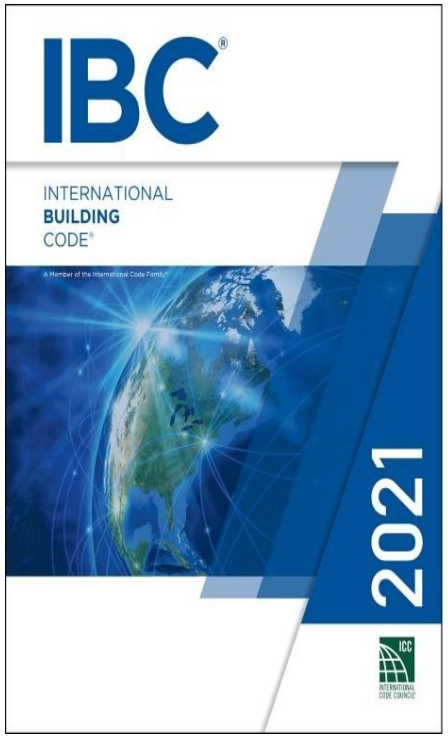
Determine Design Code



AASHTO LRFD Bridge Design Specifications



AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, 2nd Edition, with 2015 Interim Revisions



IBC(Refers to ASCE for Loads)

Vertical Loads

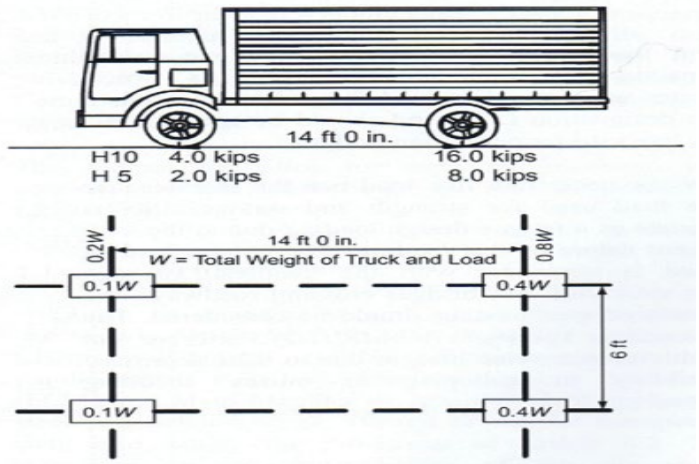
AASHTO:
- Uniform = 90 PSF
- Vehicle
- 5,000 LB>
- H5 (10,000 LB.)
- H10 (20,000 LB.)

IBC:
- 60 to 100 PSF

A single truck shall be placed to produce the maximum load effects and shall not be placed in combinations with the pedestrian load. The dynamic load allowance need not be considered for this loading.

