FHWA-HEP-15-055

U.S. Department of Transportation
Federal Highway Administration

FTA Transit Climate Change Adaptation Assessment Pilot Project:

Southeastern Pennsylvania Transportation Authority

In 2011, the Federal Transit Administration (FTA) selected seven pilot teams from across the country to conduct climate change adaptation assessments. The pilot projects were intended to advance the state of practice for adapting transit systems to the impacts of climate change. The selected projects assessed the vulnerability of transit agency assets and services to climate change hazards such as heat waves and flooding and developed initial adaptation strategies that fit with their transit agency's structure and operations. The pilot project effort is part of FTA's **climate adaptation initiative**, which also includes an **adaptation report**, workshops, and webinars.

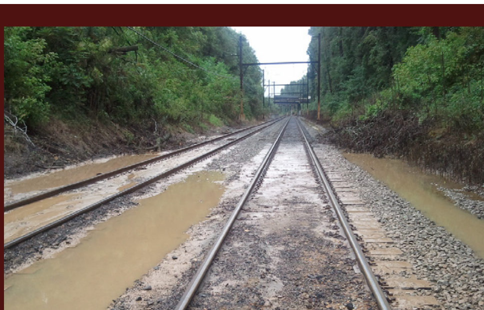
The Southeastern Pennsylvania Transportation Authority (SEPTA) transit system, which serves the Philadelphia area, has experienced an increasing number of service disruptions related to extreme weather in recent years. The FTA pilot effort provided an opportunity to formalize the process of considering these disruptions in decision making; inform existing adaptation efforts with climate science and risk analysis; better understand costs and impacts; and develop a comprehensive strategy that could be applied across the entire system. The pilot effort involved an analysis of SEPTA's current and future risk related to four types of extreme weather events (extreme heat, heavy precipitation, snow, and tropical storms) and translation of the data into terms used regularly by SEPTA decision-makers (service delays, train cancellations, and costs) to facilitate adaptation planning. ICF International, SEPTA, and the Delaware Valley Regional Planning Commission collaborated to carry out this work.

Scope

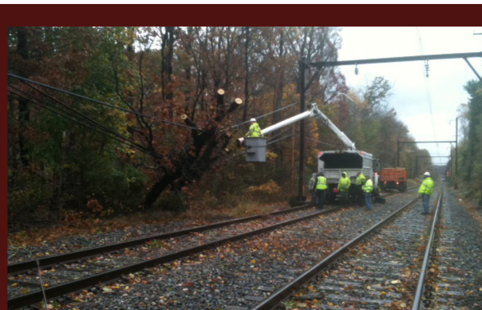
Rather than analyzing climate change impacts on the entire SEPTA system, the project team selected a critical line known to be vulnerable to extreme weather. SEPTA's Manayunk/Norristown (M/N) Regional Rail line, which has experienced several weather-related disruptions in recent years, served as a case study for assessing climate impacts on train service. The M/N line runs along the Schuylkill River, covering 18.1 miles, with 10 stations in service between the terminal stations. Other assets on the line identified for the study include bridges, culverts, grade crossings, interlockings, and power facilities.

Objectives

- Understand the M/N line's vulnerabilities under current climate conditions; the implications of current vulnerabilities in terms of relevant metrics (such as costs and delays); and how current vulnerabilities are likely to change in the future, given projected climate change.
- Identify ways that SEPTA could adapt its operations, maintenance practices, and capital planning strategies to become more resilient to extreme weather.



Damage to a SEPTA line caused by Superstorm Sandy. Photo credit: SEPTA.



Damage to power lines along the SEPTA system caused by downed trees from Superstorm Sandy. Photo credit: SEPTA.

Flooding at Spring Mill Station on the M/N line. Photo credit: SEPTA.

Approach

Assess historical vulnerabilities. SEPTA maintains a record of train delays and causes that contains flags for weather-related delays. The project team used the dataset from January 2005 through February 2012 to understand and compare the frequency and magnitude of disruptions associated with different types of weather events in the past. The M/N line had experienced delays and train annulments due to multiple types of extreme weather, including extreme heat, heavy rain, snow, and tropical storms.

The effort utilized institutional knowledge from interviews with SEPTA staff to help identify observed vulnerable locations and asset types on the line. The project team incorporated all assets within the project scope into a geographic information system (GIS) representation and asked SEPTA staff to identify areas on the map where flooding has occurred.

"Mine your data – it's the best thing you can do for your adaptation process."

