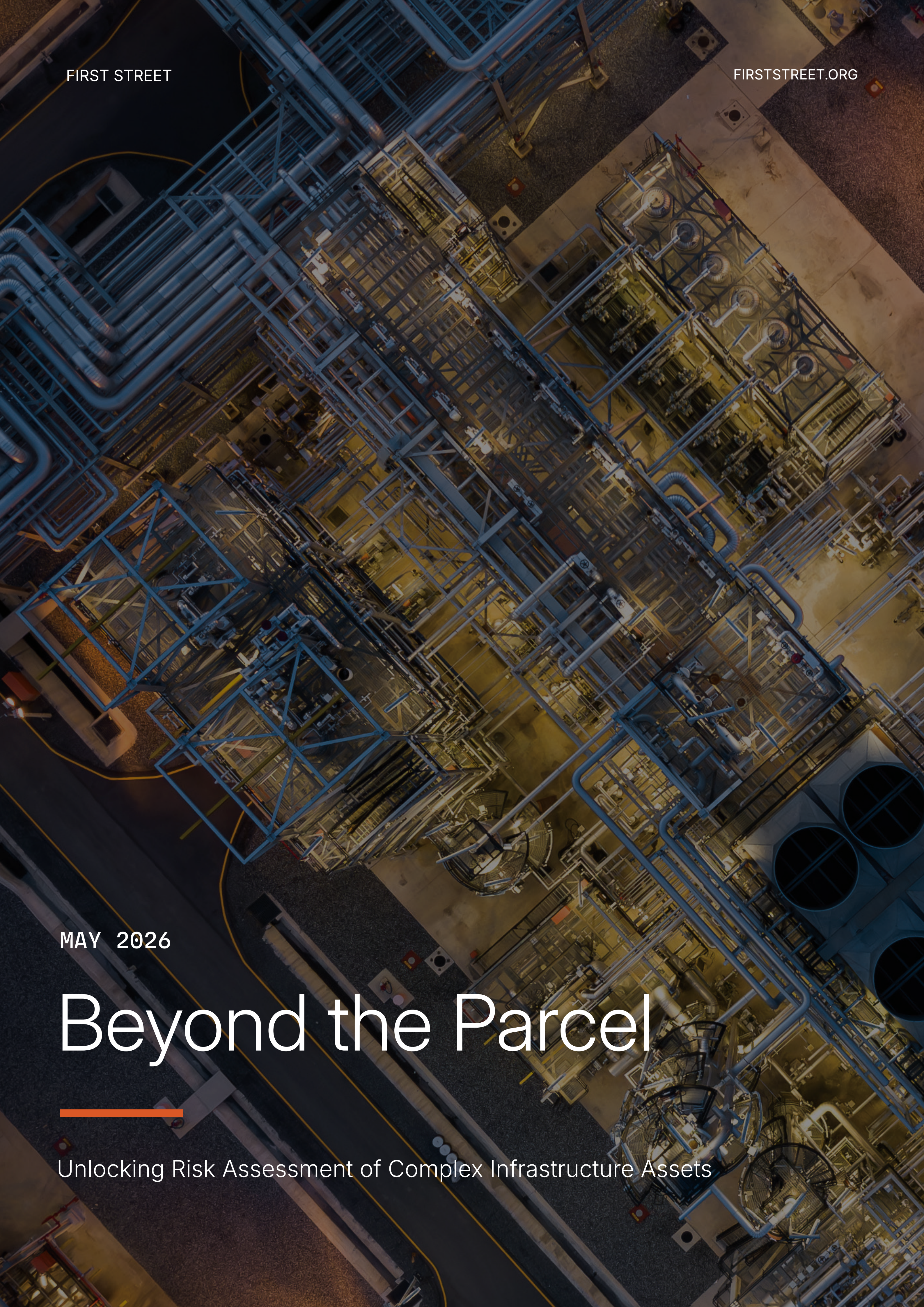

MAY 2026

Beyond the Parcel

Unlocking Risk Assessment of Complex Infrastructure Assets

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INTRODUCTION

What Climate Risk Means for Infrastructure Investments

Institutional capital is pouring into infrastructure at a historic pace, drawn by stable, long-term income streams, built-in inflation protection, and powerful demand driven by AI expansion, energy transition, and supply chain reconfiguration. But the speed of deployment is outpacing a critical conversation. As data centers, energy systems, and industrial assets scale rapidly, investors need to ask how resilient these income streams truly are under real-world operating conditions.

Unlike other asset classes, infrastructure assets are illiquid, fixed in place, exposed to the elements, dependent on physical networks that are easily disrupted, and cannot be repositioned when conditions change. Their fixed location means that exposure to physical climate risks, including flooding, extreme winds, heat, and wildfires, is embedded in the asset itself. That can disrupt operations, impair revenues, and trigger unplanned capital expenditures. In many cases, localized failures can cascade across entire systems, creating outsized financial impacts.

Despite this, most infrastructure underwriting still relies on incomplete or overly simplified physical risk assessments. Traditional parcel-based tools fail to capture the true footprint and interdependencies of complex assets such as data center campuses, ports, transmission networks, and industrial facilities. This gap creates a material blind spot in how infrastructure risk, and therefore value, is currently priced.

First Street's Complex Assets Module addresses this need by enabling asset-level, spatially precise analysis across irregular and networked infrastructure. In this report, First Street applies this methodology to five representative assets, quantifying exposure, damage probability, and operational downtime under severe weather scenarios.

