Stormwater Infiltration & Porous Pavements

How & Why

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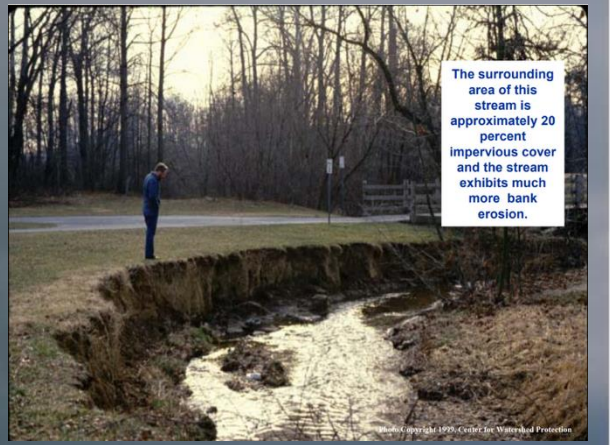




Today's Agenda

- The Impervious Surface Challenge
- Porous Pavement: Technology & Function
- Stormwater Policy & Credit Frameworks
- National Tour: Regulatory Approaches
- Implementation Challenges & Solutions
- Key Takeaways

The Impervious Surface Challenge



•Impervious cover is a primary stressor linked to altered flow, pollutant loading, and stream degradation. 40,000 sqm in U.S.

•Urban runoff is the leading source of impairment to surveyed estuaries in the U.S.

•850 billion gallons of combined sewer overflows annually

•Watershed Sensitivity Thresholds:

•Stream health typically declines when a watershed reaches 10% impervious cover; "poor" conditions are seen at 25–30%.

•When the threshold is passed, streambanks erode, streams widen and sediment destroys biological function.

Pre-Development vs. Urban Hydrology

•Natural landscapes act as a sponge; 50% Infiltration, 40% Evapo, 10% runoff, while impervious surfaces turn rainfall into immediate runoff volume.

•Urbanization disrupts the natural water cycle by preventing infiltration. 75% impervious = 15% Infiltration, 30% Evapo, 55% Runoff

•**The "First Flush":** The earliest portion of runoff often contains the highest concentration of pollutants. 0.5”-1.5” of precip = 90% of pollutant load

•Historically, the "half-inch rule" was considered the “First Flush “of the pollutant load, flawed, due to inconsideration of BUA concentration and site-specificity.

•The “Sweet Spot” for Pre-Development Hydrology is the 95th percentile storm, the Gold Standard for mimicking natural hydrology and avoiding crossing the BUA “sensitivity thresholds”.

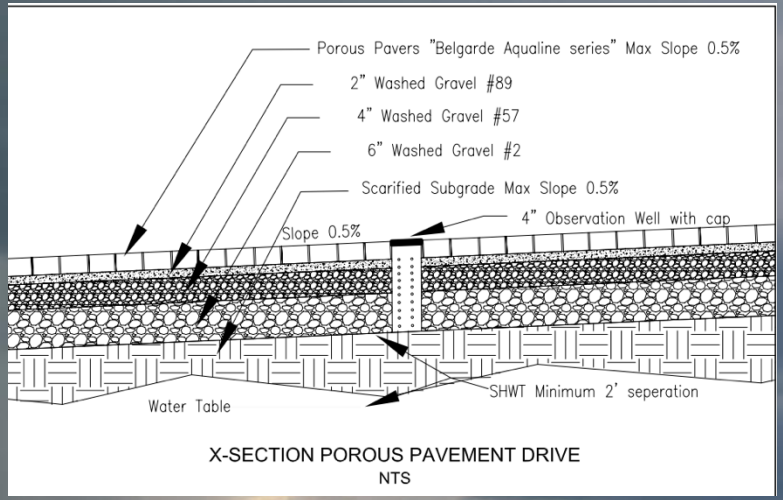
- 95th Percentile storm –Tuscaloosa, 2.4” Atlanta, 1.8” – Charlotte, 1.5”-1.6”, Seattle 1.1”-1.2”

Porous Pavement System Components

•**Surface Course:** Pervious concrete, porous asphalt, or permeable pavers.

•**Aggregate Reservoir:** Open-graded stone that provides both structural support and water storage.

•**Subgrade:** The underlying soil (can include optional underdrains if the soil has low permeability).



Porous Pavement Hydraulic Function



•**Void Content:** Pervious concrete typically maintains 15–25% interconnected voids and is pored 6” thick. A rigid pavement with a min. of 6” of gravel reservoir. Typical pavers rely on the joints for infiltration.

