Conrail Freight Train Derailment with Vinyl Chloride Release
Paulsboro, New Jersey
November 30, 2012

Accident Report

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National
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Railroad Accident Report

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National Transportation Safety Board. 2014. ***Conrail Freight Train Derailment with Vinyl Chloride Release, Paulsboro, New Jersey, November 30, 2012*****. Publication Type NTSB/RAR-14/01. Washington, DC.**

Abstract: This report discusses the 2012 accident in which a Consolidated Rail Corporation (Conrail) train derailed while traveling over a moveable bridge in Paulsboro, New Jersey. Three tank cars containing vinyl chloride came to rest in Mantua Creek, of which one was breached and released about 20,000 gallons of vinyl chloride. On that day, 28 residents sought medical attention for possible exposure, and the train crew and many emergency responders were also exposed. Damage estimates were $451,000 for equipment and about $30 million for emergency response and remediation.

This report addresses safety issues: training and qualification of train crews for moveable bridge inspection; Conrail safety management; timeliness of hazardous materials communications to first responders; failure of the incident commanders to follow established hazardous materials response protocols; firefighter training and qualifications; inadequacies of emergency planning, emergency preparedness, and public awareness for hazardous materials transported by train; and rail corridor risk management analysis. Safety recommendations to: Conrail, US Department of Transportation, Federal Railroad Administration, Pipeline and Hazardous Materials Safety Administration, Association of American Railroads, American Short Line and Regional Railroad Association, International Association of Fire Chiefs, National Volunteer Fire Council, four New Jersey state agencies, with three reiterated.

Contents

Figures

Tables

Abbreviations and Acronyms

AAR	Association of American Railroads
AEGL	acute exposure guideline levels
ALOHA	Areal Locations of Hazardous Atmospheres
API	American Petroleum Institute
ASLRRA	American Short Line and Regional Railroad Association
BCS	bridge control system
Bureau of Explosives	Association of American Railroads, Hazardous Materials Committee
CAD	computer assisted dispatch
CASE	Countermeasures Assessments and Security Experts
CBRNE	Chemical, Biological, Radiological, Nuclear, and Explosives
CFR	Code of Federal Regulations
Conrail	Consolidated Rail Corporation
CSXT	CSX Transportation
CTEH	Center for Toxicology and Environmental Health
DHS	US Department of Homeland Security
DOT	US Department of Transportation
EMS	emergency medical services
EOP	emergency operations plan
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERG	*Emergency Response Guidebook*
FRA	Federal Railroad Administration
GC	Gloucester County Emergency Response Center

GPS	global positioning system
HAZMAT database	Hazardous Materials Shipping Descriptions and Emergency Response database
HAZWOPER	*Hazardous Waste Operations and Emergency Response*
HMR	US Department of Transportation Hazardous Materials Regulations
ICAO	International Civil Aviation Organization
ICP	incident command post
IMDG	International Maritime Dangerous Goods Code
LEPC	local emergency planning committee
LPG	liquefied petroleum gas
MP	milepost
MSDS	material safety data sheets
NFPA	National Fire Protection Association
NIMS	National Incident Management System
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJDLWD	New Jersey Department of Labor and Workforce Development
NJDOH	New Jersey Department of Health
NJOHSP	New Jersey Office of Homeland Security and Preparedness
NJROIC	New Jersey Regional Operations Intelligence Center
NJSP	New Jersey State Police
NJSP-OEM	New Jersey State Police Office of Emergency Management
NORAC	Northeast Operating Rules Advisory Committee
NPRM	Notice of Proposed Rulemaking
NTSB	National Transportation Safety Board

OEM	Office of Emergency Management
OMB	Office of Management and Budget
OSC	on-scene coordinator
OSHA	Occupational Safety and Health Administration
PEOSH	New Jersey Public Employee Occupational Safety and Health Program
PHMSA	Pipeline and Hazardous Materials Safety Administration
PLC	programmable logic controller
PPE	personal protective equipment
ppm	parts per million
psig	pounds per square inch
RCRMS	Rail Corridor Risk Management System
RSS	railroad signal system
SERC	state emergency response commission
SMS	safety management system
TDG	Canadian Transportation of Dangerous Goods
TRANSCAER	Transportation Community Awareness and Emergency Response
UN/NA	United Nations identification number/North American identification number
VOC	volatile organic compounds

Executive Summary

On Friday, November 30, 2012, at 6:52 a.m. eastern standard time, southbound Consolidated Rail Corporation freight train FC4230, arrived and stopped on the main track at the Paulsboro moveable bridge near milepost 13.7 on the Consolidated Rail Corporation Penns Grove Secondary Subdivision in Paulsboro, New Jersey. A red signal aspect was displayed and did not change to green when the radio signal command was executed by the train crew, indicating that the bridge was not prepared for train movement. One of two conditions were required before the train could safety begin movement over the bridge: (1) Signal aspect changed to green, indicating that the running rails were aligned and locked to the fixed track and both ends of the bridge, or (2) The bridge was visually inspected by a qualified employee to ascertain that the running rails were aligned and locked to the fixed track at both ends of the bridge and permission was granted by the train dispatcher for the train to pass the red signal.

Despite multiple attempts by the train crew to remotely execute a radio signal command to align and lock the bridge, the signal aspect remained red and did not turn green. The conductor inspected the bridge and erroneously concluded it was properly locked to prevent movement. The engineer informed the dispatcher of the conductor's findings. The dispatcher then gave permission for the train to pass the red signal aspect and cross the bridge, as allowed by Consolidated Rail Corporation operating rules and procedures.

About 7:02 a.m., as the train traveled over the bridge, 7 cars derailed, the 6th through the 12th cars. Physical evidence indicated that the swing span locking mechanism was not engaged at the east end of the bridge. The bridge span rotated under the moving train, misaligned the running rails, and caused the train to derail. The bridge was structurally sound and did not collapse. Four tank cars that derailed on the bridge came to rest partially in Mantua Creek. Three of the derailed tank cars that entered the creek contained vinyl chloride and one contained ethanol. One tank car was breached and released about 20,000 gallons of vinyl chloride. Eyewitnesses reported a vapor cloud engulfed the scene immediately following the accident.

On the day of the accident, 28 area residents sought medical attention for possible vinyl chloride exposure. The train crew and numerous emergency responders were also exposed to vinyl chloride.

Equipment damage estimates were $451,000. The emergency response and remediation costs totaled about $30 million.

The National Transportation Safety Board determines that the probable cause of the derailment and subsequent hazardous material release at the Paulsboro moveable bridge was Consolidated Rail Corporation (1) allowing the train to proceed past the red signal aspect with the rail slide locks not fully engaged, which allowed the bridge to rotate and misalign the running rails as the train moved across it, and, (2) relying on a training and qualification program that did not prepare the train crew to examine the bridge lock system.

Contributing to the accident was the lack of a comprehensive safety management program that would have identified and mitigated the risks associated with the continued operation of the bridge despite multiple bridge malfunctions of increasing frequency.

Contributing to the consequences of the accident was the failure of the incident commander to implement established hazardous materials response protocols for worker protection and community exposure to the vinyl chloride release.

This report addresses the following safety issues:

- Training and qualification of train crews for moveable bridge inspection
- Consolidated Rail Corporation safety management
- Timeliness of hazardous materials communications to first responders
- Failure of the incident commanders to follow established hazardous materials response protocols
- Firefighter training and qualifications
- Inadequacies of emergency planning, emergency preparedness, and public awareness for hazardous materials transported by train
- Rail corridor risk management analysis

As a result of this investigation, the National Transportation Safety Board makes safety recommendations to the US Department of Transportation, the Federal Railroad Administration, the Pipeline and Hazardous Materials Safety Administration, Consolidated Rail Corporation, the Association of American Railroads, the American Short Line and Regional Railroad Association, the International Association of Fire Chiefs, the National Volunteer Fire Council, the New Jersey State Police Office of Emergency Management, the New Jersey Bureau of Fire Department Services, the New Jersey Department of Labor and Workforce Development, and the New Jersey Department of Health. The National Transportation Safety Board also reiterates recommendations to the Federal Railroad Administration and the Pipeline and Hazardous Materials Safety Administration.

1 Investigation and Analysis

1.1 Accident Narrative

On Friday, November 30, 2012, at 7:02 a.m. eastern standard time, southbound Consolidated Rail Corporation (Conrail) freight train FC4230, consisting of 2 locomotives and 82 cars, derailed 7 cars, the 6th through the 12th cars, at milepost (MP) 13.7 on the main track on the Conrail Penns Grove Secondary Subdivision in Paulsboro, New Jersey.[1, 2] The derailment occurred as the train traveled over the Paulsboro moveable bridge at a speed that did not exceed 8 mph (see figure 1). Civil twilight began at 6:33 a.m., and sunrise was at 7:03 a.m. At the time of the accident, the sky was cloudy, the wind was calm, and the temperature was 34°F.

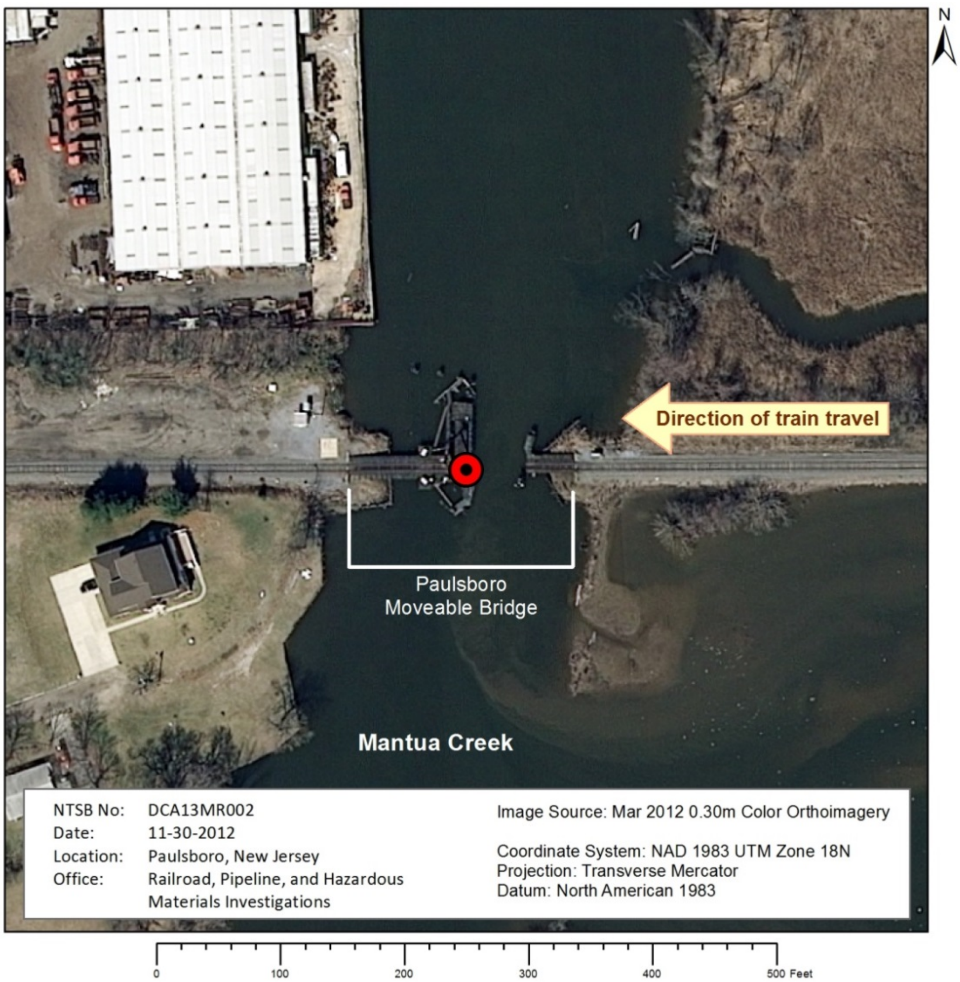

Figure 1. Accident Location, Paulsboro, New Jersey.

[1] All times in this report are eastern standard time.

[2] The train was traveling southbound in accordance with the Penns Grove Secondary Subdivision railroad timetable. All subsequent directions referenced in this report are by geographic perspective unless otherwise stated.

The Penns Grove Secondary Subdivision is a single main track which extends southwest from Woodbury to Deepwater, New Jersey. The track is designated and maintained to Federal Railroad Administration (FRA) Class 3 standards with a maximum operating speed of 30 mph and a 10 mph timetable speed restriction over the Paulsboro moveable bridge.[3] The bridge swing span was normally in the open position to accommodate the frequent marine traffic between March 2 and December 1. During this period, arriving train crews encountered a red signal aspect at the bridge from either direction and had to enter a code via radio to close the bridge. From December 1 to March 1, the bridge span was kept closed, aligned, and locked for uninterrupted train traffic. During this period of time, train crews encountered a green signal aspect at the bridge from either direction, thus allowing uninterrupted train movement across the bridge.

Mantua Creek is a navigable tidal tributary of the Delaware River with a tidal change of about 6 feet at the bridge. At the time of the derailment, the creek was approaching low tide (8:53 a.m.). Mantua Creek enters the Delaware River at the Port of Paulsboro, about 1.2 miles from the bridge and directly across from the Philadelphia International Airport.

Conrail train FC4230 consisted of 2 locomotive units at the head end configured for multiple unit operation and 82 freight cars, with 11 empty cars, 55 cars containing hazardous materials, and 16 loaded general freight cars. The train weighed 9,320 tons and was 4,917 feet long. The hazardous materials on the train consisted of 15 loaded cars of vinyl chloride, 4 loaded cars of chlorine, 3 loaded cars of liquefied petroleum gas (LPG), 29 loaded cars of petroleum crude oil, 1 loaded car of ethanol, and 3 residue cars of elevated temperature materials.[4] The train was crossing the bridge from east-to-west (timetable north-to-south).

The locomotives and the first five cars did not derail. The next seven cars derailed. Two freight cars derailed west of the bridge, and came to rest on their sides on the south side of the track. The next five cars were tank cars that derailed on the Paulsboro moveable bridge. Four of the tank cars, the 8th through 11th, came to rest partially in the creek on the south side of the bridge and one tank car, the 12th, remained derailed on the bridge. Three of the derailed cars that entered the creek were specification DOT-105 tank cars carrying vinyl chloride, a flammable liquefied compressed gas, and one was a specification DOT-111 tank car that contained ethanol, a flammable liquid. The 10th car in the train consist was punctured during the derailment and released about 20,000 gallons of vinyl chloride. Figure 2 shows the rail cars that derailed on the moveable bridge.

Eyewitnesses reported a vapor cloud engulfing the derailed tank cars and rapidly expanding along the creek immediately following the accident. On the day of the accident, 28 area residents sought medical attention for possible vinyl chloride exposure. The train crew and numerous emergency responders were also exposed to vinyl chloride. As many as 680 residents were evacuated from their homes as a result of the vinyl chloride release.

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[3] A timetable is a railroad company publication containing instructions relating to the movement of trains or equipment and other essential information for train crews operating on a particular subdivision.

[4] Residue means the hazardous material remaining in the tank car after its contents have been unloaded to the maximum extent practicable. Elevated temperature material is a material that when offered for transportation is at or above certain threshold temperatures depending on its flashpoint, or whether the material is a liquid or solid.

Equipment damage estimates were $451,000. The emergency response and remediation costs totaled about $30 million. Wreckage removal operations were completed by December 17, 2012.

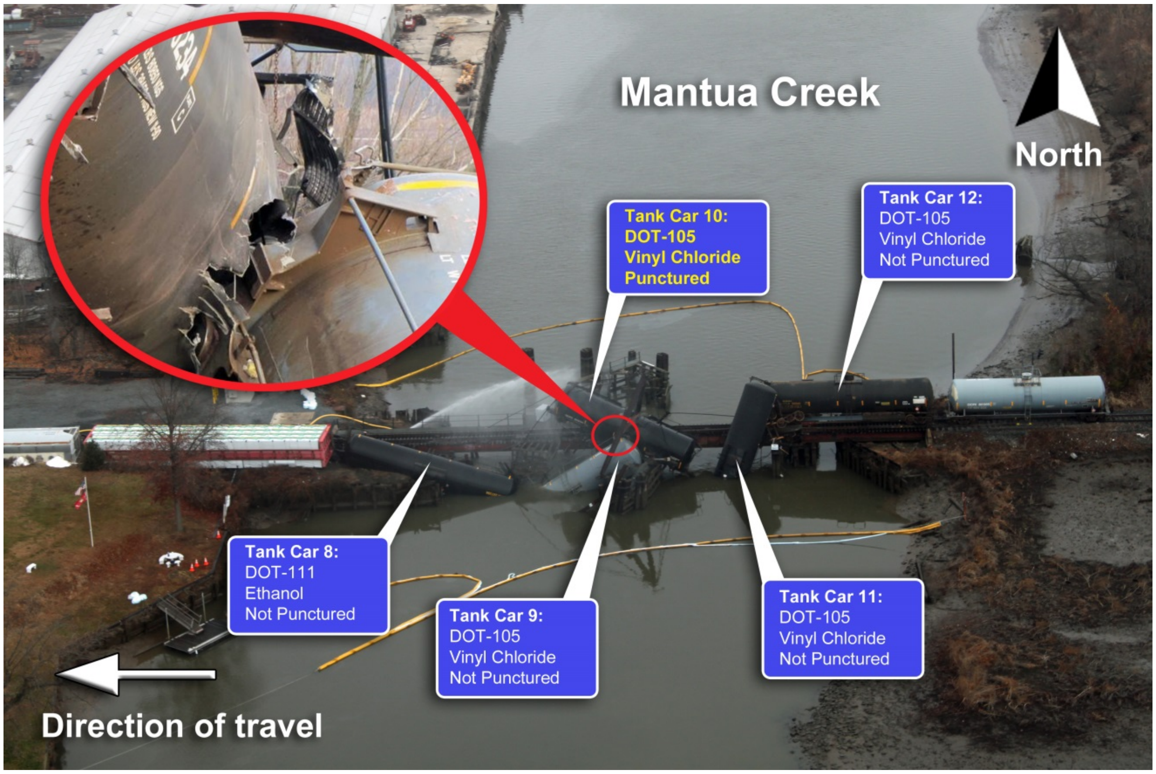

Figure 2. Five derailed tank cars, their commodities, and their condition after the derailment. The inset shows the punctured vinyl chloride tank car.

1.2 Events Preceding the Accident

National Transportation Safety Board (NTSB) investigators interviewed the crews from a Conrail train and a CSX Transportation (CSXT) train that had crossed the bridge on the day before the arrival of the accident train.[5] On November 29, 2012, about 3:00 a.m., the bridge was open for marine traffic and a red signal aspect was displayed, as expected, when the first westbound train approached the bridge.[6] However, the bridge did not complete the close sequence after the crew sent the close command to the bridge control system (BCS).[7] The crew explained that the red signal aspect failed to change to green after the bridge moved to the closed position. The conductor examined the bridge and noticed a 4-inch gap on the east end slide locks. The train crew radioed the dispatcher about the problem and a Conrail bridge maintenance employee was sent to examine the bridge.

[5] Conrail operates local railroad freight service on behalf of its owners, CSX Corporation and Norfolk Southern Corporation, in shared-assets areas of northern New Jersey, southern New Jersey/Philadelphia, and Detroit.

[6] The train was traveling southbound in accordance with the Penns Grove Secondary Subdivision timetable.

[7] For more information about bridge operation see section 1.4.

In the meantime, the train crew repeatedly sent a close command to the BCS. By the time the Conrail bridge maintenance employee arrived, he found the bridge closed to marine traffic and apparently locked, with the 4-inch gap gone, but the bridge signal aspect remained red. He gave the train crew permission to proceed across the bridge and the Conrail dispatcher gave the crew permission to proceed past the red signal aspect.

About 20 hours later, an eastbound CSXT train arrived at the bridge.[8] This time, the moveable bridge operated as intended when the train crew signaled the bridge to close. The bridge closed, locked, and the red signal aspect turned to green. However, after the train cleared the bridge, a bridge operation message, “Conrail Paulsboro, New Jersey, moveable bridge failed to operate. Out,” announced twice over the radio, about 10 minutes apart. This annunciation meant that the moveable span did not reach the fully opened or fully closed and locked position. The CSXT crew told NTSB investigators that they heard the announcement but did not report the message to the train dispatcher or the trouble desk. Bridge error messages for lower-density railroad lines, such as the Penns Grove Secondary, normally do not appear on a train dispatcher’s console. Because the “failed to operate” message was not reported to the train dispatcher, the problem was not logged and no Conrail maintenance employees were dispatched to examine the bridge.

1.3 Conrail Accident Train FC4230

On the morning of the derailment, the Conrail engineer and conductor of train FC4230 started their shift at the Pavonia Yard near Camden, New Jersey, at 3:00 a.m. After getting under way, their first stop was for a red signal aspect at the Paulsboro moveable bridge at 6:52 a.m., where they would expect to find the bridge in an open position. According to the engineer, the bridge was in the closed position with the red signal aspect displayed when the train arrived. Needing a green signal aspect to proceed, the engineer signaled the bridge via a radio signal command to close. However, the BCS did not respond and the signal aspect remained red. During this time, the conductor said he left the locomotive cab to examine the bridge from the ground. At 6:58 a.m., the engineer slowly moved the train 21 feet forward to ensure the approach circuit was occupied and attempted to clear the red signal. After multiple unsuccessful attempts to activate the close sequence and obtain a green signal aspect, the engineer called the train dispatcher and requested permission to proceed against the red signal aspect, informing the train dispatcher that the bridge had been inspected to verify correct alignment and position of the bridge locks. The following radio communications were recorded between the engineer and the dispatcher:

> Engineer (to dispatcher): “…the bridge was closed. We got a stop signal displayed. The conductor walked it, we hit the code prompt a few times to see if it would pop up clear, but it had not.”
>
> Dispatcher: “Is the bridge lined locked for your movement there?”
>
> Engineer: “Yeah, it’s giving us a failed to operate, but it is lined and locked. The conductor walked it, showing us a stop signal.”

[8] The train was traveling northbound in accordance with the Penns Grove Secondary Subdivision timetable.

> Dispatcher: "Okay, CA11 CSXT 8817, permission by the stop signal at the Paulsboro moveable bridge single to single south [geographic west] direction."

> Engineer: "CSXT 8817 has permission by the stop signal at the Paulsboro moveable bridge single to single track Penns Grove south [geographic west]."

At 7:00 a.m., after receiving permission from the dispatcher, the engineer proceeded to move the train across the bridge at a speed of 8 mph. After the two locomotives and seven cars had cleared the west end of the bridge, the brakes engaged with an emergency application and the train came to a stop at 7:02 a.m. The engineer looked in the side mirrors and saw the train derailing and tank cars falling into the creek. He announced over the radio "CA 11 to South Jersey, Emergency, Emergency, Emergency" "…the bridge is down…" "…vapor trail behind us…"

The crew stated they did not know how dangerous the chemicals were, although they believed that the fumes from the vapor cloud posed a threat to people nearby. Noticing some schools and recognizing the accessibility of the public to the accident scene, the crew gathered the train consist paperwork and stopped traffic and pedestrians from entering the vapor cloud.

