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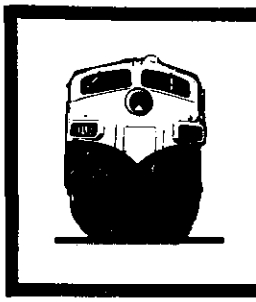
NATIONAL TRANSPORTATION SAFETY BOARD



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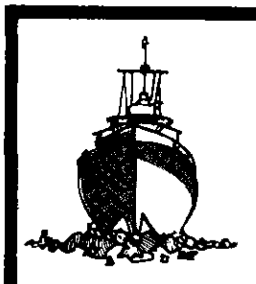
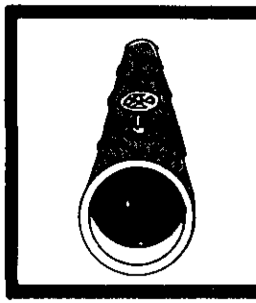


RAILROAD ACCIDENT REPORT

DERAILMENT OF AMTRAK PASSENGER TRAIN NO. 60, THE MONTREALER, ON THE CENTRAL VERMONT RAILWAY NEAR ESSEX JUNCTION, VERMONT JULY 7, 1984



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16. Abstract

About 6:50 a.m, eastern standard time, on July 7, 1984, northbound Amtrak passenger train No. 60, the Montrealer, derailed while passing over a washed-out section of gravel embankment under the main track of the Central Vermont Railway near Essex Junction, Vermont. Two locomotive units and the forward seven cars of the train derailed and were destroyed or heavily damaged. Three passengers and an Amtrak sleeping car attendant were killed; one Central Vermont crewmember died about 3 hours after the accident as a result of injuries sustained in the accident. One Central Vermont crewmember, two Amtrak attendants, and 26 passengers were seriously injured. Damage was estimated at $6,586,312.

The National Transportation Safety Board determines that the probable cause of the accident was a flash flood that destroyed the railroad support embankment over a small stream during a prolonged period of extraordinarily heavy rainfall. The flash flood was precipitated by the heavy rains and the collapse of a series of beaver dams upstream of the embankment in heavily wooded locations that were unknown and were not reasonably detectable.

17. Key Words

Derailment; passenger train; Amtrak; culvert; washout; radio; weather; weather reporting; weather notification

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WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: December 10, 1985

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SYNOPSIS

About 6:50 a.m, eastern standard time, on July 7, 1984, northbound Amtrak passenger train No. 60, the Montrealer, derailed while passing over a washed-out section of gravel embankment under the main track of the Central Vermont Railway near Essex Junction, Vermont. Two locomotive units and the forward seven cars of the train derailed and were destroyed or heavily damaged. Three passengers and an Amtrak sleeping car attendant were killed; one Central Vermont crewmember died about 3 hours after the accident as a result of injuries sustained in the accident. One Central Vermont crewmember, two Amtrak attendants, and 26 passengers were seriously injured. Damage was estimated at $6,586,312.

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INVESTIGATION

The Accident

Amtrak passenger train No. 60, the northbound Montrealer, en route from Washington, D.C., to Montreal, Quebec, departed White River Junction, Vermont, 48 minutes behind schedule at 5:05 a.m. on July 7, 1984. The train was operating over the main line of the Central Vermont Railway (CV), and it consisted of two locomotive units, a baggage car, two sleeping cars, two food service cars, and eight coaches. On board were 277 passengers, 11 Amtrak service employees, and 6 CV train crewmembers.

Train No. 60 made scheduled stops at Montpelier Junction and Waterbury, Vermont, leaving the latter at about 6:18 a.m., 28 minutes behind schedule. At 6:36, the train passed Bolton, Vermont, 78.6 miles north of White River Junction and 15 miles from its next station stop, Essex Junction, Vermont, which it should have reached about 6:52 a.m., 34 minutes behind schedule. At the time, No. 60 was the only train in operation on the CV north of White River Junction. The last train previously operated between Essex Junction and White River Junction was train No. 61, the southbound Montrealer, which passed Bolton at 10:52 p.m., July 6, about 7 hours 44 minutes before train No. 60 reached that location. The same CV train crewmembers operated both trains and they stated that they saw no abnormality in the track during these trips. They also stated that they did not see water laying in fields or low places, flooded streams, or other evidence of high water, although during both trips, they had encountered intermittent rain which had varied from a light drizzle en route to a hard downpour after they arrived at White River Junction with train No. 61. The crew was not informed of heavy rain in the Essex Junction area or cautioned to look out for high water or washouts.

The engineer and the fireman, who was operating train No. 60 as it neared Essex Junction, were in the cab of the lead locomotive unit; the baggagemaster was in the second car of the train; and the conductor and the two brakemen were in the other passenger-carrying cars preparing to disembark passengers at Essex Junction. About 2 1/2 miles south of Essex Junction, the fireman placed the locomotive throttle in the idle position to begin decelerating the train in preparation for making the station stop. Routinely, he intended to begin braking the train at a point about 1.8 miles south of the Essex Junction station. The train was moving about 59 mph as it traversed a 2-degree left-hand curve approaching an embankment over a culvert at milepost 105.97. The locomotive headlight was burning brightly. It was daylight, although overcast and hazy, and there was no significant atmospheric restriction to visibility.

According to the fireman, the track ahead "looked fine, straight and level," as the locomotive exited the curve and entered tangent track approaching the culvert at milepost 105.97. When the locomotive reached a point 200 to 250 feet east of the culvert, the fireman and engineer saw a dark area in the track where they should have seen white ballast stone, and they realized the roadbed under the track was gone. The fireman immediately applied the train brakes in emergency, but the remaining distance was not sufficient to materially reduce the train's speed before the opening was reached. About 80 linear feet of the 20-foot-high embankment had washed out, but the track structure across the opening produced by the washout remained fully intact and taut. Both locomotive units and the first two cars crossed the track over the opening. According to the fireman, the locomotive dropped 3 or 4 feet and then bounced up as though it were on a springboard. The third car, a 30-compartment "slumbercoach," dropped into the opening and came to rest on its side more or less perpendicular to the embankment. Three passengers and an Amtrak attendant in the slumbercoach were killed. A food service car and a coach followed the slumbercoach into the opening, struck the slumbercoach, and came to rest on top of it. (See figure 1.) The rear eight cars stopped short of the opening and remained coupled and in line with the track. The first two cars derailed; the rear six cars did not. (See figure 2.)

Emergency Response

One minute after the train derailed, an unidentified citizen telephoned the Essex Police Department and reported hearing a loud noise and seeing smoke rising from the site. The police dispatched two squad cars to investigate. Shortly afterward, Essex police monitored a citizens band radio report of the derailment, and at 6:59 a.m., dispatched rescue, medical heavy rescue, and fire department units to the scene. The first person to arrive on scene was an emergency control technician employed at the nearby International Business Machines (IBM) plant who was investigating reported road washouts on the plant property. After hearing the Essex police dispatching emergency units on his radio, the technician drove as close to the site as he could and then walked the remaining distance. The technician then made a radio report to the IBM base radio station, which immediately dispatched emergency control and security personnel to the emergency.

Under an area mass casualty plan activated at 8:15 a.m., July 7, 19 fire department units and 19 rescue units responded to the derailment. By 8 a.m., State officials were on the scene to direct the emergency response. At the time, the Vermont National Guard was assembling at the nearby Williston Armory for annual summer maneuvers. Helicopters being readied for flight were diverted to the accident site to transport the critically injured to hospitals. Also, the National Guard provided personnel, bulldozers, cranes, heavy-duty lighting, and other equipment. By 9 a.m., the Vermont State Police had established a command post and were effectively controlling access to

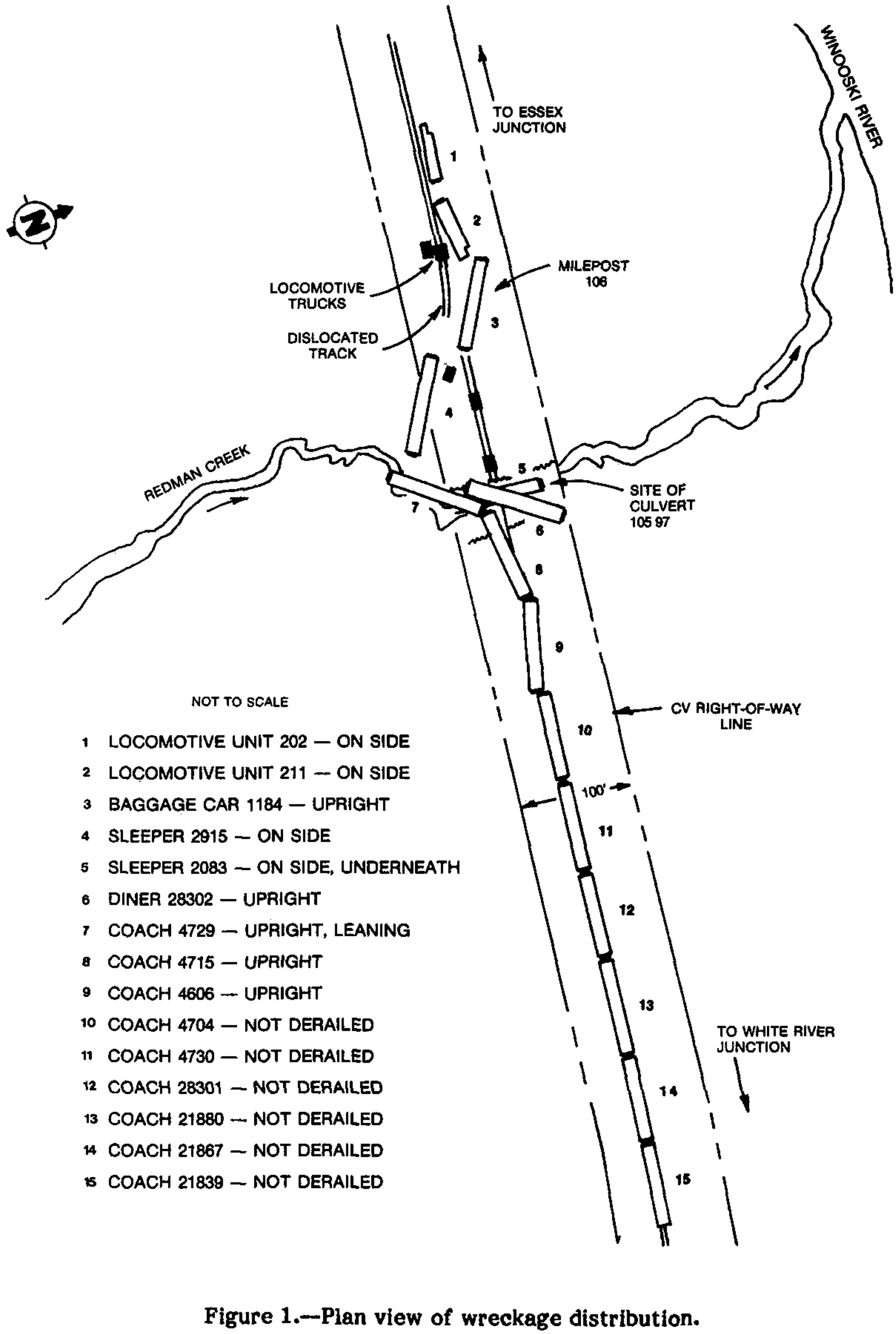

Figure 1.—Plan view of wreckage distribution.

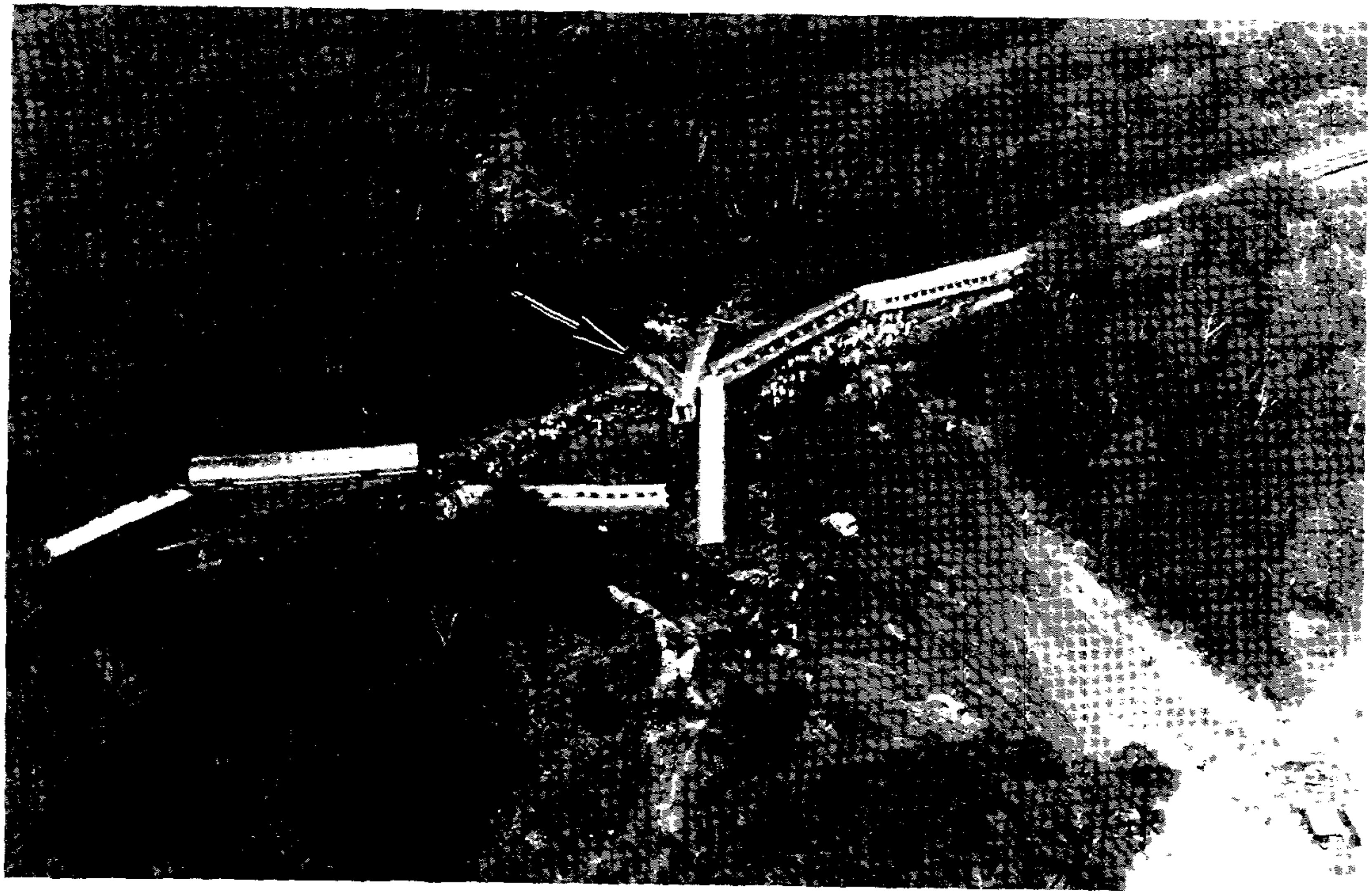

Figure 2.--Aerial view facing north showing the accident site and the wreckage of Amtrak train No. 60. The void in the embankment is in the center of the picture, and the arrow points to the slumbercoach which fell into the void. The access road built to the site is in the lower right part of the photo, and the command post and triage area are in the extreme lower right corner.

the site by way of the landfill road. Only persons and organizations needed at the site were granted access. Vehicles not needed at the site had to be left at the command post; transportation to and from the site was provided by the State Police.