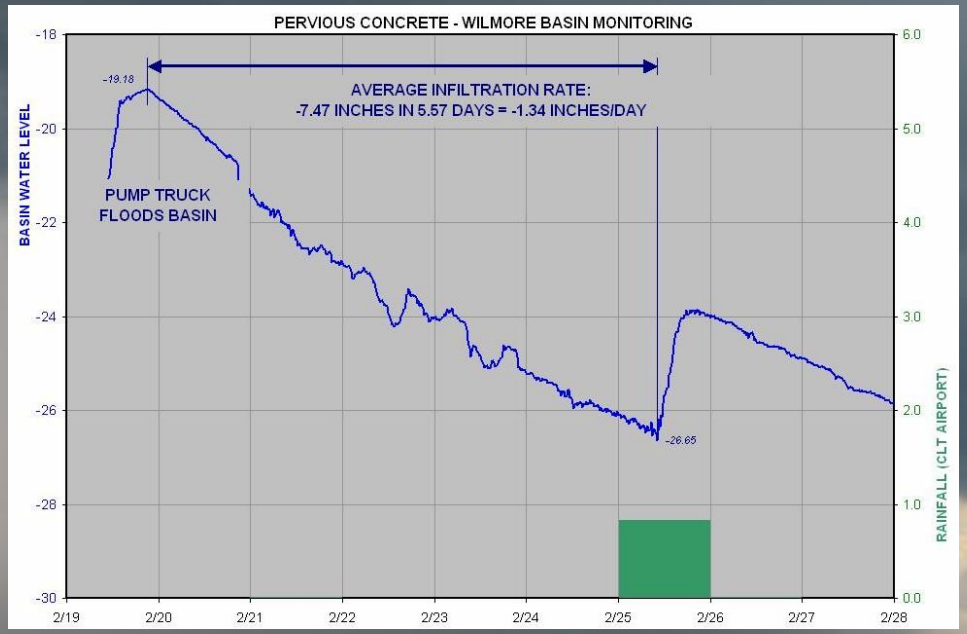
•**Flow Rates:** Extremely high infiltration capacity, typically over 1000 in/hr or 623 gallons per minute per square foot. Pavers on average 500 gallons per minute through 12% of its surface area.

•**Storage Logic:** The stone reservoir below the surface typically has a +- 40% void ratio, providing significant temporary storage volume. 6” Stone stores 2.4” precip.

CASE STUDY RESEARCH
Wilmore Walk 2005

Preliminary Monitoring Data
Saturated Soils

Preliminary data suggests average infiltration rate of
0.06 in/hr
3.6” in 24 hr





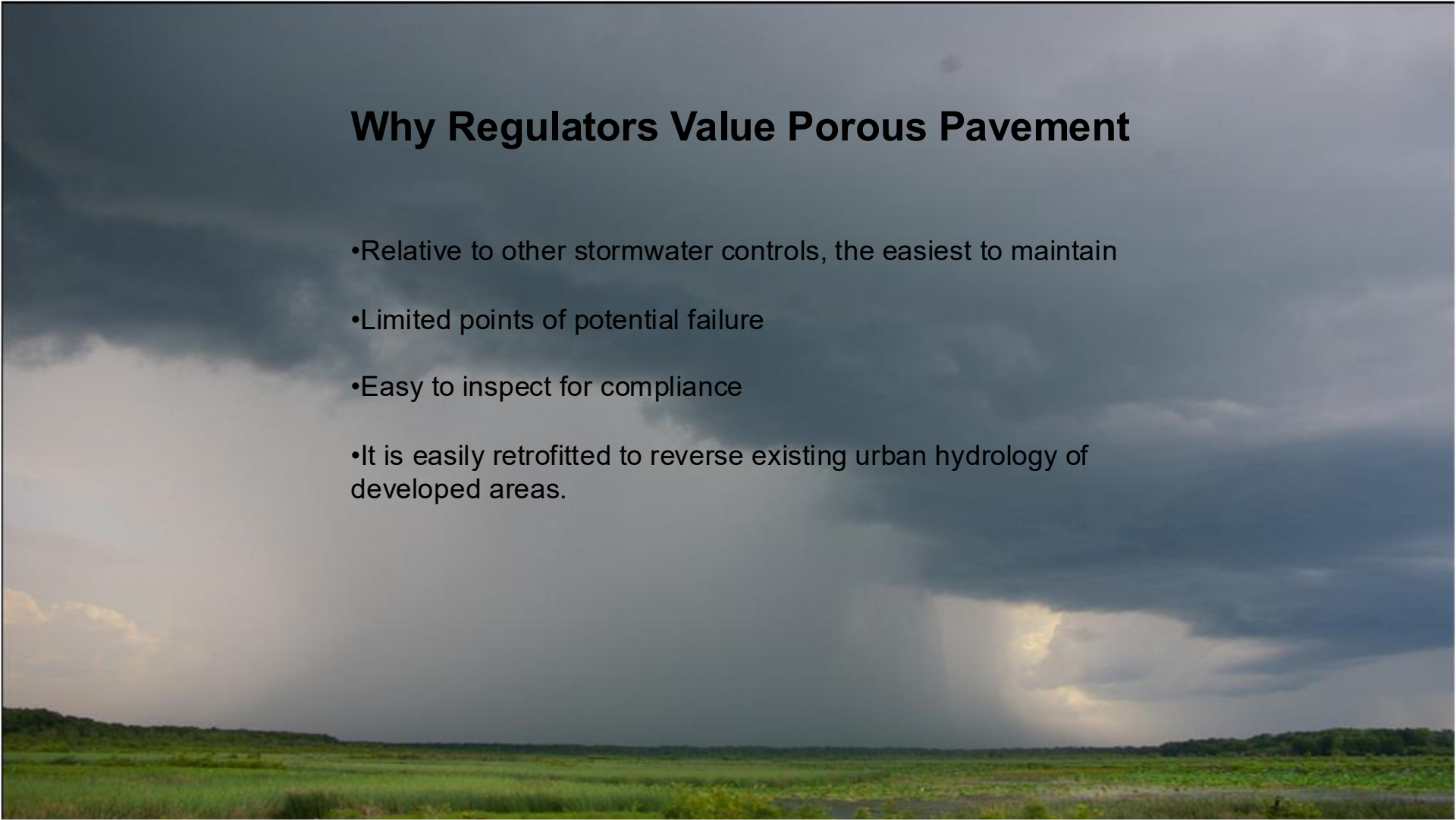
Rawls, Brakensiek and Saxton 1982 : Silty Clay Loam = K of 0.15 cm/hr