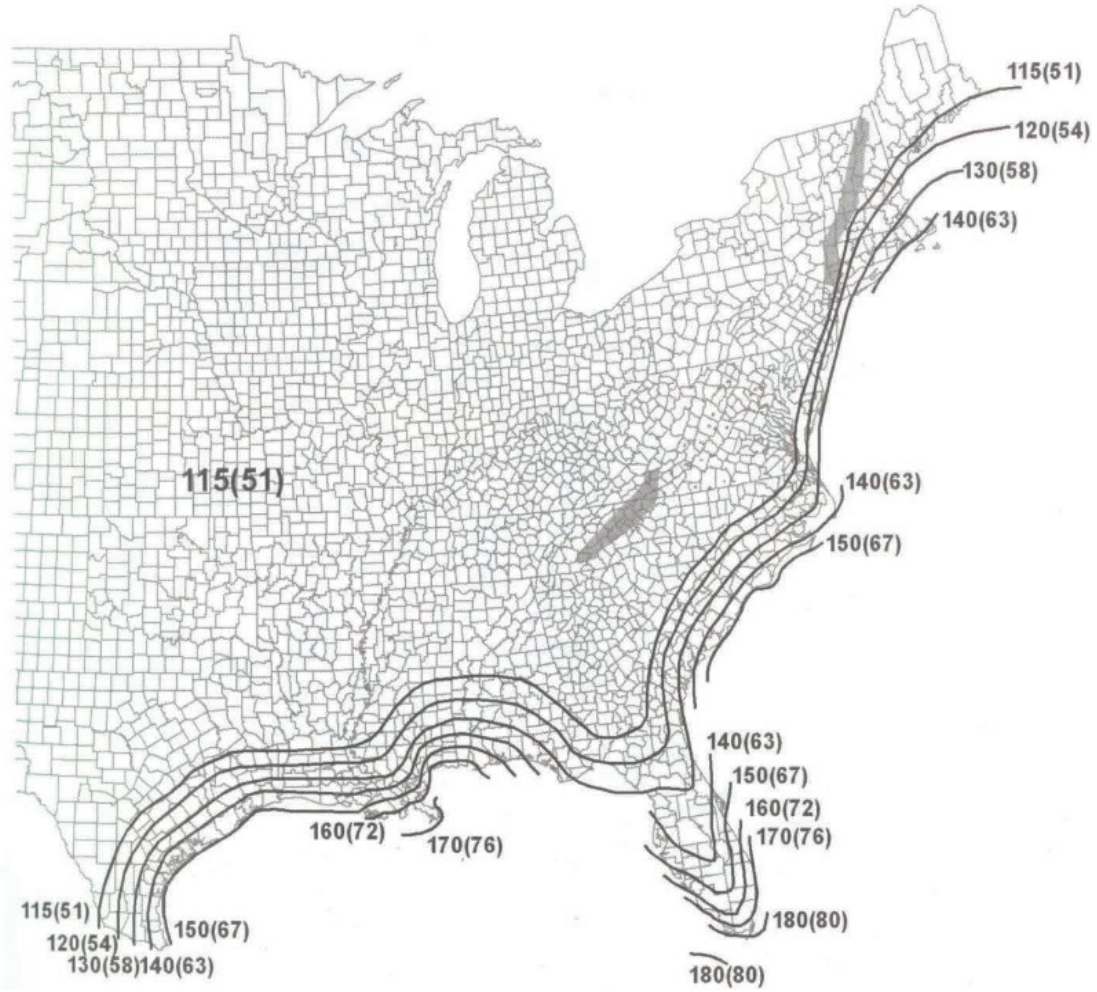
Table 3.2-1—Design Vehicle

Clear Deck Width	Design Vehicle
7 to 10 ft	H5
Over 10 ft	H10



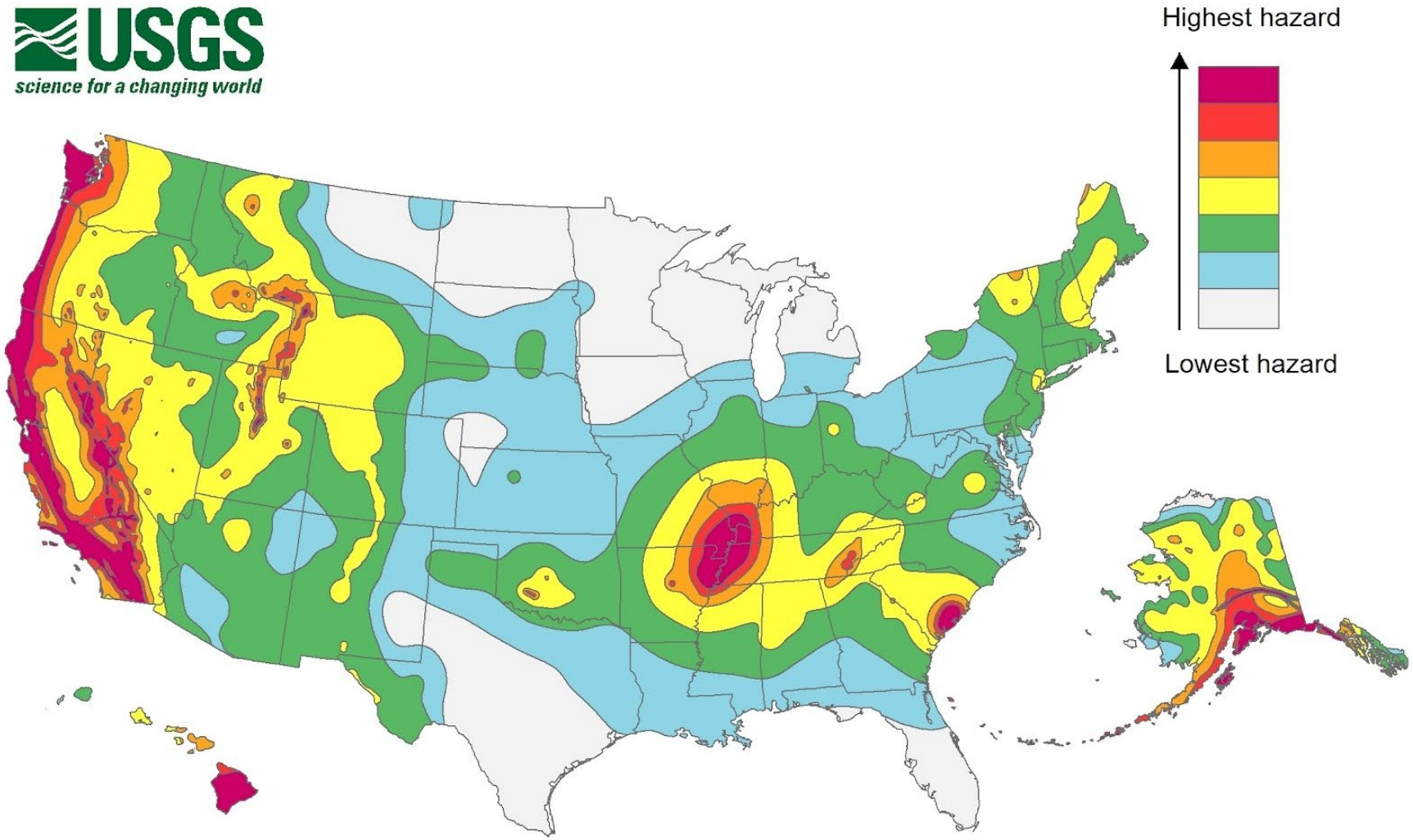
Live Load of 100 psf

Lateral Loads - Wind

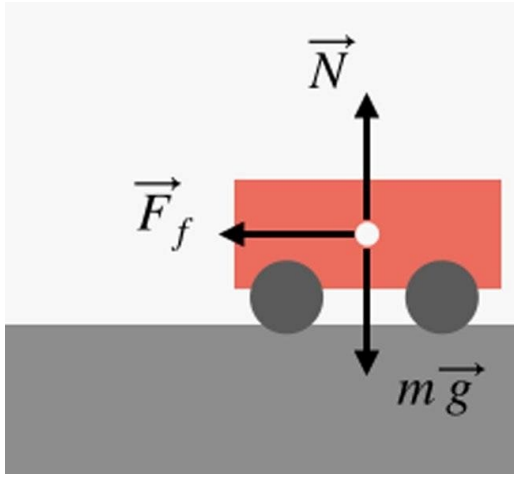


$$W = \frac{1}{2}\rho v^2$$

Lateral Loads - Seismic



Other Loads



- Braking = 25% of Design Truck Axle Load
- Snow
- Water (submerged boardwalks)
- Temperature

Load Combinations

Table 3.4.1-1—Load Combinations and Load Factors

Load Combination Limit State	*DC DD DW EH EV ES EL PS CR SH*	*LL IM CE BR PL LS*	*WA*	*WS*	*WL*	*FR*	*TU*	*TG*	*SE*	Use One of These at a Time				
										EQ	*BL*	*IC*	*CT*	*CV*
Strength I (unless noted)	γ_p	1.75	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength II	γ_p	1.35	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength III	γ_p	—	1.00	1.00	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength IV	γ_p	—	1.00	—	—	1.00	0.50/1.20	—	—	—	—	—	—	—
