

Environmental Impacts of the Francis Scott Key Bridge Collapse

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Abstract

This report presents a comprehensive environmental impact assessment of the Francis Scott Key Bridge collapse in Baltimore, Maryland, on March 26, 2024. It examines the immediate, short-term, and long-term environmental consequences of the incident, including hazardous materials risks, sediment disruption, impacts on fisheries, air quality changes, and broader social effects. Drawing upon findings from federal and state agencies, scientific institutions, and non-governmental organizations, as well as outreach and Freedom of Information Act (FOIA) requests, the study synthesizes available data and identifies key policy and research recommendations for future infrastructure resilience and ecological protection.

Keywords

Environmental Impact, Sediment Disturbance, Water Quality, Fisheries, Air Quality, Chesapeake Bay

1. Introduction

1.1. Background: The Collapse of the Key Bridge

In the early morning hours of March 26, 2024, the Singapore-registered vessel Dali experienced a loss of propulsion and struck a bridge support of the Francis Scott Key Bridge, leading to the sudden collapse of the 1.6-mile span into the Patapsco River. The collapse of this vital highway connection not only caused tragic loss of life and catastrophic infrastructure failure but also raised significant environmental concerns in one of the most industrially active and ecologically sensitive regions of the Chesapeake Bay (NTSB, 2025).

The wreckage introduced tens of thousands of tons of steel and concrete into the river channel, obstructing navigation and forcing the closure of the Port of

Baltimore, one of the busiest shipping ports on the U.S. East Coast. Compounding the debris hazard was the vessel's cargo: The vessel carried an estimated 1.5 million gallons of fuel and lubricants, in addition to 56 containers of hazardous cargo—ranging from corrosives to lithium-ion batteries—posing significant environmental risks (Fraser, 2024).

The Patapsco River and northern Chesapeake Bay are already ecologically vulnerable due to decades of industrial activity. Sediments in this area are known to contain legacy contaminants such as heavy metals, petroleum hydrocarbons, and polychlorinated biphenyls (PCBs). The collapse and subsequent salvage operations risked disturbing these sediments, potentially releasing toxins that had been buried for decades back into the water column (UMCES, 2024).

Beyond the direct risks of hazardous material release and sediment disruption, the collapse also had indirect ecological and social impacts. The closure of shipping lanes forced rerouting of freight traffic, increasing emissions and raising air quality concerns (EPA, 2024b). Local fisheries and crabbing industries faced uncertainty as dredging, salvage, and reconstruction activities threatened spawning grounds and habitats critical to migratory species (EPA, 2024b; UMCES, 2024).

1.2. Objectives of the Environmental Impact Assessment

The overarching aim of this research is to conduct a comprehensive assessment of the environmental consequences of the Francis Scott Key Bridge collapse. This study evaluates immediate environmental impacts, cleanup and removal operations, reconstruction impacts, and future environmental reverberations.

The study is guided by the following research questions:

- What were the most significant immediate environmental risks and how effectively were they contained?
- How have salvage and cleanup operations influenced sediment quality, water chemistry, and aquatic habitats?
- What environmental risks accompany reconstruction, and how might they be minimized?
- What are the anticipated long-term effects on contaminants, fisheries, and community well-being?

1.3. Research Structure and Methodology

The research structure reflects the complexity of the Key Bridge collapse and its environmental consequences. The study is organized into four work areas (immediate impacts, cleanup, reconstruction, and future reverberations), with each area examined through contaminants, fisheries, air quality, and dredging modules.

Methods include documentary analysis of EPA, NTSB, MDE, USACE, UMCES, and NGO reports; outreach and FOIA requests; and integration of cross-task collaborations with studies on traffic congestion and social impacts (EPA, 2024a, 2024b; MDTA, 2024; MDE, 2024; NTSB, 2025; UMCES, 2024).

For the purposes of this study, immediate impacts refer to conditions observed

during the first weeks following the collapse. Short-term impacts refer to effects associated with salvage, debris removal, and channel restoration activities. Long-term impacts refer to environmental conditions that may persist or develop during reconstruction and recovery. The term localized refers to impacts confined to specific areas near the collapse site, while widespread refers to impacts affecting broader portions of the Patapsco River or Chesapeake Bay.