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CASE STUDY RESEARCH
Wilmore Walk 2005

At full capacity seeping out of surface at low point.





Why Regulators Value Porous Pavement

- Relative to other stormwater controls, the easiest to maintain
- Limited points of potential failure
- Easy to inspect for compliance
- It is easily retrofitted to reverse existing urban hydrology of developed areas.

Built-Upon Area (BUA) Mitigation

•BUA is the metric used by designers to calculate stormwater requirements and for regulators to calculate a site's max allowed impervious footprint.

•In leading jurisdictions, infiltrating permeable pavement can be considered **100% pervious** for BUA calculations.

•This allows developers to maximize land use while meeting strict water quality and volume standards.

Policy Model 1: Fixed Mitigation Ratios

•A prescriptive approach offering clarity and predictability.

•Establishes a standard ratio (e.g., 1:1) where a unit of infiltrating porous pavement offsets a unit of traditional impervious surface.

•Simple to implement and easy to track.

•Typically includes minimum standards for soil infiltration rate, a prescribed static model and draw down time ranging from 24-96 hours.

MD, NC, PA, WA - 1:1 – Most common for well-designed systems
NYC CSO areas - 1.5:1 – Aggressive incentive or conservative approach
WA in some soils - 0.5:1 – Reduced credit in low-infiltration areas

Policy Model 2: Performance-Based Standards

•Outcome-driven criteria focused on a specific "Design Storm" volume.

•Often requires the system to capture and infiltrate a specific depth of rain (e.g., the first 1 inch, 85th, 90th or 95th percentile storm).

•Also includes minimum standard “reservoir drawdown" requirements to ensure the system is empty and ready for the next storm (interevent period). Seattle follows the “dynamic” modeling approach where infiltration during the storm event is recognized.

•The draw down time - GA/NC 48-72hrs, Upper Midwest 48-72 hrs. CA – up to 96hrs

Standard Water Quality **-** 1.0 inch
Minnesota standard - 1.1 inches
Chicago, Philadelphia - 1.5 inches (90% annual rainfall capture)
California - 85th Percentile Storm (varies by location)

Why Porous Pavement Is Efficient

•Storage is entirely underground, saving surface space compared to traditional detention ponds.

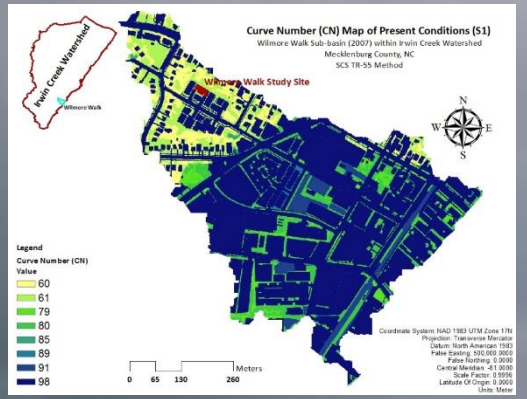
•Easily retrofitted into the existing urban landscape

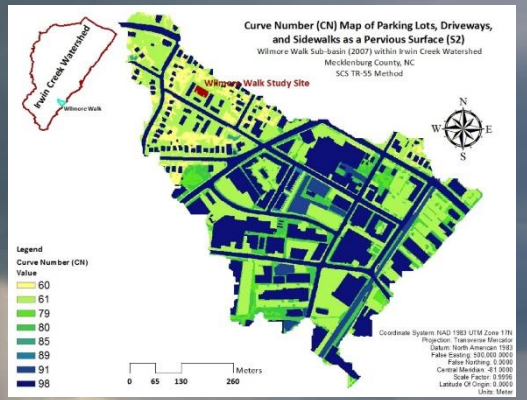
•Infiltration performance is a product of both the pavement's void space and the underlying soil's permeability.