Strength V	γ_p	1.35	1.00	1.00	1.00	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Extreme Event I	1.00	γ_{EQ}	1.00	—	—	1.00	—	—	—	1.00	—	—	—	—
Extreme Event II	1.00	0.50	1.00	—	—	1.00	—	—	—	—	1.00	1.00	1.00	1.00
Service I	1.00	1.00	1.00	1.00	1.00	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Service II	1.00	1.30	1.00	—	—	1.00	1.00/1.20	—	—	—	—	—	—	—
Service III	1.00	γ_{LL}	1.00	—	—	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Service IV	1.00	—	1.00	1.00	—	1.00	1.00/1.20	—	1.00	—	—	—	—	—
Fatigue I— *LL, IM & CE* only	—	1.75	—	—	—	—	—	—	—	—	—	—	—	—
Fatigue II— *LL, IM & CE* only	—	0.80	—	—	—	—	—	—	—	—	—	—	—	—

If you only remember one…
1.25 DL + 1.75 LL

FOUNDATION SELECTION

Design Considerations: Foundation Type

- Timber Piles
- Composite Piles
- Drilled Shaft
- Driven Steel Piles
- Steel Helical Piles
- Driven concrete piles
- Concrete piers
- Cast-in-place spread footings

HANDRAIL VS. CURB

Do I Need a Handrail?