-Erik Johanson, SEPTA

Analyze historical threshold impacts on weather-related disruption. After understanding what happened when extreme weather occurred, the team sought to analyze when weather-related service disruptions occurred. The analysis defined extreme weather conditions in the Philadelphia area as the top 1 and 5 percentile values from the distribution of temperature and precipitation values for the period 1994–2012 (the period where data were available from a local weather station). The project team paired the extreme temperature and rainfall values with the train delay data to determine how often delays occurred when the thresholds were exceeded.

Information Type	Source
Train delays and annulments, with flags for weather-related events	SEPTA
Daily weather	National Oceanic and Atomospheric Administration (NOAA) Global Historical Climatology Network (GHCN) Station – The Franklin Institute in Philadelphia

Information Type	Source
Costs of past major weather events	Federal Emergency Management Agency (FEMA) reimbursement requests; SEPTA labor costs
Climate projections	World Climate Research Programme (WCRP) **Coupled Model Intercomparison Project 3 (CMIP3) Multimodel Dataset** Federal Highway Administration's ***Regional Climate Change Effects: Useful Information for Transportation Agencies*** Union of Concerned Scientists' **Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State**

Estimate risk of service disruption. In order to compare the impacts on train service across different types of weather events, the project team developed a method to calculate the risk in terms of delay minutes and train annulments. The risk equations are a product of the probability of an extreme weather event's occurrence, the probability that an event has a consequence for SEPTA, and the magnitude of that consequence. The risk estimates were calculated based on historical data.

Estimate costs of recent extreme weather events. The project team used cost information related to labor, materials, and equipment from FEMA reimbursement requests and SEPTA payroll costs associated with each type of weather event to provide another perspective on the recent climate impacts on the M/N line.

Assess future conditions. The study combined the understanding of current risk with projections of future extreme weather conditions to estimate future risks. The study used downscaled climate projections from nine climate models and two emissions scenarios (high and low) for mid-century (2046–2065). For each model and emissions scenario, the project team determined the change in frequency of extreme heat and precipitation events and the number of days that are cold enough for possible snow. Then future risks of train delays, annulments, and payroll costs were estimated by combining the known risks associated with extreme weather events with the projected changes in the frequency of these events.

Identify adaptation options. Knowing current and future vulnerabilities, the project team began a series of roundtable meetings with SEPTA staff across several departments to discuss adaptation options. The meetings were informed by a preliminary list of rail adaptation strategies tailored to SEPTA's vulnerabilities, based on existing adaptation reports and expert knowledge. Through these meetings, the project team refined the list of suitable adaptation strategies and identified barriers to implementation and ways the options fit within existing SEPTA processes.

Key Results & Findings

Current and future vulnerabilities. The study found that when the temperature and precipitation variables crossed the 1st and 5th percentile thresholds (98.1°F and 93.0°F for high temperature and 2.5 inches and 1.4 inches for daily rainfall, respectively) in recent years, the transit line faced a much greater chance of disruption. Service on the M/N line is currently most vulnerable to track washouts from heavy rain and tropical storms, along with delays from snow storms. In addition to frequent flooding, the line may become increasingly vulnerable to more frequent extreme heat days and associated issues (e.g., sagging wires, track buckling, and equipment failures).

Risks and costs. The results show that snow, heat, and heavy rain all pose current and future risks to the M/N line. Extreme temperature events may present the greatest risk of train delays in the future, because changes in temperature will be the most pronounced. Snow, however, is the most costly weather event type for SEPTA

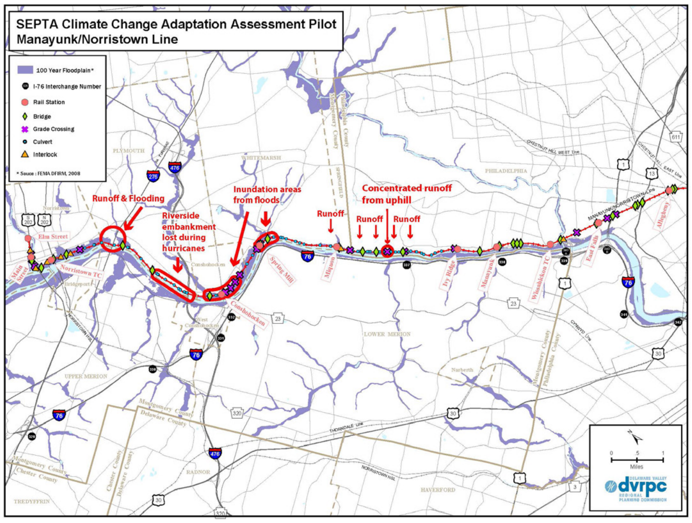


Figure 1: Assets and known areas of vulnerability on the M/N line.