•Properly designed systems significantly reduce volume, peak and pollutant load.

•75% of urban area impervious is parking lots, driveways and sidewalks. Charlotte study – CN reduction from 90 to 80.

- •55% reduction in peak flow for the 1.25 year 24 hr rain event
- •37% reduction in peak flow for the 100 year 24 hr event
- •30-minute delay in peak





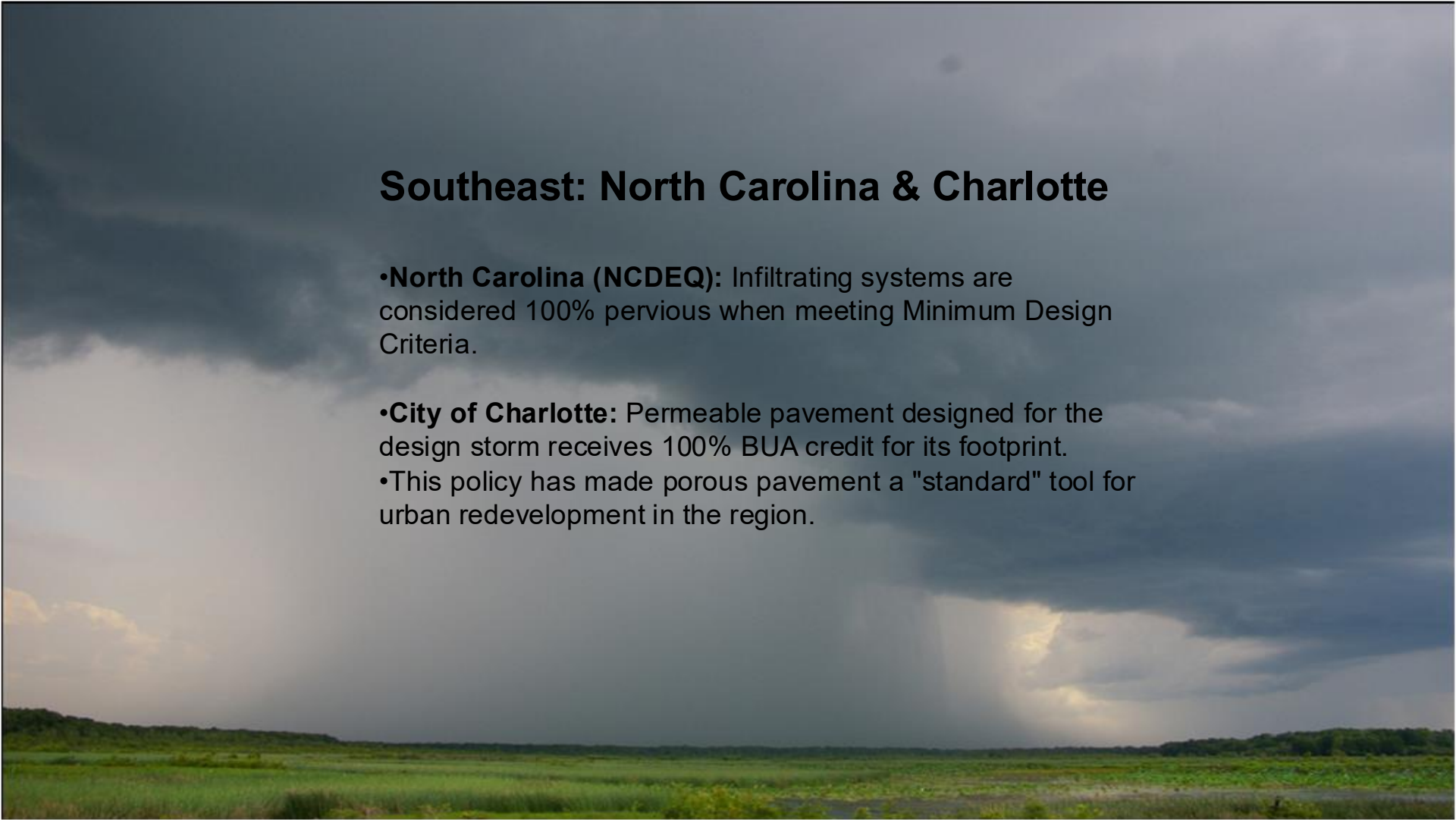


East Coast Regulatory Approaches

•High emphasis on watershed planning and estuary protection.

•**Maryland:** offers clear 1:1 credits through its Environmental Site Design mandate.

•**New York City:** utilizes an aggressive 1.5:1 ratio in CSO zones to reduce the burden on aging infrastructure.



Southeast: North Carolina & Charlotte

•**North Carolina (NCDEQ):** Infiltrating systems are considered 100% pervious when meeting Minimum Design Criteria.