Initial rescue efforts were hampered by a lack of direct access between the landfill road and the accident site. This obstacle was overcome by bulldozing a wide roadway about 450 feet long between the two points. (See figure 1.) All 294 persons aboard the train, were treated at a triage area, which was set up where the new road joined the landfill road; 47 persons received outpatient medical treatment at the IBM plant dispensary. Helicopters used a small open area as a pad and carried the most critically injured to hospitals. The less critically injured were transported in ambulances as they became available. The uninjured were taken to the Williston Armory and from that location they were transported to their destinations in Amtrak-chartered buses. Operations at the triage area continued into the night of July 7-8.

Forward medical rescue and heavy rescue command posts were set up on each side of the opening in the railroad embankment. The medical rescue force concentrated on evacuating the bedroom/roomette car. The heavy rescue operation was mainly devoted to finding and extricating the slumbercoach passengers. Every sleeping compartment in the crushed section had to be breached individually. After the last survivor was extricated, a crane pulled the cars off the slumbercoach. Thereafter, the bodies of the dead were located and removed.

Injuries to Persons

	Passengers	Amtrak Attendants	Train Crew	Total
Fatal	3	1	1*	5
Serious	26	2	1	29
Minor/None	248	8	4	260
Total	277	11	6	294

* The conductor died 3 hours 13 minutes after the accident.

Damage

Both locomotive units were heavily damaged as a result of their being separated from their trucks and overturned. The fuel tanks of both units ruptured and lost their contents, but the fuel did not ignite. The battery cases under the decks of the units were crushed and all auxiliary power was lost. Slumbercoach No. 2915 was crushed and destroyed. The baggage car (No. 1184), a standard roomette/bedroom sleeping car (No. 2083), a food service car (No. 28302), and a coach (No. 4715) had extensive exterior damage; and all of these cars, except the food service car, were determined to be damaged beyond economical repair. The remaining cars in the train sustained some damage, mostly to interior fixtures. (See figure 1.) About 80 feet of embankment, the culvert, and about 300 feet of track were destroyed.

Damage was estimated as follows:

Train Equipment	$6,085,500
Track and Culvert	310,951
Expense of Clearing Wreckage	189,861
Total	$6,586,312

Crewmember Information

The crew of train No. 60 consisted of a conductor, an engineer, a fireman who was fully qualified as an engineer, two brakemen, and a brakeman working as a baggagemaster. All were regularly assigned except an extra brakeman who was added to the regular crew because the train had more than nine cars. The extra brakeman was a promoted conductor. Except for the fireman who had 10 years of service, all the regular crewmembers were veteran employees with service ranging from 34 to 42 years. No member of the train crew had ever been discharged and rehired. All were qualified under the operating rules without restriction and had passed mandatory biennial rules and physical examinations within the 2 years preceding the accident. (See appendix B.)

At the time of the accident, the train crew had been on continuous duty for 2 hours 10 minutes, and on interrupted duty for a total of 5 hours 25 minutes. 1/ They had reported at their home terminal of St. Albans, Vermont, at 9:05 p.m., July 6, and had arrived with train No. 61 at White River Junction at 12:20 a.m., July 7. The crewmembers returned to duty at 4:40 a.m., having spent the intervening time in separate rooms provided for them in a hotel. The surviving crewmembers stated they had slept during that time. All the crewmembers had been off duty for more than 8 hours before reporting for duty on July 6. The fireman stated he had been off duty for 23 hours 25 minutes, during which time he had his normal sleep during the night of July 5-6. After arising on the morning of July 6, he took his wife and children to a zoo near Montreal, returning to his home at 5:30 p.m. After eating supper,the fireman had taken his normal call at 7:15 p.m. to report for duty at 9:05 p.m.

Training

Central Vermont examines its train and engine employees, dispatchers, and operators on the rules and instructions every 2 years. The chief train dispatcher also serves as the rule examiner. His examinations include both oral and written testing, and a passing grade of 80 is required. However, close attention is given to the employees' proficiency in rules and instructions that are critical in the performance of their job. Many train and engine service employees originally worked for CV in the maintenance crafts and were transferred when vacancies occurred. Candidates for the position of locomotive engineer receive extensive formal training at the Canadian National Engineer's School at Gimli, Manitoba, as well as on-the-job training on CV before they are qualified.

CV and Amtrak had conducted a special passenger train emergency orientation course at St. Albans during May 15-17, 1984. The training course was initiated by the CV general manager who became concerned about the preparedness of his train crews and local emergency forces when he read a Safety Board report of the Amtrak onboard train fire at Gibson, California, in 1982. 2/ At his request, Amtrak furnished a training car with instructors, and a 7 1/2-hour course was given to 34 CV conductors, brakemen, and

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1/ 49 CFR 228 permits broken, or interrupted duty by train and engine service employees provided they are given an interim rest period of not less than 4 hours at a designated terminal. The total of the duty periods before and after the rest period may not exceed 12 hours.

2/ Railroad Accident Report--"Fire Onboard Amtrak Passenger Train No. 11, Coast Starlight, Gibson, California, June 23, 1982" (NTSB/RAR-83/03).

supervisors. A 2-hour equipment familiarization and emergency procedures course also was offered to rescue squads and fire departments located along the CV in Vermont. A total of 16 units sent 36 men to attend the course. Seven of these units responded to and were directly involved in the emergency of July 7. The conductor, the extra brakeman, and the baggagemaster of train No. 60 were among the CV employees who took the Amtrak training course. Although the baggagemaster was trapped inside the bedroom/roomette car, he was able to call out and tell rescuers how to remove the car's windows after he heard them vainly attempt to knock them in.

Train Information

The Montrealer operates daily in both directions between Washington, D.C., and Montreal, Quebec. The route used is over Amtrak's Northeast Corridor lines between Washington and Springfield, Massachusetts, 362 miles; Boston & Maine (B&M) lines between Springfield and White River Junction, Vermont, 123 miles; Central Vermont lines between White River Junction and East Alburgh, Vermont, 132 miles; and Canadian National Railway (CNR) lines between East Alburgh and Montreal, 55 miles. The schedules for the 682-mile runs provide for overnight operation in both directions. Amtrak identifies the northbound train as No. 60 and the southbound counterpart as No. 61.

At the time of the accident, train No. 60 consisted of two diesel-electric locomotive units, an unoccupied baggage car, and 12 passenger-carrying cars. The locomotive units weighed about 130 tons each; the cars weighed a total of about 785 tons. The train was 1,220 feet long. Following the change from electric to diesel-electric motive power, an initial terminal air brake test was performed by Amtrak forces at New Haven, Connecticut. The air brake system performed properly when the CV crew made the required intermediate brake test and a running brake test at White River Junction.

The train's locomotive units were General Motors model F40PH single-end type, rated at 3,000 horsepower. The lead unit, Amtrak No. 202, had type 26-L air brake equipment operated in conjunction with dynamic braking by means of a blending valve, a speed indicator, a Barco tape-type speed recorder, overspeed protection at 104 mph, a Vapor Plus I crew alerter, snowplow-type front end pilot, and a 400-watt twin sealed-beam headlight. The unit had 32-cell, 420-ampere-hour batteries in a compartment which hung from the underframe of the carbody, between the front truck and the fuel tank. This is a departure from the practice in North American diesel-electric road freight locomotive design which has the batteries above or in the underframe, but never in an exposed location under the underframe. The batteries were charged by an 18-kw auxiliary generator in the unit. The trailing unit, Amtrak No. 211, was similarly equipped. The battery compartments of both locomotive units were destroyed in the derailment sequence.

Both locomotive units were equipped with removable Motorola Micors 8-channel radios, the standard model used on Amtrak locomotives. Power for operating the radios was supplied by the locomotive storage batteries. The radios were stenciled "014" and were equipped to function only on Conrail frequencies 160.800 and 161.070, used by Amtrak trains operating over the Northeast Corridor lines and over Conrail's line between Philadelphia, Pennsylvania, and Chicago, Illinois.

Central Vermont provides train crews with portable Motorola 5-watt radios for intra-train communications. These radios have a typical transmitting range of 1 to 3 miles with a fully-charged battery under optimum conditions. The conductor, the brakeman, and the baggagemaster of train No. 60 had such radios when they reported for duty at White River Junction on July 7. After the train arrived, they were informed by the Boston & Maine engine crew that the locomotive's radio did not work on the Boston & Maine channels. The CV crew was unable to communicate on the CV's channels when they tried to make the required pre-departure radio test. Before the train left White River Junction, the baggagemaster gave his portable radio to the engineer. En route the conductor communicated with the engine crew to remind them of a slow order, and before making station stops at Montpelier Junction and Waterbury. As far as could be determined, there was no communication between the train crew and the dispatcher before the accident. According to the rear brakeman, he used his portable radio after the accident but received no response to his transmissions.

All the cars in train No. 60 were nominally 85 feet long and had type H "TightLok" couplers. The passenger-carrying cars had self-contained emergency lighting systems and removable emergency windows. The forward nine cars of the train were the regular manifest--one baggage car, two sleeper cars, one diner car, and five coaches.

Although sleeping cars are usually placed at or near the rear end of Amtrak trains, it was the standard practice to place them at the head ends of the Montrealer trains operating in both directions. The second and third cars of the train, behind the baggage car, were a 63-ton, 6-double-bedroom/10-single-roomette sleeping car (No. 2915), and a 69-ton slumbercoach (No. 2083). Both cars had stainless steel bodies. The bedrooms in car No. 2915 were in the trailing end on the north, or right side; the corridor flanking them was on the south side of the car. The roomettes were in the forward half of the car, five to each side of a center corridor. The doors to all the compartments opened to the inside of the compartments. (See figure 3.) According to the train manifest, 7 passengers were assigned to 5 of the 6 bedrooms, and 8 passengers and 2 Amtrak crewmembers were assigned to 9 of the 10 roomettes. The baggagemaster stated that he was riding in the unoccupied roomette at the time of the accident.

Slumbercoach No. 2083 had 24 small, staggered-level, single-occupancy roomettes forward, and 8 double-occupancy roomettes to the rear. Half of each group of roomettes was located on each side of a center corridor. (See figure 3). Fifteen passengers and 5 Amtrak crewmembers were assigned to 20 of the single roomettes, and 11 passengers were assigned to 7 of the 8 double roomettes. Several Amtrak crewmembers who were assigned space in the sleeping cars were on duty in other cars of the train when the accident occurred.

The fourth car, from the head end of the train was a 55-ton, 51-passenger Amdinette food service car of the "Amfleet" design with a stainless steel carbody. The car had a standup food counter and service area in the middle, flanked by passenger compartments: one where table service was provided and which had 19 single fixed seats arranged around 8 small tables, and one for counter patrons that had 8 large tables, each faced by two pairs of transversely-mounted stationary seats.