INFRASTRUCTURE'S NEXT CHALLENGE

Scaling Investment While Managing Physical Risk

Portfolio resilience today requires a foundational dual approach. Smart investors are balancing diversification across market cycles while separately maintaining exposure to long-duration, income-generating assets that anchor solid returns over time. Infrastructure assets are central to this approach, offering stable, inflation-linked cash flows while reducing portfolio volatility. In an era of geopolitical tension and market uncertainty, infrastructure is not just defensive, but a strategic allocation choice.

Meanwhile, structural tailwinds are accelerating global demand for infrastructure investment. AI-related energy consumption, data center expansion, the energy transition, grid modernization, and the onshoring of industrial capacity are all rapidly spurring growth. At the same time, much of the existing infrastructure base in developed markets is aging, creating a substantial need for reinvestment and modernization.

Global infrastructure investment requirements are projected to reach approximately $106 trillion by 2040 (McKinsey, 2025), spanning both new development and upgrades to legacy assets across power, transport, water, and industrial systems. As systems evolve to meet higher energy demand and new operating conditions, integrating climate resilience is becoming fundamental to maintaining asset performance and value.

Reflecting these dynamics, infrastructure has firmly established itself as a core institutional asset class, with private AUM exceeding $1.3 trillion, having quadrupled over the past decade (BCG, 2025). Key investable themes include AI-driven power demand, energy transition and grid resilience, and onshoring-driven industrial buildout, with increasing focus on defense-related infrastructure.

However, the durability of infrastructure cash flows is inseparable from physical climate risk. As geographically fixed assets, infrastructure is directly exposed to hazards such as flooding, wildfire, and extreme heat, risks that are intensifying and often underestimated. For long-duration investors, rigorous assessment of climate exposure is critical to underwriting asset resilience and protecting long-term returns.

INFRASTRUCTURE'S NEXT CHALLENGE

A New Standard for Analyzing Complex Infrastructure Risk

Traditional climate risk tools were designed for single-point assets such as individual buildings or parcels, where exposure can be approximated at a single location. This approach breaks down for infrastructure, where value is distributed across networks and large-scale footprints, such as transmission lines, pipelines, transport corridors, and energy facilities, masking critical variation in risk.

First Street's Complex Assets Module solves for these limitations by enabling asset-level analysis across linear and large-scale infrastructure. The platform ingests linear geometries and large polygons, decomposing them into segments or sub-assets to capture spatial variation in hazard exposure across the full footprint. It then links this exposure to asset-specific damage functions and downtime modeling, translating physical climate risk into measurable financial impact across entire sites.

This allows investors to move beyond static exposure metrics to a clearer view of how risk impacts operations, revenues, and asset performance. It also replaces bespoke, consultant-led analyses with a scalable and standardized framework that can be applied consistently across portfolios.

As infrastructure allocations grow in size and complexity, this level of granularity becomes essential. Segment-level insight supports more rigorous underwriting, capital planning, and portfolio strategy, enabling investors to price risk more accurately and allocate capital with greater confidence in an increasingly climate-exposed environment.

$106T

PROJECTED GLOBAL INFRASTRUCTURE INVESTMENT BY 2040

SOURCE: MCKINSEY, 2025

FROM EXPOSURE TO IMPACT

Five Assets, Five Lessons in Infrastructure Risk

To illustrate how physical climate risk translates into financial outcomes, First Street analyzed five infrastructure assets across geographies and sectors. Each case highlights a consistent pattern: material climate exposure was either underestimated or unpriced, resulting in significant cash-flow disruption for both operators and investors.

Using the Complex Assets Module, First Street quantifies how hazard intensity, asset configuration, and revenue dynamics combine to drive damage, downtime, and business interruption. While risks vary across perils, including wind, flood, and wildfire, the financial outcomes converge on a common insight: infrastructure performance is constrained by its most vulnerable components.

For investors, this underscores the need for whole-asset analysis that captures how localized risks propagate into portfolio-level returns.

CASE STUDIES

01 AIRPORTS - Porto Alegre, Brazil

02 RESIDENTIAL DEVELOPMENT - Central Florida

03 RAIL NETWORKS - Deutsche Bahn, Germany

04 TRANSMISSION LINES - Philippines NGCP

05 TOLL ROADS - Kansas Turnpike, USA

CASE STUDY 01

Airports: Flooding Can Force Full Operational Shutdown

Airports are high fixed-cost, high-operating-leverage assets that depend on uninterrupted runway access. Unlike distributed infrastructure, airport operations cannot be partially maintained when critical surfaces are inundated. Flooding of runways, taxiways, or electrical systems typically results in full operational suspension, immediately halting both aeronautical and non-aeronautical revenue streams.

Events in Brazil in the spring of 2024 demonstrate this. In April and May 2024, Rio Grande do Sul experienced one of the most severe flooding events in its recorded history (Simoes-Sousa et al., 2025). Prolonged and intense rainfall caused rivers to overflow across the region, inundating neighborhoods, highways, and critical infrastructure. In Porto Alegre, floodwaters submerged large portions of Salgado Filho International Airport (POA), including its runway and terminal areas, reaching 2.5 meters (8.2 feet) in some areas (Brazil Reports (a), 2024; Brazil Reports (b), 2024). The flooding resulted in roughly $180 million in damage to buildings, contents, and equipment (Curtino POA, 2024). The airport suspended operations on May 3 and remained closed to commercial flights for nearly five months, reopening in late October 2024.