•**City of Charlotte:** Permeable pavement designed for the design storm receives 100% BUA credit for its footprint.
•This policy has made porous pavement a "standard" tool for urban redevelopment in the region.

Midwest: Minnesota & Resilience

•The MIDS (Minimal Impact Design Standards) goal is to capture 1.1 inches of runoff.

•Policies here specifically account for cold-climate resilience, often requiring deeper stone bases (12" or more) to protect against frost heave.

•Interevent period (draw down) is 48 hrs.

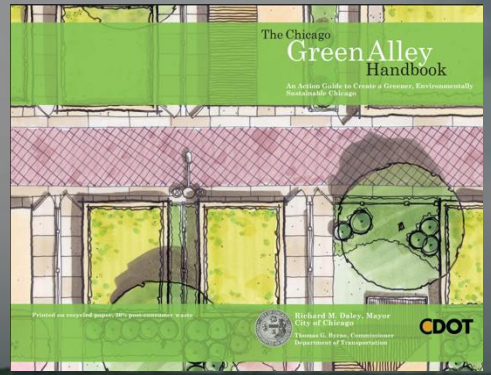


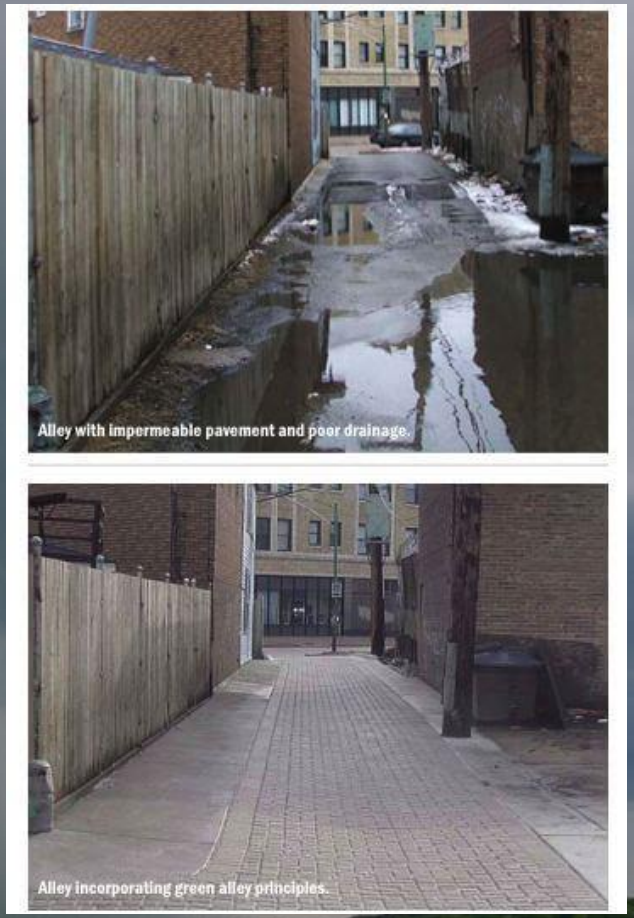
Midwest: Chicago Green Alleys

•Chicago manages one of the largest permeable pavement programs in the world.

•Over **400 Green Alleys** have been installed to date.

•The program is a model for retrofitting permeable surfaces to solve localized flooding, reduce infrastructure loading and reduce the "Urban Heat Island" effect.