Less than 30”No Handrail Required

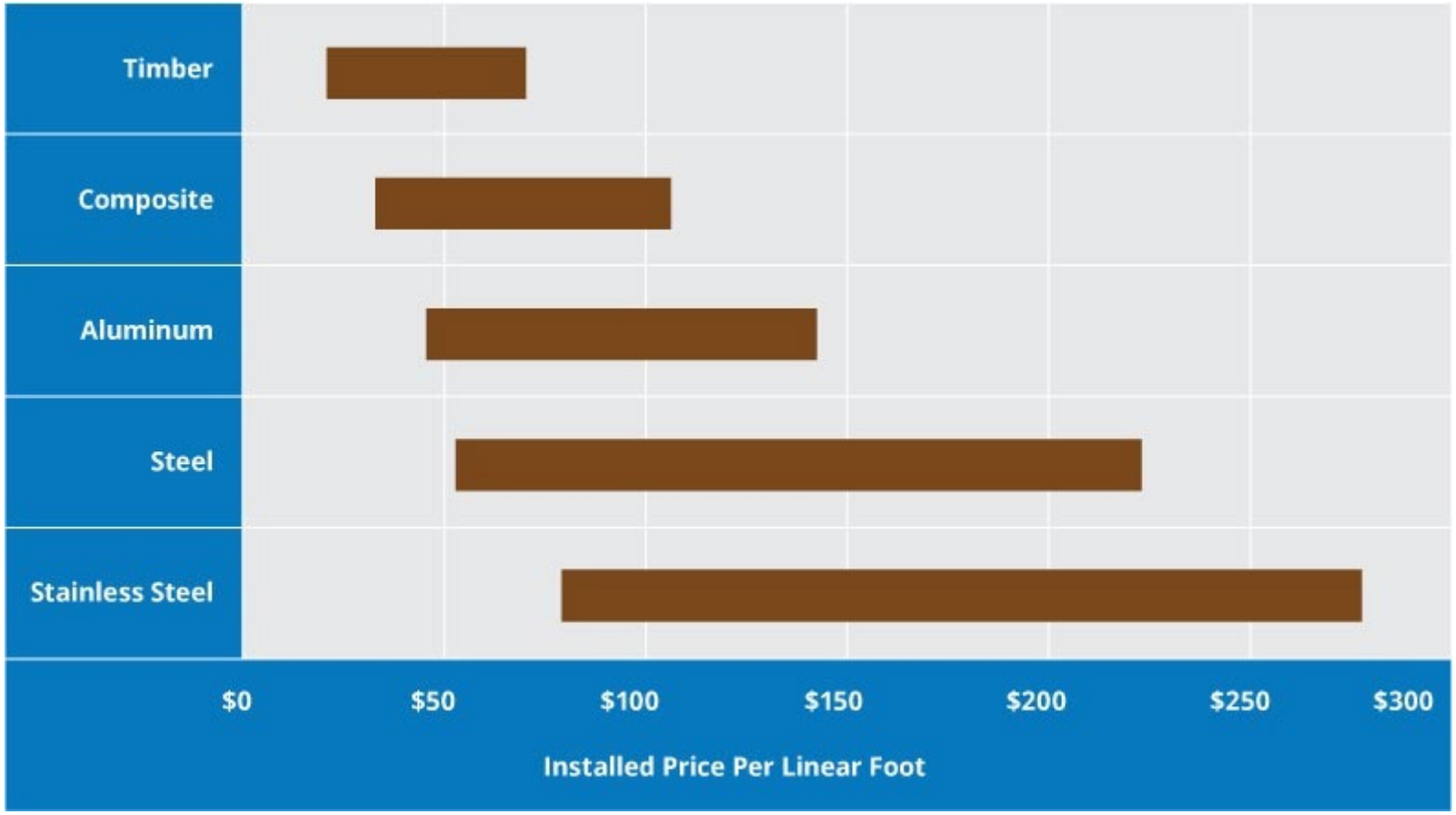
Handrail Design Loads

AASHTO
50 PLF + 200 LB.

IBC
50 PLF OR 200 LB.

Handrail Options

Handrail Cost

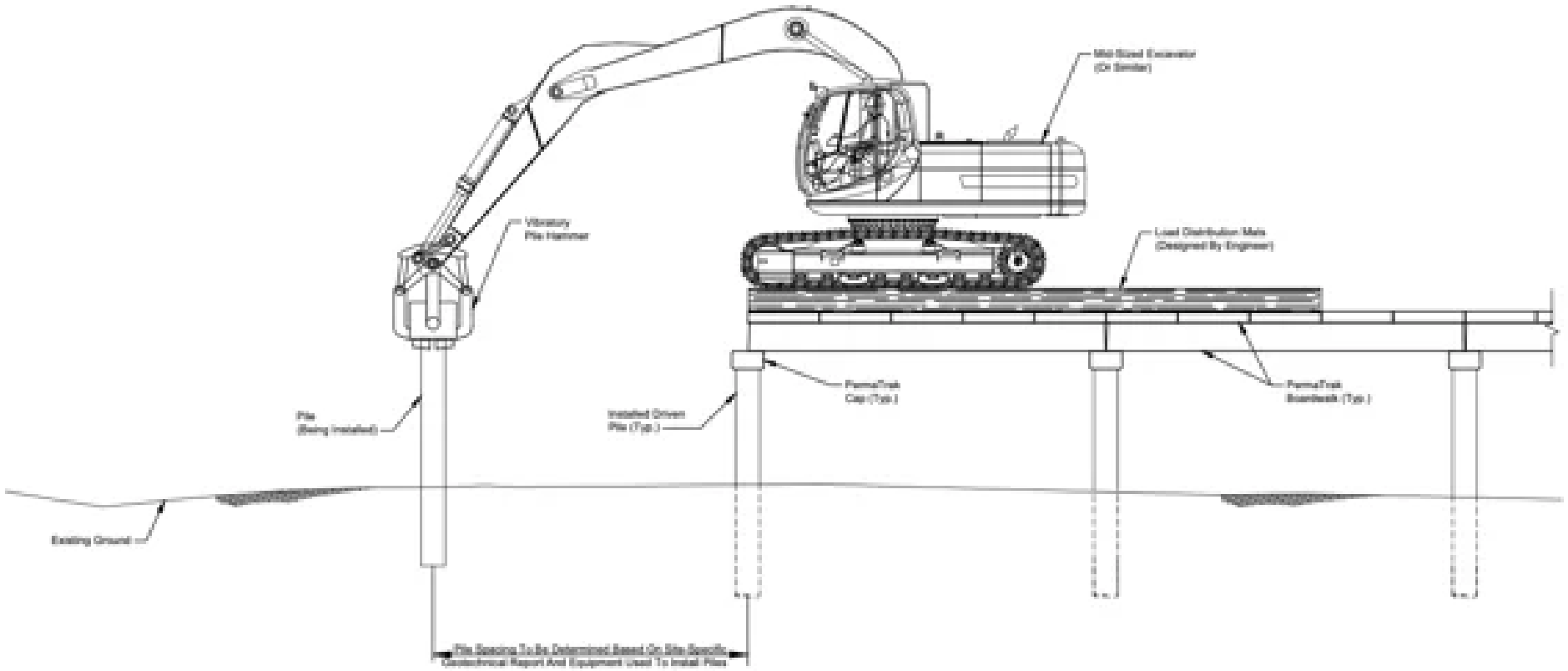


CONSTRUCTABILITY CONSIDERATIONS

Typical Construction Approaches

- Traditional from adjacent ground
- Foundations installed from ground with boardwalk installed top-down
- Full-top down with no equipment on the ground