OBSERVED EVENT: PORTO ALEGRE FLOODING AT POA AIRPORT

2.5	$180M	5MO
METERS OF FLOODING	IN DAMAGE	FACILITY CLOSURE

CASE STUDY 01: MODELED EXPOSURE & SEVERITY

To illustrate how predictable this event was, the airport boundary was delineated using satellite imagery and analyzed in First Street's Complex Assets Module, which pinpointed 376 sub-assets within the airport, including terminal buildings, warehouses, and runway infrastructure.

FIGURE 1: Modeled flood depth across Porto Alegre Airport sub-assets, 1% annual event

MODEL OUTPUTS SHOW:

83%
Sub-assets exposed to ≥1 inch flooding (increasing to 86%)

3.7FT
Average flood depth (1% event)

>10FT
Maximum depths (1% event)

CUMULATIVE PROBABILITY OF 1% EVENT

9.6% 10 Years

26% 30 Years

CASE STUDY 01: MODELED EXPOSURE & SEVERITY

This case demonstrates that flood exposure is widespread and can reach depths that impair critical infrastructure. Modeled inundation closely aligns with observed flood levels, including depths at key operational areas.

Modeled losses, $72.7 million for structures and up to $181.8 million including contents and equipment, closely match the reported $180 million in damages. Both observed and modeled outcomes highlight a consistent pattern: exposure is concentrated in operationally critical assets, and damage severity scales with flood depth.

For investors, the implication is binary. Airport operations depend on full system functionality, making maximum downtime across critical components the primary driver of business interruption and revenue loss.

OPERATIONAL & FINANCIAL IMPACT:

IN A 1% PROBABILITY EVENT

Damage to airport infrastructure translates into extended repair timelines required to restore operations:

152 DAYS

Maximum downtime

Based on assumptions around passenger throughput and revenue per passenger:

$40-44 MILLION
(~40-45% OF ANNUAL REVENUE)

Revenue loss

BUSINESS INTERRUPTION ASSUMPTIONS

Annual passengers	~7-8M
Blended revenue per passenger	~$13
Estimated annual revenue	~$95-105M
Estimated daily revenue	~$260-290K

CASE STUDY 02

Residential Development: Climate Risk Can Emerge Rapidly Within a Single Hold Period

Residential developments are often viewed as diversified asset pools rather than single points of failure. However, projects in the wildland-urban interface can exhibit highly correlated, capital-intensive climate risk. Unlike flood or wind, wildfire frequently results in total structural loss, driving multi-year reconstruction timelines, prolonged income interruption, and significant replacement costs.

Shifting development patterns are amplifying this exposure. As coastal Florida faces rising hurricane and storm-surge risks, growth has increasingly shifted inland (Fox Orlando, 2025). Areas throughout the state have seen steady expansion, even in major metropolitan regions like Miami, reducing coastal risk but increasing exposure to wildfire. The state as a whole has seen an increase in its wildfire risk, driven by extreme drought conditions (Atienza, 2026). Recent media coverage of brush fires in central Florida, including Lake County, has highlighted how drought and expanding wildland-urban interfaces increase the potential for ignition and spread (Towns, 2026). In some cases, homeowners have reportedly taken defensive measures as fires approached residential areas.

For investors, this represents a trade-off: mitigating one hazard can materially increase exposure to another, requiring a multi-hazard view of site selection and long-term risk.

OBSERVED EVENT: INCREASING WILDFIRE RISK IN FLORIDA

Development expansion into wildland-urban interface	Rising drought-driven wildfire activity	Increasing exposure across residential developments

CASE STUDY 02: MODELED EXPOSURE & SEVERITY

To test risk to development in central Florida, a residential development site in the suburbs of Parkland was delineated and analyzed using First Street's Complex Assets Module. The model identified 206 single-family home sub-assets within the project footprint.