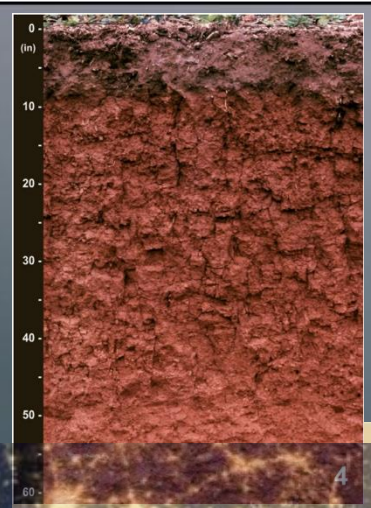


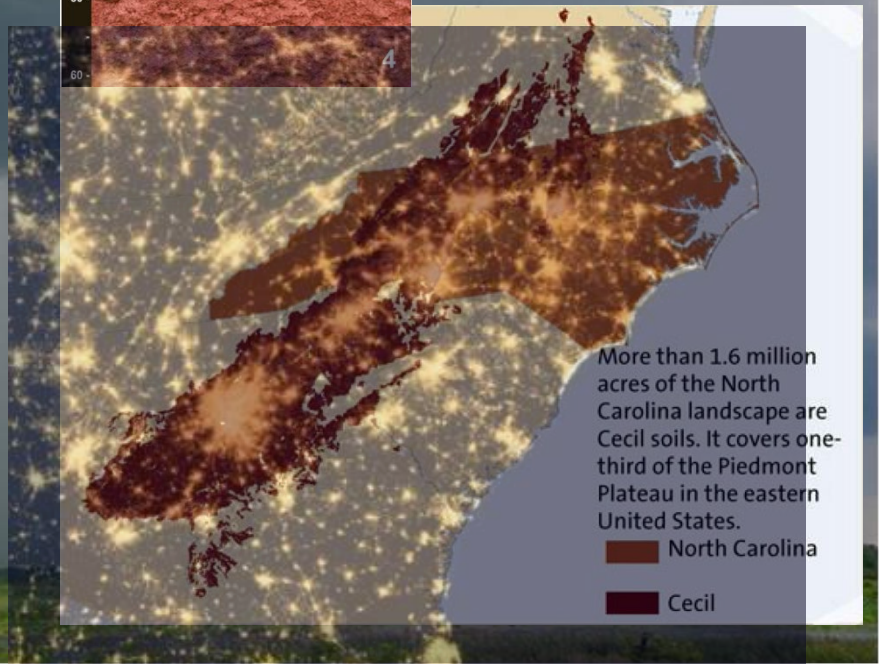
Why Policies Differ

•**Geology:** Soil infiltration capacity dictates whether a system is designed for full infiltration or partial detention. High infiltration rates may require groundwater protection

•**Climate:** Rainfall intensity and freeze-thaw cycles drive reservoir depth requirements.

•**Watershed Sensitivity:** Proximity to sensitive bodies like the Chesapeake Bay, Great Lakes and trout streams drive the strictness of the standards.





Implementation Challenge: Cost

•While initial material costs can be higher, porous pavement is often the more economical choice in high-density areas. Chicago spends on average $500k per Green Alley block

•It reduces or eliminates the need for expensive storm sewers, catch basins, and land-consuming detention ponds.

•Significantly reduces the burden of existing infrastructure when retrofitted.

•At scale can transform a watershed towards predevelopment hydrology.

Implementation Challenge: Maintenance

•Proper siting & Maintenance is the key to longevity.

    •Ideally is a top-down approach

•Standard practices include routine power washing, vacuuming or leaf blowing to prevent "clogging" of the voids.

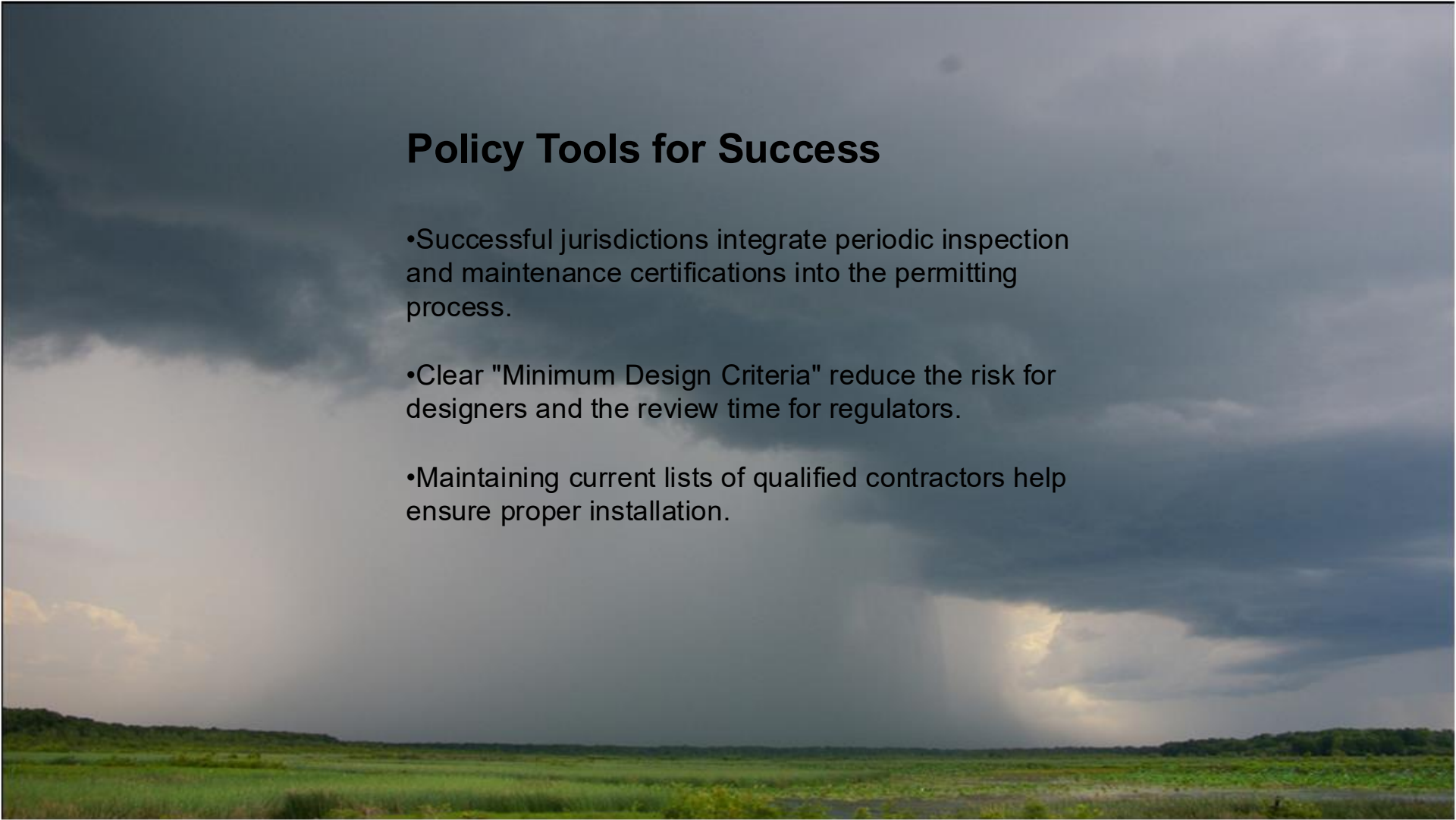
•Properly maintained systems have been shown to function for 20+ years.