Shortly after the police arrived, they asked the engineer and conductor to move the engines from the area. The Conrail Paulsboro Yard trainmaster responded to the scene and took the train consist and hazardous materials paperwork from the conductor. The conductor set brakes on two cars, disengaged the locomotives from the train, and along with the engineer, moved the engines 0.45 miles to the Paulsboro Yard at 7:22 a.m.

1.4 Paulsboro Moveable Bridge

1.4.1 Bridge Structure

The Paulsboro movable bridge was a shear pole swing span railroad bridge across Mantua Creek. The bridge consisted of one approach span on the east, three approach spans on the west, and a single 56 feet 4 inches-long movable swing span across the waterway. The span support structure was composed of two steel girders resting on steel piles. The running rails were fixed to wooden bridge timbers that, in turn, rested atop the girders to form an open timber deck. Miter rails were used to transition running rails from the fixed spans to the swing span.[9] The swing span had an asymmetric pivot centered 4 feet 4 inches from the west end and 52 feet from the east end of the span. A slide lock device on each rail secured the four rail junctions in alignment for train traffic (see figure 3).

[9] The head on both the receiving and trailing ends of a miter rail are cut at an angle to provide adequate rail-to-rail clearance for bridge rotation.

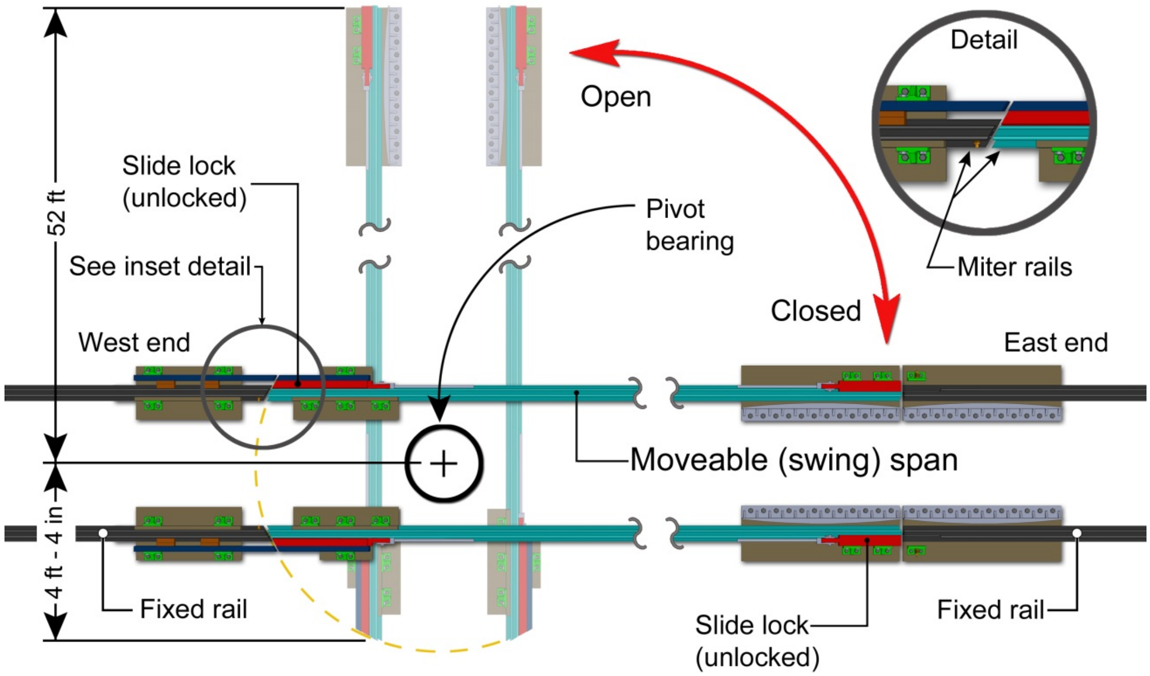

Figure 3. Paulsboro moveable bridge diagram.

When closed, the east end of the swing span was supported on the steel piles. While open and during movement, the swing span was supported by rods and an A-frame structure (see figure 4). When commanded to open, the east end of the bridge was lifted about 3/8 inch by two motor-driven worm gears and tension rods attached to the A-frame superstructure. A hydraulic piston rotated the span on a center bearing with a flat ring plate and wheels about 90° to the open position. Since the accident, the bridge has been temporarily reconfigured in the closed position for continuous railroad operation. On July 2, 2014, construction began on a replacement vertical-lift moveable bridge. The new bridge will be controlled by the South Jersey dispatcher, with bridge status indications provided to the dispatcher's work station.

Figure 4. Preaccident photograph of the Paulsboro moveable bridge. (Photograph provided by Conrail.)

1.4.2 Bridge Signal Control

The bridge was equipped with a signal at both ends of the span. The signal displayed a green signal aspect when the moveable bridge was aligned and locked for rail traffic, otherwise the signal displayed a red signal aspect. When the bridge was open to marine traffic, a train crew had to stop at the bridge signal and check that the waterway was clear before sending a radio command signal to the BCS to close and align the bridge for crossing.[10] Once the bridge was in the closed position and the rail slide locks were fully engaged, the bridge signal changed to a green aspect and the crew could proceed across the bridge. After the train cleared the bridge and signal circuit, the BCS automatically reopened the bridge for marine traffic.

1.4.3 Moveable Bridge Operation

From the locomotive, a train operator transmitted a code over a radio that signaled the BCS to close the bridge. The train had to be detected by the track circuit on the fixed track for the automated BCS to process the radio request. The BCS triggered several audible warning blasts, followed by a broadcast message over the loudspeakers that announced that the bridge would close. Next, the swing span rotated clockwise to align the rails horizontally while the A-frame tension rods supported the span.

[10] The bridge could also be controlled from pole-mounted control panels in locked boxes at the east and west approaches to the bridge. These control boxes were configured in pairs—one for maintenance and one for train operators. The control box for crew access contained two buttons: a BCS reset button and a close button. However, the crew did not access the control box.

The A-frame lift mechanism lowered the swing span onto piles, which aligned the rails in the vertical direction. Slide locks then engaged at the four rail connection points to prevent the bridge from rotating while the train was crossing the bridge (see figures 5 and 6). The slide locks traveled across the gap between the rails of both ends of the bridge. The east end slide locks would have had to travel about 8 inches to fully engage and the west end slide locks would have had to travel 6 inches to fully engage. Slide locks needed to be within 1/2 inch of proximity sensors to be fully engaged.

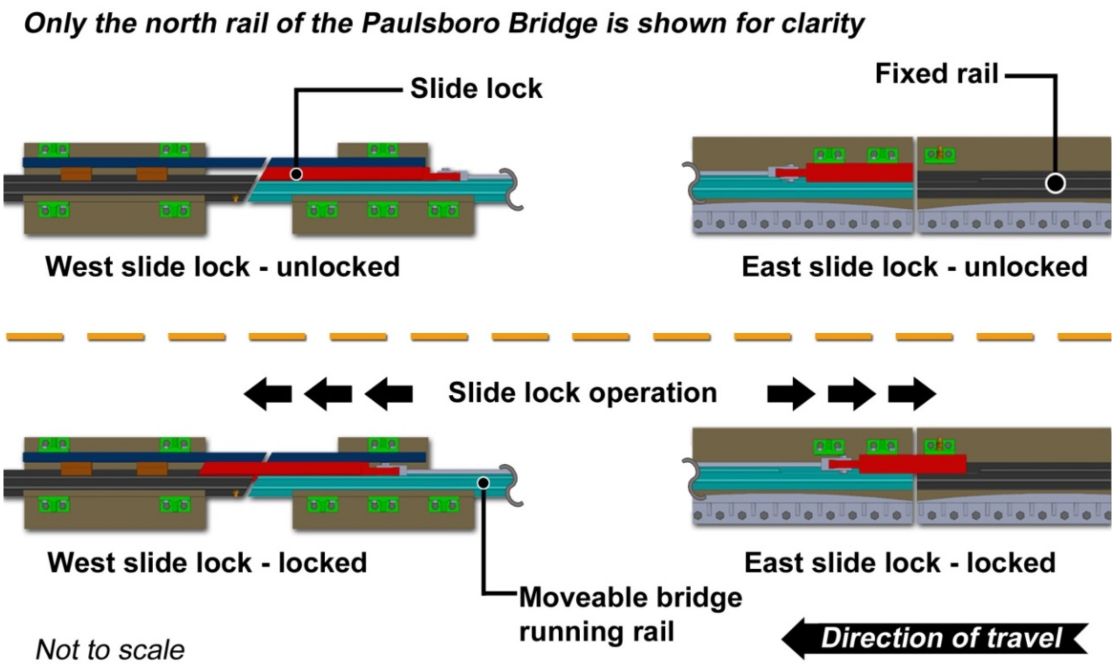

Figure 5. Slide lock operation.

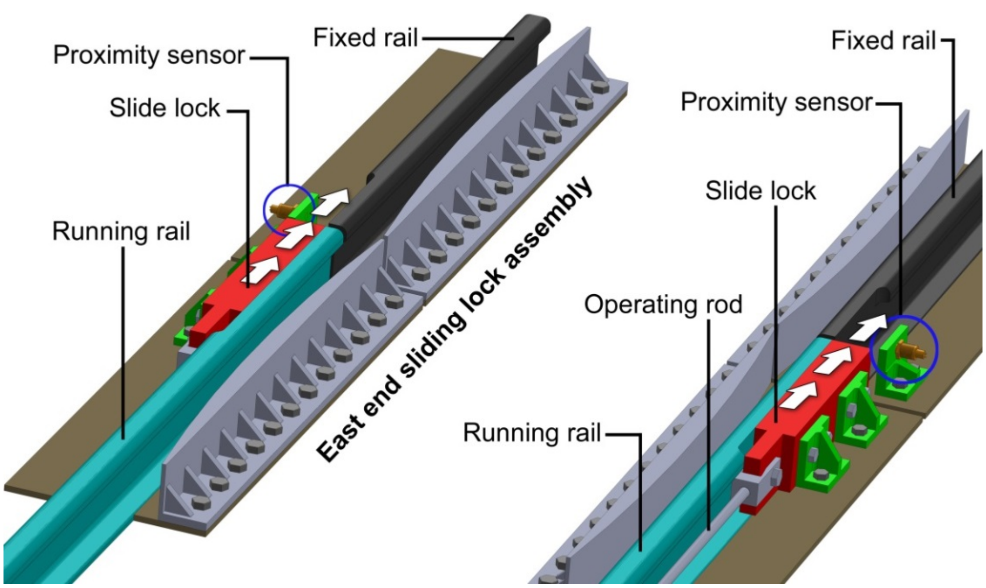

Figure 6. East slide lock details.

Bridge operation and confirmation of an “open” or “closed” state was carried out by multiple proximity sensors and mechanical limit switches that communicated to either the BCS or the railroad signal system (RSS). The BCS controlled electric motors that raised and lowered the span, and operated the slide locks and the hydraulics that rotated the span. The RSS controlled the signals and issued radio announcements to the train crew about the status of the bridge operations. The BCS was programmed to trigger voice annunciations over the radio (for train crews) and loudspeakers (for mariners) to indicate: (1) the bridge has received a command to close, (2) an emergency stop was initiated, (3) the bridge closed correctly, (4) the moveable span did not reach the fully open or fully closed position, or (5) the bridge has fully opened.

During normal operation when the BCS had finished closing the bridge and the proximity sensors confirmed to the RSS that the slide locks were fully engaged, the wayside signal aspect changed to green, indicating that the train could proceed across the bridge. Once the train had cleared the track circuit on the opposite side of the bridge, the BCS automatically retracted the four slide locks to unlock the bridge and reopen the span to permit marine traffic to pass.

The BCS was installed in 2003 and replaced a manually operated system. The system employed redundant programmable logic controllers (PLC) and two independent sets of proximity sensors and limit switches monitoring the slide locks and the bridge swing span position.[11] In the event of a malfunction in a switch or sensor, an error flag was generated in the program. If the BCS sensed an unexpected state, the system stopped bridge operation and set an internal error flag in the program. The BCS also included a timer that suspended bridge movement and generated an error flag if a specific control sequence exceeded a preset time limit. Once an error flag was set, the BCS could only be reset manually inside the bridge control bungalow at the west side of the bridge or from locked control boxes, which were located at each end of the bridge adjacent to the tracks. The system would return to normal operation only after the cause of the unexpected state was corrected or reset. Resetting the BCS erased all previously flagged error codes.

1.5 Factors Not Contributing to the Accident

1.5.1 Weather

A November 30, 2012, weather report obtained from the Philadelphia International Airport, located about 2 miles north of the accident location, reported that at the time of the derailment the wind was calm, the temperature was 33.8°F, and visibility was 7 miles. Neither the conductor nor the engineer indicated that there was limited visibility on the day of the accident.

1.5.2 Toxicology Reports

The Conrail engineer and conductor underwent postaccident toxicological testing pursuant to Title 49 *Code of Federal Regulations* (CFR) Part 219, Subpart C. Blood and urine

[11] A programmable logic controller is a computer control system that continuously monitors the state of input devices and makes decisions on the state of mechanical output devices.

specimens collected within 4 hours of the accident were tested for ethyl alcohol and illicit drugs, which included cannabinoids, cocaine metabolites, opiates, amphetamines, barbiturates, and phencyclidine. The results were negative for the regulated substances.

1.5.3 Locomotives and Train Cars

Following the accident, investigators performed a Class I mechanical inspection of the 2 locomotives and 75 cars that did not derail.[12] The brake testing showed that the brakes applied and released as designed with leakage rates within tolerance. The end-of-train device was tested and no exceptions were taken with this equipment.[13] Additionally, no defects were noted when the train passed a dragging equipment detector 2.5 miles north of the Paulsboro moveable bridge.[14] The five derailed tank cars and tank car components recovered during the salvage operation were inspected. No observations of improper wear patterns or tolerances were noted on any of the equipment. Additionally, the breached vinyl chloride tank car was loaded in accordance with tank car outage and filling limits as specified in the US Department of Transportation (DOT) Hazardous Materials Regulations (HMR) under 49 CFR 173.24b.

1.5.4 Track Inspections

The Penns Grove Secondary Subdivision single main track is designated and maintained to FRA Class 3 track standards with a maximum operating speed of 30 mph and a 10 mph timetable speed restriction over the Paulsboro moveable bridge.[15] The track is visually inspected weekly, and the track inspection is performed on foot or by using a hi-rail vehicle.[16]

In addition to the visual inspections, Conrail used a track geometry vehicle to conduct two automated track inspections, on June 1, 2012, and October 16, 2012. Both automated track inspections found no exceptions to the track geometry on or in the vicinity of the bridge. The FRA also conducted an automated track inspection on June 13, 2012, and also found no exceptions to the track geometry, either on or in the vicinity of the bridge.

The last visual inspection prior to the accident was performed 10 days before the accident.[17] The inspection found no exceptions to the federal track safety standards on the bridge or on the tracks on either side of the bridge.

[12] Title 49 CFR Part 238, Subpart D.

[13] The end-of-train device monitors critical last car information such as brake pipe pressure, motion status, battery condition, and marker light status and communicates this information to the locomotive using radio telemetry.

[14] A dragging equipment detector monitors the undercarriage of passing trains and detects dragging parts between and outside of the rails.

[15] Federal track safety standards under 49 CFR 213.9 for Class 3 track allow for 40 mph maximum operating speed for freight trains.

[16] A hi-rail vehicle is equipped with tires and flanged wheels so that it can operate on both highway and railroad tracks.

[17] For this class of track, 49 CFR 213.233 requires an inspection interval of weekly, with an interval of at least 3 calendar days between inspections. Thus, it is possible to comply with the regulation when inspections are conducted more than 7 days apart during consecutive calendar weeks.

On May 16, 2012, an automated inspection for internal rail defects was conducted and two defects were discovered about 1,000 feet east of the bridge. Both rails were replaced on June 18, 2012, as required by FRA regulations.

On December 1, 2012, the FRA reviewed the Conrail track inspection records for the Penns Grove Secondary Subdivision covering the period from December 1, 2011, to November 30, 2012. The FRA found no exceptions relating to the track on the Paulsboro moveable bridge or to the track near the bridge. The frequency of track inspections complied with standards for track Classes 1, 2, and 3 for the main track and sidings.[18] The FRA also reviewed the Conrail miter rail inspection records for the bridge and found no exceptions to the miter rails or the inspection frequency.

On December 12, 2012, investigators measured the track geometry at 20 stations east of the derailment.[19] The geometry measurements met the federal track safety standards. In addition, the bridge approach showed no evidence of dragging equipment or derailed wheels.

1.5.5 Bridge Structural Integrity

About eight trains traverse the bridge daily, for an annual gross tonnage of about 3.6 million tons. The fully loaded cars that crossed the bridge during the derailment weighed about 130 tons each and were within the bridge design capacity.

Conrail routinely performed two Level 1 bridge inspections per year.[20] The most recent inspection preceding the accident occurred on November 5, 2012. The conditions noted on this report did not indicate any adverse conditions that would have affected the bridge integrity. The bridge structure was inspected three times after the derailment to determine whether its structural integrity was compromised from the accident. An FRA bridge inspector examined the bridge structural support system and although the bridge had the appearance of having collapsed, he concluded that the bridge was structurally sound and did not collapse.[21] On December 14, 2012, the US Army Corps of Engineers reported that the overall condition of the bridge superstructure was rated good to very good with no loss of strength of any of the primary structural members. On December 16, 2012, a bridge engineering consultant inspected the underwater structure and reported that there were no abnormal conditions.

1.5.6 Bridge Control System

An NTSB review of the PLC program error codes revealed that the BCS generated a “bridge failed/to open” fault status message after the last train crossed the moveable bridge on November 29, 2012. The resulting error caused the system to suspend bridge operation and issue

[18] The federal track safety standards under 49 CFR 213 designate inspection frequency and operating restrictions for various track classes.

[19] Each station was spaced 15 feet 6 inches apart for cord-length measurement comparisons.

[20] A Level 1 bridge inspection includes a detailed inspection of the bridge structure components, including the approach bridge spans, but does not include an underwater inspection.

[21] The swing span was displaced from its resting pile and the pivot point was dislodged from its normal position by the derailing cars.

a "failure to operate" announcement, which the CSXT train crew acknowledged that they heard but did not notify the dispatcher.

When the accident train arrived at the bridge the following morning, the signal aspect was red; however, the bridge appeared to be in the closed position and aligned for rail traffic. The BCS was designed to display a red signal aspect until the cause of the error was corrected and all errors were cleared from the PLC. Only a bridge maintenance or signal maintenance employee could reset the BCS.

1.5.7 Bridge Signal System

The RSS used the output from the slide lock proximity sensors to determine if the slide locks were in an unlocked or locked position. According to the proximity sensor manufacturer specifications, all four slide locks had to be within 1/2 inch of proximity sensors before the bridge signals could display a green signal aspect. Otherwise, the bridge signals would display a red signal aspect to approaching train traffic. Selected BCS inputs (e.g., track occupancy) were also monitored and recorded by the signal system to aid in troubleshooting bridge malfunctions.

The postaccident inspection of the signal system did not reveal any evidence of tampering or vandalism. The signal lights could not be electrically tested because power had not yet been restored to the equipment and the accident scene was inaccessible during the hazardous materials response and subsequent equipment recovery operations. Insulation resistance tests on the cable for the south signal found no exceptions. All of the other cables were too damaged to test.

The signal event report indicated that when the previous train approached the bridge on November 29, 2012, the bridge closed and properly locked. The event report indicated that after the train cleared the bridge, the slide locks at both ends of the bridge were not locked and the swing span did not completely open as designed. However, the bridge signal aspect remained red, as designed, as the accident train crew observed when they arrived at the bridge the next morning. Therefore, the signal system functioned as designed.

The NTSB conducted electrical testing of the four slide lock proximity sensors. Two sensors showed evidence of significant mechanical damage that was most likely caused by the derailment. One of these sensors was shorted at the power supply inputs and the other failed to activate under any condition. The two undamaged proximity sensors operated as designed and within published specifications. The NTSB concludes that the following were not contributing factors to the accident:

- Weather
- Alcohol or illicit drugs
- Train equipment
- Track
- Structural integrity and bridge load

- BCS
- Bridge signal system

1.6 Conditions Leading to the Train Derailment

The west slide lock components on both rails were significantly damaged during the derailment. Examination of the west-side fixed rail components indicated that the locks were engaged about 6 inches, even though the slide locks were not detected by the proximity sensors and not indicated as locked on the signal system event report. A portion of the fixed-end south running rail had an overstress fracture through the web and head of the rail. Dents were apparent on the base flange side consistent with wheel impacts after fracturing. Although the BCS data indicated that none of the slide locks had reached the locked state, photographic evidence indicates that the northern slide lock was fully engaged, or nearly so. Evidence of the position of the south slide lock was less clear; however, because both slide locks were mechanically connected to a common drive mechanism, it is likely that both west end slide locks were partially engaged, meaning that the slide lock crossed the 2 and 3/4-inch normal rail gap and would prevent bridge rotation, but not engaged far enough to be detected by the proximity sensors. Based on these observations of the fractured south fixed running rail, the south slide lock was likely partially engaged.

The train crew told NTSB investigators that the conductor visually confirmed that the slide locks were locked before the train moved onto the bridge. However, the postaccident examination determined that the east end slide locks were not engaged, meaning the slide locks did not span the rail gap. The east end slide locks and fixed side-slot components were undamaged and in the open position. Had the east end slide locks been locked, significant deformations and fracturing of the slide lock components would have resulted when the bridge rotated. Although photographs taken after the derailment show the east end slide locks partially extended, the lack of damage to the mating components indicates that they had no engagement with the fixed side. Therefore, the NTSB concludes the recorded data and postaccident physical condition of the slide lock components indicate that the slide locks were not engaged on the east end of the bridge and the slide locks on the west end were only partially engaged as the train crossed the bridge.

Multiple marks and dents at the east end of the moveable span consistent with wheel flange impacts were noted on the wheel flange guard at the north rail and on top of the slide lock guide of the south rail, indicating that the bridge span rotated counterclockwise as the train crossed the bridge. Calculations showed that the east end of the bridge could have moved several inches to the north, even with the west end slide locks fully engaged. The wheel marks indicate that the swing span rotated under the train and displaced the east end of the span 6 to 12 inches to the north before the first derailed wheels struck. The point of derailment at the east end of the bridge swing span is shown in figure 7. Therefore, the NTSB concludes physical evidence shows that the east end of the bridge span rotated north under the moving train, misaligned the running rails, and caused the train to derail.