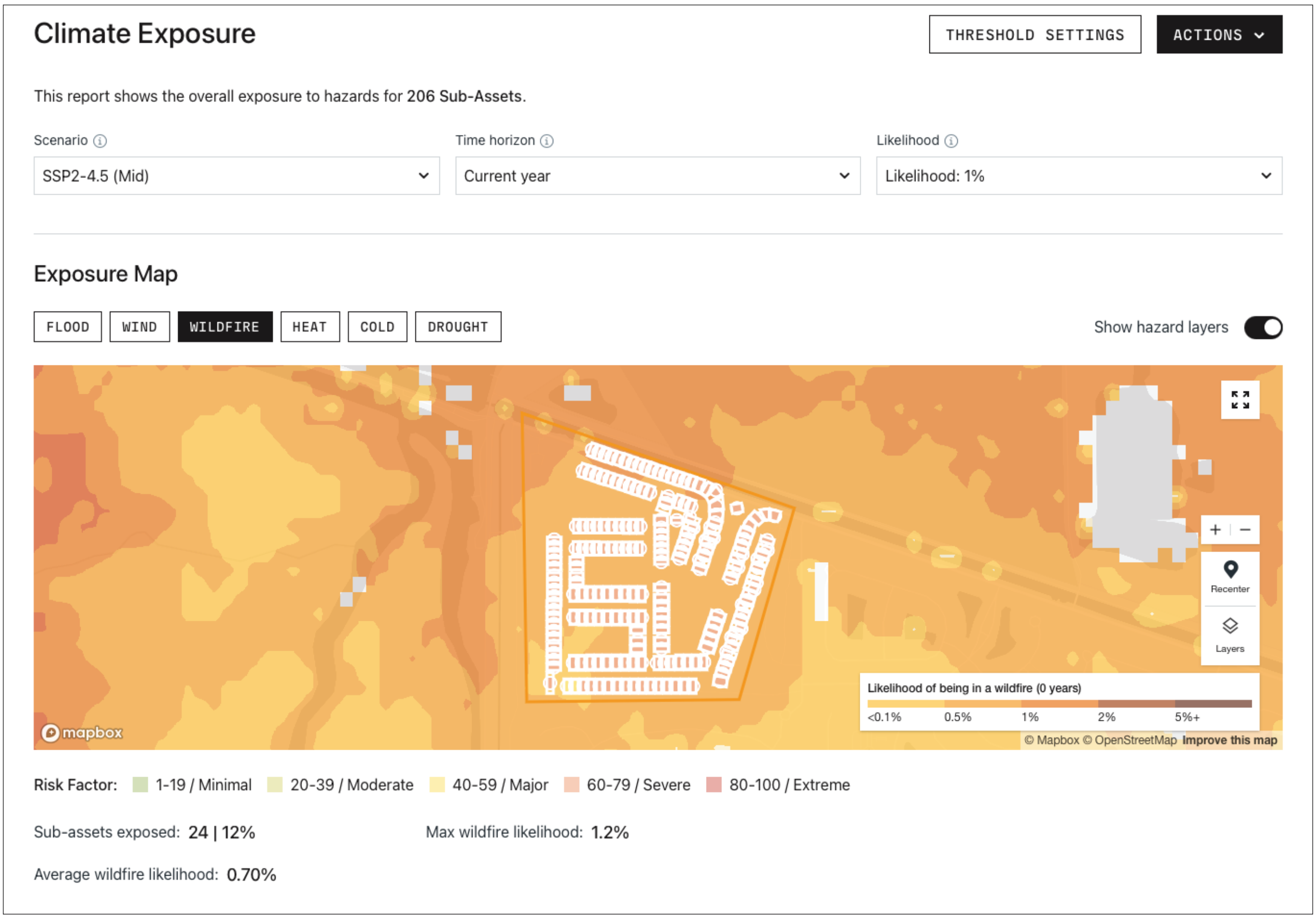

FIGURE 2: Cumulative wildfire burn probability over a 30-year hold period

MODEL OUTPUTS SHOW:
1% burn probability exposure

12%	17%	26%
Today	10 Years	30 Years

CASE STUDY 02: MODELED EXPOSURE & SEVERITY

This case demonstrates that wildfire risk can escalate rapidly within a typical investment horizon, even where current exposure appears limited. Modeled increases in burn probability align with observed trends in wildfire frequency and intensity in Central Florida, reinforcing that risk is dynamic rather than static.

Both modeled and observed outcomes point to two key drivers: exposure evolves materially over time, and risk is shaped by environmental conditions and land-use change.

For investors, the implication is severity. Wildfire is a total-loss event, meaning downtime is dictated by full reconstruction timelines, resulting in extended income interruption and significant capital reinvestment.

OPERATIONAL & FINANCIAL IMPACT:

IN A 1% PROBABILITY EVENT

Damage to homes results in full rebuild cycles:

907 DAYS

Maximum downtime

Based on assumptions around NOI per home:

$12.8 MILLION
(~248% OF ANNUAL NOI)

Revenue loss

BUSINESS INTERRUPTION ASSUMPTIONS

Annual NOI per home	~$25K
Homes	206
Estimated annual site NOI	~$5.2M
Estimated daily NOI	~$14

CASE STUDY 03

Rail Networks: Local Climate Damage Can Disrupt Entire Corridors

Rail corridors are linear infrastructure assets where service reliability depends on continuity along the line. Even localized flooding can disrupt corridor-wide throughput if track, embankments, bridges, or signaling systems fail at critical points. Because services are networked, impacts propagate quickly through rerouting, reduced capacity, and schedule disruption.

Flooding in Germany in July 2021 illustrates this vulnerability. Storm Bernd caused extreme rainfall and river flooding across key regions, damaging approximately 600 kilometers of rail lines (DB, 2021). Impacts included washed-out embankments, undermined tracks, and failed signaling systems, leading to widespread service disruption. Water gauges in these regions of Germany recorded floodwaters as high as 10.2 meters (Apel et al., 2022).

The extent of damage to these rail lines, including collapsed bridges and railroad stations, was estimated at €1.3 billion, with reopening timelines ranging from weeks to years (Reuters, 2021; Fender, 2021). Across DB's infrastructure, major corridors were disrupted, with embankments washed out, tracks undermined, and signaling systems damaged. The resulting rail disruptions had cascading effects across passenger services, freight transport, and regional mobility.

OBSERVED EVENT: EUROPEAN FLOOD DEUTSCHE BAHN IMPACTS

10.2	€1.3B	Wks-Yrs
METERS OF FLOODING	IN DAMAGE	OF DOWNTIME

CASE STUDY 03: MODELED EXPOSURE & SEVERITY

First Street analyzed a portion of the impacted Deutsche Bahn network using its Complex Assets Module to demonstrate that such a disruption was foreseeable. The high-speed ICE corridor between Dortmund and Frankfurt was mapped and segmented into 2,891 sub-assets, enabling a detailed assessment of localized risk across the full line.