Behind the forward service car were five rebuilt "Heritage" class coaches, including 2 pairs of 4700-series 68.8-ton stainless steel cars separated by car No. 4606, a 67.3-ton aluminum coach. The 4700-series cars had 12 pairs of double transversely-mounted seats on each side of a center aisle. The seats had high backs and retractable leg rests could be rotated to reverse the direction they faced. All five coaches had lounges at both ends,

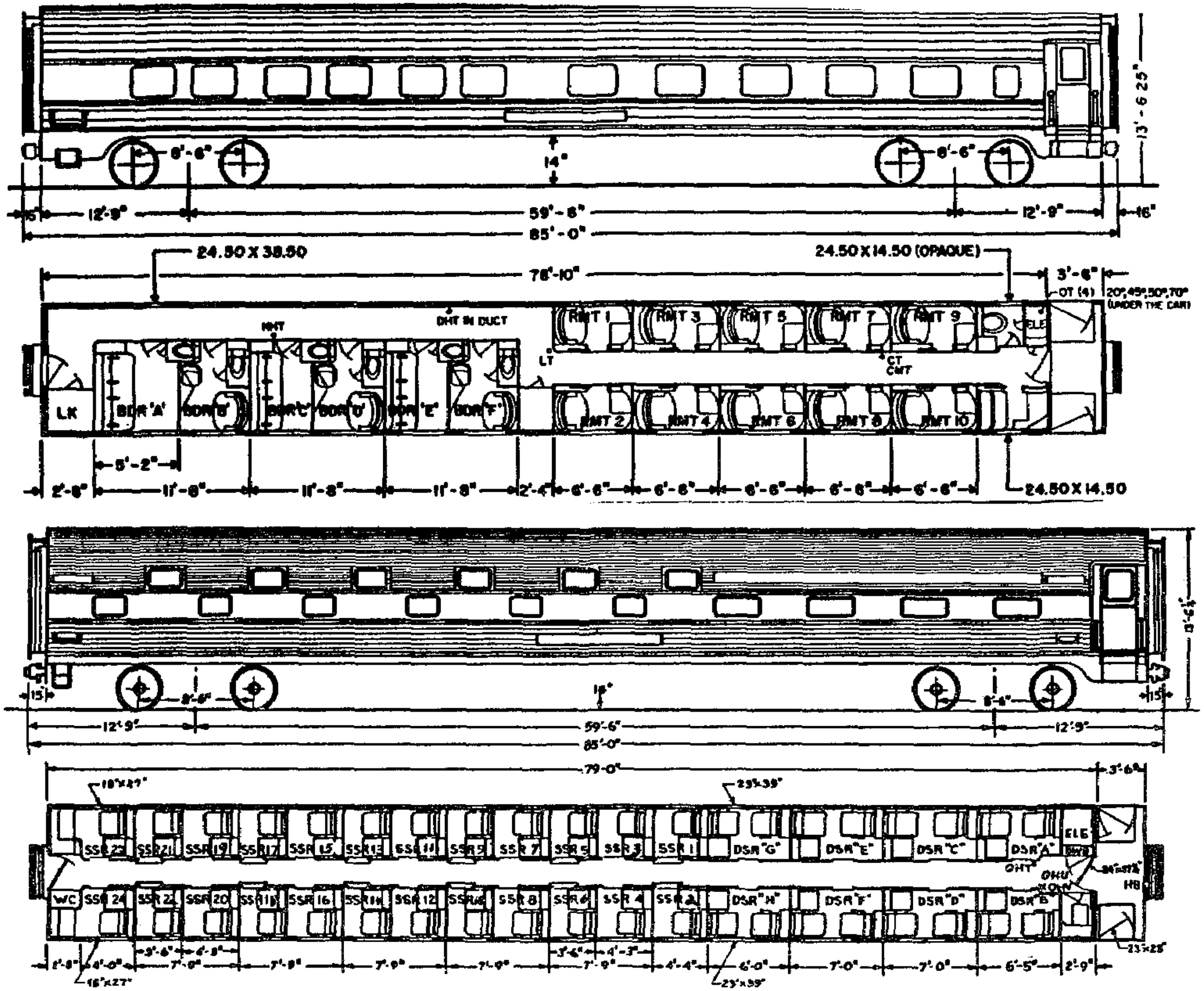

Figure 3.-- Plan view for Amtrak Bedroom/Roomette car No. 2915 (above) and Slumbercoach No. 2083 (below).

overhead luggage racks, and a small luggage storage compartment on one end. Car No. 4606 had 11 pairs of double transversely-mounted seats on each side of an aisle, lounges at both ends, open overhead luggage racks, and two removable emergency windows on each side.

The rear four cars were chartered and occupied by a weekend "Disco" excursion party from Washington. The "Disco" cars, three 64-passenger "Amcoach" cars and a 51-passenger "Amdinette" food service car were of the "Amfleet" design with stainless steel carbodies. The coaches had 16 pairs of high-back reclining seats on each side of a center aisle. The seats had removable cushions and improved seat-locking devices, and they could be rotated to reverse the direction they faced. Luggage was accommodated in open racks above the seats; there were no luggage storage compartments.

Meteorological Information

General.--According to the National Oceanic and Atmospheric Administration (NOAA), the Burlington-Essex Junction area of western Vermont is one of the cloudiest in the U.S., but there is less annual precipitation there and elsewhere in the Lake Champlain Valley than in other areas of Vermont due to the shielding effect of the Adirondack and Green Mountain barriers. 3/ Summer thunderstorms bring the heaviest rainfall to the area, but according to NOAA, excessively heavy rainfall is quite uncommon. The wettest months are June, July, and August; the record mean rainfall for those months being 3.47, 3.61, and 3.48 inches, respectively. The heaviest 24-hour rainfall recorded was 4.49 inches in 1927. This resulted in a "historic flood," according to NOAA.

Total recorded rainfall at Burlington-Essex Junction during 1984 was 35.81 inches, compared with the record mean annual rainfall of 32.97 inches, and 50.16 inches during 1983, the wettest of the past 30 years. July 1984 rainfall totaled 5.11 inches. There was less than half the normal rainfall during June 1984, but on June 6, a series of severe thunderstorms struck the upper Champlain Valley. Burlington was on the fringe of this storm and recorded only 0.09 inch of rainfall for the date. However, very heavy rains struck farther north and caused numerous washouts that closed about 50 miles of the Lamoille Valley Railroad's line. Although the storm system passed across the Central Vermont's main line north of Essex Junction, it caused no damage to it.

Rainfall in the Vicinity of the Accident.--Beginning about 2 p.m., on July 6, the Burlington-Essex Junction area was under the influence of a well-defined weather system associated with a low-pressure cell over eastern Canada, and a cold front extending southwest from the low through the lower Great Lakes and the Ohio Valley. As the cold front advanced eastward, a band of unstable moist tropical air was pumped up from the Gulf of Mexico along the Appalachian Mountains into eastern New York and northern New England. Numerous thunderstorm cells developed along this band moving northeast on a 050-degree heading at an average speed of 40 knots. (See figure 4.) During the afternoon of July 6, one such storm cell formed and intensified over the Adirondack Mountains, crossed Lake Champlain, and struck the Vermont shore about 16 miles southwest of Essex Junction shortly after 6 p.m. Moving on a narrow northeasterly track, the center of the storm passed about 1 mile east of the accident site about 7 p.m. A second cell passed the accident site on about the same track between 9 and 10 p.m. (See figure 5.) Evidence indicates that a third intense storm cell moved on a parallel track 1/2 to 1 mile east of that followed by the earlier storms between midnight and 2 a.m., July 7.

3/ NOAA 1984 Local Climatological Data for Burlington, Vermont; publication ISSN-0198-5302.

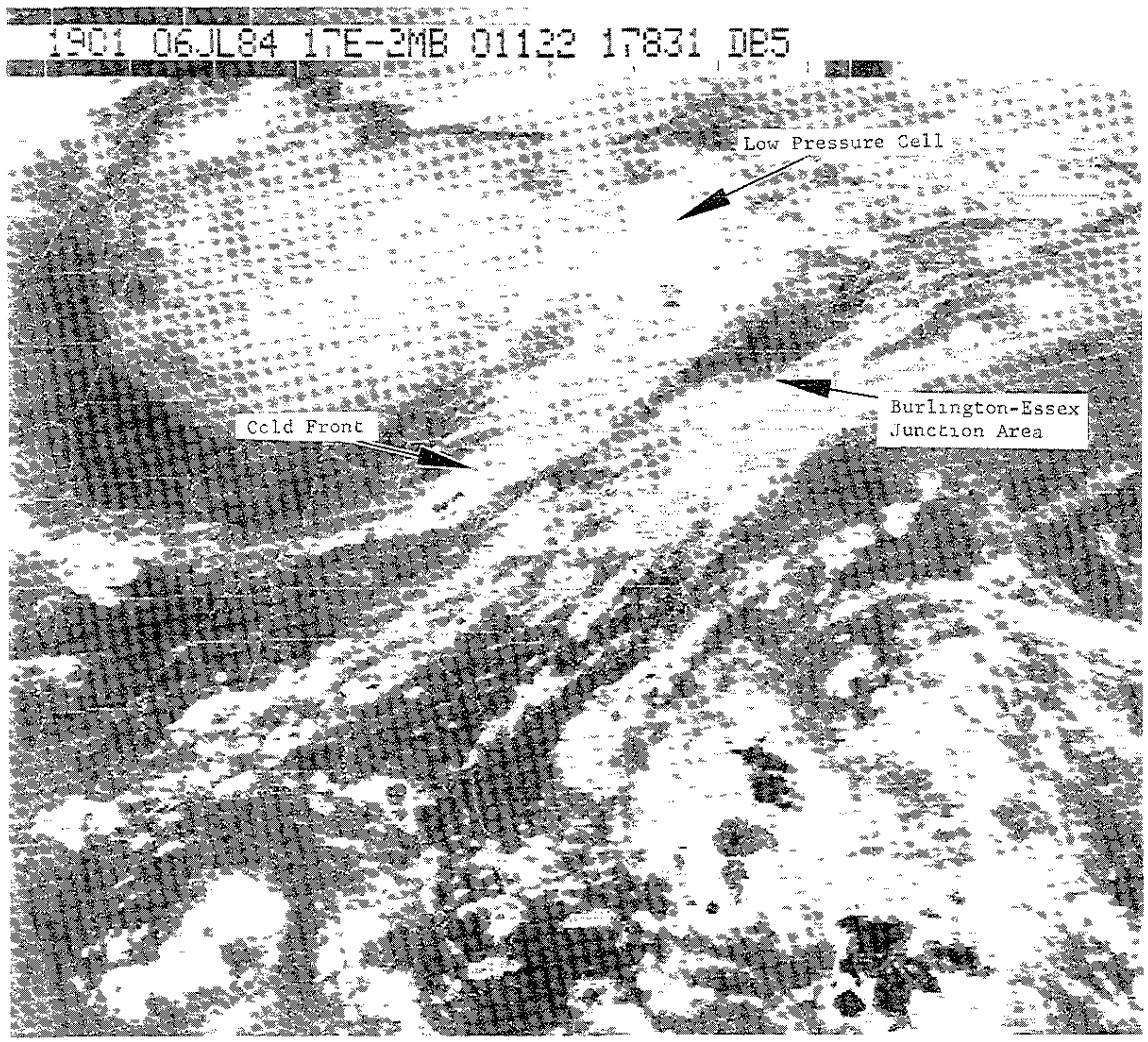

Figure 4.--Infrared weather satellite photo taken at 3:01 p.m., e.d.t. on July 6, 1984.

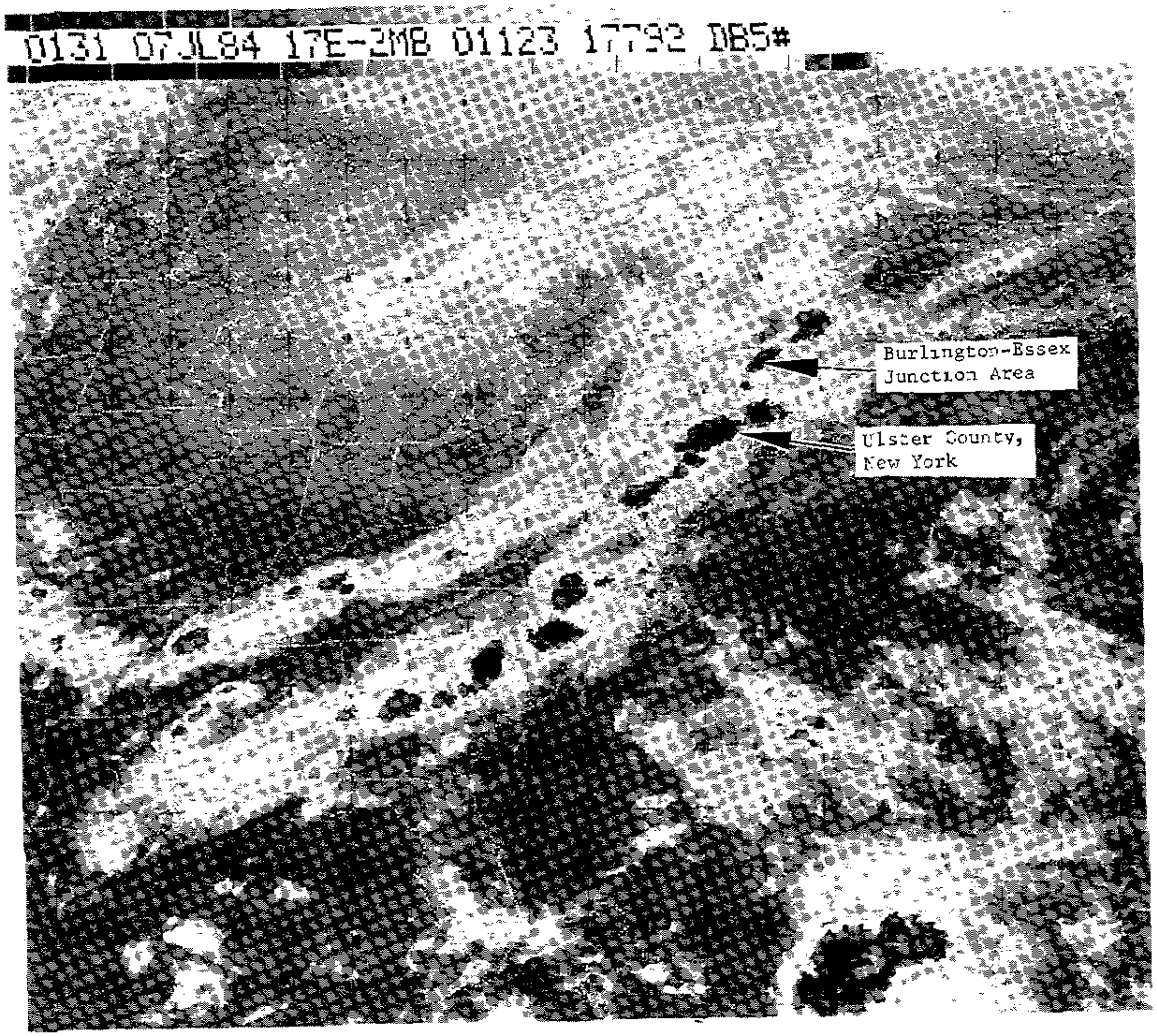

Figure 5.--Infrared weather satellite photo taken at 9:31 p.m, July 6, 1984. The dark areas are convective cells. The cell which dropped 2.67 inches of rain in less than an hour on Ulster County, New York probably struck the area east of Essex Junction, Vermont, about 3 1/2 to 4 hours after this photo was made.