Top-Down Construction



MATERIAL SELECTION

Material Selection

Timber vs. Composite vs. Precast Concrete

- Slip Resistance
- ADA Compliance
- Durability
- Aesthetics
- Environmental

Slip Resistance

Slip Resistance Testing Report

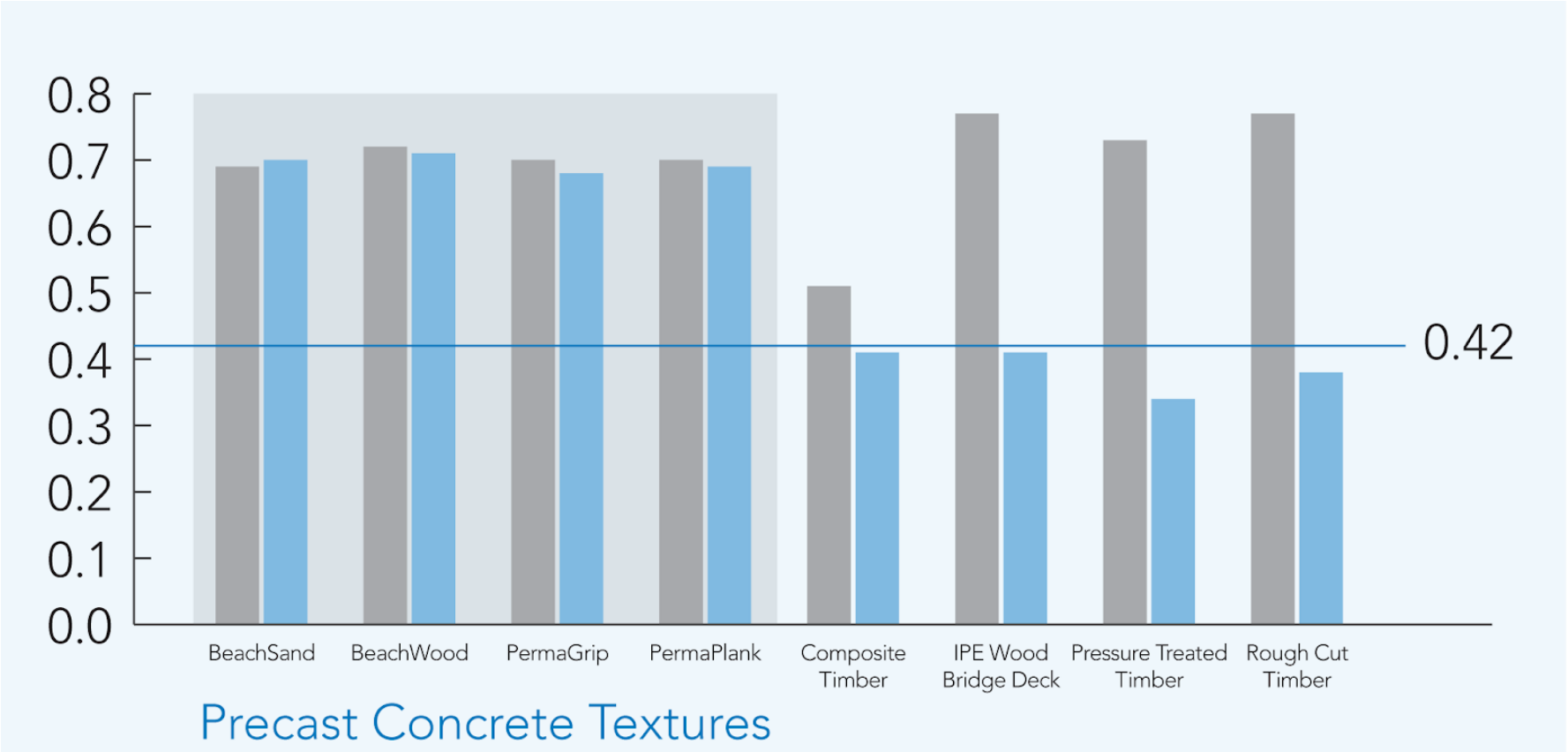
BOT-3000E Tribometer on PermaTrak PermaGrip Boardwalk Surface Texture