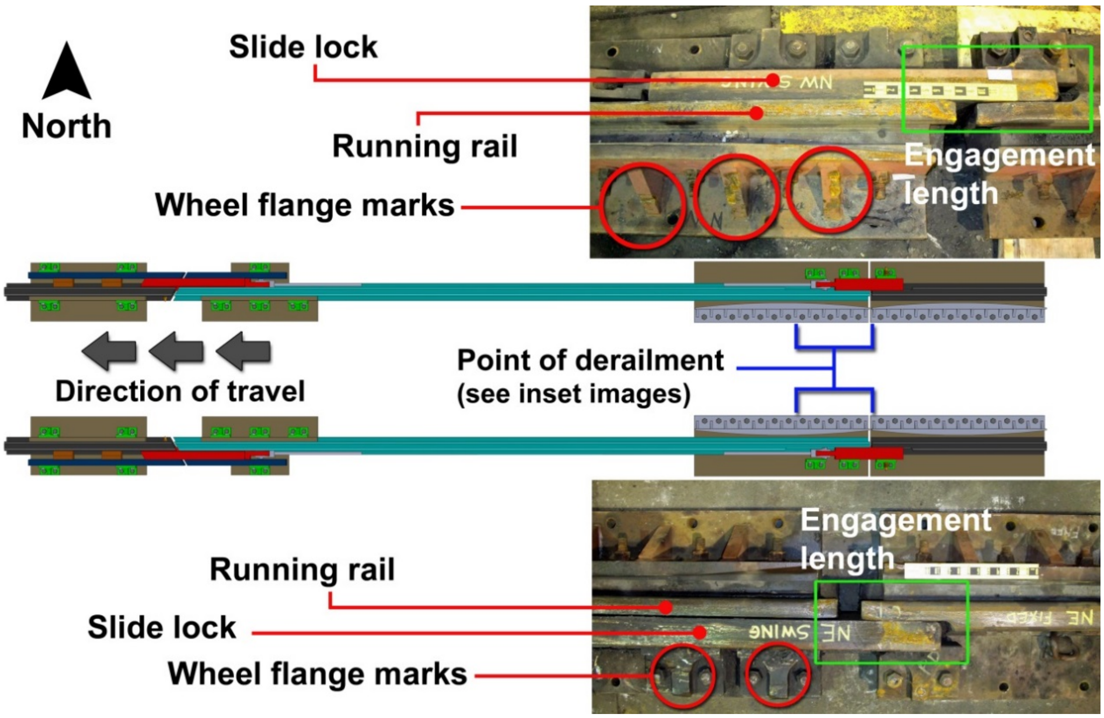

Figure 7. The point of derailment on the east end of the moveable bridge.

1.6.1 Examination of Derailed Cars

The locomotives and the first five cars behind the locomotive did not derail. Those cars came to rest on the west side of the bridge. NTSB investigators noted freshly made impact marks on the flanges of three wheels on the 4th car (TTZX 866085) and the 5th car (EQUX 641124).[22] This damage is consistent with an abnormal wheel-to-rail interface not severe enough to cause the cars to derail.

Table 1. Derailed Cars.

Consist Order	Reporting Mark	Car Number	Type of Car	Contents
6	ECUX	881493	C-Hopper	Polyethylene
7	SGLR	6298	Center beam	Lumber
8	UTLX	207938	DOT-111 tank car	Ethanol
9	OCPX	80323	DOT-105 tank car	Vinyl Chloride
10[a]	OCPX	80234	DOT-105 tank car	Vinyl Chloride
11	UTLX	98097	DOT-105 tank car	Vinyl Chloride
12	UTLX	98041	DOT-105 tank car	Vinyl Chloride

[a] Breached by coupler impact.

The 6th car (ECUX 881493) and 7th car (SGLR 6298) were derailed and lying on their sides to the south side of the track and remained mechanically coupled. The final resting positions of the 6th and the 7th cars indicate they were pulled off the track in a southerly

[22] The flange marks were observed on wheels R1 and R3 from car EQUX 641124, and wheel L2 from car TTZX 866085.

direction, along with the 8th car (UTLX 207938), which was a tank car loaded with ethanol. The 8th car remained coupled to the 7th car. Ties along the south field side of the swing span were splintered by derailed wheel contact, leading to the point where the 8th car tumbled from the bridge. A witness, standing about 100 yards west of the derailment location, described the accident sequence to NTSB investigators, stating, "all I remember is seeing, is the first tanker car [the 8th car] go down." The witness described the tank car pitching down as the derailment sequence began. The final resting position of the 8th rail car in the train consist, UTLX 207938, indicates this was the first car to derail.

1.6.2 Previous Moveable Bridge Operability Problems

The NTSB investigators reviewed audio recordings of train crews communicating to the dispatcher about problems with the Paulsboro moveable bridge in November 2012. The recordings contained repeated references to the east end of the bridge not locking. One engineer even reported to the dispatcher that the BCS announced a "bridge malfunction" message while the train still occupied the moveable span.

The train dispatcher normally notified the Conrail trouble desk when operating crews reported problems with the bridge. The trouble desk logged the problem and called the appropriate maintenance supervisor to address the issue. Conrail trouble desk records showed 23 problems were reported in the 12 months prior to the derailment. Twelve of those problems were reported in the first 10 months, and 11 were reported during the month prior to the derailment, following Hurricane Sandy, which struck the east coast at the end of October 2012, and inundated the bridge with water and debris. Five of these recent problems were logged as "under investigation" and three were logged as due to an "unknown cause."

Bridge technicians interviewed by NTSB investigators reported that they were unable to identify any specific problems with the bridge operations when they responded to the trouble tickets. Twice in November 2012, Conrail requested the engineering consultant who designed the BCS to identify the cause of the increased number of operational failures. The engineering consultant made a programming change to the PLC, but the change did not eliminate operational failures. Consequently, the consultant recommended that Conrail stop operating the bridge in advance of the December 1, 2012, seasonal realignment for uninterrupted train traffic. He recommended the early closure to expedite the inspection and evaluation of the electrical system to identify and fix the problems. The Conrail supervisor of structures stated that he considered the recommendation to close the bridge to marine traffic early, but did not follow through or act on the recommendation because he believed continuing to operate the bridge was not critical to the safety of the train operations.

1.7 Conrail Procedures and Training

The bridge seasonal operating schedule was provided to the train operating crews in the South New Jersey Dispatcher, *Daily Bulletin*, Number 9-529 (Conrail South New Jersey Dispatcher 2012), and read as follows: "MP 13.70 (Paulsboro moveable bridge) in remote: The bridge is open for the season. Crews are to operate the bridge per the timetable instructions."

Timetable No. 9 contained the bridge operating instructions (Conrail South New Jersey Dispatcher 2011). When the bridge was open to marine traffic, train crews approaching from either direction were presented with a red signal aspect upon reaching the bridge. When the bridge was closed to marine traffic and the slide locks were fully engaged, the train crews would be presented with a green signal aspect at the bridge.

In any circumstance, when a signal aspect fails to clear upon the bridge closing and remains red, the train crew must contact the train dispatcher. The Northeast Operating Rules Advisory Committee (NORAC) Rule Book (NORAC 2011) provides instructions to follow when a signal aspect does not clear:[23]

> 241. Passing a Stop Signal: To pass a Stop Signal, a train must have verbal permission of the Dispatcher (or Operator when authorized by the Dispatcher). Permission must not be given or accepted until the train has stopped at the signal. A member of the crew must contact the Dispatcher or Operator and follow his instructions….
>
> d. Stopped at a Signal Protecting Movable Bridge: Under the following conditions, a qualified employee must determine that the rails are properly lined and the bridge is safe for movement before verbal permission is given to pass the signal:
>
> 1. When the signal cannot be displayed for the first movement over a bridge after the bridge has been closed, regardless of bridge lock indications or
>
> 2. At any time a bridge unlock indication is received.

In response to the accident, on February 28, 2013, the FRA published in the *Federal Register Safety Advisory 2013–01* (*Federal Register* 2013, 13747) addressing stop signals protecting moveable bridges, which stated in part:

> 3. Review the adequacy of all training given to employees authorized to determine that a movable bridge is properly aligned and locked to ensure that employees are capable of correctly determining that the movable bridge is safe for train movements.

1.7.1 Train Crew Actions

The accident train engineer stated during interviews with NTSB investigators that he had been experiencing recurring problems with the Paulsboro moveable bridge for about 3 months prior to the accident. He reported occasions when the BCS provided conflicting messages or no audible annunciation. For example, he said that on one occasion, with a green signal aspect displayed and the first few cars of the train on the bridge, the BCS broadcasted a message warning that the bridge failed to operate. He reported these instances to the dispatcher immediately.

[23] The NORAC has developed a set of operating rules in North America for member railroads.

When asked how to determine the bridge was aligned and locked, the engineer stated that at both the east and west ends of the bridge the track is secured "on either side of the rail with a faded orange-colored splice bar." He said that when the bar is moved into place it presses into the rail, locking the bridge to the fixed track. The engineer described how he was able to tell whether or not the rail was locked in place on the day of the accident, "…as I went over with my engines, you know, the ones that are on my side, I can see. I can see that they're lined and locked. They're not gapped or anything like that and yesterday there was no gap in them. Everything was tight to the rail."

At the July 9–10, 2013, NTSB investigative hearing (NTSB 2013), the conductor explained how he inspected the bridge on the day of the accident:

> We come in front of the bridge. [The engineer] comes to a stop. He punches in the code. [The engineer] gets up and leaves the engine for a minute. I look up. I see the bridge was closed, so I got off the train. I walked the bridge. I checked the locks. I saw it was locked. I come back on the engine, I tell [the engineer] the bridge was already closed but it's locked. [The engineer] was like, "let's move the engine up a little bit," because we didn't hear any messages. He moves up the engine. He punches in the code a few more times. It didn't work, at which point we contacted South Jersey dispatch. We told South Jersey dispatch the bridge was closed, it's lined and locked, and he gave us the 241(d), which means pass the stop signal, permission to pass the stop signal.

The conductor also testified that he had inspected a moveable bridge on only one previous occasion, when a more experienced conductor showed him the Paulsboro moveable bridge slide locks during on-the-job training in 2009. Other than that, the accident conductor had not received any formal or informal training, nor had he inspected any other bridge locking devices until moments before the accident. The conductor's lack of familiarity with the bridge locking mechanism was evident when he was shown photographs of the equipment and testified that he was uncertain about the distance the slide locks needed to extend for full engagement. Therefore, the NTSB concludes the conductor erroneously determined the Paulsboro moveable bridge locking mechanism was locked.

1.7.2 Bridge Inspection Procedures

Operating procedures for trains stopping at a signal protecting a moveable bridge are contained in Rule 241 of the NORAC operating rule book (NORAC 2011), which is quoted in section 1.7, above.

The Conrail lesson plans used to instruct and train the operating crews did not contain specific instructions related to inspecting moveable bridges when stopped by a red signal aspect. Nor were there any posters or other job aids such as photos of slide locks informing the crews what to look for when inspecting moveable bridges. The Paulsboro bridge is one of seven moveable swing bridges Conrail operates in New Jersey. Conrail also operates four drawbridges and one vertical-lift bridge in New Jersey. Five operating crewmembers at the Conrail Pavonia Yard and Paulsboro Yard told NTSB investigators that they had never received formal training on how to inspect the Paulsboro moveable bridge. The Conrail manager of field operations confirmed that there were no formal instructions related to the correct inspection of the moveable bridge when the signal displayed a red signal aspect and would not clear.

The Conrail vice president/chief engineer acknowledged that there were no written instructions and that the training program did not cover the correct method of inspection for the moveable bridge or its locking components when the signal aspect would not change to green. When questioned at the NTSB investigative hearing (NTSB 2013) about how personnel are trained to determine the position of the locking mechanism, he said:

> Well, most of that comes from on-the-job familiarization and operating, either during their training or during their job assignments. All our crews that operate on our lines, movable bridges, are required to be familiar with those as part of our physical characteristics. Keep in mind, especially on our movable bridges that operate like Paulsboro, and there's several of them, where the crew activates the closure, there's a lot of successful closures where crews observe the operation of that bridge—the closing, the annunciation, the movements of the bridge—and there's a lot of familiarization that comes from observing that as part of a normal operation where it worked as intended.

During one of the conductor's on-the-job training trips (and only due to happenstance) the signal aspect at the Paulsboro moveable bridge was red and would not clear. He recalled that the more experienced conductor had accompanied him onto the bridge to inspect it before moving the train over the bridge. This event occurred 4 years before the accident and it would have been difficult to remember the details of the inspection. Further, it is unknown whether that conductor knew how the slide locks should have been positioned to properly lock the bridge for train movement.

In summary, the only Conrail training and instructions for inspecting locking devices on the moveable bridge: (1) was not formal, (2) did not include job aids or visual guides, (3) relied on happenstance during prior on-the-job training, and (4) used vague language in the operating rule book. A qualified employee should have appropriate training, tested knowledge, and demonstrated skills for the task assigned. Therefore, the NTSB concludes Conrail failed to ensure that inspections of the Paulsboro moveable bridge locking mechanisms would be conducted by properly qualified employees.

Since the accident, Conrail now requires that a moveable bridge be inspected by a qualified employee when the signal governing movement over the bridge does not allow the train to proceed. Specifically, on December 3, 2012, Conrail issued *Daily Bulletin Order No. 9-533* (Conrail 2012c) that contained the following instructions:

> The following is in effect at all moveable bridges on Conrail: The train dispatcher will no longer give [Rule] 241 permission past Stop Signals governing entrance to moveable bridges. Crews will notify the dispatcher who in turn will inform the C&S (Communications & Signals) Trouble Desk.

This requirement prohibits operating crews from inspecting moveable bridges that are protected by red signal aspects. Also, after the accident, the FRA published

Safety Advisory 2013-01 (*Federal Register* 2013, 13747) to address passing stop signals protecting moveable bridges. The safety advisory recommends that track owners and railroads ensure that employees authorized to determine whether moveable bridges are correctly aligned and secured are adequately trained to perform these duties. The NTSB is concerned that the safety advisory may not correct deficiencies in employee training, because it leaves it up to a railroad to determine whether the training is adequate. An adequate training program should be based on a job task analysis and incorporate refresher training to ensure the knowledge, skills, and abilities are current to the task to be performed. None of these elements is required under the FRA safety advisory.

The Conrail train dispatcher authorized the bridge crossing past the red signal aspect based only on the train crew's statement that the bridge was locked and aligned. However, only a qualified employee who has experience maintaining and repairing the bridge could accurately determine the engagement of the slide locks. Such a qualified employee would also be trained and knowledgeable about the BCS, critical devices specific to moveable bridge operation, and equipment troubleshooting.

As demonstrated in this accident and inferred from the FRA safety advisory (FRA 2013), the railroads and the FRA consider operating employees to be qualified to inspect moveable bridges. Conrail rules and FRA regulations use the term "qualified employee." However, the parameters for what constitutes a qualified employee have not been defined.

In contrast, the FRA regulations addressing passing a train over a broken rail contain comprehensive criteria for qualifying employees to perform this safety-critical task. Title 49 CFR 213.7(d) contains requirements for minimum experience, requires training and examinations, and periodic requalification. Furthermore, it establishes subjects to be addressed in this training. It also requires the qualified employee to watch all train movement across the defect and be prepared to stop the train. Therefore, the NTSB concludes that the requirements for ensuring that an employee is qualified to determine if a train can safely proceed across a moveable bridge when a red signal aspect is displayed are not as comprehensive as the requirements for other safety-critical operations such as operating a train over a broken rail.

Further, FRA has no means of tracking the effectiveness of actions taken in response to its safety advisories. While the safety advisory is a first step in placing railroads on notice that employees should be adequately trained to determine whether moveable bridges are aligned and secured, regulatory action would ensure the permanency of and mandate compliance with this requirement.

Therefore, the NTSB recommends that the FRA promulgate a regulation for permitting a train to pass a red signal aspect protecting a moveable bridge that is similar to the criteria for allowing a train to cross a broken rail as contained in 49 CFR 213.7(d) to ensure that the bridge has been inspected by a qualified employee before a train is authorized to proceed across the bridge.

1.8 Personnel Information

1.8.1 Engineer

The engineer was 51 years old. He was hired by the railroad as a trainman in April 2003. He had 8 years of experience working as a locomotive engineer and conductor. He operated on the Penns Grove Secondary Subdivision track for 14 months prior to the accident and he had a routine that seldom varied. He slept 6.5 hours the night before the accident and reported for duty at 3:00 a.m. However, the information obtained for the engineer is insufficient to determine whether fatigue was a factor in the accident.

Conrail observed the engineer complying with operating rules on 66 occasions during the 12 months prior to the accident. The engineer was current and within his 3-year locomotive engineer certification cycle. His most recent rules examination was on January 25, 2012, and he scored a 95 percent passing grade.

1.8.2 Conductor

The conductor was 42 years old. He was hired by the railroad as a trainman in September 2008. After completing an on-the-job training program, he was promoted to conductor in August 2009. He had operated on the Penns Grove Secondary Subdivision track before, but this was only his third day working on this assignment. He slept between 6 and 7.5 hours the night before the accident and reported for duty at 3:00 a.m. However, the information obtained for the conductor is insufficient to determine whether fatigue was a factor in the accident.

Conrail observed the conductor complying with operating rules on 22 occasions during the 12 months prior to the accident. None of those events were related to inspecting a moveable bridge. He received two 30-day suspensions in 2009 for violating operating rules and operating through a switch in the wrong position. He received a reprimand in 2011 for operating through a switch in the wrong position. Again, on January 12, 2012, he received a 10-day suspension for operating through a switch in the wrong position. The conductor's most recent rules examination was January 23, 2012, and he scored a 95 percent passing grade. Nonetheless, the conductor's history of rule violations calls into question the effectiveness of the Conrail employee training regime and its reliance on informal on-the-job training, as was done with moveable bridge inspection procedures.

1.8.3 Train Dispatcher

The train dispatcher was 53 years old. He was hired by the railroad as a trainman in September 1994. In 1996, he transferred to the position of train dispatcher.

Conrail observed the dispatcher complying with multiple rules on 127 occasions during the 12 months prior to the accident. His discipline record contained no entries. The train dispatcher's most recent rules examination was September 18, 2012, and he scored a 100 percent passing grade.

1.9 Conrail Safety Management

Conrail had compelling reasons to either troubleshoot and fix the Paulsboro moveable bridge operation or close the bridge to marine traffic prior to the accident. As discussed earlier, in the 12 months preceding the accident, Conrail train crews reported 23 bridge operating problems to the train dispatchers. Eleven of the 23 operating problems were reported in the month preceding the accident. Eight of the 11 operating problems were not resolved. Conrail dispatched its engineering consultant to inspect the bridge in response to the increased rate of problem reports. However, this expert was unable to replicate the malfunctions or determine the causes of the reported problems. Additionally, Conrail did not act on the engineering consultant's advice to close and lock the bridge ahead of the winter scheduled closing and not return it to normal service until an electrician could diagnose the equipment failures, nor did it take any additional measures to mitigate risks for bridge failure.

1.9.1 Crew Training

The training and qualification of train crews who are entrusted with moving large quantities of hazardous materials, including those that are toxic by inhalation, should be commensurate with the railroad's public responsibility to ensure safe transit of these materials through densely populated communities. Conrail relied primarily on train crews to determine if the bridge was aligned and secured properly for safe train passage in the event of a red signal aspect. Crewmembers who performed such inspections on the bridge locking mechanisms should have been formally trained to determine if the locks were fully engaged. However, Conrail did not ensure that any crewmembers were trained or had recent experience in assessing if the bridge was locked, secured, and safe for train movement.

The Conrail training program for operating crewmembers did not include any training on inspecting locking devices, nor had Conrail documented which crewmembers had received any type of on-the-job instruction on these inspection procedures. While Conrail may have anticipated that most conductors would eventually gain on-the-job training in inspecting locking mechanisms, Conrail had no process for ensuring that every conductor was correctly trained.

As a result, the conductor mistakenly concluded that the bridge was correctly aligned and locked. Therefore, the NTSB concludes that Conrail's reliance on unstructured on-the-job training to determine whether a moveable bridge was properly aligned and locked for train passage did not effectively prepare crews to handle all situations they could potentially encounter in traversing moveable bridges.

1.9.2 Conrail's Decision to Keep the Paulsboro Moveable Bridge Operational

During the month preceding the accident, several train crews reported bridge problems to company officials, as required by company policy. Conrail investigated these reports and attempted to identify the cause of these problems. Moreover, when they could not identify the bridge problems themselves, Conrail brought in additional resources to further examine these problems and identify the cause. In these instances, Conrail had a functioning system for reporting, responding to, and identifying potential hazards on the railroad.

Conrail, however, did not effectively identify the hazards and risks associated with keeping the bridge operational, nor did they make appropriate decisions based on the information available to them. A determination of whether the bridge was safe for train movement—which was possible even when a red signal aspect was being displayed—depended on untrained and unqualified train crews examining the bridge. A Conrail official told investigators that they "rely on…the confidence of the crew to know that the bridge is locked and permission was given." However, Conrail made no assurances that all crewmembers were prepared adequately to inspect the locking devices, a safety-critical task.

Moreover, Conrail was aware that prior to the accident, some crewmembers reported to train dispatchers that they were not confident in their own abilities to conduct a bridge inspection when required to do so.[24] Despite multiple undiagnosed bridge malfunctions with increasing frequency, these instances should have served as further warning to Conrail that relying on crews to inspect the bridge was not a reliable means of managing the risks associated with repeated bridge operating problems. Despite these warnings, Conrail continued to believe that its operating crews were capable of making safety-critical assessments about the condition of the bridge. Thus, the NTSB concludes that in its decision to keep the bridge operational even though the bridge continued to malfunction, Conrail failed to recognize that the hazards that existed with the moveable bridge operation could not reliably be mitigated by using operating crewmembers to inspect the bridge.

1.9.3 Safety Management Systems

A systematic way to identify hazards and control risks while maintaining assurance that these risk controls are effective is at the core of a safety management system (SMS) program. The International Civil Aviation Organization (ICAO) defines an SMS program as "an organized approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures."[25] The NTSB has identified many transportation accidents where an SMS or system safety program could have prevented injuries and the loss of life. As a result, the NTSB has recommended that aviation, railroad, highway, and marine organizations should establish an SMS or system safety program.

An SMS program establishes processes to collect and analyze data on potential safety problems and then evaluates mitigations to resolve the safety risk before an accident happens. According to ICAO (ICAO 2014), the major components to an SMS program include:

- <u>Safety Policy.</u> Establishes senior management's commitment to continually improve safety; defines the methods, processes, and organizational structure needed to meet safety goals.
- <u>Safety Risk Management.</u> Determines the need for, and adequacy of, new or revised risk controls based on the assessment of acceptable risk.

[24] In these cases, Conrail dispatchers did take appropriate measures by not granting these train crews permission to traverse the bridge when a bridge inspection was required.

[25] ICAO is a UN-specialized agency, created in 1944, that works with 191 signatory states and global industry and aviation organizations to develop international standards and recommended practices, which are used by states to develop their civil aviation regulations.

- Safety Assurance. Evaluates the continued effectiveness of implemented risk control strategies, and supports the identification of new hazards.
- Safety Promotion. Includes training, communication, and other actions to create a positive safety culture within all levels of the workforce.

In Canada, since 2001, all federally regulated railway companies are required to implement and maintain an SMS program. According to Transport Canada, (Transport Canada 2014) an SMS program "provides railway companies with a focused approach to building a safety culture throughout the organization. This helps reduce public and employee deaths and injuries, as well as the property and environmental damage that railway accidents can cause."

In the United States, railroad companies currently are not required to implement safety management programs. However, in 2012, as a result of the freight train derailment in Cherry Valley, Illinois, (NTSB 2012) the NTSB recommended that the FRA:

> Require that safety management systems and the associated key principles (including top-down ownership and policies, analysis of operational incidents and accidents, and continuous evaluation and improvement programs) be incorporated into railroad's risk reduction programs required by Public Law 110-432, Rail Safety Improvement Act of 2008, enacted October 16, 2008. (R-12-03)

On May 15, 2012, the FRA responded to the NTSB recommendation by indicating that it, in response to the Rail Safety Improvement Act of 2008, is developing two regulations that would require passenger railroads to implement system safety programs and certain freight railroads to implement risk-reduction programs. The regulations would require railroads to establish programs that systematically evaluate railroad safety hazards on their systems, and manage those risks to reduce the number and rates of railroad accidents, incidents, injuries, and fatalities.