Each thunderstorm resulted in torrential downpours lasting up to an hour or more, and there were light, intermittent showers between these episodes of heavy rain. By 10:30 p.m., highway locations about 3.75 miles southwest, 3 miles northeast, and 7.5 miles northeast of the accident site were reported to be under water. A straight line connecting these locations passes 1 mile east of the accident site, and persons living at 10 locations on or near the line later reported unofficial rainfall measurements of 5 to 7.25 inches overnight. (See figure 6.) Most of these reports were of rain gauge measurements, and, in several cases, the amateur observers had emptied their gauges after the second storm, between 10:30 p.m. and midnight. Three observers reported that their gauges showed no significant rainfall occurring after they were emptied; all were located along the projected track of the first two storms. However, three other observers located on the projected track of the third storm reported heavy rain after midnight, and their gauges indicated rainfall of as much as 2.75 inches after being emptied.

Weather Observation and Forecasting.--Vermont is served by a National Weather Service Forecast Office (NWSFO) at Albany, New York, and by a National Weather Service Office (NWSO) at Burlington International Airport, which is located about 4.5 miles west of the accident site between Burlington and Essex Junction. Burlington NWSO was equipped with a Model WSR-74C local warning radar with a practical range of 125 miles. Characteristically, this equipment's effectiveness within a range of 20 to 25 miles is largely nullified by ground interference, or "clutter." The office provided periodic weather forecasts for Vermont and issued special weather statements and weather warnings as needed. Storm and flood 4/ watches for the area were initiated by Albany NWFSO. Both the Albany and Burlington weather offices had access to the following communications systems to receive and/or disseminate weather information:

> National Oceanic and Atmospheric Administration (NOAA) Weather Radio--A continuous 162.4 Megahertz VHF radio broadcast of local weather information. Before broadcasting most weather watches and warnings, the initiating office activates a 1050-Hz alarm tone that will automatically activate some special receivers tuned to the NOAA weather radio frequency; other receivers will sound the tone but must be manually turned on to receive the broadcast. Neither Amtrak nor Central Vermont had either type of receiver at the time of the accident.
>
> The special weather statements initiated by Burlington NWSO and the flood watch initiated by Albany NWFSO on July 6 and 7 were not preceded by the sounding of the alarm tone. This was in accordance with instructions contained in the National Weather Service (NWS) operations manual. (See appendix E.)
>
> NOAA Weather Wire--A local teletype network over which weather forecasts, observations, watches, and warnings are transmitted. Neither Amtrak nor Central Vermont subscribed to this service. Subscribers in the Burlington-Essex Junction area included newspapers and radio and television stations. The weather wire was reportedly out of service from about 4:30 p.m. to 10:30 p.m. on July 6, 1984.

4/ A condition that occurs when water overflows the natural or artificial confines of a stream or other body of water, or accumulates by drainage over low-lying areas. A flash flood rises and falls quite rapidly with little or no advance warning, usually as a result of intense rainfall over a relatively small area. Other possible causes of flash floods are ice jams and dam failures.

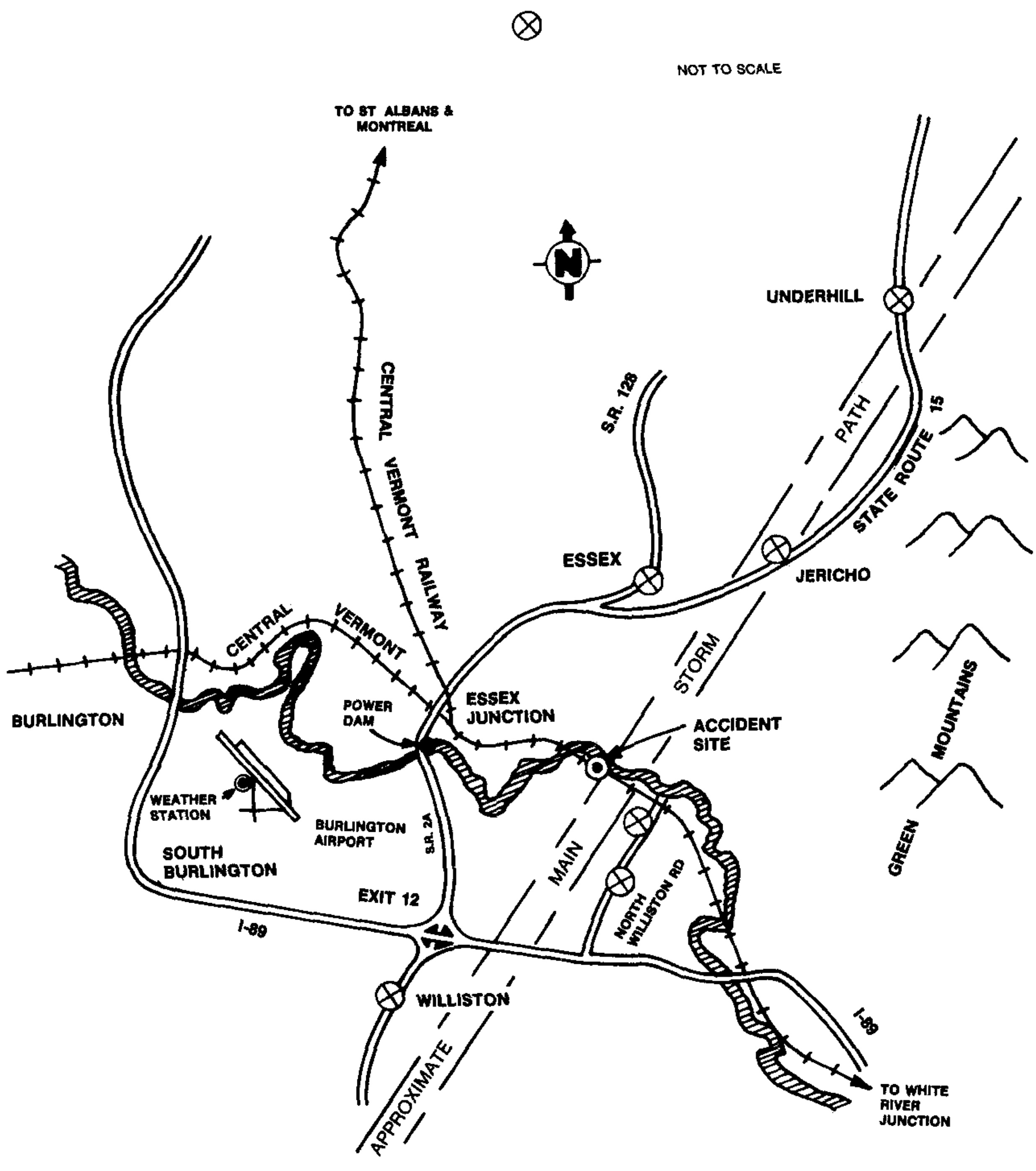

Figure 6.--Plan view of Essex Junction area showing locations where roads were flooded and/or washed-out during the night of July 6-7, 1984.

National Warning System (NAWAS)--A telephone hot line service primarily designed to direct disaster warnings to emergency response and civil defense organizations that, in turn, pass information received from the service to other interested agencies and persons. The Vermont Civil Defense headquarters, Vermont State Police Center at Waterbury, and several police and fire departments in Vermont subscribed to this service. Neither Amtrak nor Central Vermont subscribe to this service.

At 9:20 a.m., July 6, Burlington NWSO issued a forecast calling for a 60 percent chance of afternoon showers and thunderstorms, and showers and thunderstorms, "some heavy," at night. A 60 percent chance of showers and thunderstorms also was forecast for the following day. This forecast was modified at 11:30 a.m., giving showers and thunderstorms "likely by late afternoon," and "showers and thunderstorms tonight, some possibly heavy." The 4:10 p.m. forecast was "warm and humid tonight," with showers, heavy thunderstorms, and winds that "may become quite wild and strong near thunderstorms." No mention of the projected direction and speed of the anticipated storms was made in these forecasts--the only weather advisories issued by Burlington NWSO until 8:27 p.m. In the interim, Albany NWSFO reportedly issued a flood watch 5/ for the Adirondacks at 4:30 p.m. This watch did not include the Lake Champlain Valley or any part of Vermont.

Burlington NWSO was staffed by a meteorologist-in-charge and six weather specialists; normally there is one weather specialist on duty between 4 p.m and 8 a.m. On July 6, 1984, the meteorologist-in-charge worked the 4 p.m. to midnight shift, and then stayed over at the station until 3 a.m. on July 7. After about 10:15 p.m., he was assisted by a weather specialist who was assigned the midnight to 8 a.m. shift, but was called in early by the meteorologist-in-charge. Shortly after he went on duty, the meteorologist-in-charge noted that the radar indicated showers were forming 20 to 40 miles to the south and southwest. Since an inch of rain had fallen the previous day, he was concerned that flooding might occur after the first light showers began to fall at 6:25 p.m. Moderate to heavy showers began at 7:04 p.m., continued to 7:34 p.m., resumed at 9 p.m., and ended at 10:15 p.m. Thereafter, light showers continued until midnight, and the total rainfall measurement was 1.47 inches for the 24-hour period ending at 12:50 a.m., July 7. The official readings during the period rain fell were as follows:

Time Period	Precipitation (in inches)
5:50 to 6:50 p.m.	0.04
6:50 to 7:50 p.m.	0.43
7:50 to 8:50 p.m.	0.18
8:50 to 9:50 p.m.	0.64
9:50 to 10:50 p.m.	0.11
10:50 to 11:50 p.m.	Trace
11:50 p.m. to 12:50 a.m.	0.07
12:50 to 1:50 a.m.	0.08
1:50 to 2:50 a.m.	Trace
2:50 to 3:50 a.m.	Trace
3:50 to 4:50 a.m.	Trace

5/ A weather watch is initiated when a potential threat exits. A weather warning is issued when the threat has materialized, or is imminent, and requires persons in the affected area to take immediate precautions. There is no record of this watch having been initiated, probably because of the breakdown of the NOAA weather wire.

A power company operated a hydro-electric dam on the Winooski River at Essex Junction, about midway between the Burlington Airport and the accident site. (See figure 4.) The dam was attended 24 hours a day and rain gauge dip-stick readings were made and recorded there every 2 hours. A total of 1.80 inches of rain fell at the dam between 6 p.m. and 10 p.m., July 6. There was no measurable rainfall accumulation at the dam between 10 p.m. and 8 a.m., on July 7. The cumulative readings were:

Time of Reading	Precipitation (in inches)
8 p.m.	0.07
10 p.m.	1.80
Midnight	1.80
8 a.m.	1.80

The meteorologist-in-charge at Burlington NWSO stated that he was aware that the power company routinely recorded rainfall at the dam and that he had contacted personnel at the dam for information in the past. However, he did not do so on the night of July 6-7, 1984.

At 8:27 p.m., July 6, Burlington NWSO issued a special weather statement over the NOAA weather radio advising that heavy showers and thunderstorms were moving through northern Vermont and the eastern Adirondacks. The line of storms was described as extending from Sherbrooke, Quebec, southwest to the upper Champlain Valley, including Burlington and surrounding area, with about a half inch of rain already having fallen at Burlington. According to the meteorologist, he was aware that the storms were passing 4 to 5 miles east of Burlington Airport and he continued to monitor the radar in an effort to measure their intensity. However, the close proximity of the storms made this difficult because of ground interference. As a result, the meteorologist telephoned the Vermont Highway Dispatcher and the Vermont Civil Defense Director about 9:30 p.m. to determine the conditions in the storm area. About 10 p.m., he began receiving reports from these sources that water was over roads south of Exit 12 of Interstate 89, southwest of Essex Junction, and State Highway 128, about 3 miles northeast of the accident site. (See figure 6.)

The meteorologist responded to the flooding reports by calling in the weather specialist and by issuing a second special weather statement at 10:15 p.m. The statement advised that heavy showers and thunderstorms were "over the Champlain Valley from Burlington northward to St. Albans, and eastward to include Lamoille and Orleans counties" of Vermont. It was noted that rainfall totaling more than an inch during the evening was common in this area. Additional heavy rain during the night was forecast and persons residing near streams were warned to remain alert and be prepared to move to higher ground. By 11 p.m., the meteorologist had learned that State Highway 15, at a point about 7.5 miles northeast of the accident site, 6/ was flooded and had been closed at 10:30 p.m. (See figure 6.) In response, the meteorologist contacted the forecaster on duty at Albany NWSFO and informed him of this development, the earlier flooding reports, and his concerns about potential flooding.