Pervious concrete 25 years later



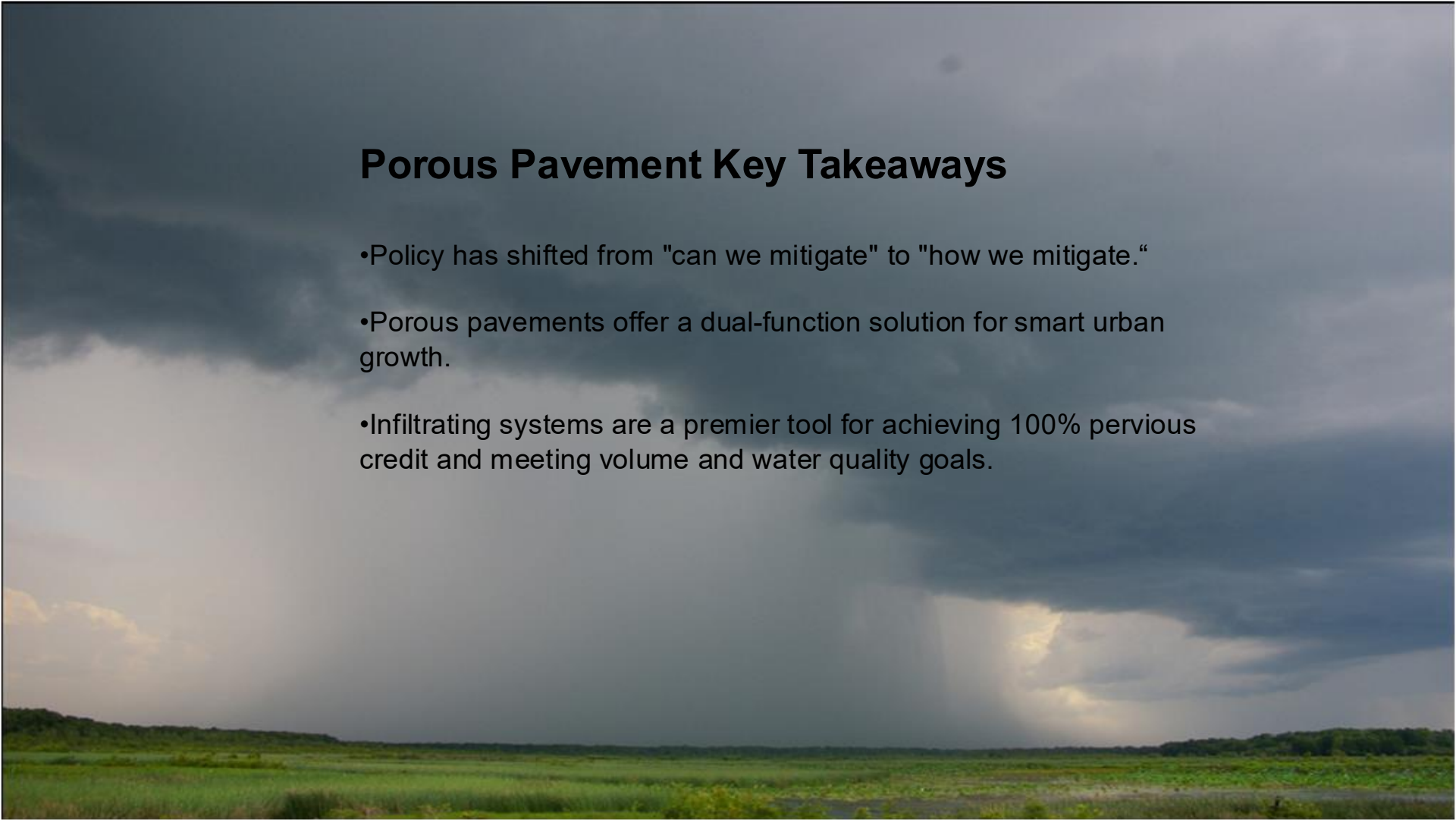


Policy Tools for Success

•Successful jurisdictions integrate periodic inspection and maintenance certifications into the permitting process.