In May 2014, the FRA informed the NTSB that this safety recommendation was being addressed as part of a risk-reduction regulation that is under development. At that time, a draft of that Notice of Proposed Rulemaking (NPRM) for the risk-reduction regulation was being evaluated by the Office of Management and Budget (OMB). Upon receiving comments from the OMB, the FRA is planning to address their comments and subsequently publish an NPRM in the summer of 2014. Therefore, this recommendation is classified "Open—Acceptable Response."

While an SMS program does not guarantee that companies act prudently after identifying hazards, it does provide a systematic means for identifying hazards and mitigating risks to help prevent accidents. For example, the ICAO *Safety Management Manual* (ICAO 2013) that provides guidance for the development and implementation of an SMS program for the aviation industry recommends assessing the probability and severity of a mishap associated with an identified hazard. According to the guidance, the process of controlling safety risks begins with assessing the probability that the consequences of hazards will materialize during activities performed by the organization. This determination can be aided by examining the history of occurrences, or whether such an occurrence is isolated. The guidance suggests that given the inability of the engineering consultant to diagnose the source of the bridge problems and the number and frequency of the bridge trouble tickets, the probability of a mishap would be at least “occasional,” meaning the condition is likely to occur sometimes, or has occurred infrequently. The next step is to assess the severity of the safety risk, taking into account the potential consequences related to the hazard based on the extent of harm that might reasonably occur. The severity of a mishap on the Paulsboro moveable bridge could have been catastrophic, meaning a likelihood of multiple fatalities or equipment destruction, because it was a critical infrastructure component on a route where poison inhalation hazard materials, such as chlorine, are routinely transported through a populated area. Therefore, the ICAO risk matrix characterizes the risk as “high risk” and “unacceptable under existing circumstances.” A properly implemented SMS approach would have required Conrail to more thoroughly evaluate the decision to continue bridge operations and could have more clearly identified the deficiencies and risks of operating crews examining the moveable bridge. Therefore, the NTSB concludes that the severity and probability of a mishap occurring on the bridge should have prompted Conrail to cease bridge opening and closing operations until appropriate mitigation measures were taken. Therefore, the NTSB reiterates Safety Recommendation R-12-03 to the FRA.

1.10 Breached Vinyl Chloride Tank Car

The breached tank car, OCPX 80234, was in position 10 in the train consist. It was manufactured by Trinity Industries, Inc. in 1990 to the DOT-105A300W specification for pressure tank cars, and had a capacity of 24,894 gallons.[26] DOT-105A300W tanks are insulated, pressure tested to 300 pounds per square inch (psig), and have a rated burst pressure of 750 psig. The tank was manufactured from TC128 grade B normalized steel plate.[27] The cylindrical shell portion of the tank was made from four steel plates with a minimum wall thickness of 0.5625 inches, with full penetration double submerged-arc welds along the longitudinal and circumferential seams. Ultrasonic thickness gauge measurements in an undamaged tank wall area found the tank wall thickness was 0.605 inches, which exceeded the minimum wall thickness requirement. The heads were made from a 0.5625 inch-thick steel plate.

1.10.1 Tank Car Damage

The outer jacket was torn open and the tank car was punctured by the coupler of the adjacent tank car in position 9 in the train consist, which had come to rest with its body bolster in contact with the breached tank car. The orientation of the coupler, along with the size and shape of the gouge (about 2 inches in width) ahead of the initial puncture, were consistent with initial contact by an edge/corner of the coupler lower shelf. The breach initiated at a circumferential weld located midway along the length of the shell. The fracture ran along the toe of the weld for a length of about 2.5 inches, at which point the two ends of the fracture turned and began to tear the tank in the longitudinal direction, curling the material between the tears inward, as shown in

[26] The tank car had a jacket and was stenciled DOT-105J300W.

[27] The material properties of Association of American Railroads (AAR) specification TC 128 grade B steel plate are contained under 49 CFR 179.100-7(a).

figure 8. The tears opened into an irregularly shaped hole with additional inward deformation that folded sections of the wall inside the shell. The hole measured 37 inches at its widest point.

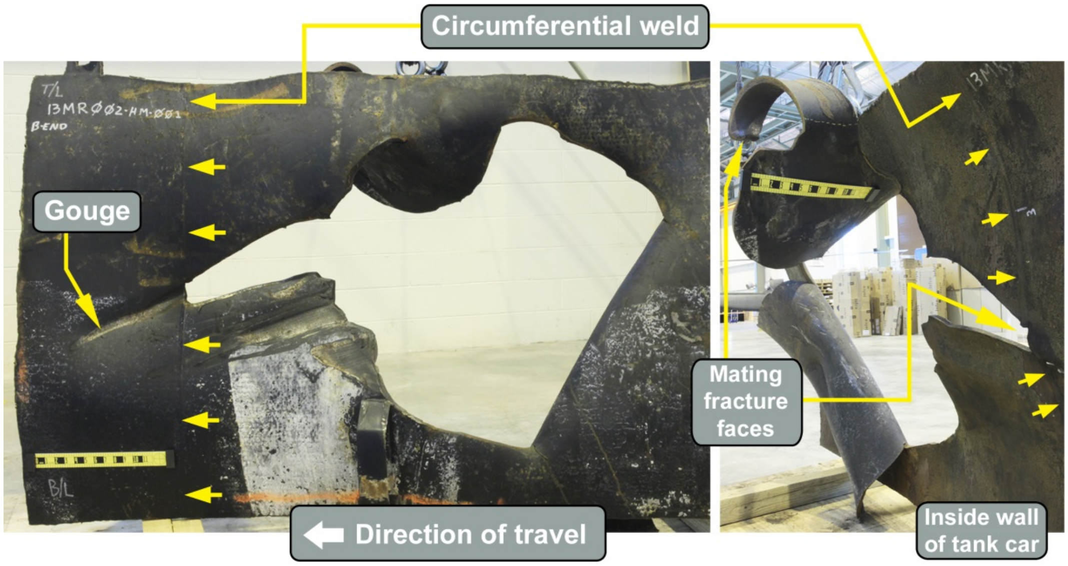

Figure 8. Puncture and tears on the shell of the breached vinyl chloride tank car.

1.10.2 Tank Material Properties and Failure

The base metal and weld metal specimens met the respective mechanical property requirements in the AAR *Manual of Standards and Recommended Practices Section C-III: Specifications for Tank Cars* (AAR 2007).[28] The chemical composition and the microstructure of the steel on each side of the weld met the requirements of the TC128 grade B material specifications for the year built. The weld met the radiographic inspection and hardness criteria in the AAR tank car specifications (AAR 2007). Therefore, the NTSB concludes that the thickness and material properties of the tank shell and the weld size, quality, and material properties where the breach occurred met the requirements for DOT-105A300W tanks.

In March 2013, the FRA published a report titled, *Detailed Puncture Analyses [of] Tank Cars: Analysis of Different Impactor Threats and Impact Conditions* (FRA 2013b). The report is part of the Next Generation Rail Tank Car project to understand tank failures under typical impact conditions with the eventual goal of improving the impact resistance of the next generation of tank cars. The study shows that for a given tank car design and impact velocity, the force required for an impactor to breach a tank depends upon, among other things, the size of the impactor, the impact angle, and the degree it is constrained (whether the tank is a moveable or immoveable object). The force required to breach the tank goes down as the size of the impactor decreases, the impact angle becomes more oblique, and the constraint on the tank increases.

In this accident, the breached vinyl chloride tank car encountered a small impactor (the coupler lower shelf) at an oblique angle, a near worst-case scenario for these conditions and

[28] The NTSB had mechanical testing conducted in accordance with ASTM A370-12a.

more severe than those considered in the FRA study. Although the train velocity was only about 8 mph, nearly the entire weight of the tank car was imparted on the impacting coupler. The shell fracture, which started at the root of the weld on the inside of the tank, resulted from the coupler impact loads and exceeded the strength of the tank material. Therefore, the NTSB concludes that the tank car shell was punctured by an impact with the lower shelf of the adjacent tank car coupler that exceeded the strength of the tank shell material.

1.11 Hazardous Materials Response

1.11.1 Vinyl Chloride Information

Vinyl chloride is a colorless gas with a mild, sweet odor that is used to make polyvinyl chloride. It is a gas at room temperature; however, it is shipped as a liquid under pressure. Vinyl chloride is highly flammable and vapor/air mixtures are explosive. The odor threshold for detection is about 3,000 parts per million (ppm) in air. The shipper classified the product as follows: Vinyl chloride, stabilized; Class 2.1; UN 1086.

Inhalation is the primary route of exposure to vinyl chloride. As found under 49 CFR 1910.1017(c), the Occupational Safety and Health Administration (OSHA) mandates that no employee may be exposed to vinyl chloride at concentrations greater than 1 ppm averaged over any 8-hour period; that no employee may be exposed at concentrations greater than 5 ppm averaged over any period not exceeding 15 minutes; and that no employee may be exposed to vinyl chloride by direct contact with the material. Workers can easily be overexposed without becoming aware of vinyl chloride presence because the odor threshold is too high to provide warning for hazardous concentrations.

1.11.2 Effects of Exposure to Vinyl Chloride

Vinyl chloride irritates the eyes, mucous membranes, and respiratory tract. Escaping compressed gas or liquid can cause frostbite or irritation of the skin and eyes. An acute exposure to vinyl chloride primarily targets the central nervous system. Several minutes of exposure to high concentrations (more than 1,000 ppm) may cause central nervous system depression with effects such as dizziness, drowsiness, disorientation, tingling, numbness or burning sensation of the hands and feet, impaired vision, nausea, headache, difficulty breathing, cardiac arrhythmias, unconsciousness, or even death.

Chronic exposure to vinyl chloride can cause permanent liver injury, neurological or behavioral symptoms, and changes to the skin and bones of the hand. The US Department of Health and Human Services (HHS 2014) has classified vinyl chloride as a known human carcinogen.

1.11.3 Vinyl Chloride Environmental Information

Vinyl chloride is believed to be almost nontoxic to aquatic organisms on an acute basis. It readily degrades under aerobic conditions and may degrade under anaerobic conditions. If released into the air, it will remain in the gas phase. Its atmospheric half-life is estimated to be

23 hours. If released to soil, volatilization will occur, but the material that does not volatilize may be highly mobile. If released to water, evaporation will occur.

1.11.4 Community Exposure Guidance

The National Advisory Committee for the Development of Acute Exposure Guideline Levels (AEGL) for Hazardous Substances has developed guidelines to help authorities deal with emergencies involving chemical spills. The guideline levels are intended to describe the risks to humans resulting from occasional exposure to airborne chemicals. These levels can be used for emergency planning and response activities related to the accidental release of hazardous substances and public exposures.

The guidelines contain three AEGL exposure levels based on the expected health effects on the public (see table 2).

- An AEGL-1 is the airborne concentration of a substance above which it is predicted that the general population could experience nondisabling and transient/reversible effects.[29]
- An AEGL-2 is the airborne concentration of a substance above which it is predicted that the general population could experience irreversible long-lasting adverse health effects or an impaired ability to escape.
- An AEGL-3 is the airborne concentration of a substance above which it is predicted that the general population could experience life-threatening health effects or death.

Table 2. Vinyl Chloride AEGL Concentration Levels.

Vinyl Chloride Concentration (ppm)					
	10 minutes	**30 minutes**	**60 minutes**	**4 hours**	**8 hours**
AEGL-1	450	310	250	140	70
AEGL-2	2,800	1,600	1,200	820	820
AEGL-3	12,000	6,800	4,800	3,400	3,400

On the day of the accident, the Interagency Modeling and Atmospheric Assessment Center produced a chemical dispersion model for the vinyl chloride release that predicted with 90 percent confidence that an AEGL-2 or AEGL-3 concentration was possible in Paulsboro.

1.11.5 Reported Community and Emergency Responder Health Effects

On April 19, 2014, the New Jersey Department of Health (NJDOH) provided the NTSB with a preliminary summary of surveys it conducted with the Agency for Toxic Substances and Disease Registry relating to the public health impact of the vinyl chloride release from this accident. Between December 14 and December 21, 2012, interviewers conducted a door-to-door survey of randomly selected households, evenly distributed across zones where residents were

[29] Expressed as ppm or milligrams per cubic meter.

and were not evacuated. To ensure that all Paulsboro residents had an opportunity to participate, in late December 2012, the NJDOH mailed a survey that consisted of a self-administered questionnaire to all postal delivery addresses. The surveys collected information about public health experiences during the week following the accident from 1,930 individuals, which is about 31 percent of all Paulsboro residents.[30]

A high percentage of participants in the two surveys reported smelling or tasting an unusual odor in the air during the incident. The most commonly reported symptoms were headache, upper respiratory symptoms, and coughing. Other common symptoms included: neurological symptoms (predominantly dizziness or lightheadedness), eye irritation, and difficulty breathing. The symptoms that were more commonly reported are consistent with what is known to occur from exposure to vinyl chloride.[31] Symptoms were most commonly reported from evacuated areas and the area within 1 block of evacuated areas, and were least frequent in areas farther than 3,500 feet from the accident location.

In the in-person survey, 10 individuals reported being provided medical care by an emergency medical technician or paramedic; 40 individuals reported going to a hospital emergency room; and 22 sought medical care elsewhere for health concerns related to the incident. In the mailed survey, 15 households reported that someone in the household received medical care from an emergency medical technician or paramedic and 67 had a household member who went to the hospital emergency room. For households within 1,500 feet of the derailment, 21 percent reported that someone from the household went to a hospital.

On December 11, 2012, the Centers for Disease Control and Prevention, the Agency for Toxic Substances and Disease Registry, and the National Institute for Occupational Safety and Health assisted NJDOH with characterizing the vinyl chloride exposure of emergency personnel who responded to this accident (Brinker and others 2013). Their survey of emergency responders included emergency medical services personnel, firefighters, police officers, and hazardous materials technicians. The report concluded that acute symptoms of vinyl chloride exposure were common. The most frequently reported symptoms were headaches and upper and lower respiratory illness. Twenty-one of the 91 respondents sought medical care.

1.11.6 Fire/Rescue Response Operations

The NTSB constructed an incident event chronology to identify the facts of the emergency response to the event and to address potential issues involving the initial notification to the local emergency response authorities, as well as to examine the execution of the emergency response effort (e.g., search and rescue, evacuation, and hazardous materials remediation). The principal responding emergency services agencies were requested to provide incident response data and communications information. The NTSB investigators also conducted individual debriefing interviews with key personnel from the emergency services agencies and Conrail.

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[30] The US Bureau of the Census estimates that the population of Paulsboro was 6,152 in 2012.

[31] The NJDOH reported that all of these symptoms have multiple causes, and many may occur as a result of anxiety, fear, or stress induced by traumatic events.

The Gloucester County Emergency Response Center (communications center) receives all 911 calls and dispatches emergency responders for all municipalities within the county. Using communications center records and documentation provided by various response agencies, the NTSB prepared a composite timeline of initial emergency response events, which is presented in appendix B.

At 7:01 a.m., the communications center received the first 911 call from the home of the Paulsboro deputy fire chief, which is located adjacent to the derailment site with a direct line of sight to the bridge.[32] The deputy fire chief's wife told the 911 operator that a train had derailed and that the Paulsboro train bridge had collapsed. She said she watched the train derail and that there was "smoke everywhere." The deputy fire chief then took the phone and told the 911 operator the train derailed into Mantua Creek and was "spewing out all kind of gas."

The first police officer arrived about 7:05 a.m., followed shortly thereafter by two other police officers. The officers reported that a "heavy cloud was hovering over Mantua Creek" near the Paulsboro moveable bridge (see figure 9).

Figure 9. View of a dense, low lying vapor cloud over Mantua Creek. (Photo provided by a private citizen)

[32] The communications center computer-assisted dispatch (CAD) system event times were not aligned with the global positioning system (GPS)-corrected locomotive event recorder data, which indicated that the derailment occurred at 7:02 a.m. The witness telephoned the 911 operator immediately after the derailment.

The deputy fire chief established the initial incident command post (ICP) at his residence, which was only about 50 yards from the ruptured vinyl chloride tank car. He radioed the communications center with additional information and requested Paulsboro Fire Department and Conrail officials to respond. Figure 10 shows the deputy fire chief's view of the accident scene. About 7:17 a.m., the fire chief arrived on scene and assumed the role of incident commander. Arriving support agencies were directed to the ICP and the incident command staff congregated within several feet of the accident scene during the response.

Figure 10. The breached tank car leaning off the bridge and the vinyl chloride vapor cloud. (Photograph provided by a private citizen)

Nearly 6 hours after the accident, the ICP was relocated to the Paulsboro Borough Hall to establish a unified command. About 2:00 p.m., the ICP was moved a second and final time about 3 miles to the Gloucester County Fire Academy in Clarksboro. The Coast Guard Captain of the Port assumed the role of the federal on-scene coordinator. The unified command consisted of the Coast Guard, Conrail, New Jersey State Police Office of Emergency Management (NJSP-OEM), New Jersey Department of Environmental Protection (NJDEP), and the Paulsboro Fire Department.

1.12 Hazardous Materials Communications

1.12.1 Hazardous Materials Communications

An accurate train consist that conveys the identity, quantity, and location of hazardous materials on a train is critical for helping emergency responders locate and account for these materials. Important safety decisions that depend on timely hazard communications include determining appropriate isolation distances, deciding whether to evacuate or shelter-in-place, selecting appropriate levels of personal protection for responders and rescuers, and identifying suitable firefighting tactics.

At 7:05 a.m., the first emergency responder, a Paulsboro Police Department officer, arrived on scene. He met the train conductor at the East Commerce Street railroad crossing. The conductor told him that the situation was “life threatening,” and that “people are going to die.” The conductor verbally provided the officer with hazardous materials information from the train consist. The officer radioed the communications center that the train contained “1987—ethanol alcohol and 1086—vinyl chloride.” The officer also repeated an erroneous report from the train crew that the vapor cloud was propane or liquefied petroleum gas.

The deputy fire chief also radioed the communications center that he read placard number “1086” on one of the tank cars. The communications center responded that placard number 1086 signifies “stabilized vinyl chloride.”

Responders continued their attempts to identify the contents of the other tank cars. At one point, the fire chief was notified by the communications center of the police department report that at least one propane tank was leaking, which was incorrect, as noted above. At 7:25 a.m., the fire chief radioed the communications center: “We are getting some information that a couple of these tanks have bad stuff, we just can’t get the placards.”

The Conrail trainmaster met with the police officer and the train conductor and took the train consist from the conductor. The trainmaster then entered the derailment scene alone to identify which rail cars derailed and to assess their condition.

Later, the trainmaster reviewed the train consist with the deputy fire chief at the ICP. He told the deputy fire chief that the first derailed tank car contained ethanol and the last four contained vinyl chloride. He added that he knew one of the tank cars was punctured, but he was unable to determine which one. The trainmaster then departed the ICP, retaining possession of the only available copy of the train consist.

The trainmaster returned to the derailment scene with the Conrail director of risk management and identified the punctured vinyl chloride tank car. They observed a chemical substance in the water, prompting the director of risk management to order his personnel away from the area. The trainmaster and the Conrail director of risk management returned to the ICP. They briefed the fire chief and advised him to evacuate, once again leaving without providing the train consist. They then returned to the train to assess the condition of the chlorine tank cars that were further back on the train east of the derailment.

The fire chief made several requests to be provided with the train consist; however, the trainmaster retained possession of the consist for almost 3.5 hours, leaving emergency responders with no means of referencing the document for response planning. The trainmaster ultimately provided a copy of the consist to Conrail's hazardous materials risk manager for distribution at the ICP.

Paulsboro emergency responders testified at the NTSB investigative hearing (NTSB 2013) that their actions were hindered by the lack of timely and accurate train consist information. While emergency responders quickly determined that one of the derailed tank cars contained vinyl chloride, they were uncertain about the contents of the surrounding tank cars, including those that were partially submerged in the creek.

Federal regulations 49 CFR 172.600(c) and 174.24(b) require railroads to make emergency response information and shipping papers (train consists) available to authorized officials. When accidents occur, the incident commander is the individual responsible for assessing the safety hazards of the scene. Thus, rail crews should immediately provide the emergency response information and the shipping papers, in printed form or electronically, to the incident commander.

As a result of the NTSB investigation of the Anding, Mississippi, (NTSB 2007), train collision, and to ensure the timely availability of train consist information to emergency responders, the following safety recommendations were issued to the FRA and the Pipeline and Hazardous Materials Safety Administration (PHMSA):

> Work together to develop regulations requiring that railroads immediately provide to emergency responders accurate, real-time information about the identity and location of all hazardous materials on a train. (R-07-02) and (R-07-04)

In a May 15, 2012, response to Safety Recommendation R-07-02, the FRA informed the NTSB that it had met with the AAR, the American Short Line and Regional Railroad Association (ASLRRA), and PHMSA to discuss the available systems and to identify systemic gaps and formulate measures to close those gaps. Although the FRA appears to be taking some action, the agency as of the issuance of this report had not clearly identified any specific initiatives to address Safety Recommendation R-07-02. Therefore, Safety Recommendation R-07-02 is classified "Open—Unacceptable Response."

On September 6, 2013, PHMSA published an advance notice of proposed rulemaking (*Federal Register* 2013, 66326), seeking comment on the implementation of a response to Safety Recommendation R-07-04. The NTSB commented that it continues to investigate accidents where emergency responders did not receive timely and accurate hazard information from railroad operators, including the November 30, 2012, Paulsboro, New Jersey, derailment.

The NTSB believes that available technologies can and should be used to supplement the paper-based train consist for improving the dissemination of chemical hazard information to emergency responders. However, Safety Recommendation R-07-04 has remained open for more than 5 years. The NTSB is encouraged by the PHMSA Hazardous Materials Automated Cargo

Communications for Efficient and Safe Shipments program and notes that PHMSA has instituted a paperless hazard communication pilot program to evaluate the feasibility and effectiveness of paperless electronic communication systems. Therefore, Safety Recommendation R-07-04 is classified "Open—Acceptable Response."

While Conrail did verbally relay information about the hazardous materials to emergency responders, the train consist and emergency response information were not provided to the incident command for more than 3 hours. The NTSB concludes that during the early hours following the accident, Conrail personnel did not immediately provide critical hazardous materials information to emergency responders that could have assisted in executing a safer response to this accident.

Therefore, the NTSB reiterates Safety Recommendation R-07-02 to the FRA and Safety Recommendation R-07-04 to PHMSA.

Current railroad industry guidance and instructions related to the transfer of emergency response information and shipping papers could be contributing to delays in providing shipping papers and critical hazardous materials communications. The AAR Hazardous Materials Committee (Bureau of Explosives) published guidance to the railroad industry for the safe handling of hazardous materials in a document titled the *United States Hazardous Materials Instructions for Rail* (AAR 2011). The guidance document advises railroads that these instructions may be appropriately modified by an individual railroad to be consistent with any unique operating rules or practices. Conrail has adopted the instructions into its operating procedures contained in *Hazardous Materials Instruction for Rail, HM-1* (Conrail 2012d), but has made only minimal company-specific adjustments.