Prepared for:
PermaTrak
Charlotte, North Carolina

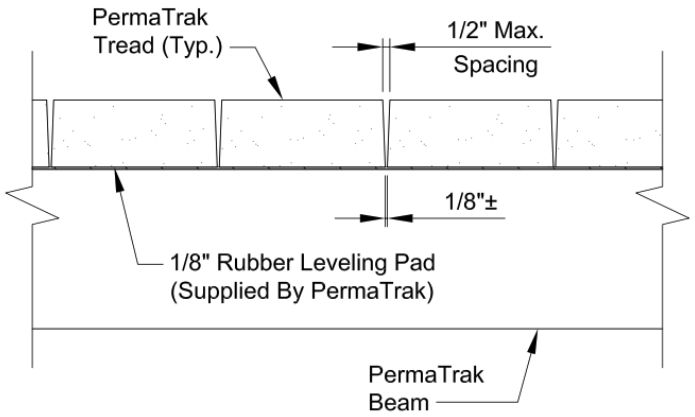
Prepared by:
Theorem Geo Associates Engineering, PLLC
Charlotte, North Carolina

December 2020

Slip Resistance



ADA Compliance



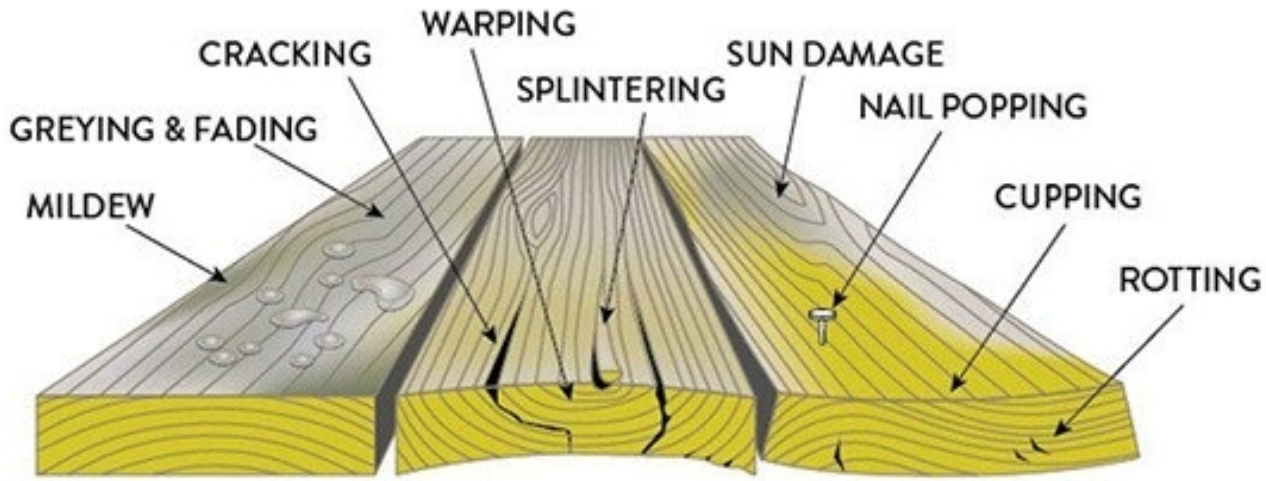
TYPICAL TREAD SPACING DETAIL

Scale: Not To Scale

Vertical and horizontal boardwalk gaps must remain ADA-compliant

Durability

- **Timber:** Potential swelling, rotting and warping, leading to ADA compliance and safety issues
- **Composite:** Vulnerability to mold and algae, especially under heavy shade.
- **Precast concrete:** 50-75 year design life, no maintenance