•Clear "Minimum Design Criteria" reduce the risk for designers and the review time for regulators.

•Maintaining current lists of qualified contractors help ensure proper installation.

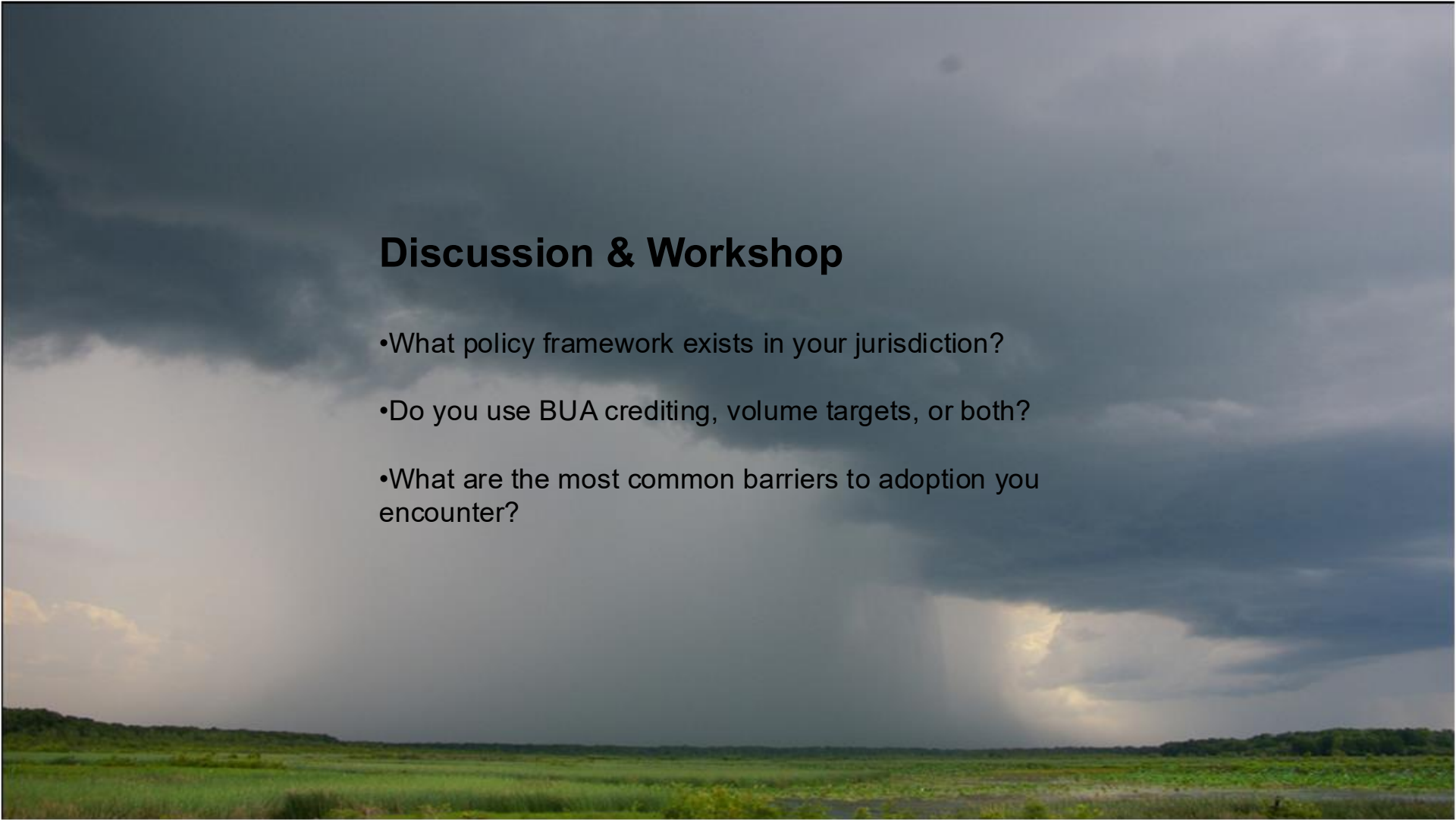


Porous Pavement Key Takeaways

•Policy has shifted from "can we mitigate" to "how we mitigate.“

•Porous pavements offer a dual-function solution for smart urban growth.

•Infiltrating systems are a premier tool for achieving 100% pervious credit and meeting volume and water quality goals.



Discussion & Workshop

- What policy framework exists in your jurisdiction?
- Do you use BUA crediting, volume targets, or both?
- What are the most common barriers to adoption you encounter?

Key References

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Thank you for your time!



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