Within Section VIII.4 of the *United States Hazardous Materials Instructions for Rail* (AAR 2011) titled "Cooperating with Local Emergency Responders," railroads are instructed to share any requested information from the shipping papers with emergency response personnel, and:

(1) Provide an extra copy of the train consist/train list, when available.
Note: Retain any waybills and a copy of the train consist/train list until you can deliver them to the first railroad manager on the scene.

(2) Provide a copy of the emergency response information provided with the shipment.

The Conrail HM-1 (Conrail 2012d) contains the exact language listed above.

Federal regulations allow this emergency response information to be on the shipping papers or in a document other than a shipping paper that meets certain requirements.[33] Similar to other railroads, Conrail shipping papers contain both shipping information and the emergency response information. In addition to a train consist, railroads are also required under 49 CFR 172.600 to make emergency response information used to mitigate an incident involving hazardous materials immediately available to emergency responders for use at all times.

[33] Title 49 CFR 172.602(b)(3).

Conrail instructs its personnel to take the train consist and move crewmembers upwind to the recommended evacuation distance. Conrail should have immediately surrendered its copy of the train consist with the appended emergency response information to the incident commander, as the data must be available to the incident commander to assist with assessing the accident scene and planning safe response actions. The actions of the train conductor and trainmaster to retain the train consist were consistent with the instructions in HM-1 (Conrail 2012d) because the train conductor retained the train consist until he gave it to the trainmaster and the trainmaster retained the consist until he could make copies. Therefore, the NTSB concludes that the AAR instruction Conrail adopted that directs railroad employees to provide an extra copy of the train consist "when available" does not meet the intent of the requirements found under 49 CFR 172.600, given that train consists frequently contain the emergency response information.

The NTSB recommends that the AAR amend the *United States Hazardous Materials Instructions for Rail* (AAR 2011) to require train crews to immediately provide their train consists and the emergency response information for all hazardous materials on the train to federal, state, or local emergency response officials when accidents occur.

The NTSB recommends that Conrail amend *Hazardous Materials Instructions for Rail, HM-1* (Conrail 2012d) to require train crews to immediately provide their train consists and the emergency response information for all hazardous materials on the train to federal, state, or local emergency response officials when accidents occur.

1.12.2 Emergency Response Information Content

The content of the emergency response information that was appended to the train consist was inconsistent and less protective than emergency response guidance provided in the DOT *Emergency Response Guidebook* (ERG) (DOT 2012). The ERG is intended to be used by emergency response personnel who are the first to arrive at a transportation incident involving hazardous materials. The ERG is primarily a guide to aid first responders in quickly identifying the hazards of the material involved in the incident, and in protecting themselves and the general public during the initial incident response activities.

The ERG provides guidance for initial isolation and protective action distances based on the predicted size of downwind areas that could be affected by a toxic gas cloud. People in this area should be evacuated or sheltered-in-place inside buildings.

As required under 49 CFR 172.602, emergency response information for first responders must contain the minimum following information:

(1) The basic description and technical name of the hazardous material as required by the HMR [Hazardous Materials Regulations–49 CFR 100-85], ICAO Technical Instructions, IMDG [International Maritime Dangerous Goods] Code or the TDG [Canadian Transportation of Dangerous Goods] Regulations;

(2) Immediate hazards to health;

(3) Risks of fire or explosion;

(4) Immediate precautions to be taken in the event of an accident or incident;

(5) Immediate methods for handling fires;

(6) Initial methods for handling spills or leaks in the absence of fire; and

(7) Preliminary first aid measures.

The AAR Bureau of Explosives maintains a Hazardous Materials Shipping Descriptions and Emergency Response database (HAZMAT database) that contains both shipping description data and emergency response information for each hazardous material. Railroads subscribe to the HAZMAT database and use it as the basis for electronic data interchange transactions and for supplemental train consist hazard communications.[34] The Conrail director of risk management stated that the Conrail emergency response information provided for the accident train consist came from the HAZMAT database.

However, NTSB investigators identified inconsistencies between the emergency response information on the consist and the ERG for two hazardous materials in the accident train's consist—vinyl chloride and chlorine (see table 3).

The initial evacuation distance provides emergency responders with important information that helps them understand the level of danger a material poses to emergency responders and the public. The vinyl chloride emergency response information appended to the train consist did not specify an initial evacuation radius for a "release without fire." Additionally, its guidance for evacuations during a fire was only half the evacuation distance (0.5 miles) recommended by the ERG (1 mile). An even larger inconsistency in the recommended evacuation distance was noted in the emergency response information provided for the chlorine tank cars that were in the train.

[34] Electronic data interchange transactions allow railroads and shippers to exchange business information, such as freight car waybills and invoices, using a standard form that allows for the electronic exchange of information, rather than using paper.

Table 3. Inconsistencies between the ERG and Conrail Shipping Papers Emergency Response Information.

Material	DOT Emergency Response Guidebook (ERG)	Shipping Papers Emergency Response Information
Vinyl Chloride	For a large spill, consider initial downwind evacuation for at least 800 meters (0.5 mile). If a tank car, rail car, or tank truck is involved in a fire, isolate it for 1,600 meters (1 mile) in all directions; also, consider initial evacuation for 1,600 meters (1 mile) in all directions.	If material leaking (not on fire) consider evacuation from downwind area based on the amount of material spilled, location, and weather conditions. If the fire becomes uncontrollable or if the container is exposed to direct flame, consider evacuation of 0.5 mile radius.
Chlorine	For rail tank car incidents, an initial evacuation radius of 3,000 feet (0.57 miles) then, based on if the release occurred during the day or night and wind speed, protect people downwind for a distance that can exceed 7 miles.	If material is leaking (not on fire) consider evacuation of a 0.5 mile radius based on the amount of material spilled, location, and weather conditions.

During the first hour of the emergency response, the Conrail director of risk management discussed with the fire chief the Conrail emergency response information appended to the train consist. The director of risk management told NTSB investigators that he recommended a 0.5-mile evacuation, similar to the ERG guidance (DOT 2012); however, the emergency response information did not specify a nonfire event evacuation distance. It is uncertain whether this inconsistent information influenced the emergency responder actions on the day of the accident. Nevertheless, the Conrail emergency response guidance was inconsistent with and less protective than the ERG. Therefore, the NTSB concludes that railroad-provided emergency response information that deviates from nationally recognized ERG information has the potential to confuse emergency responders faced with making timely isolation and protective action distance decisions in response to hazardous materials releases.

The NTSB recommends that PHMSA take action to ensure that emergency response information carried by train crews is consistent with and is at least as protective as existing emergency response guidance provided in the ERG.

The NTSB also recommends that the AAR update the HAZMAT database to ensure that emergency response information provided for hazardous materials shipments is consistent with and is at least as protective as guidance contained in the ERG.

1.13 Hazardous Waste Operations and Emergency Response

The OSHA standard under 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response* (HAZWOPER), applies to emergency response operations for releases of hazardous substances.[35] The standard defines "emergency response" as response efforts by employees from outside the immediate release area or by other designated

[35] The OSHA definition of *hazardous substance* includes those substances defined as hazardous materials by the DOT.

responders (e.g., mutual aid groups and local fire departments). Paragraph (q) of the standard covers the specific requirements applicable to emergency response operations to hazardous substance releases.

The state of New Jersey operates a public sector-only occupational safety and health program under a plan approved by the US Department of Labor. The New Jersey Public Employee Occupational Safety and Health Program (PEOSH) covers safety and health for all state and local government agencies within the state. The PEOSH program has adopted the federal OSHA HAZWOPER standard without modification. Thus, local and state emergency responders are subject to workplace safety and health regulations administered by the New Jersey Department of Labor and Workforce Development (NJDLWD) and the NJDOH. OSHA maintains jurisdiction over all private sector workplaces and other workplaces not under the jurisdiction of PEOSH.

The HAZWOPER standard states that the senior emergency response official responding to an emergency shall become the individual in charge of the incident command system. The Paulsboro Emergency Operations Plan (EOP) further specifies that the fire chief shall serve as the incident commander. The deputy fire chief served as the initial incident commander until the fire chief arrived at 7:17 a.m.

The HAZWOPER standard requires the incident commander to identify all involved hazardous substances and perform a site hazard assessment, implement appropriate emergency operations, and assure that appropriate personal protective equipment (PPE) is used. For workers engaged in emergency response and exposed to hazardous substances presenting a potential for inhalation hazard, such as vinyl chloride, the standard requires these workers to wear a positive pressure self-contained breathing apparatus until such time that the incident commander determines through the use of air monitoring that a decreased level of respiratory protection will not result in hazardous exposures.

Within minutes of the accident, emergency responders reported a visible vapor cloud indicating that a potentially hazardous chemical release was occurring (see figure 11). Six minutes after the initial report, the Gloucester County Communications Center told the fire chief that “four tank cars [were] in the water leaking.” The deputy fire chief also reported seeing placard number 1086, which corresponds to vinyl chloride. Therefore, the incident commander had compelling information that a vinyl chloride release had occurred and that all personnel should have retreated to a safe location, isolated the area in accordance with the ERG, and should have required the use of appropriate PPE, including respiratory protection.

Figure 11. Emergency responders and a resident in the vapor cloud near the breached tank car. The breached tank car is circled. (Photograph provided by a private citizen)

About 30 minutes after the train derailed, the incident commander contacted the communications center and stated that five confirmed tank cars of vinyl chloride were derailed. He requested a synopsis of the hazards of vinyl chloride. The communications center responded via radio transmission:

> Vinyl chloride. It says handle with care, can cause reproductive damage, contact can severely irritate and burn eyes, cause eye damage. Irritate in terms of skin, contact with liquid can cause frostbite, irritate nose, throat, lungs, cause coughing, wheezing, shortness of breath, also cause headache, nausea, vomiting, dizziness, fatigue, weakness, confusion. Also can cause you to pass out and damage liver, nervous systems, and lungs. Highly flammable reactive chemical and is a dangerous fire and explosion hazard.

The HAZWOPER standard requires incident commanders to ensure operations are conducted a safe distance from the accident scene, while limiting the number of exposed responders. Instead, the incident commander and other first responders remained within about 50 yards of an active vinyl chloride release, much closer than the ERG isolation guidelines. Additionally, air monitoring to determine the appropriate actions that would be needed to protect the responders and the community was not performed until about 90 minutes after the accident.

Emergency responders did not perform air dispersion modeling to determine the appropriate actions that would be needed to protect the community, such as evacuation or shelter-in-place. The community protective measures were developed without deference to available guidance and without seeking any site-specific data.

About 6 hours into the incident, the fire chief had yet to relocate the ICP to a safe location and failed to establish PPE requirements for the accident scene, despite the availability of air monitoring data that should have prompted these actions. At 8:34 a.m., a Paulsboro Refining Company air monitoring team began testing for volatile organic compounds (VOC) such as vinyl chloride.[36] The air monitoring team's certified industrial hygienist told NTSB investigators that while attempting to calibrate air monitoring instruments near the initial ICP situated next to the accident scene, their meters detected high atmospheric concentrations of a volatile compound. He informed those assembled at the ICP that the team had measured VOC concentrations in excess of 500 ppm and that the permissible exposure limit for vinyl chloride was only 1 ppm.[37] The team reported that the air monitoring results indicated the ICP was located in a hazardous atmosphere. The highest level of vinyl chloride detected was at 1,444 ppm, far exceeding the AEGL-2 concentrations for a 60-minute public exposure.

During the initial incident response, Conrail personnel entered the derailment scene within feet of the punctured vinyl chloride tank car without using any respiratory protection to identify the involved tank cars and assess them for damage and chemical releases. The trainmaster testified during the NTSB investigative hearing (NTSB 2013) that he felt that it was his job to assess the situation and gather information about the derailed tank cars.

The trainmaster also testified that having previously read vinyl chloride emergency response guidance, he was familiar with the requirement to use a self-contained breathing apparatus when the product is released. The trainmaster told NTSB investigators that he observed the chemical fog and was concerned about exposure to the material, but regardless, decided to enter the accident scene without appropriate PPE.

About 10:45 a.m., the Conrail hazardous materials risk manager; the CSXT hazardous materials manager; and the Gloucester County Chemical, Biological, Radiological, Nuclear, and Explosives team (CBRNE) lieutenant approached the wreckage by boat.[38] Although none of these individuals wore respiratory protection, they closely inspected tank car valves and fittings. They acknowledged the accumulated frost on the tank cars and bridge equipment, thus confirming that the release of a compressed gas had occurred. Furthermore, two people climbed on the wreckage and peered into the breached tank car and estimated that 3,000 to 4,000 gallons of product remained in the tank (see figure 12).

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[36] The Paulsboro Fire Department had a mutual aid agreement with the Paulsboro Refining Company to provide hazardous materials support.

[37] The measured reading of 500 ppm of VOC is equivalent to 950 ppm of vinyl chloride when corrected for the type of monitoring equipment used.

[38] Conrail's assets are shared by CSXT and Norfolk Southern Corporation. Thus, CSXT personnel provided response assistance.

Figure 12. Personnel inspecting the breached tank car containing vinyl chloride liquid and vapor.

Although the fire chief testified in the NTSB investigative hearing (NTSB 2013) that he did not ask Conrail employees to examine the wreckage, the HAZWOPER standard found under 29 CFR 1910.120(q)(3) requires the incident commander to delineate and control access to the site.

Assisting agencies, such as the CBRNE team, the NJSP-OEM, and the NJDEP also failed to fully implement their emergency response operations in accordance with HAZWOPER regulations. Their personnel were exposed to vinyl chloride. The NTSB concludes that personnel exposure to vinyl chloride would have been minimized had the incident commander followed guidance contained in the ERG, accepted the advice from hazardous materials emergency responders, and conducted the emergency operations in accordance with HAZWOPER standards under 29 CFR 1910.120.

Following the accident, the NJDLWD investigations of the Paulsboro Fire Department and assisting state and local agencies resulted in the issuance of multiple citations for violations of the HAZWOPER standard. State inspectors have identified HAZWOPER violations in about 25 percent of inspections of local fire protection agencies in the state. The NJDOH has conducted 89 inspections of local fire protection agencies. Through these inspections, 21 facilities have been cited for 33 violations of the HAZWOPER standard. Therefore, the NTSB recommends that the NJDLWD and the NJDOH develop an emphasis program that incorporates enforcement and outreach activities to ensure New Jersey state and local public sector employee compliance with the HAZWOPER regulations.

1.14 Community Evacuation and Shelter-in-Place

The ERG provides first responders with initial guidance for implementing evacuations and sheltering in place, and for determining initial isolation and protective action distances until technically qualified emergency response personnel are available. To adjust protective distances for a specific hazardous materials incident, technically qualified emergency responders should consider many variables derived from air sampling, dispersion modeling, weather conditions, and other available information. The Paulsboro EOP places the primary responsibility for evacuations on the police department.

The NTSB investigators determined that the initial evacuation and shelter-in-place decisions were based on erroneous information that LPG had released and that the vapor cloud was nontoxic.[39] However, the ERG recommends the same evacuation distance for an LPG release as is recommended for vinyl chloride. LPG is also a highly flammable liquefied compressed gas that is capable of causing damage to the heart and central nervous system in high concentrations. The incident commander failed to consider these hazards. Minutes after the derailment, the train crews told the first police officer on scene that the derailed tank cars contained ethanol and vinyl chloride. But as they became engulfed in a vinyl chloride vapor cloud, the train crew told the police officer that the cloud was propane or LPG. About 7:30 a.m., police radio transmissions suggested that the vapor cloud was “nontoxic.” The police then changed the evacuation orders from mandatory evacuation to shelter-in-place. The police department did not become aware that vinyl chloride had been released until 8:30 a.m., just before the first incident command briefing. The situation was further confused when, at 10:30 a.m., the NJDEP publically announced that the hazard had dissipated. Therefore, the community protective measures were based on incorrect information about the released material.

The public information component of the National Incident Management System (NIMS) establishes the role of a public information officer to support the incident commander by gathering, verifying, and coordinating accurate, accessible, and timely information on the incident’s cause, size, and current situation. Well-developed public information, education strategies, and communications plans help to ensure that lifesaving measures, evacuation routes, threat and alert systems, and other public safety information are coordinated and communicated in a timely and consistent manner (NIMS 2008).[40] The NTSB concludes that the dissemination of inaccurate public information about the release of vinyl chloride revealed the lack of an effective system for communicating to the public accurate information about the current situation following the accident.

[39] See appendix B for a chronology of the emergency responder communications.

[40] NIMS provides a systematic approach to guide departments and agencies at all levels of government and the private sector to work seamlessly to prevent, protest against, respond to, recover from, and mitigate the effects of incidents, regardless of cause, size, location, and complexity, in order to reduce the loss of life and property and harm to the environment.

The decisions regarding community protective actions were also affected by the very limited resources available to the community. The Gloucester County HAZMAT chief stated during the NTSB investigative hearing (NTSB 2013) that no municipality within Gloucester County would be able to evacuate its entire community within a short period of time.

The determination to evacuate or shelter-in-place a community during a hazardous materials release must be made after evaluating and analyzing the hazards and risks. If it is determined that the movement of residents would endanger their safety and health more so than keeping them at home, then a shelter-in-place order should be implemented. It is important to understand that evacuation decisions are always, to a large extent, driven or affected by available resources.

For example, a report published by the Oak Ridge National Laboratory (Oak Ridge 2002) states:

> The ability of a protective action to adequately protect people in an affected area throughout the duration of the emergency depends on the characteristics of the toxic chemical(s) involved, the size and nature of the release, meteorological conditions, the characteristics of the population affected, and the ability of available structures in the area to provide protection from outdoor chemical concentrations. For shelter-in-place, the emergency planner must be able to predict the outdoor plume concentration of the toxic chemical(s) that will occur in the risk area, estimate the concentration that will occur inside the buildings in which people seek shelter, and calculate the indoor estimated level of exposure. For evacuation, the planner should be able to predict the outdoor concentration of the toxic chemical(s) that will occur in the risk area, estimate when people will leave and when they will reach a safe distance, estimate the concentration that will occur while people are still evacuating, and calculate exposures to those who evacuate in the plume and those who have not left.

Emergency responders must implement procedures that would allow them to collect and analyze information to make reasonable evacuation decisions. An example of a commonly used chemical release modeling tool is the National Oceanic and Atmospheric Administration and the Environmental Protection Agency (EPA) publically available and free web-based software program known as Areal Locations of Hazardous Atmospheres (ALOHA). The ALOHA program estimates a threat zone and the corresponding types of hazards (such as toxicity, flammability, thermal radiation, or explosion overpressure) based on exposure guidelines.[41]

Fact-based decisions regarding the community exposure did not occur until the unified command was established at 1:00 p.m., when the federal on-scene coordinator directed more information to be gathered about community exposures. The Center for Toxicology and Environmental Health (CTEH) deployed a comprehensive air monitoring regime in and around the accident scene. They detected significant airborne vinyl chloride concentrations, which prompted the unified command to order an expanded evacuation at 5:00 p.m. All subsequent

[41] The program bases exposures on AEGL’s or the American Industrial Hygiene Association Emergency Response Planning Guidelines, which are considered once-in-a-lifetime, short-term exposures to airborne concentrations of acutely toxic chemicals.

evacuation decisions were based upon air monitoring data and community exposure guidance. Through December 8, 2012, about 680 residents had been displaced.

The NTSB concludes that although air dispersion modeling tools are readily available, the incident command team did not use any of these tools to evaluate toxic exposure threats during the first hours following the accident.

The NTSB recommends that the International Association of Fire Chiefs notify its membership about the circumstances of this accident and develop a plan to incorporate into ongoing training curricula lessons learned concerning the need to promptly use adequate data collection and analysis tools and to develop and implement community protective measures for mitigating the threats of hazardous materials releases.

The NTSB recommends that the National Volunteer Fire Council notify its membership about the circumstances of this accident and develop a plan to incorporate into ongoing training curricula lessons learned concerning the need to promptly use adequate data collection and analysis tools and to develop and implement community protective measures for mitigating the threats of hazardous materials releases.

1.15 Firefighter Hazardous Materials Response Training

1.15.1 Firefighter Training Requirements

The OSHA HAZWOPER regulations under 29 CFR 1910.120(q)(6) specify the required training levels and qualifications for workers engaged in hazardous materials response operations. The required training levels are based on worker duties and functions. The levels of training qualification are: first responder awareness, first responder operations, hazardous materials technician, hazardous materials specialist, and on-scene commander. Both initial and annual refresher training are required for each level of worker qualification.

Appendix E of the OSHA standard provides nonmandatory training curriculum guidelines. These guidelines reference the knowledge competencies covered in the document *Standards for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, National Fire Protection Association (NFPA) standard 472 (NFPA 2013).

Firefighters trained to the first responder awareness level should be capable of:

(1) Analyzing the incident to determine both the hazardous materials present and the basic hazard and response information for each hazardous materials agent by completing the following tasks:

   a. Detect the presence of hazardous materials.

   b. Survey a hazardous materials incident from a safe location to identify the name, United Nations identification number/North American identification number (UN/NA) (whole name) identification number, type of placard, or other distinctive marking applied for the hazardous materials involved.

c. Collect hazard information from the current edition of the DOT *Emergency Response Guidebook.*

(2) Implementing actions consistent with the authority having jurisdiction and the current edition of the DOT *Emergency Response Guidebook* by initiating protective actions and notifications.

The first responder "operations level" describes the level of skill expected of firefighters or other individuals who are part of an initial response to releases of hazardous substances to protect persons, property, or the environment from the effects of the release. They are trained to respond in a defensive fashion without trying to stop the release. Their function is to contain the release from a safe distance, keep it from spreading, and prevent exposures. The standard requires first responders at the operational level to receive at least 8 hours of training or have sufficient experience to demonstrate competency in the following areas:

- Basic hazard and risk assessment techniques
- Selection and use of correct PPE
- Basic hazardous materials terms
- Perform basic control, containment, and/or confinement operations
- Basic decontamination procedures
- Relevant standard operating procedures

In addition, NFPA 472 (NFPA 2013) further establishes the minimum competencies required for those who respond to hazardous materials incidents and emphasizes the need for a risk-based response to these incidents. The recommended core competencies for operations-level responders include:

- Analyzing a hazardous materials incident to determine the scope of the problem and potential outcomes.
- Planning an initial response to a hazardous materials incident within the capabilities and competencies of available personnel and PPE.
- Implementing the planned response for a hazardous materials incident to favorably change the outcomes consistent with the emergency response plan and/or standard operating procedures.
- Evaluating the progress of the actions taken at a hazardous materials incident to ensure that the response objectives are being met safely, effectively, and efficiently.

Furthermore, all members of the fire service within the state of New Jersey must obtain training and certification in accordance with Title 5 of the New Jersey Administrative Code (NJAC) Chapter 73, *Standards for Fire Service Training and Certification* (NJAC 2012). Specific qualification requirements include:

- Subchapter 2, Educational Programs and Facilities, which lists NFPA Standard 1001, *Standard for Fire Fighter Professional Qualifications*, 2008 Edition, as its Firefighter I and II training standard.
- Subchapter 4, Firefighter I and II, provides that candidates for Firefighter 1 shall complete a recognized hazardous materials awareness and operations level course(s).
- Subchapter 6, Hazardous Materials/Incident Management System Certification, addresses requirements for the management of hazardous materials including the levels of training and continuing education.
- Subchapter 6.5 states continuing education requirements set forth in the OSHA HAZWOPER regulations shall apply to all individuals holding Hazardous Materials—Awareness, Hazardous Materials—Operational and/or Hazardous Materials—On-Scene Commander certification(s).
- Subchapter 8, Fire Officers, prescribes the training criteria required to achieve a certification for Fire Officer 1 through Fire Officer IV.