At 10:20 p.m., Albany NWSFO had issued a flood watch for the Catskill Mountains and the lower Hudson River valley of southeastern New York, and noted that the flood watch for the Adirondacks was still in effect. The forecast called for very heavy

6/ This location, as with the two flooding locations reported earlier and the accident site, was in Chittenden County, which was not mentioned in the 10:15 p.m. advisory.

thunderstorms and reported that "more than 3 inches of rain could fall in a few spots." Residents of flood-prone areas were warned to "keep an eye on the weather" and motorists were alerted to the possibility of flooded roads and washouts. Following his conversation with the Burlington meteorologists, the Albany forecaster at 11:05 p.m. extended the flood watch to cover the Champlain Valley of Vermont and north central and southwest Vermont. At this time, it was noted that 2.67 inches of rain had fallen in less than an hour in Ulster County, New York, and very heavy rains had fallen in parts of western Vermont.

Burlington NWSO issued a forecast at 11:02 p.m., which included the extension of the flood watch to parts of Vermont and, at 11:15 p.m., issued a third special weather statement which warned that heavy rains might bring some stream flooding to parts of Vermont. The statement also reported the closure of State Route 15 and water over State Route 128 in Essex Town. At 11:50 p.m., Burlington NWSO issued a bulletin for immediate broadcast advising that a flood warning expiring at 6 a.m., July 7, was in effect for Chittenden, Franklin, Lamoille, and Orleans counties of Vermont, and that this meant that flooding was imminent. The area under the warning comprised the entire northwestern quarter of Vermont. The warning cited Civil Defense reports of many roads washed out or awash with water in the towns of Essex, Underhill, and Charlotte--all in Chittenden County along the main storm track. The weather office requested that radio and television stations make frequent broadcasts of the bulletin.

The following weather advisories were issued after the 11:50 p.m. flood warning.

1:20 a.m., July 7-	Burlington NWSO; flood warning continued for Chittenden, Franklin, Lamoille, and Orleans counties until 6 a.m. Flood watch in effect for Champlain Valley, southwestern and central Vermont.
3:45 a.m., July 7-	Burlington NWSO; flood warning for Chittenden, Franklin, Lamoille, and Orleans counties in effect to 6:00 a.m.
4:15 a.m., July 7-	Albany, NWSFO; flood watch extended to include the Connecticut River Valley of Vermont. Flood watch continues in effect for remainder of Vermont.
4:30 a.m., July 7-	Burlington NWSO; flood warning for Chittenden, Franklin, Lamoille, and Orleans counties. Flood watch in effect for all Vermont. Showers and a few heavy thunderstorms forecast for today.
6 a.m., July 7-	Burlington NWSO; flood warnings for Chittenden, Franklin, Lamoille, and Orleans counties have been dropped.
6:45 a.m., July 7-	Burlington NWSO; flood watch in effect for all of Vermont today.

The possibility that flash flooding might occur, particularly in the mountains and foothills, was never mentioned in the forecasts or special weather statements. However, the National Weather Service Eastern Region had issued a Regional Operations Manual letter effective April 1, 1984, authorizing the deletion of the word "Flash" when issuing weather watches and warnings in flash flood situations. (See appendix E.)

Track and Culvert Information

The Central Vermont main line at the accident location is single track and is constructed of 100-pound RE section 7/ jointed rail laid in double-shouldered tieplates atop 9- by 7-inch, 8-foot, 6-inch treated crossties. There are two rail-holding and two plate-holding spikes per tieplate. To each 39-foot rail length there are 16 rail anchors; essentially, every third crosstie has anchors bearing on each side. The track is laid in crushed limestone ballast with compacted full tie cribs and shoulder ballast section extending 6 inches beyond the crosstie ends. CV maintains the track to the Federal Railroad Administration (FRA) class 4 standards, although train speeds are voluntarily restricted to those FRA stipulates for class 3 standards because of extensive track curvature. 8/ Inasmuch as there are no block signals on the line, Federal regulations restrict the maximum authorized speed of passenger trains to 59 mph. 9/ At the accident site, the gradient was 0.31 percent ascending northbound, and the track alignment was in a tangent to a point about 400 feet east 10/ where it enters a 2-degree curve about 900 feet long. This is a left-hand curve northbound. East of the curve, the track is in a tangent for approximately 1 mile.

The CV has been in continuous operation since the early 1850's, and although the main line follows a "water level" grade over virtually its entire length, there is no record of any part of it having been flooded since 1927. As the CV traverses Vermont and the Green Mountains from east to west, it closely parallels the White and Winooski Rivers. At the accident site, the track is about 800 feet south of the Winooski River and is elevated about 45 feet above the normal level of the river. An embankment consisting of a relatively uniform cross-section of well-graded gravel carries the track across the sloping terrain. This varies in height from 20 feet at the accident site to about 9 feet at a point 1 mile to the east. The embankment at the accident site was about 60 feet wide at the base and 10 feet wide at track level. The railroad's right of way at this point was 99 feet wide.

The hilly terrain south of the railroad is drained by numerous streams and brooks tributary to the river. These are carried through the railroad embankment by stone box culverts which are as old as the railroad. Four such culverts were found in slightly more than a mile eastward from the accident site. 11/

Location (milepost)	Height (feet)	Width (feet)	Length (feet)
105.97	4	2	60
105.32	2	1.5	75
105.06	5	4	23.25
104.85	3	3	51.5

7/ Rail weighing nominally 100 pounds per linear yard and rolled to a standard recommended by the American Railway Engineering Association.
8/ 49 CFR 213.9 prescribes maximum operating speeds for class 4 track of 80 mph for passenger trains and 60 mph for freight trains. The maximum speeds for class 3 track are 60 mph for passenger and 40 mph for freight trains.
9/ 49 CFR 236.0(c)
10/ Central Vermont's timetable establishes the direction of train movements as north and south. However, a northbound train actually is traveling west at the accident location.
11/ This was relatively representative of the railroad as a whole, there being about 1,300 culverts on the 370-mile main line. According to CV, the only previous washout on the main line in recent history resulted from the blockage of a culvert by a farmer.

The four culverts were of similar construction with stone floors and walls, but lacked headwalls. The roof of the culvert at milepost 105.97 was about 6 feet wide and consisted of pairs of 3- by 2-foot capstones varying from 6 to 13 inches in thickness. It was estimated that a 6-inch thick capstone weighed at least 300 to 400 pounds. After the accident, some of these stones were found 100 feet or farther downstream from the culvert. Only the stones at the culvert's inlet end were still in place.

Central Vermont inspects its main track three times weekly and its culverts annually. The track at the accident site was last inspected on July 6, 1984, the day before the accident, and the culvert at milepost 105.97 was last inspected on June 20, 1984. Neither inspection revealed any defective condition. According to the foreman of the culvert inspection party, the culvert was free flowing and contained no debris at the time of the inspection. In the event of a known condition affecting the culvert or the track, the dispatcher or other official could call for an inspection any time. Such an inspection was not requested before the accident.

Terrain, Stream, and Hydrological Information

The culvert at milepost 105.97 was part of the course of Redman Creek, a small spring-and runoff-fed brook which normally had a depth of 3 to 6 inches at the culvert. The stream dropped 145 feet in elevation in the 4,000 feet from its source to the railroad culvert along a relatively deep and narrow ravine paralleling the railroad. This ravine and most of the remainder of the 348 acres drained by Redman Creek were densely wooded and uninhabited. Most of the watershed area was composed of the north slope of a hill that was 400 feet higher in elevation than the railroad culvert. The slope drained directly to the headwaters of the creek. The only road in the watershed area crossed the creek a short distance above the railroad culvert and provided access to two small cleared landfills located on elevated ground between the railroad and the stream course. One of the landfills was within the watershed area. (See figure 7.)

The upper 1,500 to 2,000 feet of Redman Creek consisted of ponds formed by a series of 11 or 12 beaver dams. The nearest of these ponds was 2,000 to 2,500 feet east of the railroad culvert; the main storm track passed over or was a short distance east of the beaver ponds. The largest pond was about 150 feet wide and, when full, had a maximum depth of about 6 feet. (See figure 8.) Only this pond could be seen from the air; the others were concealed by overhanging trees. According to a hydrologist who surveyed the stream course, at least 150,000 cubic feet of water may have been impounded by the beaver dams. The ponds and dams were discovered 5 days after the accident by investigators documenting evidence of high water along the stream course. The dams appeared to have been recently overtopped and ruptured, and beavers had already repaired most of the damage. The stream banks downstream from the beaver dams were severely eroded. Above the banks, high grass was flattened in a downstream direction, and there was much accumulation of silt and debris from the beaver dams.

The Safety Board's investigation revealed that the existence of the beaver colony on Redman Creek was unknown to CV maintenance forces or even to local residents who trapped beavers. A highly detailed topographical map of the area, prepared from aerial photographs in 1983, showed only the largest beaver pond. Beavers are common in Vermont, and in the past, it had been necessary for CV maintenance forces to destroy beaver dams on streams crossed by the railroad. According to the fireman who was operating train No. 60 at the time of the accident, in 1978, the CV had destroyed a large beaver dam across Redman Creek immediately upstream from the railroad's culvert and had destroyed the beavers to prevent their rebuilding the dam. The dam was on the

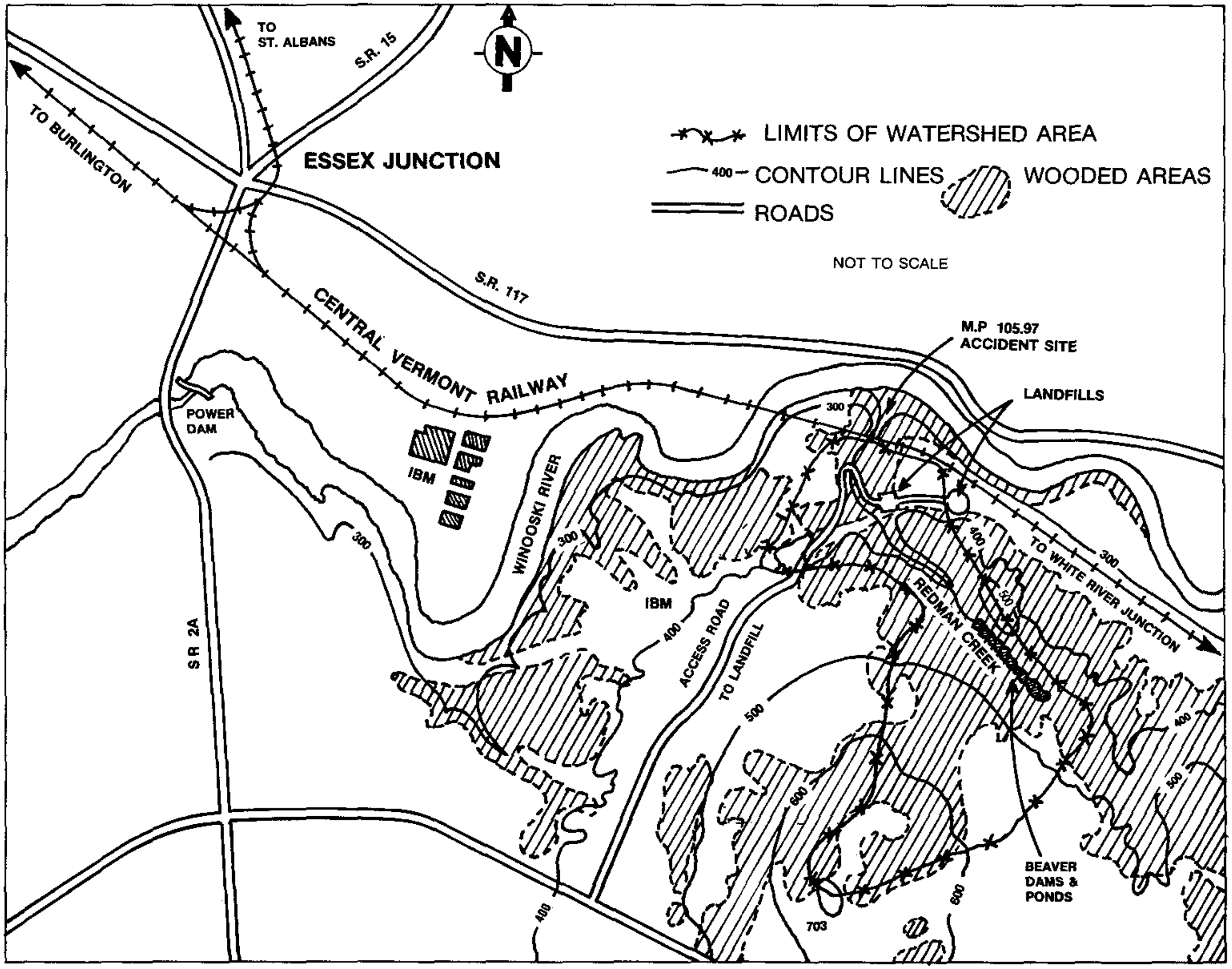

Figure 7.-- Plan view of Redman Creek and its watershed area.