1.4. Methods

This study uses a document-based environmental assessment approach. Sources reviewed included reports and updates from the U.S. Environmental Protection Agency (EPA), Maryland Department of the Environment (MDE), U.S. Army Corps of Engineers (USACE), National Transportation Safety Board (NTSB), University of Maryland Center for Environmental Science (UMCES), and relevant non-governmental organizations. Additional information was obtained through public records requests and review of publicly available project documents (EPA, 2024a, 2024b; MDTA, 2024; MDE, 2024; NTSB, 2025; UMCES, 2024).

The assessment focuses on information published between March 2024 and January 2026. Documents were selected based on their relevance to hazardous materials, water quality, sediment disturbance, fisheries, air quality, dredging, and reconstruction activities. The effectiveness of mitigation measures was evaluated using reported monitoring results, documented environmental conditions, and agency findings regarding contaminant containment and environmental protection (EPA, 2024b; MDTA, 2024; MDE, 2024; UMCES, 2024).

2. Immediate Environmental Impacts

2.1. Hazardous Material Spills: Fuel and Container Cargo

At the time of the incident, the Dali reportedly carried approximately 1.5 million gallons of fuel and lubricants and 56 containers of hazardous materials. Early response actions focused on containment and monitoring, with no indication of active hazardous releases into surface waters (EPA, 2024a).

To reduce the likelihood of secondary releases, containment measures were implemented, including closing deck scuppers, constructing berms, pumping rainwater into storage systems, and applying soft patches to hull damage. Sampling identified hazardous constituents such as lead in bridge paint (~235 ppm) and variable chemical conditions in waste samples (EPA, 2024b; MDTA, 2024; MDE, 2024; UMCES, 2024).

2.2. Water Quality and Wildlife Exposure

Initial water-quality monitoring did not document widespread exceedances of environmental standards. However, exposure pathways included localized contamination, increased turbidity, and disturbance from salvage operations (EPA, 2024b; MDTA, 2024; MDE, 2024; UMCES, 2024).

Although no large fish-kill events were reported, sublethal effects on larval fish

and benthic organisms remained possible, particularly during sensitive spawning periods (UMCES, 2024; Fraser, 2024).

2.3. Disruption of Sediment-Bound Chemicals

The collapse and subsequent salvage operations disturbed sediments containing PCBs, heavy metals, and petroleum hydrocarbons. When these sediments are re-suspended, contaminants can re-enter the water column, potentially to increase bioavailability and uptake by aquatic organisms (UMCES, 2024; Fraser, 2024).

Sediment disturbance represents a credible mechanism for both short-term exposure and long-term ecological risk, requiring sustained monitoring (UMCES, 2024; Hesselgrave, 2024).

2.4. Media Narratives vs. Documented Immediate Impacts

Media narratives emphasized worst-case environmental scenarios, including potential large-scale contamination. In contrast, agency assessments reported no widespread hazardous releases (EPA, 2024a, 2024b; Cox, 2024; Baltimore Banner, 2024).

This divergence highlights the challenges of environmental risk communication and the importance of transparent, data-driven reporting (Baxter, 2024; EPA, 2024b).

While early media coverage emphasized the potential for catastrophic environmental contamination, agency reports consistently indicated that no widespread hazardous material release occurred. This discrepancy between perceived and documented risk highlights the importance of transparent, data-driven communication during environmental emergencies. The persistence of uncertainty, particularly regarding sediment-bound contaminants, contributed to public concern despite measured conditions remaining within acceptable thresholds (EPA, 2024a, 2024b; Baltimore Banner, 2024; Cox, 2024).

3. Environmental Impacts of Salvage and Debris Removal

This disturbance increased turbidity and reduced water clarity in localized areas, limiting light penetration and affecting submerged aquatic vegetation. As sediments were resuspended, previously contained contaminants may have been re-introduced into the water column, increasing their potential to be absorbed by aquatic organisms and transferred through the food web (EPA, 2024b; Baltimore Banner, 2024; Cox, 2024).

Environmental monitoring conducted during this phase focused on parameters including pH, dissolved oxygen, hydrocarbons, and metals. While results did not indicate widespread exceedances of environmental standards, localized variations were observed near debris removal zones, suggesting short-term changes in water quality conditions (MDTA, 2024; MDE, 2024).

Sampling also identified the presence of hazardous constituents, including lead in bridge paint and variable chemical conditions within confined waste compartments. Although asbestos was not detected in preliminary assessments, continued

monitoring was necessary to ensure environmental safety (MDTA, 2024; MDE, 2024).