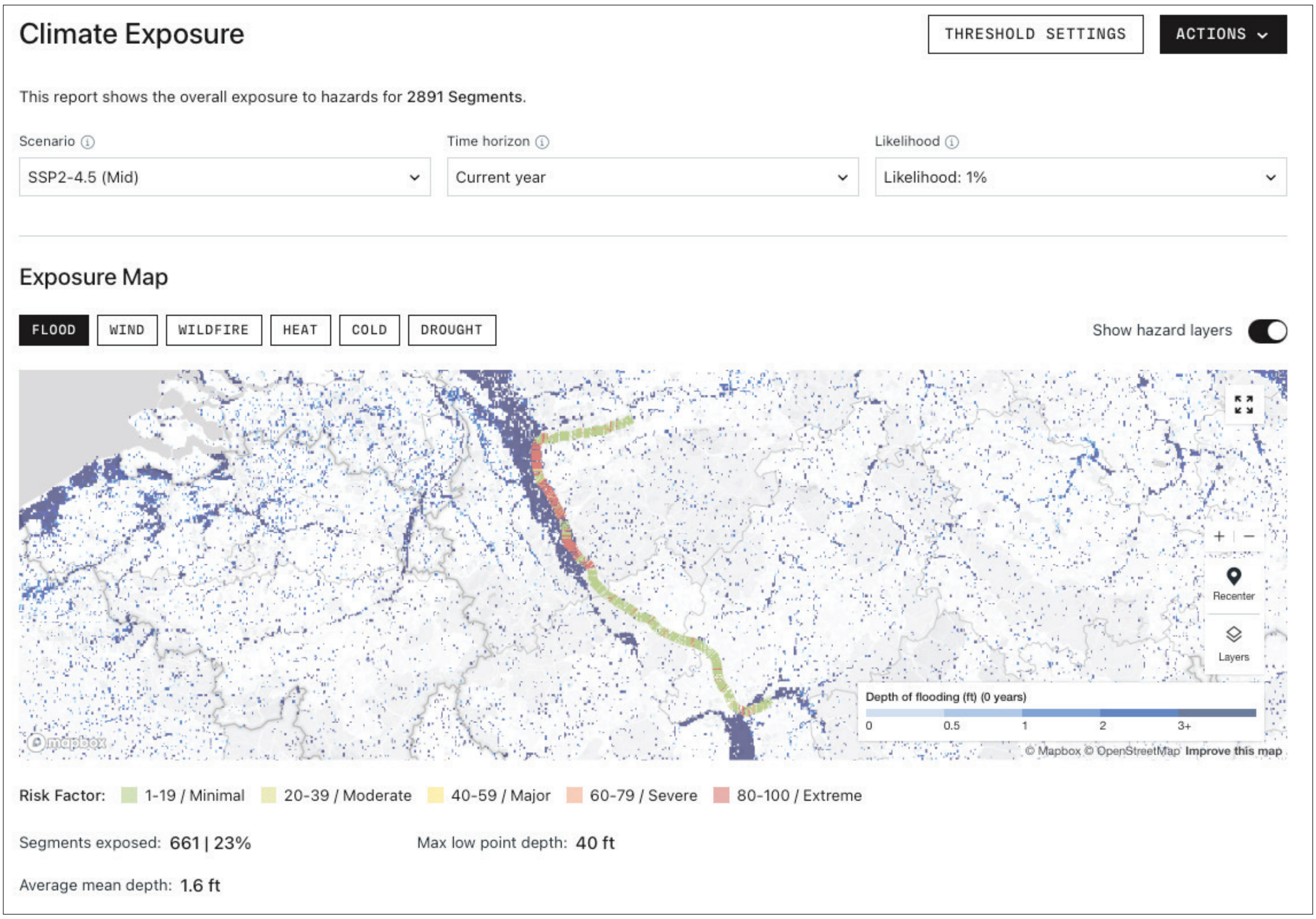

FIGURE 3: Segment-level flood exposure along the Dortmund-Frankfurt ICE corridor

MODEL OUTPUTS SHOW:

23%
Segments exposed to ≥1 inch flooding

1.6FT
Average flood depth (1% event)

16.8FT
Maximum depths (1% event)

CUMULATIVE PROBABILITY OF 1% EVENT

9.6% 10 Years

26% 30 Years

CASE STUDY 03: MODELED EXPOSURE & SEVERITY

This case demonstrates that while exposure may be localized, severe flooding at critical segments can drive system-wide disruption. Modeled results align with observed outcomes, where damage to a limited number of segments cascaded across the network.

Both modeled and observed outcomes reinforce two key dynamics: localized exposure can propagate across the corridor, and overall system performance is constrained by the most severely impacted segment.

For investors, the implication is structural. Rail networks require continuous operability, meaning disruption at a single critical point can reduce throughput across the entire line, making maximum downtime the primary driver of realized revenue impact.