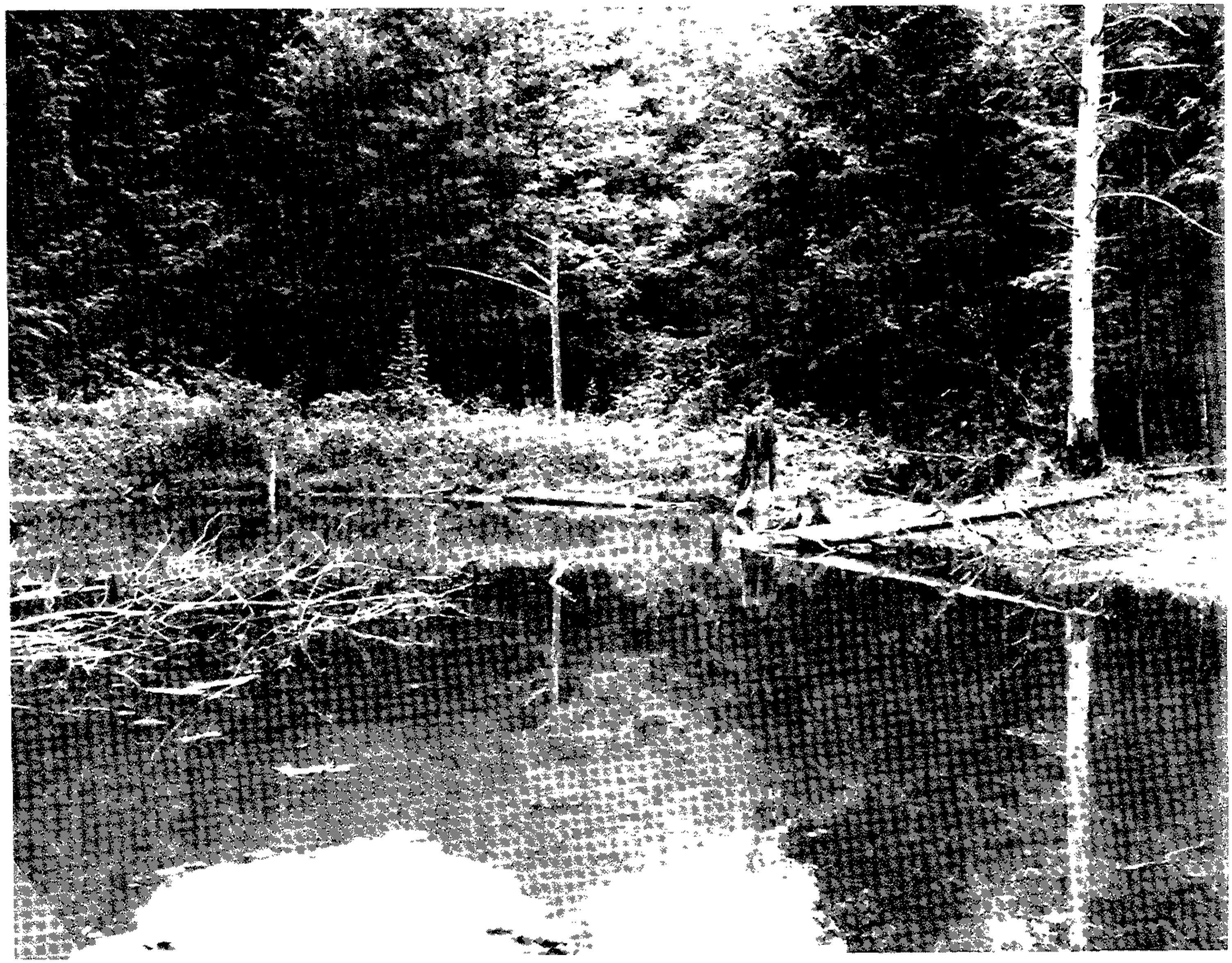

Figure 8.--Partial view of the beaver pond farthest upstream on Redman Creek, looking toward the dam. Blowout hole is at center right. The dam showed evidence that the pond had filled up behind it and had flooded over the top before the blowout.

CV's right of way and a large pond formed behind it. The fireman stated that he had not seen water ponded behind the embankment after the dam was destroyed, and that he was certain water was not there when he passed the location on the southbound Montrealer about 10:30 p.m., on July 6.

Analysis of the soil indicated that the topsoil in the watershed area was a thin layer of porous loam underlaid by dense clay, "almost rock-like in appearance," that had a very low plastic index and was very low in permeability. According to the hydrologist, relatively little precipitation was needed to saturate the topsoil and any additional precipitation or water penetration would run off above the clay subsoil. He calculated a runoff rate at the railroad culvert of 379 cubic feet per second, based on a precipitation rate of 3.8 inches per hour. He estimated that about 682,200 cubic feet of water would have reached the culvert during the first 30 minutes of rainfall at the 3.8-inch rate and that, of this, 216,000 cubic feet would have passed through the culvert in that time, assuming that it was unobstructed 12/ and taking into account an increasing flow rate through the culvert in that time as the upstream head built up behind the culvert. During the same period, seepage through the embankment would be about 22,500 cubic feet.

The high water mark on that part of the embankment which was intact after the accident indicated that the upstream hydraulic head reached a maximum of 10.6 feet above the midpoint of the culvert, and was about 7.4 feet below the top of the embankment. The hydrologist calculated that the maximum retained volume of water behind the embankment was about 632,000 cubic feet, or 188,300 cubic feet more than the 443,700-cubic-foot difference between the calculated total runoff and the culvert outflow combined with seepage through the embankment. According to the hydrologist, this unexplained shortage approximated the volume of water that was released by the ruptured beaver dams.

Under the calculated hydraulic head, the embankment became saturated with seepage in less than an hour, according to the hydrologist, and piping, or soil transport, began causing progressive sloughing of the downstream side of the embankment. The hydrologist stated that when sufficient sloughing had occurred to reduce the embankment to the point where it could no longer resist the hydraulic load of the impounded water, a catastrophic rupture, or "blowout," of the remaining embankment occurred.

Method of Operation

Central Vermont is affiliated with the Grand Trunk Railroad which includes the other lines of the Canadian National Railways system (CNR) in the United States. CV train operations are governed by the Uniform Code of Operating Rules (UCOR) prescribed by the Board of Transport Commissioners for Canada, and CN Rail General Operating Instructions. Trains are operated by timetable, train orders, and operational bulletins. At the time of the accident, CV operated Amtrak trains Nos. 60 and 61, one scheduled through freight train each way daily, and an occasional extra freight train between White River Junction and Essex Junction. Maximum authorized speeds were 59 mph for passenger trains and 40 mph for freight trains.

12/ No evidence of significant culvert blockage was found after the accident. The hydrologist stated that if partial blockage had occurred, it was unlikely that this would have decreased the flow through the culvert by more than 10 to 15 percent.

Night operations on the CV were directed by train dispatchers from an office at St. Albans, 24 miles north of Essex Junction. The third shift dispatcher relieved the second shift dispatcher at 11:59 p.m., July 6 and was on duty until 7:59 a.m., July 6. A CV operator was on duty at White River Junction, and Amtrak ticket agents were on duty at the stations at Essex Junction and Montpelier Junction. At 12:01 a.m., July 7, the third shift dispatcher wrote on his train sheet that it was raining in St. Albans and, on advice from the White River Junction operator, that it was raining at that location. The dispatcher stated that before going to work he had heard on the evening news that there was heavy rain and road washouts at Jericho, Vermont, about 4.7 miles northeast of the derailment site on State Route 15. Two observers at Jericho subsequently reported 5 inches of rainfall overnight. (See appendix D.) According to the dispatcher, he received no reports of unusual or alarming weather conditions during the time he was on duty.

About 6:30 p.m., July 6, a northbound local freight train passed milepost 105.97, and during the next 4 hours was engaged in switching operations in the Essex Junction-Burlington area. A through northbound freight train passed milepost 105.97 about 8:25 p.m., and about 10:35 p.m., Amtrak No. 61 passed the location southbound. The local freight left Essex Junction at 10:45 p.m. and arrived at St. Albans at 11:55 p.m. Neither train crew reported any threatening conditions en route. From 12:20 a.m., when No. 61 reached White River Junction, to 5:05 a.m., when Amtrak No. 60 departed the station, there was no train in operation on the CV north of White River Junction.

Rule 108 in the Uniform Code of Operating Rules states that, "In case of doubt or uncertainty the safe course must be taken." The wording of the rule is identical to that of comparable rules of most North American railroads and dates from the origin of railroad operating rules. According to the fireman of train No. 60, he understood the rule to mean that when threatening weather conditions, high water, or reduced visibility were encountered, he was required to operate his train accordingly without regard to maintaining timetable speeds. Further, he stated that the rule had always been interpreted this way in rules classes he had attended. The fireman's understanding of Rule 108 was the same as that expressed by the rules examiner, general manager, and other officers and employees who were interviewed during the Safety Board's investigation.

Radio is used extensively by CV to transmit train orders, other instructions to train crews, and communication between train crewmembers. Amtrak had six modified Motorola Micors 8-channel locomotive radios that were stenciled "012" and were dedicated to use on train Nos. 60 and 61 between New Haven and Montreal. These radios were fitted to function on two B&M frequencies, four CV/CNR frequencies (161.205, 161.415, 160.935, and 161.025), and two Conrail frequencies (160.800 and 161.070). Base radio stations were located at Essex Junction, White River Junction, and two intermediate locations. The distance between the base stations varies between 25 and 32 miles. The CV/CNR frequencies were channels B1, B2, B3, and B4; the Conrail frequencies were channels A1 and A2. The locomotive radios were maintained and stored when not in use at Amtrak's New Haven facilities. No spare units were kept at Montreal or at any point between New Haven and Montreal. There was no means of talk-testing the B&M and CV/CNR frequencies at the New Haven locomotive facility.

None of the 012 radios were available to replace the 014 radios, which functioned only on Conrail frequencies, on units 202 and 211 when the units were assigned to relieve electric locomotive units on train No. 60 on July 6, 1984. At the time, three 012 radios were in Amtrak's New Haven radio shop; one was repaired and serviceable, and the others needed to be repaired. 13/ Amtrak's motive power dispatcher at Washington gave the New Haven locomotive facility permission to use units 202 and 211 on train No. 60 with the 014 radios, and he subsequently informed the CV dispatcher that this was being done. Testimony at the Safety Board's public hearing into the accident revealed that train Nos. 60 and 61 had been frequently operated without the 012 radios during the 3 months preceding the accident.

On July 20, 1984, CV's general manager notified Amtrak that CV would no longer accept any Amtrak train that did not have a radio on the locomotive which would transmit and receive on the CV/CNR frequencies. In response, Amtrak assigned a spare 012 radio to the CNR Montreal locomotive facility, a procedure was initiated to assure that a serviceable 012 radio was always available for train No. 60 at New Haven, and the New Haven locomotive facility was provided the means of talk-testing the B&M and CV/CNR frequencies on 012 radios.

Also, on July 20, 1984, CV provided its St. Albans dispatcher's office with a weather alert radio receiver to monitor the NOAA weather radio. Subsequently, Amtrak acquired 50 weather alert radio receivers for installation at points on its Northeast Corridor lines and in Michigan. In addition, CV requested that the Vermont Civil Defense and the Vermont State Police Center advise them whenever flooding conditions occurred in areas traversed by the railroad.

On August 11, 1984, a torrential rainstorm struck the Burlington-Essex Junction area with an inch or more of rainfall in half an hour resulting in widespread street flooding. Burlington NWSO broadcast a special weather statement on the storm over the NOAA weather radio but did not activate the alarm tone, and the CV dispatcher was unaware of the storm until informed of it by the State police. Subsequently, CV received two storm warnings over the NOAA weather radio. None of the storms resulted in damage to CV's tracks, but on July 15, 1985, a highly localized downpour at Burlington resulted in a mud slide that blocked the tracks of CV's Essex Junction-Burlington branch line. In this instance, no alarm had been broadcast over the NOAA weather radio, and the CV dispatcher was unaware of the storm. The slide was discovered by a train crew.

Survival Aspects

At the time of the accident, the fireman and engineer remained in their seats as both locomotive units and the first two cars crossed the void at the culvert. The lead locomotive then separated from its trucks, overturned, and came to rest on its right side on the embankment north of the track. As the unit slid along on its side, dirt and gravel was scraped up through the right side cab window, covering the fireman and shoving him backwards. The engineer slid from his seat and fell down in front of the fireman. The fireman remained conscious and remembered noting the time as being 6:50 a.m. According to the fireman, the engineer appeared to be unconscious. When the engineer failed to respond to him, the fireman climbed up out of the cab and set out to get help.

13/ Three radio technicians worked at the New Haven radio shop. One was on vacation and one was on jury duty. The third technician had repaired one radio before leaving to repair a base station, but he did not return the serviceable radio to the locomotive facility before going home. According to Amtrak's manager of radio engineering, the normal procedure was to use radio technicians on overtime if necessary. He stated that there was adequate time to correct the radio deficiency before No. 60's scheduled departure from New Haven.

Once out of the locomotive, he saw no one else moving about, so he ran about a half-mile west on the track, across the Winooski River bridge toward Essex Junction, to the home of an elderly couple who lived near the track west of the bridge. The couple then telephoned the rescue squad and fire department, and the fireman called and informed the dispatcher at St. Albans of the accident. The fireman then returned to the derailment site, where he found that the engineer had regained consciousness and had climbed out of the locomotive unit unassisted.

The conductor, the regular brakeman, and the extra brakeman had been in the forward food service car and, shortly before the derailment, they began to proceed to their respective stations to assist passengers in detraining at the station stop. The conductor, who apparently was passing between food service car No. 28302 and slumbercoach No. 2083 when the train derailed, fell into the void in the embankment; the regular brakeman, who had stopped in the counter section of the food service car to answer a passenger's inquiry, was thrown to the floor and pinned there by part of the service counter; and the extra brakeman, who had been passing between the two lead Heritage coaches (Nos. 4729 and 4715), entered the door of the rearmost car and dropped to the floor. Rapid deceleration caused the extra brakeman to slide along the floor into a wall, but he was unhurt and immediately began using his portable radio in an effort to communicate with other crewmembers. However, he received no response to his repeated transmissions. Coach No. 4729 was essentially upright and coupled to the car behind it, but it was balanced atop the remaining embankment, teetering up and down with the front end hanging out over the opening where the culvert had been. Concerned that the car might tip over, the extra brakeman calmed the passengers in the car and began evacuating them through the rear end door into the next rear car. Eventually, the extra brakeman cleared most of the ambulatory passengers from the cars east of the void to safe ground, and he gathered blankets, window shades, and other items to make the passengers comfortable until help arrived.