Overall, while containment measures limited visible pollution, sediment disturbance associated with cleanup activities represents a key pathway for long-term environmental impact, particularly through contaminant mobilization and potential bioaccumulation in aquatic systems (UMCES, 2024; Cox, 2024).

3.1. Water, Air, and Material Exposure during Recovery

Cleanup operations required continuous monitoring of environmental conditions to assess the impacts of salvage activities. Water quality testing focused on parameters such as pH, dissolved oxygen, hydrocarbons, and metals. Results indicated no widespread exceedances of environmental standards, although localized variations were observed near debris zones (MDTA, 2024; MDE, 2024).

Air monitoring was conducted to evaluate exposure risks associated with hazardous materials and emissions from salvage operations. Worker Air Protection Levels were established to guide protective measures, particularly in areas with volatile compounds and hazardous cargo. Material testing identified the presence of lead in bridge paint and variable chemical conditions in waste compartments. While asbestos was not detected in preliminary samples, continued monitoring was required to ensure safe handling of debris and materials (MDTA, 2024; MDE, 2024).

Sampling identified the presence of lead in bridge paint at approximately 235 ppm, along with variable chemical conditions in confined waste compartments. Although asbestos was not detected in preliminary samples, continued monitoring was required to ensure safe handling and environmental protection (EPA, 2024b; MDTA, 2024).

3.2. Sediment Disturbance and Contaminant Mobilization

Sediment disturbance remained a central environmental concern throughout cleanup operations (UMCES, 2024; Hesselgrave, 2024).

During cleanup activities increased turbidity and reintroduced contaminants into the water column. These contaminants can become bioavailable and enter aquatic food webs, leading to potential long-term ecological impacts (UMCES, 2024; Cox, 2024).

Although containment measures such as booms and controlled water management were effective in preventing visible pollution, the cumulative effects of repeated sediment disturbance during prolonged cleanup operations remain uncertain. This highlights the importance of sustained monitoring of sediment, water quality, and biological systems (EPA, 2024b; MDTA, 2024; UMCES, 2024).

4. Bridge Reconstruction Impacts

4.1. Dredging, Sediment Disturbance, and Water Quality Impacts

Reconstruction of the Francis Scott Key Bridge required large-scale dredging and debris removal to restore navigation and prepare for new structural elements.

These activities posed significant environmental risks due to the disturbance of historically contaminated sediments in the Patapsco River. The river contains legacy pollutants, including heavy metals, petroleum hydrocarbons, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs), which have accumulated over decades of industrial activity (UMCES, 2024; USACE, 2024; Winfield, 2024).

Disturbance of these sediments increased turbidity and reduced light penetration, threatening submerged aquatic vegetation critical for juvenile fish and invertebrates. Resuspended contaminants may re-enter aquatic food webs through plankton and benthic organisms, increasing bioavailability and long-term ecological risk. The timing of dredging operations near spawning seasons may have increased risks to sensitive life stages of species such as striped bass and blue crabs (UMCES, 2024; Hesselgrave, 2024).

Although mitigation strategies such as silt curtains, confined disposal, and controlled dredging were considered, their implementation in an active port environment was complex and limited. As a result, dredging remains one of the most significant environmental stressors associated with reconstruction (USACE, 2024; MDE, 2024; Hofstaedter, 2024).

4.2. Air Emissions and Regional Environmental Effects

Reconstruction activities generated substantial air emissions from diesel-powered equipment, including dredges, cranes, pile drivers, and hauling vehicles. These operations released nitrogen oxides (NO_x), particulate matter (PM_{2.5}), sulfur dioxide (SO₂), and carbon dioxide (CO₂), contributing to both local and regional air quality degradation (USACE, 2024; MDE, 2024; Hofstaedter, 2024).

In addition, the closure of the Port of Baltimore forced rerouting of freight traffic, increasing emissions from heavy-duty trucks traveling longer distances. This shift intensified air quality pressures and compounded environmental impacts beyond the immediate construction zone (EPA, 2024b; Strong, 2025).

While monitoring and mitigation measures were implemented to protect workers, broader community-level air quality impacts were less extensively addressed. Communities near the site experienced increased exposure to emissions from both construction activities and rerouted traffic, raising concerns about cumulative environmental and health effects (NOAA, 2024; Baxter, 2024).

4.3. Long-Term Habitat and Ecological Impacts

Reconstruction activities altered both the chemical and physical structure of the river environment. Sediment disturbance mobilized persistent contaminants that can bioaccumulate in aquatic organisms and magnify through the food web. These effects pose long-term risks to fisheries and human populations reliant on the ecosystem (UMCES, 2024; Cox, 2024).