OPERATIONAL & FINANCIAL IMPACT:

IN A 1% PROBABILITY EVENT

Flooding across exposed segments translates into repair timelines required to restore safe operating conditions along the corridor:

60 DAYS

Maximum downtime

Based on assumptions around passenger throughput and revenue per passenger:

~€72 MILLION
(~20% OF ANNUAL REVENUE)

Revenue loss

BUSINESS INTERRUPTION ASSUMPTIONS

Estimated daily passengers	**~30K**
Blended fare	**~€40**
Estimated daily revenue	**~€1.2 M**
Estimated annual corridor revenue	**~€438M**

CASE STUDY 04

Transmission Lines: Even Modest Climate-Driven Failures Cause Network-Wide Losses

Transmission corridors are the backbone infrastructure that connect multiple cities and load centers, enabling power delivery across regional grids. While revenues may be regulated and less volume-sensitive than merchant assets, physical disruption can trigger widespread outages and emergency restoration requirements, increasing both direct repair costs and longer-term capital needs. For long corridors, the probability of at least one segment failing in a severe wind event rises with the number of exposed spans, making reliability a function of system-wide resilience.

A recent storm in the Philippines demonstrates the vulnerability of transmission lines to high wind speeds. Typhoon Odette (Rai) struck the Philippines in December 2021 with sustained winds around 121 mph and gusts reaching 168 mph, making landfall multiple times across the archipelago (Relief Web, 2021). The National Grid Corporation of the Philippines (NGCP) reported at least 95 facilities damaged, including 12 transmission towers and more than 600 transmission poles, by the storm (NGCP, 2021). The grid operator later reported roughly $3.4 million in repair and restoration costs for damaged transmission assets, while restoration of damaged transmission infrastructure continued for weeks, with roughly 85% of facilities restored by late December 2021 (Lectura, 2023; Marquez, 2021).

OBSERVED EVENT: TYPHOON WIND DAMAGE TO NCGP TRANSMISSION LINES

168MPH	$3.4M	Wks
WIND GUSTS	IN DAMAGE	OF DOWNTIME

CASE STUDY 04: MODELED EXPOSURE & SEVERITY

First Street ran a portion of the NGCP transmission lines impacted through its Complex Assets Module to showcase that this sort of event could have been predicted. A major transmission corridor connecting Surigao City to Davao City was mapped, identifying 3,650 segments along the line.

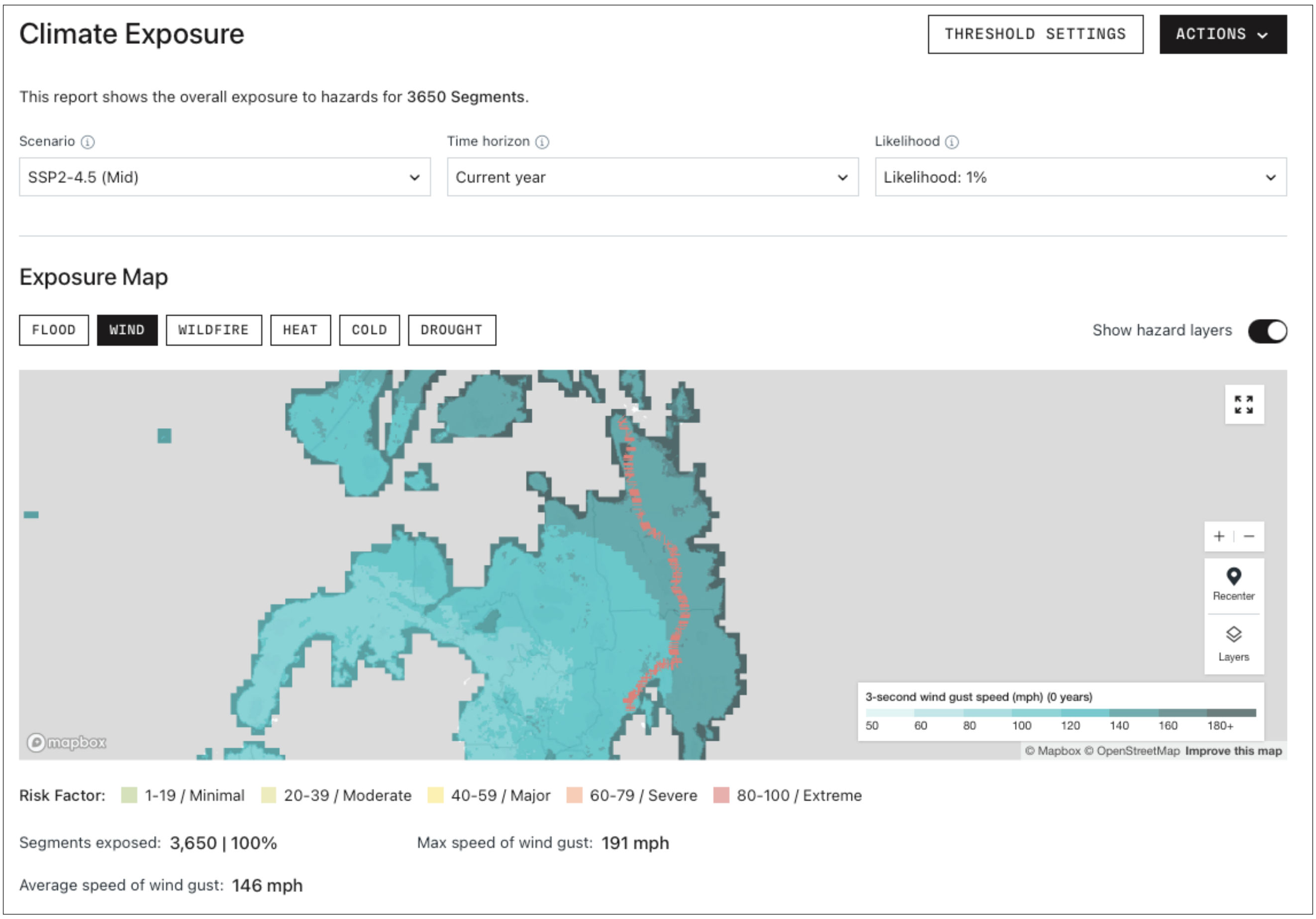

FIGURE 4: Wind exposure across the Surigao-Davao transmission corridor

MODEL OUTPUTS SHOW:

100%
Segments exposed to ≥74 mph winds

146MPH
Average wind speed (1% event)

191MPH
Maximum wind speed (1% event)

CUMULATIVE PROBABILITY OF 1% EVENT

9.6% 10 Years

26% 30 Years

CASE STUDY 04: MODELED EXPOSURE & SEVERITY

This demonstrates persistent exposure to severe wind conditions. The modeled wind speeds align with observed storm conditions, confirming that the transmission system operates in areas with failure-level wind speeds and that damage is likely to occur across multiple segments simultaneously. Because transmission systems exhibit weakest-link characteristics, failure at a single span can interrupt network flow.

While the direct revenue impact may appear modest under regulated models, the financial significance lies in restoration cost, outage scale, and the likelihood of repeated events. For investors, these results indicate that while downtime may be short, repeated failures can drive cumulative capex and reliability risk.

OPERATIONAL & FINANCIAL IMPACT:

IN A 1% PROBABILITY EVENT

Damage to transmission towers, lines, and supporting infrastructure translates into repair timelines required to restore full power transfer capacity along the corridor:

3 DAYS

Maximum downtime

Based on assumptions around passenger throughput and revenue per passenger:

$1.6-2.1 MILLION
(~1% OF ANNUAL REVENUE)

Revenue loss

BUSINESS INTERRUPTION ASSUMPTIONS

Transfer capacity	**~1-1.5K MW equivalent**
Estimated average utilization	**~60-70% capacity**
Blended transmission tariff equivalent	**~$35-45 per MW-day**
Estimated annual gross revenue allocation (corridor-equivalent)	**~$180-220M**
Estimated daily revenue equivalent	**~$500-600K**

CASE STUDY 05

Toll Roads: Local Flooding Can Disrupt Corridor-Wide Revenue

Toll roads are revenue-generating transportation assets whose performance depends on uninterrupted corridor throughput. While flooding may affect limited portions of a roadway, closures at key segments can interrupt toll collection, disrupt freight mobility, and create revenue volatility. Because diversion options can be constrained, localized flooding can produce corridor-wide effects disproportionate to the geographic footprint of exposure.

A recent flood in the US demonstrates how highways may be vulnerable to flooding. In May 2019, more than 10 inches of rainfall fell within 24 hours across south-central Kansas near Wichita, causing flash flooding along Slate Creek (National Weather Service, 2019). Floodwaters inundated a four-mile stretch of the Kansas Turnpike south of Wellington, leading to the closure of the highway between Wellington and the Oklahoma border for approximately two days (Kansas Turnpike, 2019). While the duration was relatively short, the event illustrates how localized flooding can disrupt broader transportation flows and revenue continuity.

OBSERVED EVENT: KANSAS TURNPIKE FLOODING

10IN

FLOODING

48HRS

DISRUPTION

CASE STUDY 05: MODELED EXPOSURE & SEVERITY

First Street mapped the full Kansas Turnpike corridor and ran it through the Complex Assets Module to showcase how this impact could have been predicted. Once mapped, the turnpike was divided into 3,803 segments, which were analyzed for flood exposure.