Evacuation of bedroom/roomette car No. 2915 proved difficult. The car came to rest on its left side on the south side of the embankment west of the opening. The rear end was at the base of the embankment; the forward end was at the top. The doors of the occupied compartments were closed, and many were jammed making it impossible for the occupants to open them unassisted. The windows of the five roomette compartments on the bottom side were against the embankment, so the occupants of these compartments were trapped and had to be extricated from above. Since the emergency lighting apparatus did not function, these occupants were in total darkness. Most occupants of the topside roomettes were able to evacuate through their window openings after rescuers had removed the windows. Injured occupants of one bedroom had to be rescued through the compartment window; persons in the other bedrooms had to crawl down the narrow corridor to the rear vestibule. Head room was greatly reduced because the car was on its side. (See figure 3.) The baggagemaster and passengers in the bottom side roomettes were evacuated through topside window openings after rescuers forced open their compartment doors and helped them climb out. The baggagemaster stated that upwards of an hour passed before he was evacuated.

Slumbercoach No. 2083 came to rest nearly perpendicular to the track at the bottom of the void. It was tilted to the right with the right side resting against the sloping surface of the remaining embankment west of the old culvert location. The rear of the car was in the stream; the forward end was under diner car No 28302 and lead Heritage coach No. 4729 which had fallen on it. (See figure 2.) The 24 small single roomettes of the slumbercoach were crushed by the impacts. Those on the left side were compressed downward through the corridor and into the right side compartments. Ten surviving occupants were trapped in the small roomettes for as long as 10 hours; some reported that their compartments were so compressed that there was only room for their bodies. They were in total darkness, but could hear the cries of other passengers. Rescuers extricated them by cutting through and jacking apart the wreckage.

Three occupants of single roomettes on the right side of slumbercoach No. 2083 and an Amtrak attendant in the extreme forward end of the corridor were killed. All 12 surviving passengers in single roomettes sustained head, upper torso, and/or arm injuries. Six of these persons were hospitalized. Two passengers in the forward double roomette on the right side also were hospitalized, one with a head injury and the other with a chest injury. Some double roomettes at the rear of the slumbercoach were partly flooded by stream water, but most of this end of the car was relatively undamaged and its occupants were evacuated through the rear end door and waist-deep stream water that had pooled behind the car. Several passengers in the sleeping cars were cut when they were thrown into and shattered the glass mirrors on their compartment bulkheads and doors.

Lead Heritage coach No. 4729 and food service car No. 28302 received severe impacts as they dropped into the opening and struck slumbercoach No. 2083. Both cars remained upright and their occupants ultimately left them through end doors. The rear half of the right side of the Heritage coach was crushed inward as much as a foot as a result of colliding with the food service car during the derailment sequence. Four paired seats in this section were damaged with seat mounts torn loose or tilted inward; 3 of these seat pairs were rotated to some degree as were 16 other seat pairs elsewhere in the car. Postderailment impacts and rapid deceleration caused passengers to be thrown from their seats to the floor, against foot and leg rests, or into the seats in front of them. Several passengers received severe head and facial injuries when thrown into sheetmetal headrest supports that were exposed when the covering cushions came off them. Unrestrained baggage was thrown from overhead racks in this car and others, striking and injuring passengers, and some wall mirrors in the lounges were shattered.

About 20 persons were in forward food service car No. 28301; many were thrown from seated or standing positions by the postderailment impacts. Table tops were detached from their pedestals. Microwave ovens, storage compartment liners, coffee pots, food containers, and other unsecured items in the food dispensing area were thrown about. Some struck and injured passengers and attendants. Much of the debris blocked aisles and impeded rescue and evacuation efforts.

Medical and Pathological Information

The three passengers and the Amtrak attendant were pronounced dead at the scene. Autopsy reports indicated that the passengers, aged 38, 77, and 83, died as a result of (1) chest compression with respiratory restriction, (2) pulmonary edema and contusion due to blunt impact injury to the chest, and (3) skull fracture with multiple visceral and skeletal injuries, respectively. The attendant's cause of death was a brain injury with basilar skull fracture.

The conductor was transported to a Burlington hospital by helicopter and was admitted to surgery; however, he died 3 hours 13 minutes after the accident. Cause of death was pelvic and retroperitoneal hemorrhage due to extensive fractures of the pelvic ring.

Of the 29 persons hospitalized, 19 were treated for injuries to the head, neck, upper arms, shoulders, and chest. Four were hospitalized for foot and leg injuries, 4 for pelvic and abdominal injuries, 1 for spinal injury, and 1 for multiple contusions.

Because there was no indication that the fireman's condition was suspected as being abnormal or causal to the accident, he was not taken into custody or requested to submit to a toxicological examination. According to the fireman, he was aware that crewmember use of alcohol was considered a causal factor in previous train accidents around the country. Hence, he was sensitive to the possibility that it might be thought that he had been similarly impaired, and he insisted that he be tested for blood alcohol. He was taken to a St. Albans hospital where his blood was drawn in the presence of a Vermont State trooper at 11:50 a.m., July 7. The sample was tested by the Vermont State Public Health Laboratory on July 10, 1984, and the analysis report indicates it contained 0.000 percent blood alcohol. No testing was done for drugs. The postmortem toxicological scan of the conductor's blood was negative for ethanol, narcotics, barbiturates, tranquilizers, salicylates, antihistamines, and antidepressants. The investigation did not reveal any indication that any train crewmember was in other than alert and otherwise normal condition before the accident.

Tests and Research

The fireman said that he checked the locomotive speed indicator against the mileposts en route and found that with an indicated speed of 59 mph, it required 64 seconds to cover a mile. Thereafter, he operated the train at an indicated speed of 60 mph to compensate for the discrepancy in the indicator. The speed recorder tape removed from locomotive unit No. 202 after the accident showed a consistent speed of 58 to 59 mph wherever the maximum authorized speed of 59 mph was permitted, including the approach to the accident location. The tape also indicated that a temporary slow order of 40 mph was complied with en route.

After the accident, the speed indicator and recorder were removed from Amtrak locomotive unit No. 202 and calibrated at Amtrak's New Haven locomotive facility in the presence of a Federal Railroad Administration (FRA) inspector. The calibration tests revealed that the indicator was 1 mph slow at 40 mph and 2 mph slow at 80 mph. The recorder registered the correct speeds at 10 and 40 mph; at 80 mph, the recorder registered 80.5 mph.

The radios in the accident locomotive units were inspected and tested under Safety Board supervision at the New Haven radio shop. Both radio units were stenciled "014." After being installed in Amtrak locomotive unit No. 203, the radios transmitted and received normally on frequencies 160.800 and 161.070, channels B1 and B2, respectively.

After CV had repaired the embankment at milepost 105.97 and had restored train service, a Safety Board investigator rode the lead locomotive unit of train No. 61 to establish the range of area illuminated by the locomotive headlight at the culvert. The unit and headlight were of the same types that train No. 61 was equipped with on the night of July 6-7, 1984. The headlight on bright was observed to fully illuminate the sides of the embankment at the culvert, as well as the area at least 150 feet perpendicular to the track south of the embankment.

ANALYSIS

The Weather

The Burlington-Essex Junction area of western Vermont was subjected to a series of intense convective storms with varying amounts of rainfall during a 7- to 8-hour period on the night of July 6-7, 1984. Some localities received as little as an inch, while others reportedly received as much as 8 to 10 inches. The heaviest rainfall apparently fell along a narrow track that crossed the Central Vermont Railway mainline in the Green Mountain foothills, about 4 to 5 miles east of the National Weather Service office at the Burlington Airport. Unofficial observers at locations along the storm track reported rainfall of 5 to 8 inches during three episodes of torrential downpours, each lasting 30 to 90 minutes. Since an inch of rain had fallen in the area the day before, the ground probably was saturated and runoff may have swollen some streams above normal levels before the storms of July 6-7. Under the circumstances, the heavy rains that fell that night could be expected to result in flash-flooding of streams, especially in hilly terrain with relatively impermeable subsoil.

According to the National Weather Service, excessively heavy rainfall is "quite uncommon" in the Burlington-Essex Junction area. During the 100 years that official rainfall records had been kept at Burlington, the heaviest 24-hour rainfall was 4.49 inches in 1927. Hence, the 5 to 8 inches of rain that fell east of Burlington and Essex Junction in 8 hours or less on the night of July 6-7 was completely inconsistent with the norm for the area. In fact, it may have been nearly double the previous record for a 24-hour period. Statistically, there was less than a 1 percent chance of a storm of this intensity occurring at any given location during the course of a year.

The Railroad and the Stream

The Safety Board's investigation developed no indication that the location, construction, and condition of the CV's track, embankment, or culvert were causal factors in this accident. The CV line was well elevated above the Winooski River flood plain, and neither the Burlington-Essex Junction area, in general, nor the accident location, in particular, was prone to flooding. Moreover, the embankment and culvert at milepost 105.97 had proven adequate for more than 130 years. Although an 80-foot section of the track was totally unsupported, it apparently remained taut and straight enough to appear to the fireman and engineer of the Montrealer to be level and in completely normal alignment until they were close enough to see that there was no ballast stone under it. The fact that both 130-ton locomotive units crossed the void before derailing amply supports the crewmembers testimony in this regard. The existence of a signal system would not have prevented the accident, since there was no disturbance to the track that would have caused the shunting necessary to produce restrictive signal indications.

Redman Creek was not a likely location for a flash flood. It was no more than a common spring-fed brook, a few feet wide and only a few inches deep at the railroad culvert. It was short and the wooded watershed it drained was almost entirely in an undisturbed, natural state. Although an IBM plant with a large parking lot had been built near the accident site, it was established that the parking lot was not within the Redman Creek watershed. There had been no significant change in the watershed area that would have materially increased the runoff rate normally imposed on the stream. Typical summer rainstorms in the area probably caused no remarkable increase in the runoff rate because of the retentive nature of the wooded watershed. Under normal rainfall conditions, the series of beaver dams along the upper reaches of Redman Creek also served to impound and regulate the watershed runoff.

The ability of the watershed area to retain rainfall was limited by its relatively shallow topsoil underlaid by a virtually impermeable clay subsoil. Once the topsoil was saturated, any prolonged heavy rainfall would substantially increase the runoff to the stream. Similarly, the beaver dams constituted a serious threat if they failed as a result of extraordinary runoff and released the very substantial volume of water they had the capacity to impound. The resultant flash flood downstream and the substantial head of water it would temporarily create behind the culvert could cause serious damage to the embankment. The potential for such an event was understood by the CV which in 1978 had removed a large beaver dam immediately above the culvert and had destroyed the beavers to prevent them from rebuilding the dam. However, the beaver dams farther upstream were so remote from the CV's right-of-way and were so well-concealed from view that neither the railroad's forces nor the local population were aware of their existence.

According to the train crew, they encountered no heavy rains on the southbound trip of the Montrealer until they reached White River Junction. It is unlikely that they would have failed to see water impounded behind the culvert, or even the stream overflowing its banks when they passed milepost 105.97 about 10:35 p.m. Any serious sloughing of the downstream side of the embankment also should have been obvious to them. Illumination from the locomotive headlight would have revealed all these features had they existed at that time. Inasmuch as the fireman had helped remove the beaver dam in 1978 when he was a maintenance-of-way employee, he was familiar with the locations and would have understood the significance of high water and any visible damage to the embankment. The Safety Board doubts that either the fireman or the engineer would have failed to recognize the threat to the embankment such evidence would indicate, or would have failed to inform the dispatcher of what they had seen.

Based on reports made to Safety Board investigators, it is probable that at least 5 inches of rain had fallen on the Redman Creek watershed by the time the southbound Montrealer reached milepost 105.97. The second and heaviest episode of rain had probably ended 35 to 50 minutes earlier. The heaviest rain of the night measured at the Burlington weather office had ended by 9:50 p.m., and there was no measurable rainfall after 10 p.m. at the Essex Junction power dam. According to the hydrologist, it would have taken only about 30 minutes for 682,000 cubic feet of runoff water to reach the embankment, assuming that 3.8 inches of rain had fallen on the watershed during the preceding hour. The Safety Board believes that the rainfall assumption is not unreasonable; the actual rainfall during that period at least approximated that amount, and may have been greater given the reports and observations of residents along the storm track.

The Safety Board believes that there is very little probability that the culvert was obstructed, at least during the first two episodes of heavy rain. The culvert was clean and unobstructed when it was inspected 2 1/2 weeks before the accident, and there was no debris observed at the still-intact inlet end after the accident. Even with the stream flowing freely through the culvert, it was estimated that less than a third of the calculated runoff could have passed through the culvert. Thus, a very substantial head of water should have been standing behind the embankment when the southbound Montrealer passed over it. Such a head may have built up, but if that was the case, it apparently had completely receded by the time the train arrived for it was not seen by the locomotive crewmembers. Partial saturation may have occurred, but this may not have as yet caused any noticeable sloughing.

Other factors may have delayed or diminished the heavy runoff rate calculated by the hydrologist. These could include a greater actual retention capability of the watershed area, as well as the possibility that the beaver ponds were only partially filled before the storm that occurred between 9 p.m. and 10 p.m. This was particularly likely in the case of the largest and farthest upstream dam which had been abandoned by its builders for some time and was in poor repair. Moreover, the hydrologist's calculations were made on the conservative side; collectively the ponds may have held considerably more than 150,000 cubic feet of water. In any event, all the ponds probably were full by the time the second storm had passed. Some overtopping already was occurring, and the dams were becoming saturated and weakened in the process.