Physical alterations to the riverbed, including dredging and debris removal, disrupted benthic habitats and ecological processes. Habitat fragmentation, under-

water noise, and prolonged industrial activity may impair reproductive success and reduce habitat quality for key species (UMCES, 2024; USACE, 2024).

Although immediate environmental impacts were limited, the cumulative effects of reconstruction activities are expected to unfold over extended timeframes, potentially affecting ecosystem resilience in the Chesapeake Bay (UMCES, 2024; Winfield, 2024).

5. Future Environmental Reverberations

5.1. Chemical Balance and Contaminant Persistence

The collapse and subsequent reconstruction introduced long-term concerns regarding the chemical balance of the Chesapeake Bay. Legacy contaminants embedded in sediments may continue to be mobilized during ongoing dredging and construction activities, increasing the risk of persistent contamination.

Monitoring efforts included water sampling for hydrocarbons, pH, asbestos, lead, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs). While no catastrophic releases were detected, the presence of contaminants such as lead and potential acid residues highlights the need for continued monitoring (EPA, 2024b; MDE, 2024; MDTA, 2024).

Recovery of the Bay's chemical balance depends on sustained environmental oversight and long-term monitoring of sediments and aquatic organisms (EPA, 2024b; MDE, 2024; MDTA, 2024).

5.2. Impacts on Fisheries and Aquatic Ecosystems

The Patapsco River serves as a critical habitat for migratory species, including striped bass, Atlantic menhaden, and blue crabs. Sediment disturbance, turbidity, and underwater noise associated with salvage and reconstruction activities pose risks to spawning success and larval survival. Direct case-specific evidence primarily relates to the presence of sediment disturbance, increased turbidity, and habitat disruption within the affected area (MDTA, 2024; MDE, 2024; UMCES, 2024). Potential effects on species such as striped bass, Atlantic menhaden, blue crabs, and their early life stages are inferred from broader estuarine research regarding spawning habitat disturbance and contaminant exposure (UMCES, 2024; Fraser, 2024).

Although immediate impacts were limited, long-term risks include reduced recruitment, altered habitat conditions, and bioaccumulation of contaminants in aquatic species. These effects may influence fisheries productivity and ecosystem stability over time. The timing of disturbance during peak spawning periods may have increased vulnerability for early life stages of aquatic species. Larval fish and benthic organisms are particularly sensitive to changes in turbidity and contaminant exposure, which can affect survival rates and long-term population stability. In addition, resuspended contaminants may be transferred through the food web, increasing the potential for bioaccumulation in higher trophic levels (UMCES, 2024; Fraser, 2024).

5.3. Community and Environmental Health Impacts

Communities near the collapse site experienced increased environmental stress due to emissions, construction activity, and uncertainty regarding water quality and seafood safety. These impacts were particularly significant in areas already affected by industrial pollution (UMCES, 2024; Fraser, 2024).

Monitoring efforts included the deployment of noise monitoring systems and public communication through environmental agencies. However, the cumulative effects of prolonged construction activity and increased emissions raised concerns about long-term community health and environmental justice (Baxter, 2024; EPA, 2024b).

Cross-task collaboration highlighted the connection between environmental impacts and community-level effects. Increased emissions, disruptions to fisheries, and uncertainty regarding environmental quality contributed to broader social and economic stress. These impacts were particularly relevant for communities dependent on local waterways and natural resources (Strong, 2025; UMCES, 2024).

5.4. Policy

Policy recommendations emphasize the need for enhanced sediment monitoring, improved interagency coordination, and increased transparency in environmental reporting. Long-term monitoring frameworks should be established to track contaminant transport, ecological recovery, and cumulative impacts over time (MDE, 2024; MDTA, 2024; EPA, 2024b).

In addition, integrating environmental considerations into infrastructure recovery planning is critical to minimizing future risks. This includes aligning emergency response actions with long-term environmental protection strategies (Winfield, 2024; USACE, 2024).

6. Discussion

6.1. Synthesis of Environmental Findings

The environmental response to the Key Bridge collapse demonstrated that the highest risks were indirect and time-dependent rather than immediate catastrophic events. Early containment measures successfully prevented large-scale hazardous releases, but sediment disturbance emerged as the dominant pathway for environmental impact (EPA, 2024a, 2024b; UMCES, 2024).