The New Jersey Bureau of Fire Department Services, Office of Training and Certification is responsible for the training and education of New Jersey firefighters. The bureau issues firefighter certifications under the NJAC. Certification is achieved by passing a proctored written examination.

1.15.2 Paulsboro Fire Department Hazardous Materials Training

The Paulsboro Fire Department has 25 volunteer firefighters who are mostly trained to the firefighter level I. It performs only defensive hazardous materials response. Table 4 provides a summary of the most recent hazardous materials or safety officer training for key members of the Paulsboro Fire Department.

Table 4. Summary of Fire Department Hazardous Materials or Safety Officer Training.

Title	Training Course	Training Provider	Date of Completion
Fire Chief	Hazardous Materials Level 2 Operations Competency Refresher	Gloucester County Fire Academy	April 10, 2012
Deputy Fire Chief	No record available[a]	N/A	N/A
Fire Captain/ Emergency Management Coordinator	Hazardous Materials Level 2 Operations Competency Refresher	Gloucester County Fire Academy	April 10, 2012
	Hazardous Materials Awareness Refresher and Usage of the 2008 ERG Book	Gloucester County Fire Academy	March 27, 2012

[a] NTSB investigators requested the deputy fire chief's training records, but he did not provide them.

Training records for the fire chief and fire captain/emergency management coordinator suggest that they had received the recommended training for firefighters engaged in hazardous materials operations. The NTSB concludes that the New Jersey firefighter certification and training requirements were not effective as demonstrated by the failure of emergency responders to conduct operations in accordance with established health and safety protocols and OSHA HAZWOPER standards, and their lack of familiarity with available tools to evaluate toxic exposure threats.

The NFPA director of government affairs testified at the NTSB investigative hearing (NTSB 2013) that training requirements and the corresponding commitment of time and effort continue to place a huge burden on the volunteer fire services personnel. Because there are many other functions and competing needs fire departments must consider, the scarce hazardous materials training opportunities must be effective. The shortcomings of the emergency response to the Paulsboro accident should reinforce the basic requirement to conduct hazardous materials operations in compliance with OSHA HAZWOPER and NFPA 472 standards to prevent personnel from needlessly being exposed to toxic chemical releases. Therefore, the NTSB recommends that the New Jersey Bureau of Fire Department Services update the firefighter training curricula relating to hazardous materials operations to incorporate lessons learned from this NTSB accident investigation concerning the emergency response to the Conrail Freight Train Derailment with Vinyl Chloride Release in Paulsboro, New Jersey, on November 30, 2012**.**

1.16 Community Awareness Programs and Emergency Planning

1.16.1 Community Awareness Programs

Community outreach and awareness about hazardous materials that are transported through communities by railroad is addressed in various voluntary programs. One program is the Transportation Community Awareness and Emergency Response (TRANSCAER) program, founded in 1986, which is a national outreach effort that focuses on assisting communities to prepare for and to respond to transportation-related hazardous materials incidents. (TRANSCAER 2014) Its membership consists of volunteer representatives from the chemical manufacturing, transportation, distribution, and emergency response industries, as well as federal, state, and local governments. The AAR publication OT-55, *Recommended Railroad Operating Practices for Transportation of Hazardous Materials* (VanderClute 2013), describes TRANSCAER as a "system-wide community outreach program to improve community awareness, emergency planning, and incident response for the transportation of hazardous materials."

The AAR publication instructs railroads to assist with implementing the TRANSCAER objectives, including:

- When requested, assist Local Emergency Planning Committees (LEPC) in assessing the hazardous materials moving through their communities and the safeguards that are in place to protect against unintentional releases.[42] Upon written request, AAR members will provide bona fide emergency response agencies or planning groups with specific commodity flow information covering, at a minimum, the top 25 hazardous commodities transported through the community in rank order. Because railroads consider the information security sensitive, it may only be released to bona fide emergency response planning and response organizations. It should be noted that commodity flow may change over time with changing commercial requirements;
- Assist LEPCs in developing emergency plans to cope with hazardous materials transportation incidents;
- Assist community response organizations in preparations for responding to hazardous materials incidents.

Railroads, including Conrail, express frustration with local emergency responders for a lack of participation in railroad- or TRANSCAER-organized training events. Prior to the accident, TRANSCAER of New Jersey held several free tank car training sessions in and around Gloucester County. Training was held at Woodbury Rail Yard in Gloucester County on April 20–21, 2012, 7 months before the accident. This training was sponsored by the Dow Chemical Company, which teamed with Norfolk Southern Railroad, Conrail, the Firefighters Education and Training Foundation, the Chemical Transportation Emergency Center, and many other local supporting agencies to make this educational opportunity available to local responders. However, no members of the Paulsboro Fire Department attended that training.

Like many small fire departments throughout the country, the Paulsboro Fire Department was unprepared for large-scale hazardous material emergency responses. The frequency of hazardous materials train traffic through the borough would have suggested a higher level of awareness and preparedness. The firefighters need to understand how to respond to incidents

[42] An LEPC is a 15-member emergency planning committee that includes representation of elected officials; emergency management coordinators; law enforcement; fire service; emergency medical service; health, environmental, and transportation agencies; hospitals; media; community groups; local businesses; and facilities subject to emergency planning and community right-to-know requirements of the Superfund Amendments and Reauthorization Act.

involving such hazards and advise the community on whether to evacuate or shelter in place if a release does occur.

In addition to TRANSCAER, many railroads have their own voluntary outreach and assistance programs for emergency response organizations in the communities along their routes. However, these programs are usually limited to emergency responders, not the public. Furthermore, the voluntary programs seldom include requirements for evaluating the efficacy of these programs.

In contrast to nonmandatory, voluntary railroad programs, community outreach and awareness programs are mandatory for nearly all industrial facilities. The most overarching community awareness requirements are contained in the EPA Emergency Planning and Community Right-to-Know Act (EPCRA) regulations. In 1986, Congress passed EPCRA in response to concerns regarding the environmental and safety hazards posed by the storage and handling of toxic chemicals. The legislation stemmed from concerns about the 1984 release of methyl-isocyanate at a Union Carbide facility in Bhopal, India, that killed or severely injured more than 2,000 people.

To reduce the likelihood of such a disaster in the United States, Congress developed and imposed requirements for emergency planning and community right-to-know reporting on certain hazardous and toxic chemicals. The intent of the community right-to-know provisions is to “help increase the public's knowledge and access to information on chemicals at individual facilities, their uses, and releases into the environment.” (EPA 2014b) The EPCRA requirements are codified under 40 CFR 355 and 370 and require fixed facilities handling certain hazardous materials to make chemical information, such as material safety data sheets (MSDS), available to local officials, fire departments, and the public. These facilities are also required to work with emergency responders and planning committees to develop emergency plans to protect public health and the environment.

PHMSA has also promulgated public awareness program requirements, outlined under 49 CFR 192.616 and 195.440, for pipeline operators. Affected pipeline operators must develop, implement, and evaluate a public education program using American Petroleum Institute (API) Recommended Practice RP 1162, *Public Awareness Programs for Pipeline Operators* (API 2003), which is incorporated into the federal regulations. The RP 1162 public awareness programs help the public understand how to prevent and respond to pipeline emergencies. In its May 19, 2005, final rule, PHMSA stated that such programs are an important factor in establishing communications with affected stakeholders and improving emergency response coordination. (*Federal Register* 2005, 28833)

Currently, the LEPCs and State Emergency Response Commissions (SERC) can, through a cumbersome process, request commodity flow information about the top 25 hazardous materials that the railroad transports through their communities as provided in AAR Circular OT-55. (VanderClute 2013) Communities with advanced hazardous materials response capabilities have the experience and dedicated hazardous materials response teams trained to obtain and process this data. Smaller communities, with limited hazardous material expertise, are at a disadvantage in obtaining commodity flow data, especially given the limited resources available to volunteer firefighting services.Many communities that are unaware of the risks posed by releases of hazardous materials learn about these hazards for the first time during an actual incident. Such was the case in Paulsboro where local emergency responders were unfamiliar with vinyl chloride and its chemical properties, the needed chemical detection equipment, and the needed procedures to determine the appropriate protective measures for both responders and the individuals living or working nearby. The Paulsboro fire chief told NTSB investigators that he could not smell or taste the chemical and therefore assumed that there was no chemical release—yet he was exposed to measured concentrations that had the potential for causing irreversible long-lasting health effects. The emergency responder actions and their failure to take appropriate precautions to protect themselves from exposure to the vinyl chloride and maintain scene control demonstrated their lack of awareness about the nature of the hazardous commodities being transported through their community. The NTSB concludes that had Conrail executed an effective public awareness program, the Paulsboro community and emergency response organizations would have been better prepared to safely and effectively respond to the vinyl chloride release.

The NTSB recommends that PHMSA require railroads transporting hazardous materials to develop, implement, and periodically evaluate a public education program similar to that required for pipeline operators under 49 CFR Parts 192.616 and 195.440 for the communities along railroad hazardous materials routes.

1.16.2 Emergency Planning and Preparedness

Unlike stationary or fixed facilities, railroads transporting hazardous materials are not required to work with communities to develop emergency plans. A fixed facility with a threshold quantity of a material designated as an extremely hazardous substance, as defined under 40 CFR 355, has significant obligations to the LEPC for both emergency planning and release notification.[43] The facility emergency planning responsibilities include providing emergency planning notification to the LEPC and SERC, providing an emergency coordinator who will participate in the local emergency planning process, providing notice of any changes occurring at the facility that may be relevant to emergency planning, and, most importantly, providing any information necessary to develop and implement the emergency plan. This information typically includes the type and quantity of the hazardous materials as well as other relevant data.

Although EPCRA defines "facility" to include railroad rolling stock, Congress provided the following exemption (U.S.C. 2009):

> Except as provided in section 11004 [Emergency Notification] of this title, this chapter does not apply to the transportation, including the storage incident to such transportation, of any substance or chemical subject to the requirements of this chapter, including the transportation and distribution of natural gas.

Therefore, railroads are exempt from the EPCRA requirements to work with local emergency responders and the LEPCs or SERCs for emergency planning.

[43] The regulation applies only to the chemicals in quantities above threshold quantity limits as listed under appendix A and B of 40 CFR 355.

The absence of any federal requirements for railroads to assist with local emergency planning leaves communities unprepared for hazardous materials releases. The issue is even more significant when the threshold quantities that trigger the EPCRA emergency planning regulations are examined. The threshold planning quantities for hazardous chemicals used at a fixed facility are often several orders of magnitude less than quantities that are routinely transported through these same communities, frequently to or from the regulated facility. For example, the fixed-facility threshold planning quantity for chlorine is 100 pounds. The train that derailed in Paulsboro was transporting four tank-car loads of chlorine (each with approximately 180,000 pounds of chlorine), more than 700,000 pounds. Although chlorine was not released in this accident, it could have been since it was in a tank car only 14 cars behind the last derailed tank car.

Responding to significant railroad incidents in 2013 and 2014 involving crude oil unit trains, the DOT issued an Emergency Restriction/Prohibition Order on May 7, 2014, that requires railroads transporting 1 million gallons or more of Bakken crude oil in a single train (about 35 tank car loads) to notify SERCs about the operation of these trains through their states (DOT 2014). The notification must: (a) provide an estimate of the number of crude oil trains that are expected to travel per week through each county within the state; (b) identify and describe the crude oil; (c) provide all emergency response information required under 49 CFR Part 172, Subpart G; and (d) identify routes over which the material will be transported. The notification must also identify at least one point of contact for SERCs and relevant emergency responders. Railroad carriers must also assist SERCs as necessary to aid in the dissemination of information to the appropriate emergency responders in affected localities.

The NTSB believes the Emergency Restriction/Prohibition Order targeting railroad transportation of crude oil produced from a single region in the United States does not go far enough. The lack of emergency planning and the mishandling of the emergency response during the Paulsboro incident, which involved the release of more than 20,000 gallons of a toxic and flammable chemical shows the need for the DOT to address planning for all the hazardous materials transported by railroads.

Proper local planning for transportation-related accidents helps to ensure safe and efficient response operations guidelines are available in the EOPs. All EOPs in New Jersey must contain an annex specific to hazardous material releases that outlines the required resources, responsible agencies and their capabilities, and community evacuations and protective measures.[44] During the NTSB investigative hearing (NTSB 2013), the Paulsboro fire chief highlighted the borough's lack of preparedness when he testified that the department has had limited experience with hazardous material emergency responses. The Paulsboro EOP did not sufficiently address the resources that would be needed to manage a hazardous materials incident of the magnitude that occurred.

Citizens should expect the emergency planners to address concerns about how prepared the community is to respond to a release (DelFava 2002). Effective emergency planning must include the participation of the company that brings the hazardous materials into the community.

[44] The EAP also includes annexes for emergency medical, evacuation, fire and rescue, law enforcement, public health, public works, social services, and terrorism.

A fixed facility in the community most likely has expertise and resources on site that can assist the local emergency responders in the event of an incident. However, railroad staff who are experts in hazardous materials incident response may not be readily available at accident sites to immediately assist the community. Therefore, this transportation industry expertise and direct railroad involvement, are essential elements in planning for safe hazardous materials incident responses. The LEPCs and SERCs must be provided with accurate information regarding the hazardous materials transported through their communities. The NTSB concludes active participation by railroads in local emergency planning would result in safer and more efficient emergency responses to railroad accidents involving hazardous materials releases.

Therefore, the NTSB recommends that the DOT require railroads transporting hazardous materials through communities to provide emergency responders and local and state emergency planning committees with current commodity flow data and assist with development of emergency operations and response plans.

1.16.3 State Oversight of Emergency Operations Plans

According to the New Jersey Civilian Defense and Disaster Control Act, each county and municipality must prepare a written EOP with appropriate annexes necessary to implement the plan. These plans must be submitted to the NJSP-OEM for approval and recertification every 4 years to ensure compatibility with state EOP guidelines. At the time of the accident, the Paulsboro EOP was more than 2 years overdue for the NJSP-OEM recertification and approval.

A New Jersey State Police sergeant testified at the NTSB investigative hearing (NTSB 2013) that the state relies on county emergency management agencies to review each plan, as local agencies have greater understanding of the challenges, risks, and hazards facing their respective municipalities. He also testified that the NJSP-OEM does not have the resources necessary to audit plans that are developed by each municipality. He added that the NJSP-OEM accepts and approves EOPs based on the recommendation and approval of the county emergency management agency. In the case of the Paulsboro EOP, the plan that was in effect at the time of the accident was approved by the Gloucester County Office of Emergency Management on July 19, 2006. Based on this approval, the NJSP-OEM approved the plan 1 week later, on July 27, 2006.

The NTSB examined both county and municipal EOP recertification compliance rates in New Jersey. According to NJSP-OEM, there is a 100-percent recertification compliance rate from all counties. However, municipal EOP recertification compliance has been a problem. The municipal recertification rates, according to NJSP-OEM, are as follows for the North, Central, and South regions of New Jersey: 80 percent, 84 percent, and 89 percent, respectively. The lowest compliance was in Union County in the Central region, where only 57 percent of its 21 municipalities have an approved EOP. At least four municipalities in the Central region have EOPs that were 4 years overdue for recertification. Trailing Union County is Warren County in the North region; only 60 percent of its 23 municipalities have an approved EOP (see table 5).

These statistics indicate that many communities in the state still do not have NJSP-OEM-approved EOPs and that these communities are likely unprepared for emergencies that could occur in their jurisdictions, as was the Paulsboro community. This problem is amplified by New Jersey home rule laws that keep authority for managing an incident at the lowest local government level, thus discouraging regional and state authorities from intervening in an incident, even when faced with obvious response deficiencies.

Table 5. New Jersey Regions and Compliance Rate of Emergency Operations Plans.

Region	County	Number of Municipalities	Municipality Compliance Rate (%)
North	Bergen	70	83
	Essex	22	91
	Hudson	12	92
	Morris	39	77
	Passaic	16	75
	Sussex	24	79
	Warren	23	60
Central	Hunterdon	26	100
	Mercer	13	85
	Middlesex	25	80
	Monmouth	53	85
	Ocean	33	85
	Somerset	21	95
	Union	21	57
South	Atlantic	23	100
	Burlington	40	73
	Camden	37	95
	Cape May	16	100
	Cumberland	14	93
	Gloucester	24	79
	Salem	15	100

The director of government affairs for the NFPA testified at the NTSB investigative hearing (NTSB 2013) that community emergency operations planning could be improved if risks specific to particular locations are identified and mitigation procedures are addressed in the plans. The chairman of the hazardous materials committee for the International Association of Fire Chiefs testified (NTSB 2013) that it is essential for communities to assess their risks, determine their level of response capability to address the particular risk, and perform appropriate gap analyses to enhance their preparedness to respond to the assessed risks.

In 2011, the Transportation Research Board published a report, *A Guide for Assessing Community Emergency Response Needs and Capabilities for Hazardous Materials Releases* (Transportation Research Board 2011) containing comprehensive, step-by-step guidance on assessing hazardous materials emergency response needs at state, regional, and local levels; matching state, regional, and local capabilities with potential emergencies involving different types of hazardous materials; and assessing how quickly resources can be deployed in an emergency. The report recommends that municipalities use a risk-based approach to support hazardous materials emergency response decisions and planning. This approach requires understanding the hazards of chemicals present, the vulnerabilities of the community, and the consequences of an incident. The NTSB concludes that had the borough of Paulsboro performed an assessment of the emergency response needs and capabilities for the hazardous materials that are present and transiting through its community, it would have been apparent that the emergency response capabilities and plans were inadequate for the types of high consequence incidents that can occur in the jurisdiction.

NTSB investigators have observed in this and other hazardous materials incidents that the content of the EOPs often provide generic descriptions of hazards, rarely going beyond the templates provided by the regulatory authority. The National Response Team (NRT) (NRT 2001) further emphasizes the importance of communities maintaining a continuing preparedness strategy because of the risk of incidents involving hazardous materials releases and because local governments will be completely on their own in the first stages of any incident.[45] An emergency plan is specific tangible evidence of being prepared.

In New Jersey, the municipal emergency management coordinator organizes members of the LEPC from various stakeholder organizations, and they meet to write the EOP (NJSP-OEM 2001). The NJSP-OEM suggests that the plan be updated on a regular basis and be tested with periodic exercises. The format of the local plan is dictated by state guidelines, and must conform to a standardized line-by-line checklist. The EOP must contain an annex specific to hazardous materials that provides for the coordination of personnel, resources, and experts to effectively respond to an incident. The hazardous materials annex must also address the collection of site-specific data, personnel training, and equipment.

The content of the Paulsboro EOP reflects that no detail risk analysis was conducted relative to any hazardous materials threats, and that an emergency response needs and capability assessment was not performed. For instance, the hazardous materials annex listed outdated resources and lines of authority, along with the names and addresses of five chemical handling facilities and the CSXT railroad in Paulsboro. The annex provided no information about the hazardous materials that are routinely transported through Paulsboro. The NTSB concludes the New Jersey EOP review process fails to ensure that the EOP content is based on an adequate emergency response needs and capability assessment, and fails to adequately provide for responses to releases of hazardous materials in transportation.

The NTSB recommends the NJSP-OEM ensure communities base their EOP content on hazard analysis and risk assessments that adequately provide for response to specific hazardous materials threats facing communities, including railroad transportation.

The NTSB recommends the NJSP-OEM develop EOP recertification and approval procedures with adequate accountability, quality control measures, and audit methods to ensure that communities maintain accurate, appropriate, and current plans.

1.17 Rail Corridor Risk Management System

Title 49 CFR Part 172, Subpart I, prescribes requirements for the development and implementation of plans to address security risks related to the commercial transportation of hazardous materials. The planning and route selection requirements under 49 CFR 172.820

[45] The NRT is composed of 16 federal agencies having responsibilities in environmental, transportation, emergency management, worker safety, and public health areas. It is the national body for coordinating federal planning, preparedness, and response actions related to oil discharges and hazardous substance releases.

require railroads that transport more than 5,000 pounds of a Division 1.1, 1.2, or 1.3 explosive in a single car load; a single bulk package of a material toxic by inhalation; or a highway route-controlled quantity of a Hazard Class 7, radioactive material, to annually compile commodity flow data to identify routes on which these materials are transported. The railroad must use this data and annually analyze the safety and security risks for the transportation routes used to transport these materials.

Twenty-seven risk factors must be examined and evaluated. These include items such as the volume of hazardous materials transported, past incidents, population density along the route, emergency response capability along the route, and areas of high consequence along the route as identified under 49 CFR 172.820(c). Railroads are required to identify alternate routes over which they have authority to operate and perform a safety and security risk assessment of those routes for comparison. The railroad must use its analysis to select the best practicable route posing the least overall safety and security risk. PHMSA also noted that even in the absence of alternative routes, assessing the safety and security risks along the route is critical to enhancing rail transportation safety and should prompt railroads to address identified vulnerabilities.

Railroads document and perform their planning and route selection using the Rail Corridor Risk Management System (RCRMS) software tool. It was developed through a partnership with the FRA, Federal Emergency Management Agency, Transportation Security Agency, and PHMSA, and was issued in 2009. This web-based tool maintains the commodity flow information and analyzes and compares the risks of alternative routes, if available.

Conrail transports materials, such as chlorine, that require it to compile commodity flow data and perform risk assessments and route planning. Conrail uses the RCRMS tool to enter its commodity flow data and document its risk assessments and route selection analysis. However, the RCRMS software does not provide a meaningful risk assessment when there are no alternate routes. In the absence of alternate routes, the tool only provides the user with confirmation that the only available route is the most suitable route for the transport of these materials. Therefore, no true route risk assessment and safety and security risks evaluation is performed.

In 2012, the ASLRRA and the FRA had discussions about the RCRMS not being a viable risk assessment tool for short line railroads having only one route. Many short line railroads continue to use the RCRMS to comply with the regulation. The ASLRRA and one of its associate members, Countermeasures Assessments and Security Experts (CASE), approached the FRA with an alternative method for Class III railroads with only one route. The two organizations designed a risk assessment tool that incorporates the 27 risk factors, but evaluates them using specific risk ranges based on preassigned CASE values. The FRA agreed that this tool would satisfy the short-term requirements of the RCRMS for those railroads having a single available route. In November 2010, the template was provided to the affected ASLRRA member railroads (42 railroads) and to the railroads having one route and multiple interchanges (28 railroads). The ASLRRA has also received a federal grant to help fund the development and implementation of a more permanent solution for this problem.

Conrail was aware of the shortcomings of the RCRMS software tool, yet it did not attempt to conduct a thorough risk assessment to identify the vulnerabilities along the route. The NTSB concludes that had Conrail performed an adequate hazardous materials transportation route risk assessment, factors such as the characteristics of the moveable bridge, population density, and emergency response capability that caused and/or contributed to the accident would have been identified.

The NTSB recommends that the FRA collaborate with PHMSA and ASLRRA to develop a risk assessment tool that addresses the known limitations and shortcomings of the RCRMS software tool.