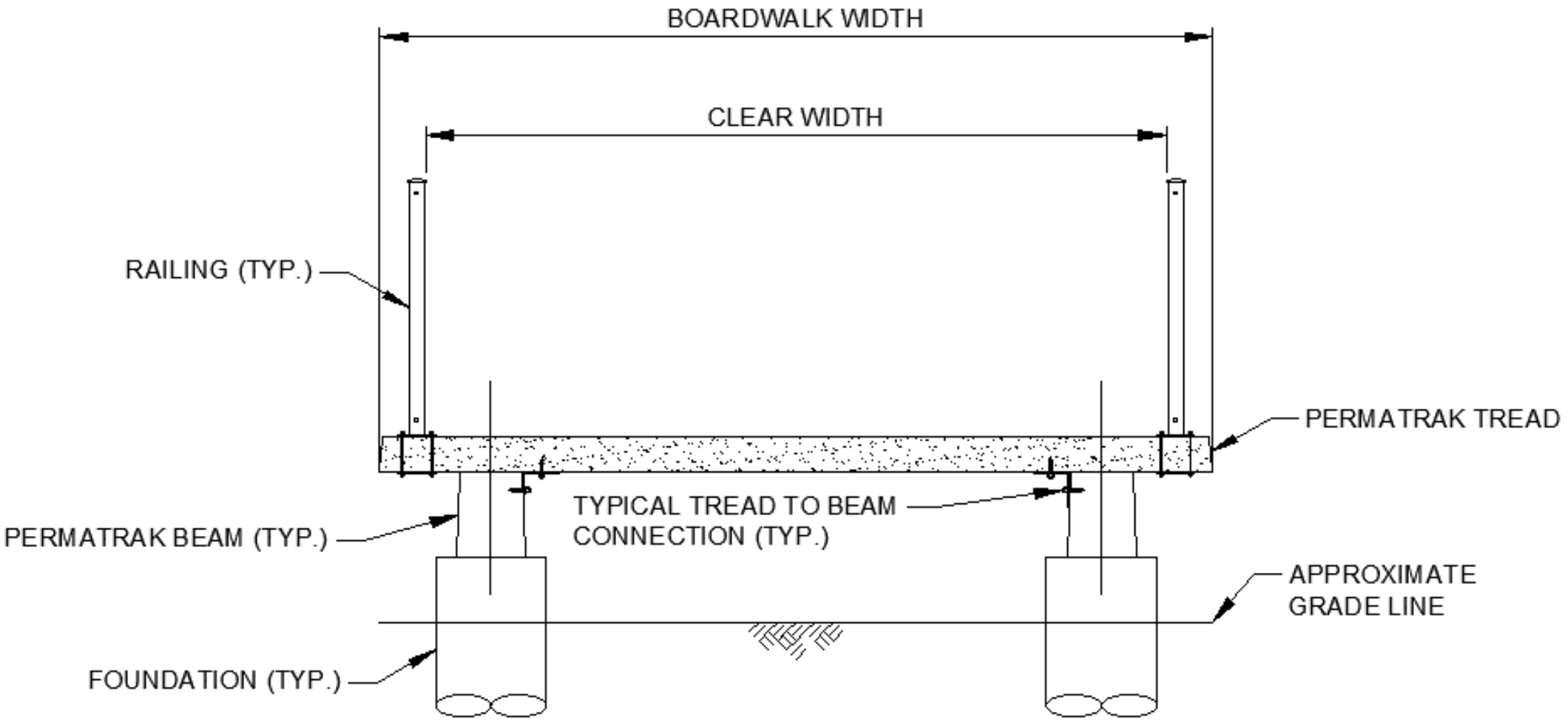
When it comes to durability, timber has issues with swelling, rotting & warping.

Environmental

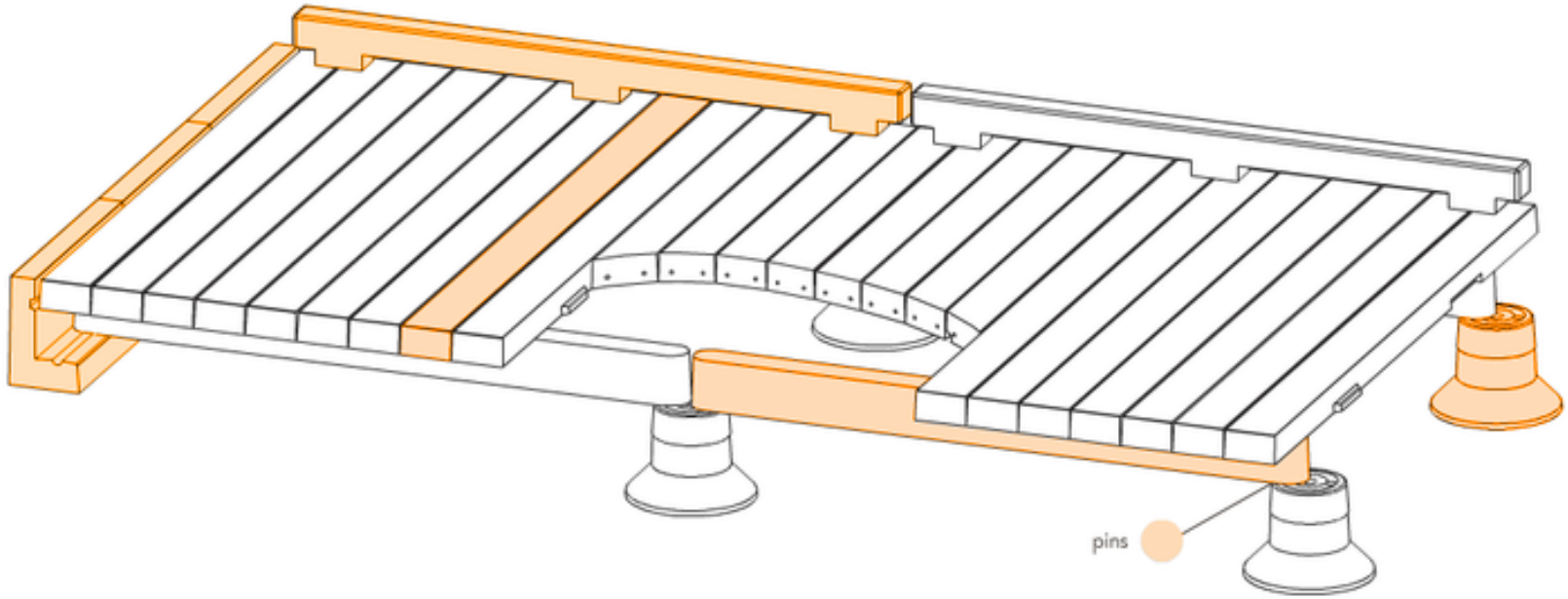
- **Timber:** Pressure-treated timber can contain chemicals that leach into soils.
- **Composite:** Eco-friendly, biologically inert material, not chemically treated.