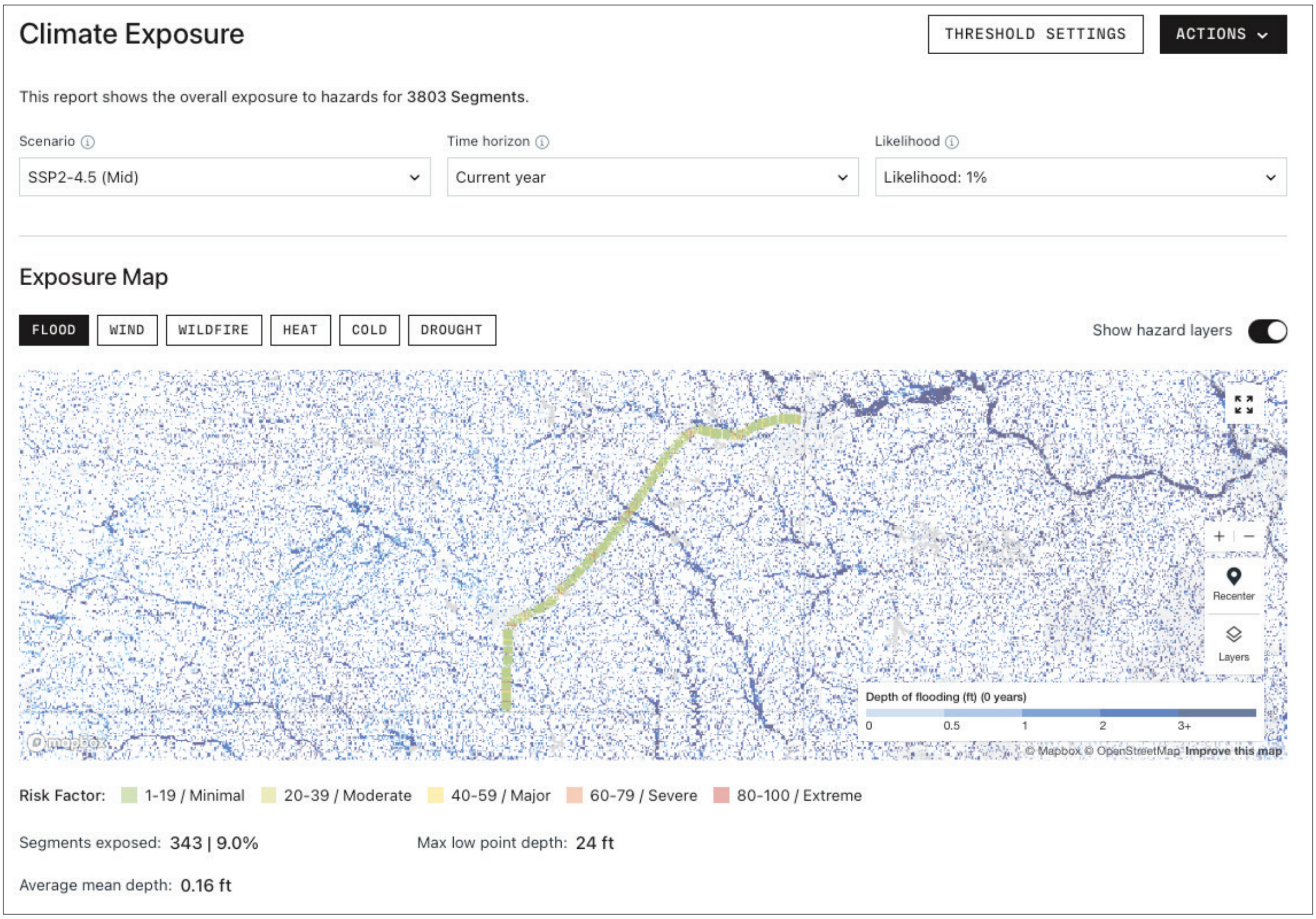

FIGURE 5: Segment-level flood exposure along the Kansas Turnpike corridor

MODEL OUTPUTS SHOW:

9%
Segments exposed to ≥1 inch flooding

~2IN
Average flood depth (1% event)

13.6FT
Maximum depths (1% event)

CUMULATIVE PROBABILITY OF 1% EVENT

9.6% 10 Years

26% 30 Years

CASE STUDY 05: MODELED EXPOSURE & SEVERITY

This demonstrates that exposure is geographically limited but includes critical segments. The modeled results align with observed disruption patterns, validating that localized flooding can halt traffic flow, and system performance depends on key chokepoints.

Because toll roads rely on continuous traffic flow, disruption at key segments can constrain movement across the entire corridor. Even when flooding is geographically limited, closures at critical points reduce vehicle throughput and toll collection system-wide, making maximum downtime a representative indicator of realized business interruption.

For toll road investors, this profile indicates that while exposure is geographically concentrated, disruption at critical segments can create material revenue volatility and operational risk over long hold periods.

OPERATIONAL & FINANCIAL IMPACT:

IN A 1% PROBABILITY EVENT

Flooding of low-lying or flood-prone segments translates into closure timelines required to restore safe passage and full corridor throughput:

40 DAYS

Maximum downtime

Based on assumptions around traffic volumes, toll rates, and corridor utilization:

$40-45 MILLION
(~10-12% OF ANNUAL REVENUE)

Revenue loss

BUSINESS INTERRUPTION ASSUMPTIONS

Blended toll revenue per vehicle	**~$7-8 (passenger + commercial mix)**
Estimated annual transactions	**~13-15M Vehicles**
Estimated annual gross toll revenue	**~$375M**
Estimated daily gross revenue	**~$1M**

CONCLUSION

Infrastructure Risk Is Investment Risk

Across these case studies, a consistent insight emerges: infrastructure risk is shaped not only by exposure but also by the interaction among exposure, asset design, spatial configuration, and system dependencies.

Localized vulnerabilities, whether a flooded runway, a damaged network segment, or a wind-exposed solar array, can extend through interconnected systems and translate into broader operational disruption and financial impact. These effects tend to follow nonlinear patterns and often sit outside the scope of traditional point-based risk frameworks.

For investors, this shifts the focus toward understanding how risk manifests across the full asset footprint and throughout the systems that support performance. Cash flow durability becomes closely linked to how well these underlying dynamics are understood and incorporated into investment decisions.

First Street's Complex Assets Module supports this shift by connecting hazard exposure with modeled damage and downtime across real-world asset configurations. This approach brings greater clarity to how physical risk translates into operational and financial outcomes.

With this more complete perspective, investors are better positioned to surface vulnerabilities that might otherwise remain obscured, assess resilience strategies in context, and approach underwriting, pricing, and capital allocation with greater precision. In an environment where both capital allocation and physical risk are increasing in scale, this level of insight becomes foundational to how infrastructure value is understood and sustained over time.