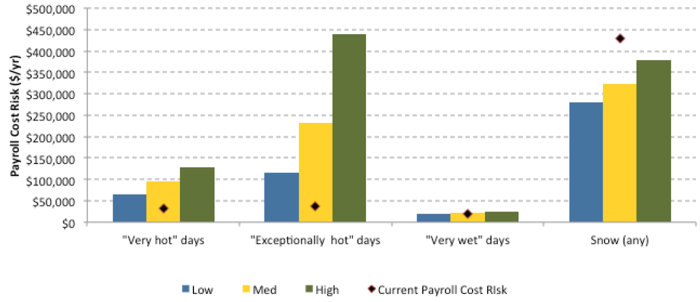


Figure 2: Estimated payroll cost risks of extreme weather to the M/N line in the mid-century for low, medium, and high climate model and emissions scenarios.

in terms of labor, followed by tropical storms. Overall, weather-related events may become an increasing burden on SEPTA's service, labor system, and budget.

Adaptation options. The project team evaluated several adaptation options in the categories of capital planning, operations, and maintenance strategies. Ultimately, the team recommended 29 adaptation strategies for addressing SEPTA's greatest current and projected vulnerabilities. The recommended adaptation options have low barriers to implementation and carry benefits regardless of future climate conditions.

Findings from Superstorm Sandy

Superstorm Sandy struck the northeastern United States during the study. The extreme weather event provided SEPTA the opportunity to demonstrate the transit system's resilience, test adaptation strategies, and learn how to improve resilience. SEPTA suspended service in advance of the storm, maintained frequent communication with customers, relocated assets to less vulnerable locations, trimmed trees near power and transit lines, and spent the duration of the storm conducting a system-wide assessment of vehicles and infrastructure.

SEPTA developed a charge code specifically for Superstorm Sandy that enabled the authority to more easily capture the storm's costs. Tracking costs will help SEPTA adaptively manage the system in preparation for future extreme weather events. The storm cost SEPTA over $1.3 million, including emergency protective measures before the storm, emergency repairs, and labor. Despite the damages, SEPTA's response to the storm demonstrated numerous adaptation strategies the authority should continue to practice to maximize system resilience.

Lessons Learned

Look to the past and present in trying to understand the future. The pilot examined climate change vulnerability through the lens of current weather conditions and service disruptions, which allowed the project team to effectively engage SEPTA staff about their existing and future vulnerabilities. That approach proved to be a productive alternative to the often time-consuming and resource-intensive discussions and analysis related to criticality and climate scenarios.

Capture and utilize institutional knowledge. The stakeholder-driven approach provided valuable institutional knowledge about the system's existing vulnerabilities and response measures; veteran SEPTA staff managers have been responding to weather-related issues for decades and have many best practices in place to manage for these weather events. To continue to capitalize on this information, one of the top recommended adaptation strategies was that the transit authority document and disseminate the institutional knowledge about extreme weather indicators and protocols.

Mine existing data, but recognize caveats and limitations. The study focused on a single regional rail line, which allowed SEPTA to utilize available data within the project budget. The project team recognized that the quality of the underlying historical data is important for this approach because the estimation of future risks is only as strong as the information on current vulnerabilities and risks. For example, the quantified costs do not capture the full costs associated with transit disruptions, including materials costs and the larger societal costs of disruptions (which SEPTA does not track). Additionally, this approach cannot quantify projected disruptions and costs from novel stressors such as sea level rise, for which there are no historical examples.

Next Steps

Implement recommended adaptation strategies. SEPTA is already implementing many of the recommended strategies across the transit system to better maintain service during and after extreme weather events. These strategies include adjusting operations and maintenance practices, acquiring backup power sources, elevating signal huts, accelerating tree trimming, and enhancing rider communication. The authority is planning to continue such efforts, as well as pursue additional strategies including:

- Adding a flag or module to its asset management system that documents climate and weather-related vulnerabilities, so that this information will appear when decision-makers are considering maintenance or long-term planning activities related to the asset; and
- Improving use of weather-related charge codes and other cost-tracking mechanisms to help inform decision making.

For More Information

Resources:

A Vulnerability and Risk Assessment of SEPTA's Regional Rail

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