  That being said, it is non-renewable and non-biodegradable.
- **Precast concrete:** Eco-friendly, not chemically treated

Typical Precast Concrete Section



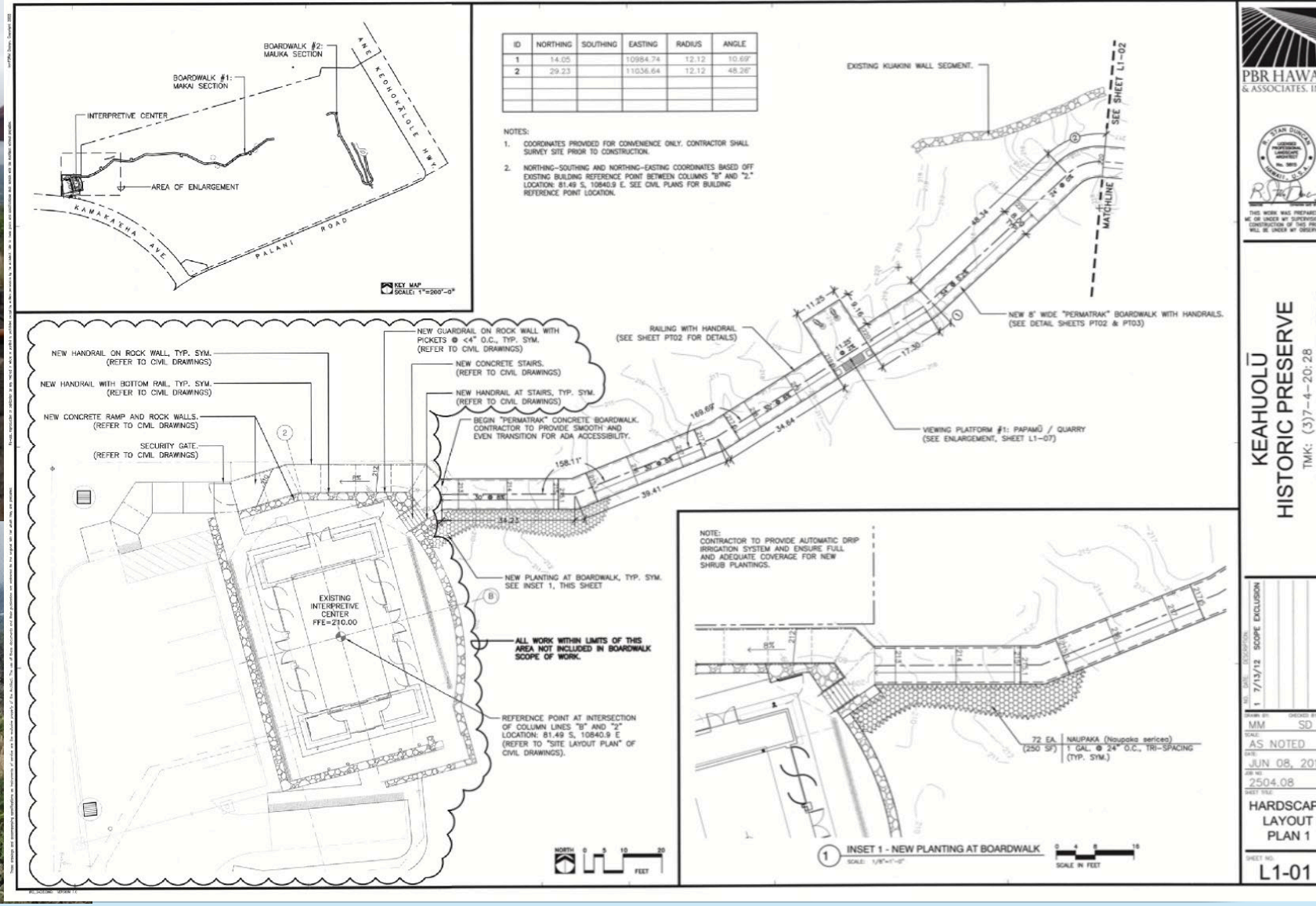
Typical Precast Concrete Section



- Abutment
- Curb
- Piers
- Beams
- Treads

CASE STUDIES

Stakeholder Buy-In



Keahuolu Preserve – Kona, Hawaii
Owner: Queen Lili'uokalani Trust

Tree Root Crossings

Flat Branch Nature Preserve – Charlotte, NC
Owner: Mecklenburg County Parks & Recreation

Lakes & Lagoons

Logan Lake Boardwalk at Adams Park – Sumter, SC
Designer: Pond and Company
Owner: Park Pride

Observation Decks

Judaculla Rock – Cullowhee, NC
Owner: Jackson County, NC Parks & Recreation

Multi-Use Trails

Shot Pouch Greenway – Sumter, SC
Owner: City of Sumter

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Q & A

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