The combination of debris removal, dredging, and reconstruction activities increased turbidity and mobilized legacy contaminants, creating conditions for long-term ecological stress. These findings emphasize the importance of considering sediment dynamics in environmental risk assessments for infrastructure failures (UMCES, 2024; Cox, 2024; Hesselgrave, 2024).

6.2. Data and Monitoring Limitations

Several limitations affect the interpretation of the available data. First, baseline environmental conditions were not available for all monitoring locations, limiting

direct before-and-after comparisons. Second, long-term biological monitoring data remain limited because reconstruction activities are ongoing. Finally, this assessment relies primarily on agency reports, FOIA responses, and publicly available documents rather than independent field investigations. As a result, some conclusions regarding long-term environmental effects remain subject to uncertainty (UMCES, 2024; Cox, 2024; Hesselgrave, 2024).

The environmental assessment relied primarily on agency reports, monitoring data, and publicly available documentation. While these sources provided valuable insight into immediate and short-term conditions, limitations remain regarding long-term environmental effects (UMCES, 2024; Cox, 2024; Hesselgrave, 2024).

Additional evidence gaps should also be recognized. Baseline environmental conditions were not available for all monitoring locations, limiting direct comparison of conditions before and after the collapse. Long-term biological monitoring data remain limited because reconstruction activities are ongoing. Furthermore, this assessment relies primarily on agency reports, FOIA responses, and publicly available documents, which may not capture all project-level environmental information (UMCES, 2024; Cox, 2024; Hesselgrave, 2024).

6.3. Implications for Environmental Monitoring and Management

The incident highlights the need for enhanced environmental monitoring frameworks that extend beyond initial emergency response. Continuous monitoring of sediment, water quality, and biological systems is essential to detect delayed or cumulative impacts (Baxter, 2024; MDE, 2024).

Data transparency and interagency coordination were critical components of the response, but gaps in long-term monitoring and community-level assessment remain. Improved integration of environmental considerations into construction planning is necessary to reduce future risks (EPA, 2024b; MDTA, 2024).

6.4. Lessons for Environmental Risk Management

Several key lessons emerge from the environmental response (EPA, 2024a, 2024b; UMCES, 2024):

- Environmental impacts may be dominated by long-term processes such as sediment disturbance rather than immediate contamination.
- Monitoring systems must extend throughout all phases of recovery and reconstruction.
- Environmental communication should balance uncertainty with evidence-based findings.
- Infrastructure recovery efforts must integrate environmental protection with operational efficiency.

6.5. Role of Environmental Agencies and Scientific Institutions

Environmental response efforts were supported by multiple federal, state, and ac-

ademic institutions. The Environmental Protection Agency (EPA) provided environmental monitoring, data collection, and technical guidance throughout the response. The Maryland Department of the Environment (MDE) conducted water quality assessments and regulatory oversight, including sediment and debris analysis (EPA, 2024b; MDE, 2024).

Scientific institutions, including the University of Maryland Center for Environmental Science (UMCES) and the University of Maryland, Baltimore County (UMBC), contributed expertise on ecological impacts, sediment behavior, and contaminant dynamics. These organizations provided critical insight into long-term environmental risks, particularly related to sediment disturbance and fisheries (UMCES, 2024; Fraser, 2024).

Non-governmental organizations, including Blue Water Baltimore, American Rivers, and Clean Water Action, emphasized community-level concerns and environmental accountability, highlighting the importance of public engagement during environmental incidents (Blue Water Baltimore, 2024; Baltimore Banner, 2024).

7. Conclusion

Current evidence indicates that the Francis Scott Key Bridge collapse did not cause widespread hazardous-material releases or significant acute environmental contamination (Blue Water Baltimore, 2024; Baltimore Banner, 2024). Nevertheless, sediment disturbance, contaminant mobilization, fisheries stress, air emissions, and community impacts remain important environmental concerns throughout the recovery and reconstruction process (UMCES, 2024; Fraser, 2024; Strong, 2025). Significant uncertainties persist regarding long-term ecological consequences and the effects of continued sediment disturbance. Therefore, sustained monitoring of water quality, sediment conditions, aquatic ecosystems, and community exposures is essential to assess ongoing environmental risks and inform effective management as reconstruction advances (UMCES, 2024; MDTA, 2024).

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cluding Blue Water Baltimore, American Rivers, and Clean Water Action, for their role in highlighting community and environmental concerns associated with the incident (Blue Water Baltimore, 2024; Baltimore Banner, 2024).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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