The NTSB recommends the FRA collaborate with PHMSA and ASLRRA to conduct audits of short line and regional railroads to ensure that proper route risk assessments that identify safety and security vulnerabilities are being performed and are incorporated into an SMS program.

The NTSB recommends PHMSA collaborate with the FRA and ASLRRA to develop a risk assessment tool that addresses the known limitations and shortcomings of the RCRMS software tool.

The NTSB recommends PHMSA collaborate with the FRA and ASLRRA to conduct audits of short line and regional railroads to ensure that proper route risk assessments that identify safety and security vulnerabilities are being performed and are incorporated into an SMS program.

The NTSB recommends ASLRRA collaborate with the FRA and PHMSA to develop a risk assessment tool that addresses the known limitations and shortcomings of the RCRMS software tool.

The NTSB also recommends ASLRRA collaborate with the FRA and PHMSA to conduct audits of short line and regional railroads to ensure that proper route risk assessments that identify safety and security vulnerabilities are being performed and are incorporated into an SMS program.

2 Conclusions

2.1 Findings

1. The following were not contributing factors to the accident:
   - Weather
   - Alcohol or illicit drugs
   - Train equipment
   - Track
   - Structural integrity and bridge load
   - Bridge control system
   - Bridge signal system

2. The recorded data and postaccident physical condition of the slide lock components indicate that the slide locks were not engaged on the east end of the bridge and the slide locks on the west end were only partially engaged as the train crossed the bridge.

3. Physical evidence shows that the east end of the bridge span rotated north under the moving train, misaligned the running rails, and caused the train to derail.

4. The conductor erroneously determined the Paulsboro moveable bridge locking mechanism was locked.

5. Consolidated Rail Corporation failed to ensure that inspections of the Paulsboro moveable bridge locking mechanisms would be conducted by properly qualified employees.

6. The requirements for ensuring that an employee is qualified to determine if a train can safely proceed across a moveable bridge when a red signal aspect is displayed are not as comprehensive as the requirements for other safety-critical operations such as operating a train over a broken rail.

7. Consolidated Rail Corporation’s reliance on unstructured on-the-job training to determine whether a moveable bridge was properly aligned and locked for train passage did not effectively prepare crews to handle all situations they could potentially encounter in traversing moveable bridges.

8. In its decision to keep the bridge operational even though the bridge continued to malfunction, Consolidated Rail Corporation failed to recognize that the hazards that existed with the moveable bridge operation could not be mitigated by using operating crewmembers to inspect the bridge.

9. The severity and probability of a mishap occurring on the bridge should have prompted Consolidated Rail Corporation to cease bridge opening and closing operations until appropriate mitigation measures were taken.

10. The thickness and material properties of the tank shell and the weld size, quality, and material properties where the breach occurred met the requirements for DOT-105A300W tanks.

11. The tank car shell was punctured by an impact with the lower shelf of the adjacent tank car coupler that exceeded the strength of the tank shell material.

12. During the early hours following the accident, Consolidated Rail Corporation personnel did not immediately provide critical hazardous materials information to emergency responders that could have assisted in executing a safer response to this accident.

13. The Association of American Railroads instruction Consolidated Rail Corporation adopted that directs railroad employees to provide an extra copy of the train consist "when available" does not meet the intent of the requirements found under Title 49 *Code of Federal Regulations* 172.600, given that train consists frequently contain the emergency response information.

14. Railroad-provided emergency response information that deviates from nationally recognized *Emergency Response Guidebook* information has the potential to confuse emergency responders faced with making timely isolation and protective action distance decisions in response to hazardous materials releases.

15. Personnel exposure to vinyl chloride would have been minimized had the incident commander followed guidance contained in the *Emergency Response Guidebook*, accepted the advice from hazardous materials emergency responders, and conducted the emergency operations in accordance with *Hazardous Waste Operations and Emergency Response* standards under Title 29 *Code of Federal Regulations* 1910.120.

16. The dissemination of inaccurate public information about the release of vinyl chloride revealed the lack of an effective system for communicating to the public accurate information about the current situation following the accident.

17. Although air dispersion modeling tools are readily available, the incident command team did not use any of these tools to evaluate toxic exposure during the first hours following the accident.

18. New Jersey firefighter certification and training requirements were not effective as demonstrated by the failure of emergency responders to conduct operations in accordance with established health and safety protocols and Occupational Safety and Health Administration *Hazardous Waste Operations and Emergency Response* standards, and their lack of familiarity with available tools to evaluate toxic exposure threats.

19. Had Consolidated Rail Corporation executed an effective public awareness program, the Paulsboro community and emergency response organizations would have been better prepared to safely and effectively respond to the vinyl chloride release.

20. Active participation by railroads in local emergency planning would result in safer and more efficient emergency responses to railroad accidents involving hazardous materials releases.

21. Had the borough of Paulsboro performed an assessment of the emergency response needs and capabilities for the hazardous materials that are present and transiting through its community, it would have been apparent that the emergency response capabilities and plans were inadequate for the types of high consequence incidents that can occur in the jurisdiction.

22. The New Jersey emergency operations plan review process fails to ensure that the emergency operations plan content is based on an adequate emergency response needs and capability assessment, and fails to adequately provide for responses to releases of hazardous materials in transportation.

23. Had Consolidated Rail Corporation performed an adequate hazardous materials transportation route risk assessment, factors such as the characteristics of the moveable bridge, population density, and emergency response capability that caused and/or contributed to the accident would have been identified.

2.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the derailment and subsequent hazardous material release at the Paulsboro moveable bridge was Consolidated Rail Corporation (1) allowing the train to proceed past the red signal aspect with the rail slide locks not fully engaged, which allowed the bridge to rotate and misalign the running rails as the train moved across it, and (2) relying on a training and qualification program that did not prepare the train crew to examine the bridge lock system.

Contributing to the accident was the lack of a comprehensive safety management program that would have identified and mitigated the risks associated with the continued operation of the bridge despite multiple bridge malfunctions of increasing frequency. Contributing to the consequences of the accident was the failure of the incident commander to implement established hazardous materials response protocols for worker protection and community exposure to the vinyl chloride release.

3 Recommendations

3.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations:

To the Consolidated Rail Corporation:

> Amend *Hazardous Materials Instructions for Rail, HM-1* to require train crews to immediately provide their train consists and the emergency response information for all hazardous materials on the train to federal, state, or local emergency response officials when accidents occur. (R-14-13)

To the US Department of Transportation:

> Require railroads transporting hazardous materials through communities to provide emergency responders and local and state emergency planning committees with current commodity flow data and assist with development of emergency operations and response plans. (R-14-14)

To the Federal Railroad Administration:

> Promulgate a regulation for permitting a train to pass a red signal aspect protecting a moveable bridge that is similar to the criteria for allowing a train to cross a broken rail as contained in Title 49 Code of Federal Regulations 213.7(d) to ensure that the bridge has been inspected by a qualified employee before a train is authorized to proceed across the bridge. (R-14-15)

> Collaborate with the Pipeline and Hazardous Materials Safety Administration and the American Short Line and Regional Railroad Association to develop a risk assessment tool that addresses the known limitations and shortcomings of the Rail Corridor Risk Management System software tool. (R-14-16)

> Collaborate with the Pipeline and Hazardous Materials Safety Administration and the American Short Line and Regional Railroad Association to conduct audits of short line and regional railroads to ensure that proper route risk assessments that identify safety and security vulnerabilities are being performed and are incorporated into a safety management system program. (R-14-17)

To the Pipeline and Hazardous Materials Safety Administration:

> Take action to ensure that emergency response information carried by train crews is consistent with and is at least as protective as existing emergency response guidance provided in the *Emergency Response Guidebook*. (R-14-18)

Require railroads transporting hazardous materials to develop, implement, and periodically evaluate a public education program similar to Title 49 *Code of Federal Regulations* Parts 192.616 and 195.440 for the communities along railroad hazardous materials routes. (R-14-19)

Collaborate with the Federal Railroad Administration and the American Short Line and Regional Railroad Association to develop a risk assessment tool that addresses the known limitations and shortcomings of the Rail Corridor Risk Management System software tool. (R-14-20)

Collaborate with the Federal Railroad Administration and the American Short Line and Regional Railroad Association to conduct audits of short line and regional railroads to ensure that proper route risk assessments that identify safety and security vulnerabilities are being performed and are incorporated into a safety management system program. (R-14-21)

To the Association of American Railroads:

Amend the *United States Hazardous Materials Instructions for Rail* to require train crews to immediately provide their train consists and the emergency response information for all hazardous materials on the train to federal, state, or local emergency response officials when accidents occur. (R-14-22)

Update the Hazardous Materials Shipping Descriptions and Emergency Response database to ensure that emergency response information provided for hazardous materials shipments is consistent with and is at least as protective as guidance contained in the *Emergency Response Guidebook*. (R-14-23)

To the American Short Line and Regional Railroad Association:

Collaborate with the Federal Railroad Administration and the Pipeline and Hazardous Materials Safety Administration to develop a risk assessment tool that addresses the known limitations and shortcomings of the Rail Corridor Risk Management System software tool. (R-14-24)

Collaborate with the Federal Railroad Administration and the Pipeline and Hazardous Materials Safety Administration to conduct audits of short line and regional railroads to ensure that proper route risk assessments that identify safety and security vulnerabilities are being performed and are incorporated into a safety management system program. (R–14–25)

To the International Association of Fire Chiefs:

Notify your membership about the circumstances of this accident and develop a plan to incorporate into ongoing training curricula lessons learned concerning the need to promptly use adequate data collection and analysis tools and to develop and implement community protective measures for mitigating the threats of hazardous materials releases. (R-14-26)

To the National Volunteer Fire Council:

Notify your membership about the circumstances of this accident and develop a plan to incorporate into ongoing training curricula lessons learned concerning the need to promptly use adequate data collection and analysis tools and to develop and implement community protective measures for mitigating the threats of hazardous materials releases. (R-14-27)

To the New Jersey State Police Office of Emergency Management:

Ensure communities base their emergency operations plan content on hazard analysis and risk assessments that adequately provide for response to hazardous materials threats facing communities, including railroad transportation. (R-14-28)

Develop emergency operations planning recertification and approval procedures with adequate accountability, quality control measures, and audit methods to ensure that communities maintain accurate, appropriate, and current plans. (R-14-29)

To the New Jersey Bureau of Fire Department Services:

Update the firefighter training curricula relating to hazardous materials operations to incorporate lessons learned from this National Transportation Safety Board accident investigation concerning the emergency response to the Conrail Freight Train Derailment with Vinyl Chloride Release in Paulsboro, New Jersey, on November 30, 2012. (R-14-30)

To the New Jersey Department of Labor and Workforce Development:

Develop an emphasis program that incorporates enforcement and outreach activities to ensure New Jersey state and local public sector employee compliance with the *Hazardous Waste Operations and Emergency Response* regulations. (R-1431)

To the New Jersey Department of Health:

Develop an emphasis program that incorporates enforcement and outreach activities to ensure New Jersey state and local public sector employee compliance with the *Hazardous Waste Operations and Emergency Response* regulations. (R-14-32)

3.2 Previously Issued Recommendations Reiterated in this Report

As a result of this accident investigation, the National Transportation Safety Board reiterates the following previously issued safety recommendations:

To the Federal Railroad Administration:

> Require that safety management systems and the associated key principles (including top-down ownership and policies, analysis of operational incidents and accidents, and continuous evaluation and improvement programs) be incorporated into railroad's risk reduction programs required by Public Law 110-432, Rail Safety Improvement Act of 2008, enacted October 16, 2008. (R-12-03)
>
> Work together to develop regulations requiring that railroads immediately provide to emergency responders accurate, real-time information about the identity and location of all hazardous materials on a train. (R-07-02)

To the Pipeline and Hazardous Materials Safety Administration:

> Work together to develop regulations requiring that railroads immediately provide to emergency responders accurate, real-time information about the identity and location of all hazardous materials on a train. (R-07-04)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

CHRISTOPHER A. HART
Acting Chairman

ROBERT L. SUMWALT
Member

MARK R. ROSEKIND
Member

EARL F. WEENER
Member

Adopted: July 29, 2014

Acting Chairman Hart and Member Sumwalt filed the following statements.

Board Member Statements

Acting Chairman Christopher A. Hart filed the following concurring statement on August 5, 2014.

In concurring with this report, I would like to add that this accident is a wake-up call regarding how to ensure that our nation's emergency responders are up to the very difficult challenges that they might encounter. Two issues became apparent from this accident that warrant further attention.

First, what is the best way for the emergency response community to prepare for potentially catastrophic events that are infrequent nationwide, and that at any given location may not occur more than once, if that often, in the entire career of the emergency responders at that location?

Second, given the large percentage of volunteer firefighters in our nation's firefighting forces, how can volunteer firefighters obtain the training they need to do their jobs adequately without being required to have so much training that people who have full-time jobs will choose not to be a volunteer firefighter because the training requirements are more than they can reasonably handle?

Rare Catastrophic Events. With respect to potentially catastrophic events that are rare, the fact that they occur rarely usually means that (a) training resources are probably not focused on them but are instead focused on events that occur more frequently, and hence (b) the emergency responders are not usually as prepared for those events as they are for events that occur more frequently. The result is that the likelihood of mistakes and poor decisions by emergency responders is generally greater for rare events than for frequently occurring events.

Given that it is generally desirable to focus resources and training largely on more frequently occurring events, so that emergency responders will be well prepared to handle what they most often see, what is the most effective way for us, as a nation—not just the emergency response community—to address this issue of how to prioritize resources as between events that occur frequently and events that are rare?

With respect to training regarding hazardous materials, for example, query whether general hazmat training is necessary, or could the training in a given community be more efficient by focusing primarily on the hazardous materials that go through that community without using scarce resources to prepare for hazardous materials that probably will not pass through. To the extent that hazmat-specific training is the most effective course of action, this report includes an important recommendation to the Department of Transportation:

> Require railroads transporting hazardous materials through communities to provide emergency responders and local and state emergency planning committees with current commodity flow data and assist with development of emergency operations and response plans.

This recommendation applies to railroads because this accident was a railroad accident, but I hope the Department of Transportation will take a more global approach to help ensure that communities are adequately aware of hazardous materials going through their communities by any mode.

In this regard, I would note that the Department of Transportation recently issued an Emergency Order that requires railroads to notify states through which large quantities of Bakken crude oil will be transported. This Order is a step in the right direction, but it applies only to Bakken crude oil and then only in very large quantities, i.e., it would not have affected the outcome in Paulsboro. Clearly, further action is needed to make the coverage more complete.

I hope that this accident will be a wake-up call to address this issue. If the International Association of Fire Chiefs has not already begun to do so, it might be an appropriate organization to lead a collaborative effort that includes all who have a “dog in the fight” to explore the most effective ways of being prepared to respond to rare but potentially catastrophic events.

Training of Volunteer Firefighters. Finding time for training is a major problem for volunteer firefighters. Many parts of the country, especially more rural areas, are struggling to recruit and maintain volunteer firefighters, due in part to increasing training requirements and other time demands. These demands are becoming greater as firefighting operations have become more sophisticated and complex. This is largely due to increased safety precautions, more complex technology, and departments taking on more responsibilities, such as EMS.

The time required to become and remain a competent firefighter can deter volunteers. Although the opportunities for on-line training are increasing, much of the training must be done in person in order to be effective. Query how many choose not to volunteer simply because they cannot reasonably handle these time requirements. The challenge may be even greater in rural areas where there may be additional travel time due to the lack of local training opportunities. Moreover, given that many of the requisite skills must be practiced in order to be retained, query how many more choose not to volunteer because they do not have time to remain proficient. Proficiency is obviously important because firefighting, including the type of hazmat response that occurred in this accident, can be a very unforgiving activity. Again, this is probably a greater challenge in smaller departments whose call volume is relatively small.

Hazardous materials incidents may present different challenges than other types of responses because the initial priority may not be mitigating the incident—putting out the fire—but rather identifying the problem and taking protective measures. Often, small departments will call in outside resources, either a regional hazmat team or private industry, to do the mitigation. It isn’t necessary for everyone on a hazmat scene to be a hazmat expert, but it is necessary for everyone to understand the basic principles of controlling the scene, identifying the hazards and risks, and calling for help.

I hope that this accident will also be a wake-up call regarding this issue. If it has not already begun to do so, the National Volunteer Fire Council might be an appropriate organization to explore the issue of how to assure adequate training while not unduly deterring people from volunteering.

As with most of the accidents that we investigate, the lessons learned present opportunities for improvement, and I hope that the relevant organizations will take advantage of these opportunities.

Members Sumwalt, Rosekind, and Weener joined in this statement.

Member Robert L. Sumwalt filed the following concurring statement on July 31, 2014.

The purpose of an accident investigation is to learn from the event so future events can be prevented, or in the case of emergency response, so that lessons can be learned to improve the quality of future response efforts. This concurring statement puts a fine point on some inadequacies that the investigation identified related to the emergency response. Yes, it is a harsh message for those who were involved, but the intent of the statement—and the entire report, for that matter—is not to assign blame or fault, but instead to learn so that improvements can be made.

There are dozens of rail accidents each year that result in hazardous material (HAZMAT) release. This accident at Paulsboro stands out, however, because of the poorly executed emergency response.

Just as the citizens of communities expect and count on an effective emergency response when disasters occur, the very men and women putting their lives on the line as first responders count on prudent, informed decision-making by their incident commanders. While the decision to not evacuate nearby Paulsboro residents can be somewhat explained by logistical concerns and uncertainty, what is indefensible are the decisions, actions, and inactions that placed first responders directly in harm's way.

The probable cause, as unanimously determined by the Board, stated that, "contributing to the consequences of the accident was the failure of the incident commander to implement established hazardous materials response protocols for worker protection and community exposure to the vinyl chloride release."

In making that determination, one must consider the responsibility of an incident commander. Federal hazardous waste operations and emergency response (HAZWOPER) standards dictate that an incident commander identify all involved hazardous substances, perform a site hazard assessment, implement appropriate emergency operations, and assure that appropriate personal protective equipment (PPE) is used.

The investigation revealed that this responsibility was not fulfilled. For example, guidance that was readily available in the emergency responder's "bible," the DOT *Emergency Response Guidebook*, was not followed. The *Guidebook* stated that an evacuation within a 1/2-mile radius should be considered. Furthermore, self-contained breathing apparatus should be used by emergency responders. Despite the availability of such information, the initial incident command post was established only about 50 yards from the ruptured tank car. Instead of wearing protective clothing and equipment and keeping citizens away, responders and a resident stood nearby without such clothing and equipment, as shown in figure 11 of the report.

For nearly 6 hours, despite the availability of air monitoring data, the incident commander did not relocate the incident command post, and did not establish PPE requirements for those at the accident scene. After the urging of others experienced with air quality readings and HAZMAT response, the incident command post was relocated. However, this new location was only about 1/4 mile from the ruptured tank car—a distance that still posed unacceptable risk because the responders were not wearing protective clothing and equipment.

Finally, about 7 hours after the accident, the incident command post was again moved—this time to a safe distance from the ruptured tank car. Throughout the incident, the emergency operations were not conducted in accordance with federal HAZWOPER standards.

It is perplexing why, despite federal requirements to do so, a trained incident commander would not take seriously the guidance and precautions provided in the *Guidebook*, written information in the train's consist, and verbal information provided by outside HAZMAT and air quality specialists. Because of this lack of attention to critically important information, the emergency responders were placed at unncessary and unacceptable risk: nearly a quarter of these 91 responders sought medical care with symptoms of acute vinyl chloride exposure.

The above puts a fine point on failures of the incident commander, but there were systemic weaknesses, as well. The investigation revealed that these weaknesses permeated throughout the local and state emergency response system.

For example, at the local level, the community of Paulsboro did not adequately assess the emergency response needs of the community by considering the amount of, and type of, HAZMAT that transited the community on a regular basis. Furthermore, even though town leaders were advised that the emergency plan needed to be updated in 2010, this was not done. By the time the accident occurred, the plan was 2 years out of date—important contact names, phone numbers, and other vital information were incorrect.

At the state level, the New Jersey Emergency Operations Plan review did not ensure that the Paulsboro's emergency plan was adequate, considering the nature of the HAZMAT that was routinely transported through the community. Additionally, with respect to the leadership of the Paulsboro event, at least, it is fair to say that the New Jersey HAZMAT certification and training requirements were ineffective; this training is intended to teach acceptable methods of dealing with emergency situations, and this transfer of learning apparently did not occur.

State and local entities were not alone in their mistakes, however. The Board found that Conrail did not perform an adequate HAZMAT route risk assessment, considering factors such as the characteristics of the movable bridge, the population density, and the emergency response capability of Paulsboro. Additionally, Conrail personnel did not provide the consist information to emergency responders in a timely manner. This information could have assisted with a safer, faster response to the accident. Furthermore, Conrail's public awareness program was ineffective. A more comprehensive public awareness program would have better prepared the community to safely and effectively respond to the release.

I hope the findings of this report can become lessons learned for emergency responders and communities throughout the country. After all, a saying attributed to several is certainly true in this case: "Learn from the mistakes of others. You can't live long enough to make them all yourself."

4 Appendixes

4.1 Appendix A–Investigation and Hearing

The National Transportation Safety Board (NTSB) was notified on November 30, 2012, of the derailment of the Consolidated Rail Corporation (Conrail) freight train FC4230 near milepost 13.7 on the Conrail Penns Grove Secondary Subdivision in Paulsboro, New Jersey. Four tank cars derailed on the bridge and came to rest partially in Mantua Creek. Three of the derailed tank cars contained vinyl chloride and one contained ethanol. The NTSB launched an investigator-in-charge and 10 other investigative team members from its headquarters in Washington, DC and regional offices. Then-Chairman Deborah A.P. Hersman was the NTSB Board Member on scene. Thirteen staff members from NTSB headquarters also launched to this investigation.

Parties to the investigation included the Federal Railroad Administration; Consolidated Rail Corporation; the Brotherhood of Locomotive Engineers and Trainmen; the International Association of Sheet Metal, Air, Rail and Transportation Workers; Trinity Rail; and the state of New Jersey Offices of Emergency Management and Environmental Protection.

An en banc investigative hearing for this accident investigation was held at the NTSB headquarters on July 9–10, 2013. This hearing addressed four major issues: (1) Conrail bridge operations, (2) initial emergency response, (3) hazardous materials incident management, and (4) state and federal emergency response actions. The parties to the hearing were Consolidated Rail Corporation; the US Coast Guard, the Federal Railroad Administration; the Pipeline and Hazardous Materials Safety Administration; the borough of Paulsboro, New Jersey; the state of New Jersey; the Brotherhood of Locomotive Engineers and Trainmen; and the International Association of Sheet Metal, Air, Rail and Transportation Workers. The transcript of the hearing proceeding is available in the public docket.

4.2 Appendix B–Timeline of Selected Emergency Response Events

The following timeline is from the Gloucester County Emergency Response Center. Its time stamp was not synchronized with the global positioning system (GPS)-corrected locomotive event recorder, which indicated that the derailment occurred at 7:02 a.m.

Time	Event	Source
7:01	Initial call to Gloucester County Emergency Response Center (GC) reporting train derailment into the water at Paulsboro moveable bridge. Caller (wife of deputy fire chief of Paulsboro) reports: "…smoke's everywhere." Deputy fire chief reports, "Train is spewing out all kind of gas…Tank car leaking something into the water."	Gloucester County 911 Call
7:01	Initial call for train into the water.	Paulsboro Police computer aided dispatch (CAD)
7:02	Deputy fire chief (1702) recorded on location.	Gloucester County 911 Call
7:02	Call dispatched to Paulsboro units.	Paulsboro Police CAD
7:03	Tank car leaking.	Paulsboro Police CAD
7:04	Second calls reporting train accident.	Paulsboro Police CAD
7:05	First police officer on location–verified derailment.	Paulsboro Police CAD
7:05	Fire station dispatched.	Fire Dept./Emergency Medical Services (EMS) CAD
7:05	Deputy fire chief reported: "Four tank cars in water leaking/three box cars/bridge collapsed." He continued to report that "tank cars have been pierced and have leaked out all of their contents into the creek. The creek is full of vapors from these cars."	Channel 3 Fire ops
7:06	Police officer 218 reports, "It's a major emergency. Bridge collapsed and major hazards. Potentially life threatening."	District 2 (Police) radio transmissions
7:06	Officer reporting release of unknown substance.	Paulsboro Police CAD
7:06	Police officer 218 reports,"I have an odor out here that I am not familiar with. This odor is hazardous…hazard released." Dispatcher asked "how close is it to the schools?" He responds, "about 1/2 mile or 1/3 mile."	District 2 (Police) radio transmissions
7:06	Deputy fire chief requests a representative from Conrail to the site.	Channel 3 Fire ops
7:06	Deputy fire chief requested a wind direction report from Gloucester County dispatch. Dispatch responded: "we're getting a wind direction for you."	Channel 3 Fire ops
7:07	Dispatch asks police officer 206 if he can get DOT placards. Police officer 206 reports on location.	District 2 (Police) radio transmissions
7:07	Dispatcher reports to fire chief (1701): "1702 reports four tank cars in the water leaking/three boxcars of the track end/bridge has collapsed."	Channel 3 Fire ops
7:07	He requested that Conrail be contacted. Dispatch reports that they are contacting them now.	Channel 3 Fire ops
7:07	Fire chief (1701) requesting "CBRNE to start off here with the consist." He requested Paulsboro Refining Hazmat response as well.	Fire Dept/EMS CAD
7:08	FD deputy chief on location, chief incident commander responding.	Fire Dept/EMS CAD
7:08	811 calls to 218 and reports that he has a gentleman stating that he believes that propane has released. He saw the fog of propane while coming over the bridge.	District 2 (Police) radio transmissions
7:08	1702 reports that "there are at least four tank cars in the creek—tank cars they have all been broken wide open.…am trying to get a read on what is in them."	Channel 3 Fire ops

Time	Event	Source
7:09	County dispatch reports to chief and deputy fire chief that the National Weather Service is reporting "light and calm surface winds that are vertical. West to Southwest."	Channel 3 Fire ops
7:09	1702 reports to the county that he can see with his binoculars placard 1086.	Fire Dept/EMS CAD
7:09	1730 confirms heavy cloud over top of the water.	District 2 (Police) radio transmissions
7:10	Conrail has been notified.	Channel 3 Fire ops
7:11	Police say at least one propane tank leaking.	Fire Dept/EMS CAD
7:11	Officer 206 reports, "there is a lot of thick smoke coming from the creek area…" He states, "car 8 may be something to worry about."	District 2 (Police) radio transmissions
7:12	Officer 218 reports placards "1987 ethanol alcohol and 1086 vinyl chloride."	District 2 (Police) radio transmissions
7:14	Contact schools: close schools and guardian angels.	District 2 (Police) radio transmissions
7:15	Officer 218 reports "liquefied petroleum gas."	District 2 (Police) radio transmissions
7:17	1701 requests to be recorded on location. He also states that NJ DOT "whoever is next…the state."	Channel 3 Fire ops
7:18	Chief (incident commander) states, "bring the rescue, bring the...the engine and bring some warm stuff it's mighty chilly out here." "And my estimates for Emergency Management Coordinator we have, one, two, three, four, or seven cars possibly overturned and derailed." Communication likely with Emergency Management Coordinator.	Channel 3 Fire ops
7:19	Contact NJ DOT, Fire chief on location.	Fire Dept/EMS CAD
7:19	Chief (incident commander) reports to Gloucester County dispatch: "Command post will be set up at 230 West...East Jefferson Street. We have an open area field maybe 50 yards from the initial car overturned with the way it's punctured..." He instructed to have the apparatus come down East Jefferson Street.	Channel 3 Fire ops
7:19	Dispatch repeats the command post location and apparatus movement instructions.	Channel 3 Fire ops
7:20	Command post at 230 E. Jefferson.	Fire Dept/EMS CAD
7:22	County CBRNE notified.	Fire Dept/EMS CAD
7:25	1701 requests that county contact the Coast Guard and other notifications needed. 1701 states, "we are getting some information feedback now that a couple of these tanks have bad stuff...we just can't get the placards."	Channel 3 Fire Ops
7:26	Dispatch asks officer 206 if the evacuation is going to be mandatory or a lockdown on residents. He responds, "mandatory for at least 3 blocks."	District 2 (Police) radio transmissions
7:26	Paulsboro High School notified to shut down.	Paulsboro Police CAD
7:27	Dispatch asks 206, "where are we housing them?" He responds, "Paulsboro Fire Hall."	District 2 (Police) radio transmissions
7:27	Contact Coast Guard—tidal water, also information other materials may be in cars.	Fire Dept/EMS CAD
7:27	Attempted to notify Billingsport School, their school message stated school was closed.	Paulsboro Police CAD
7:28	Paulsboro Refining Company HAZMAT team reported on location.	District 2 (Police) radio transmissions
7:29	Officer 205 reports, "be advised...it's not that toxic…stay in the house with the windows closed is their best bet for now."	District 2 (Police) radio transmissions
7:29	Officer 217 reports that the procedure now is to tell people to stay in their homes with the windows shut.	District 2 (Police) radio transmissions
7:29	Fire chief (incident commander) reports to Gloucester County: "We have the conductor...looks like we have five cars of vinyl chloride. Can you give me a quick synopsis on the hazards I have with vinyl chloride?" Repeated message, "We have the train conductor here with his sheets and he's confirmed the cars have vinyl chloride." Dispatcher, "five cars vinyl chloride—stand by."	Channel 3 Fire ops

Time	Event	Source
7:29	Dispatcher reports, "vinyl chloride: it says handle with care, can cause reproductive damage, contact can severely irritate and burn eyes, cause eye damage. Irritate in terms of skin, contact with liquid can cause frostbite, irritate nose, throat, lungs, cause coughing, wheezing, shortness of breath, also cause headache, nausea, vomiting, dizziness, fatigue, weakness, confusion. Also can cause you to pass out and damage liver, nervous systems and lungs. Highly flammable reactive chemical and is a dangerous fire and explosion hazard..." (Chief "Do we have the reactivity in water?" "Sir, do you have a fax available where we can fax this to you?"	Channel 3 Fire ops
7:30	Chief (incident commander): "we don't have a fax right now, can you scan it? I have Paulsboro Refining Company on location now." Dispatcher: "we have six pages, we're checking through it."	Channel 3 Fire ops
7:30	Attempted to notify Loudenslager School, their message stated school was closed.	Paulsboro Police CAD
7:30	Officer 205 reports to 218, "the fog we have is a nontoxic…the chlorine cars…the most dangerous are 27 cars back." He reports that they will be moved out of the way.	District 2 (Police) radio transmissions
7:32	Paulsboro Refinery HAZMAT team on scene.	Fire Dept/EMS CAD
7:33	Officer 206 reports to County that the vapor is nontoxic and people should shelter in place.	District 2 (Police) radio transmissions
7:37	Gloucester County to Mantua Creek Command. "Your command post is still at 230 E. Jefferson, correct?" Mantua Creek Command, "that's affirmative."	Channel 3 Fire ops
7:38	Gloucester County reports water reaction information to the incident commander. He acknowledges receipt.	Channel 3 Fire ops
7:39	Billingsport School notified to shut down.	Paulsboro Police CAD
7:40	New Jersey Regional Operations Intelligence Center (NJROIC) message: reporting that Gloucester County HAZMAT unit is responding to Paulsboro train derailment. Initial information that several tanker cars containing unidentified chemicals have derailed into Mantua Creek. No request for additional assets at this time.	NJDEP 0001
7:40	1702 to 1701, "We got two railroad workers on the bridge at this time confirming what is in the other cars. I'll let you know." The chief acknowledges message.	Channel 3 Fire ops
7:40	Loudenslager School notified to shut down.	Paulsboro Police CAD
7:41	Gloucester County asks the chief, "Trying to find out from you if the Mantua Creek marine terminal would be a safe location for the basic life support units...for the people?"	Channel 3 Fire ops
7:41	Chief states, "EMS units should be staged at my fire station (primary staging), the secondary staging should be Paulsboro Plaza, the immediate staging should be at my location (the command center) at this time."	Channel 3 Fire ops
7:41	Police chief and Captain notified and responding.	Paulsboro Police CAD
7:42	Gloucester County informed chief that there are 18 patients at Paulsboro Marine Terminal. Attempting to know if it is a safe zone for basic life support units to go. The chief replies, "negative—get them out of there."	Channel 3 Fire ops
7:42	Notifying businesses on Broad Street and Delaware Avenue.	Paulsboro Police CAD
7:44	Gloucester County reports to IC, "Coast Guard is responding."	Channel 3 Fire ops
7:44	Request that Conrail be contacted for shipping papers.	Fire Dept/EMS CAD
7:45	Incident Commander reports to Gloucester County, "contact Conrail and tell them we need the consist…shipping papers."	Channel 3 Fire ops
7:47	Incident Command request Gloucester County to contact Conrail to request representative come to the location.	Channel 3 Fire ops
7:49	CBRNE 1 responding to Fire Academy.	Channel 55 Fire ops
7:49	Conrail HAZMAT contacted.	Fire Dept/EMS CAD

Time	Event	Source
7:48	EM6 requests Gloucester County to contact Solvay, Moonstar, Gloucester County utilities - in the wind direction.	Channel 3 Fire ops
7:53	Per PD, sheltering in place.	Fire Dept/EMS CAD
7:55	Conrail faxing weigh bills.	Fire Dept/EMS CAD
8:00	Police captain: “202 reports to county dispatch that ICP will be fire hall.”	District 2 (Police) radio transmissions
8:00	Gloucester County reports Conrail faxing weigh bills.	Channel 3 Fire ops
8:01	EPA Region 2 situation unit message to Region 2 Emergency Response List: Area is considered Coast Guard response jurisdiction; however, the evacuation zone includes EPA response areas. Total of seven cars derailed with four of them impacting waters of Mantua Creek. At least one has been breached and efforts are under way by Conrail to secure the car and scene. Reports of locals experiencing adverse health effects (nausea and irritation of eyes, nose, and throat), have sent 18 people to area hospitals. Media outlets show dense vapor cloud in the area. EPA personnel, along with Coast Guard and NJDEP are enroute.	NJDEP 0017
8:03	Officer 205 reports that he is at the forward command post with the fire chief, Conrail, and DHS.	District 2 (Police) radio transmissions
8:04	Call to 205 that “cloud is coming toward us…do we need to be concerned?” “Stay in your cars, you'll be fine. It will irritate your eyes and noses. Stay with the windows closed, you should be okay.”	District 2 (Police) radio transmissions
8:15	NJ ROIC Message: NJ State Police Emergency Response Bureau - south personnel will be deployed to this event. There are no evacuations at this time. Local residents are being advised to remain indoors. Approximately seven train cars derailed, three of which contain vinyl chloride, which is leaking. No requests for additional assets at this time.	NJDEP 0002
8:20	GC requests ICP number because Coast Guard wants to contact incident commander.	Channel 3 Fire ops
8:22	Officer reports to 205, “...Moved from Commerce down to Delaware due to the cloud.…”	District 2 (Police) radio transmissions
8:24	EPA Region 2 Situation Unit message to Region 2 Emergency Response List: At approximately 7:45, the EPA Regional Emergency Operations Center received notification of a rail bridge collapse in Paulsboro over Mantua Creek. Five rail cars have fallen into the creek, with one known tank holding vinyl chloride compromised. Residents located within a 1/2-mile radius are being evacuated. EPA has deployed emergency resources to the area, including on-scene coordinators (OSC) and Emergency Response Team air monitoring support. EPA will meet with NJDEP and Coast Guard responders that are currently en route.	NJDEP 0009
8:28	Command post at St. James Church at Commerce and Jefferson Street.	Fire Dept/EMS CAD
8:33	Paulsboro Refining Company HAZMAT Team arrive on location (corner of Jefferson and Commerce Street), cannot zero equip., obtain high level alarms, informs incident commander of high levels. Levels recorded were 631 ppm, 694 ppm, and 760 ppm of volatile organic compounds (VOC).	Paulsboro Refining Company Mutual Aid Summary
8:34	New Jersey State Police Office of Emergency Management on location.	Officer Richards interview
8:39	Operations (1702) to incident commander: “Everything has lifted….We have a lot better visual of everything now.”	Channel 3 Fire ops
8:40	Paulsboro Refining Company HAZMAT Team leaves incident and goes west (to Delaware and Billings Street) to zero instruments.	Paulsboro Refining Company Mutual Aid Summary
8:40	NJDEP first responder arrived and began coordinating with fire department personnel.	NJDEP 1298
8:42	Delaware Valley Early Warning System reported a water quality event from collapse of rail bridge over Mantua Creek with several rail cars in creek. At least one tank car holding 1086 vinyl chloride has been compromised.	NJDEP 0003

Time	Event	Source
8:44	Paulsboro Refining Company HAZMAT Team: Shortly after zeroing equipment, obtain readings >100 ppm near Heritages. Readings were 193 ppm at Delaware and Billings Rd.	Paulsboro Refining Company Mutual Aid Summary
8:46	Indiscernible – then, "If I understand correctly, you are going to move." Incident Commander says, "Stand by on that...The readings themselves are changing down here...we may not be moving."	Channel 3 Fire ops
8:47	GC to incident commander, "Where are you moving your command post to…last I have is the St. James Church." IC says, "We are staying at St. James for now." He says secondary command post will be borough hall.	Channel 3 Fire ops
8:48	DHS Current Situation Report: As many as seven CSX freight cars derailed and overturned after a rail bridge crossing Mantua Creek collapsed in Paulsboro. CSX reported one tank car leaking unknown amount of vinyl chloride. Onlookers reported seeing vapor cloud rise from the scene. Coast Guard and Gloucester County Emergency Response, including HAZMAT, are on scene and ordered residents to shelter in place. A 1/2-mile radius evacuation zone was also issued for local residents. Paulsboro High School has been on lock down since 7:15. Eighteen residents report possible effects from the spill and have been placed in a staging area for decontamination.	NJDEP 0081
8:50	CBRNE to GC, "Have supervisor repeat message..." "County EMS is refusing to go into the hot zone to treat the patients...until they have been deconed. I have life support 100 enroute to survey these patients." EMS is staged at the fire academy. I have decon 10 rerouted to your location."	Channel 3 Fire ops
8:51	Officer 217 reports that she has someone from the EPA at the Fire Hall.	District 2 (Police) radio transmissions
8:55	Paulsboro Refining Company HAZMAT Team (incident monitoring) moves northwest out of high readings zone [from Delaware and Roosevelt up to Delaware in front of Paulsboro High School].	Paulsboro Refining Company Mutual Aid Summary
8:59	NJ DEP e-mail regarding developing HAZMAT situation. "Train derailment has caused chemical spill in Mantua Creek. Trenton dispatch called to send our officers out, but I'm not sending anyone until the trained professionals have reported the area to be safe. Individuals on scene (TV news coverage) aren't in HAZMAT suits."	NJDEP 0011
9:00	Message from NJ Regional Operations Intelligence Center to NJ Office of Homeland Security and Preparedness (NJOHSP), NJDEP, and DHS, "Conrail is on scene, train has chlorine but those cars are intact. There is a spill into Mantua Creek that is vinyl chloride, which is a flammable gas that is not toxic by inhalation."	NJDEP 0004
9:08	Coast Guard at ICP.	Officer Richards interview
9:08	Paulsboro police chief arrived.	Officer Richards interview
9:10	New Jersey Department of Environmental Protection (DEP) on location.	Officer Richards interview
9:15	NJDEP e-mail response to 8:59 a.m. e-mail directing: "have someone go to command post only if it is upwind."	NJDEP 0011
9:16	Inquiry to dispatch about location of ICP. Dispatch reports that it is at fire hall.	District 2 (Police) radio transmissions
9:19	NJ ROIC is reporting that New Jersey State Police (NJSP) Hazardous Materials Response Unit personnel will be deployed to this event.	NJDEP 0012
9:20	Any resident who would like to return to their residence can, but they should shelter in place. If they do not feel comfortable, they can continue to the fire house.	District 2 (Police) radio transmissions
9:23	Police captain advised residents can return to their property and shelter in place. "If they don't feel comfortable, they can continue to the fire house. Red Cross will be on location."	Paulsboro Police CAD
9:25	Train was separated at Paradise Road.	Paulsboro Police CAD

Time	Event	Source
9:31	"Poly Vinyl (former name of Oxy Vinyls, shipper of vinyl chloride tank cars) is on location...they have a couple of meters that can meter the chemical and they also have the MSDS sheets." They will be coming up with two techs. "Confirm forward command post is still Commerce and Jefferson. Correct?" Incident commander states, "That is affirmative."	Channel 3 Fire ops
9:33	Oxy Vinyls, LP (shipper of the vinyl chloride tank cars) on scene with two meters. Deployed to forward ICP.	Fire Dept/EMS CAD
9:35	Meeting at church with all representatives.	Interview statements (Dolgos, Richards, and Richter)
9:55	Paulsboro Refining Company HAZMAT Team returns to the incident location (Conrail shack north side of railroad tracks – west side of Mantua Creek) and records 10 ppm VOC.	Paulsboro Refining Company Mutual Aid Summary
10:18	Notified by NTSB, investigation team en route.	Paulsboro Police CAD
10:19	Police captain advised students and faculty can go home. Chief spoke to school superintendent.	Paulsboro Police CAD
10:36	Donna Leusner NJDOH message to NJ DEP and DOH regarding short-term health effects of vinyl chloride. DOH is sending a member of its Consumer, Environmental and Occupational Health Service to the scene to meet with the health inspector.	NJDEP 0049
10:36	Message from NJDEP regarding early assessment of Paulsboro train derailment. Message includes: "one car fully in the water containing vinyl chloride, car did leak but the chemical has dissipated, three other cars carrying vinyl chloride – none believed to be leaking." "We believe there are minimal health and environmental impacts at this time. Wind was blowing towards the river and an open/marshy area. Bridge is adjacent to a residential area. Twenty-two people taken to the hospital with respiratory issues. Air monitors are set up – Air levels appear to be safe. DEP is also monitoring the air. Gloucester County Office of Emergency Management (OEM) is coordinating and led briefing.	NJDEP 0084
10:41	NJDEP, message to deputy advisor to the commissioner NJDEP, "We're monitoring the Paulsboro vinyl chloride spill. This is dangerous material and we will not be responding until the area is secure. There appears to be only one compromised tank....The event is more of a human health/inhalation problem."	NJDEP 0091
10:46	Incident commander: "We are moving operations to Borough Hall which will probably be a better spot because it's a 1/2-mile evacuation area and when they start the lifting of these tanks that are full, we are not going to be in this area."	Channel 3 Fire ops
10:48	Per incident commander – operations and ICP are being moved to Borough Hall on Delaware St. due to hazardous conditions.	Fire Dept/EMS CAD
10:53	NJ OHSP, message to DEP – spoke to Paulsboro police chief, four rail cars believed to contain vinyl chloride…there was a small release but the wind shifted to the west and the earlier visible cloud has dissipated. DEP and legions of fire and HAZMAT trucks are on site.	NJDEP 0089
11:09	EPA Region 2 Situation Unit message to Region 2 Emergency Response List: Update #4, EPA OSCs have arrived on scene and are currently assessing the situation with local fire and police, NJDEP, County HAZMAT, Coast Guard, Conrail representatives, and other responders. NJDEP is conducting air monitoring activities. Readings indicate high levels of vinyl chloride over 1/2 mile away from the derailment scene. EPA is assisting in determining a location for establishment of the ICP given the readings...A vapor cloud is present at the location of the derailment, near the end of East Jefferson Street in Paulsboro.	NJDEP 0092

Time	Event	Source
12:39	Message from Delaware Valley Early Warning System to NJDEP: the status of this water quality event has been changed to resolved at 12:35 p.m. Vinyl chloride car was compromised releasing 180,000 pounds of material into the atmosphere. Miller Environmental was on location placing booms in Mantua Creek.	NJDEP 0108
12:52	NJ ROIC Update #3: as of 12:19 p.m. Residents within 1/2 mile were advised via reverse 911 to shelter in place. Three schools in Paulsboro closed for the day. Up to 18 people at a marine terminal reported symptoms and were transported to Underwood Memorial Hospital. Up to 20 others reportedly taken to Kennedy Health System. Respiratory problems reported in nearby communities, but plans for wider evacuations were unclear. Emergency crews staged at Gloucester County Fire Academy. Gloucester County HAZMAT team and PRC Refinery were metering and monitoring the site.	NJDEP 0117
13:00	CTEH monitoring teams arrive and begin air monitoring.	
14:10	The Coast Guard captain-of-the-port, Sector Delaware Bay, is now the incident commander and the ICP has been moved to Gloucester County Fire Training Academy.	NJDEP 0137
14:30	NJSP reports elevated readings above 1 ppm for vinyl chloride in the area of the incident. Paulsboro OEM will declare a local state of emergency with evacuation order for 40–45 residents and an 8:00 p.m. curfew for Paulsboro residents.	NDEP 0140
16:13	HAZMAT team monitoring on self-contained breathing apparatus. 17 ppm readings.	Fire Dept/EMS CAD
16:31	1721 has deck gun in service on the rail car.	Fire Dept/EMS CAD
17:15	Commerce Street evacuated from Broad Street to Railroad, one block radius. Residents either went to neighbors or to fire hall.	Paulsboro Police CAD
17:17	One block area, Commerce Street, Broad Street to area of railroad tracks evacuated.	Fire Dept/EMS CAD
18:00	6:00 p.m. briefing: Based on air monitoring, decision made by unified command to expand the evacuation to a 12-block area is being executed. This will be approximately 500 residences within Paulsboro.	NJDEP 0218
18:50	Police chief advised they will be making mandatory evacuations from Commerce to Delaware Street from the railroad tracks to Broad Street.	Paulsboro Police CAD
19:10	Air sampling is picking up increased readings of vinyl chloride and a decision has been made to increase the evacuation zone downwind, involving roughly 400 people. The change in readings is due to the sun setting and atmospheric conditions holding vapors in where it is settling in low areas and also penetrating through structures—thus evacuation over shelter.	NJDEP 0182
20:00	Seven refusals to evacuate were documented.	Paulsboro Police CAD
23:28	Approximately 400–500 persons evacuated. Forty families have been taken to 48 hotel rooms at various locations. Both Fire Academy and Regional Ops Center are being used by federal agencies with security provided by sheriff's department.	Fire Dept/EMS CAD

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