Composed as they were of interlaced cut saplings and twigs bound by dried mud and grasses, the beaver dams probably were very effective in resisting the buildup of water pressure behind them until water began pouring over their tops. Logically, the abandoned dam farthest upstream would have been the first to fail, since it was the weakest and was subject to the greatest pressure. The failure of this dam probably was triggered by the effect of the third storm which dropped 2 to 3 inches of rain on the watershed between 1 a.m. and 2 a.m. on July 7. This downpour may have occurred in less than an hour, and it certainly would have resulted in very rapid runoff from the hill slope to the headwaters of the stream at the abandoned beaver dam. The resultant beaver dam failures probably occurred in a rapid "domino" sequence, creating a flash flood along the narrow ravine downstream. The physical evidence left no doubt that the dams had blown out and that a flash flood had occurred below them.

The third storm may have resulted in some water backing up behind the embankment by the time the flood reached it. Assuming the embankment was already saturated, the flash flood may have resulted in an almost immediate blowout of the embankment. The high-water mark observed on the surviving portions of the embankment was not necessarily an indication that a head of water had stood that high for any appreciable time. It could have been made by a massive wall of water striking the embankment and momentarily rising up the slope.

Weather Forecasting and Reporting

The general weather forecasts issued by Burlington NWSO on the morning and afternoon of July 6 proved to be very accurate. There was nothing particularly unique or ominous in the forecasts; afternoon and evening thunderstorms are frequently forecast and occur commonly in midsummer in Vermont. By the time the meteorologist-in-charge reported on duty at 4:30 p.m., the weather system in advance of a cold front was well-developed and was beginning to produce severe convective storms all along the Appalachian mountain chain. There was a very strong likelihood that such storms would eventually strike western Vermont and that they could be highly localized and severe.

Shortly after going to work, the meteorologist began tracking storm cells approaching the Burlington-Essex Junction area on radar. No record was made of the radar observations then or later, but the meteorologist and the weather specialist he called to duty at about 10:15 p.m. stated that as the cells entered the area within a 20- to 25-mile radius of the weather station, they were no longer identifiable due to the characteristic ground clutter within that area on the radar scope. However, it should have been possible to establish the headings of the most severe cells, so that they could be tracked accurately before and after they had passed through the ground clutter on the radar scope. Continuous monitoring of the radar and keeping a record of the tracks of the most severe storm cells should have established the area where the heaviest rain was falling east of the weather station, in the foothills of the Green Mountains.

More than 4 hours passed between the 4:10 p.m. general weather forecast and the first of several special weather statements issued by Burlington NWSO. Although the meteorologist stated that he was concerned about potential flooding since an inch of rain had fallen the previous day, he did not update the local weather information to reflect the rapid development of adverse weather conditions until 8:27 p.m., well after he had become aware of them. At 4:30 p.m., the Albany weather station had issued a flood watch for the Adirondack Mountains, to the west and southwest of Burlington. Shortly afterward, the Burlington meteorologist observed storm cells developing 20 to 40 miles south and southwest on the radar. The first of these storms reached the Vermont shore 16 miles southwest of Essex Junction at 6 p.m. Rain began falling at the weather station at 6:25 p.m., and a 30-minute episode of heavy rain began there at 7:04 p.m. The second and most prolonged episode of heavy rain began about 9 p.m., and during the next hour the weather station recorded .64 inch of rainfall, bringing the total measurement of rain since the onset of the first downpour to 1.25 inches.

The meteorologist stated that he continuously monitored the radar to establish the intensity of the storm cells and, as a result, he knew that heavy storms were passing 4 to 5 miles east of the weather office. Nevertheless, none of the special weather statements or subsequent flood watch and flood warning broadcasts actually reflected this knowledge or the significance of reports of flooding along what probably was a major storm track. By 10 p.m., the meteorologist had been informed that roads were awash with water east and southeast of Essex Junction along the path of the heavy cells. He knew that the Essex Junction power dam periodically measured rainfall, yet he did not contact the dam personnel who were about midway between the weather station and the flooded roads. Had he done so, he would have learned that more than twice as much rain had fallen at the dam than at the weather station during the second episode of heavy rain.

The 8:27 p.m. special weather statement referred generally to heavy showers moving through the upper Champlain Valley and northern Vermont. The only specific information provided was that about a half inch of rain had fallen at Burlington and more showers were expected. The direction the storms were moving and their probable tracks were not given. The second special weather statement, issued at 10:15 p.m., reported heavy showers north and east from Burlington into the counties to the north. None of the specific information that Burlington NWSO had concerning the line of heavy storms passing to the east and flooded ground conditions was included.

By 11:15 p.m., when a third special weather statement was issued, the meteorologist was aware that Highway 15 had been closed in the foothills northeast of Essex Junction. The location was on the same line as the flood locations reported to him earlier. Although the statement referred to the closing of Highway 15 and to water over the road on Highway 128 in Essex, the significance of these reports and the probability of extraordinary rain along the line that connected these locations was not mentioned. The statement did, however, advise that a flood watch was in effect for this and other parts of Vermont. The 11:10 p.m. flood warning covered the entire northwestern quarter of Vermont, including Chittenden County where the accident occurred. The warning included almost no site-specific information other than general references to flooded and washed-out roads in five townships, three of which were along the principal storm path.

Had the personnel at the Burlington weather station realized the historic magnitude of the rainfall that had been measured along the storm track by the time they issued the flood warning, they probably would have been more site-specific in the warning. It is possible, as well, that they may have been sufficiently alarmed to have issued a flash flood warning instead of a flood warning. Persons along the storm track had, by this time, observed that the rain gauges were full and overflowing, and they knew that a phenomenal weather event had occurred. Yet, none of the observers informed the weather station of the fact, possibly because they did not have access to the weather station's unlisted telephone number.

The NWS office has the responsibility for issuing severe weather information for the State of Vermont and, in the case of flooding conditions, the responsibility often must be met with limited real-time information about conditions throughout the State. The number of rainfall observations obtained after the July 7 accident demonstrates that observations were being made near the derailment site and that many observers would be willing to assist in providing weather information.

The Safety Board believes that the NWS should endeavor to enlist the cooperation of amateur observers to submit observations in a timely manner during periods of severe weather conditions when there is a likelihood of injury to people or damage to property. Through such a system, the NWS office could significantly increase its knowledge of local conditions and improve both the timeliness and accuracy of severe weather condition reports.

Neither the flood watch that was extended to include Vermont, nor the flood warning issued by the Burlington NWSO suggested the possibility of flash flooding. Had a flash flood watch or a flash flood warning been issued, the required sounding of the alarm tone over the NOAA weather radio would have occurred. This also was required in the event a flood warning was broadcast. However, the alarm tone was not to be sounded for a flood watch. NWS instructions indicated that the requirement for sounding the alarm tone was "not applicable" for a flood watch. Further, recent NWS Eastern Region instructions tended to encourage the issuance only of flood watches and flood warnings in flash flood situations.

Because the NWS operations manual does not require the weather radio alert tone to be sounded when special weather statements or a flood watch are broadcast, the alarm tone was not sounded until the 11:50 p.m. flood warning was issued. Unless persons who had the weather radio receivers were continuously monitoring them, they would not have heard the information that was broadcast prior to 11:50 p.m. The value of the weather radio receivers is considerably diminished if the users are not alerted until a very serious weather event is about to occur, or more likely, is occurring. Inasmuch as the local NOAA weather wire was out of service until 10:30 p.m., the media subscribers to the wire apparently missed the early special weather statements. As a result, very little information on the weather situation was available in time for the late news broadcasts. However, if the CV had been aware of the 11:50 p.m. flood warning, it could have inspected the track in the Essex-Junction area.

The Safety Board believes that the Burlington NWSO may have failed to radar-monitor adequately the third storm that moved along the main storm track after midnight, or having monitored it, failed to relate the event to the earlier storms and the effect it would have on streams in the foothills. There was no upgrading of the flood warning to reflect the third storm, and the warning was allowed to expire at 6 a.m., 50 minutes before the derailment. It seems inconceivable that the weathermen would not have been aware of the potential for flash flooding that a third major storm would create after the heavy rains and flooding that had previously occurred in the area, and to which they had become alerted after 10 p.m. by local authorities on July 6.

The decision of the Albany weather office to issue a flood watch instead of a flash flood watch was inconsistent with the reports of 2 to 3 inches of rain falling in less than an hour in mountainous localities. A flash flood could be expected to occur under such circumstances with sudden and far more serious consequences than would occur with the gradual overflow of streams and accumulation of water in low-lying places which the definition of a flood clearly implies. Since the Green Mountains of western Vermont were being subjected to an extension of the weather system affecting the Catskill and Adirondack Mountains of New York, it was probable that they also would receive similarly locally intense rainfall. For this reason, the Safety Board believes the issuance of a flash flood watch and, ultimately, a flash flood warning for the area would have been more suitable and entirely justified.

Operation of the Train

Postaccident examination of the speed recorder tape and calibration of the speed indicator and recorder corroborated the fireman's statement that the indicator registered 1 mph slow at 59 mph, and that he therefore operated the train at an indicated speed of 60 mph to compensate for the discrepancy. The recorder tape indicated train speeds of no more than 59 mph where the maximum authorized speed was permitted, and also that a 40 mph slow order was complied with en route.

According to the fireman, he reduced speed at one location where haze or fog reduced visibility in line with his interpretation of Rule 108 which requires that the safe course be taken in cases of doubt or uncertainty. This interpretation conformed with that espoused by CV management, CV's rules examiner, and other CV employees interviewed by the Safety Board. The Board believes that the fireman would have just as prudently reduced speed approaching milepost 105.97 if he had seen anything out of the ordinary at that location on the southbound run. The train crew was not aware that heavy rain had fallen in the area during the night, and they could not have detected the void in the embankment until their locomotive was too close to it for them to be able to reduce the train's speed. The train's brakes were applied in emergency before the train derailed, an indication that the fireman was alert and was keeping a sharp lookout ahead.

The dispatcher at St. Albans understood that there were heavy rains in the area north of the accident site. However, neither the crew operating the Montrealer trains nor a local freight crew that had left Essex Junction at 10:45 p.m. and had arrived at St. Albans at 11:55 p.m. reported encountering any adverse conditions to him. Had there been a NOAA weather radio receiver in his office, the dispatcher would have been alerted to the flood warning issued by Burlington NWSO at 11:50 p.m. It is unlikely that he would have reacted to such a general warning which applied to the entire northwestern quarter of Vermont since the heavy storm early in June 1984, that had done extensive damage to another railroad in northern Vermont, had caused no damage to the CV main line. In the absence of specific information that would indicate a situation, such as a flash flood that definitely posed a threat to the CV's line, it is not reasonable to expect that the dispatcher would have called someone out on overtime to patrol the track all the way from St. Albans to White River Junction. The Safety Board believes that if the CV had in effect a method of obtaining weather information through contact with local authorities along its routes, the dispatcher may have been alerted to the serious weather occurrences near Essex Junction.

The dispatcher could have contacted Amtrak's Essex Junction ticket agent who would have informed him that heavy rain had fallen there before 10 p.m., but not afterward. Such a report probably would have discouraged the dispatcher from taking further action since the southbound Montrealer had left Essex Junction about 10:30 p.m. and had encountered no heavy rain or any indication of flooding or damage. Even had the dispatcher assumed the worst and had called out a track patrol east of Essex Junction, it is entirely conceivable that such a patrol, if called too early, would have passed milepost 105.97 before the flash flood occurred on Redman Creek.

This accident underscores the inability of today's train dispatchers to obtain detailed and accurate information on local weather conditions that may affect the safety of trains. Radio has made it unnecessary for the CV and other railroads to have a station with operators on duty around the clock in every town along the line. Elsewhere, centralized traffic control and automatic interlocking plants also have helped eliminate most of the manned lineside facilities the railroads once had. System maintenance gangs have replaced the section gangs once headquartered all along the railroads. Even dispatching has been centralized on many large railroad systems. As a result of these changes, the railroads gained many economic benefits, but their dispatchers lost a highly effective means of keeping track of weather conditions along their lines. During the 7 hours preceding the derailment near Essex Junction, the only CV employees on duty on the entire northern half of the railroad were the dispatcher, an operator at White River Junction, and the crew on board the Montrealer. The Safety Board believes that railroads should become more cognizant of this circumstance and take measures to overcome such shortcomings when eliminating agents or employees along their routes.

As demonstrated by the CV's postaccident experience, the NOAA weather radio can be a valuable aid in helping dispatchers learn about severe weather conditions that could affect the safety of trains. It would be of even greater value if the NWS had a more effective information-gathering system and it was NOAA policy to alert radio users when special weather statements and flood watches are broadcast. Subscribing to the weather wire will provide the railroads with a flow of weather data, but the data needs to be more site-specific. And, as also revealed by the Safety Board's investigation of this accident, the wire can become inoperative for long periods during adverse weather. CV's postaccident experience clearly shows that railroad dispatchers need to be notified by local police and civil defense agencies when extraordinary local weather conditions occur.

Personnel in the widely-dispersed NWS offices are bound to be frequently ignorant of highly localized severe weather until long after it has occurred, even when it is relatively nearby as was the case in this accident. In the washout-related Amtrak derailment investigated by the Safety Board near Connellsville, Pennsylvania, on May 29, 1984, 14/ 2.1 inches of rain had fallen in the area resulting in rapid runoff that backed up behind a blocked box culvert. About 60 feet of the Chessie System Railroad's embankment was washed into the Youghiogheny River before Amtrak's Capital Limited reached the location at 6:40 a.m. Although this line had a signal system, the track remained intact and the train was proceeding on clear signal indications. The NWS at Pittsburgh, about 50 miles away, had not issued a flood or flash flood watch or warnings. Forecasts issued during the night were for occasional and light rain.

Amtrak's Locomotive Radios

The accident location was in such a remote location that trees screened it from view in all directions, except along the railroad's right-of-way. It could not even be seen from the landfill access road. Nevertheless, had someone seen the washed-out embankment during the brief period of daylight and reported the fact to the CV dispatcher, there was little chance that the dispatcher could have contacted and warned the train crew. There were no open stations and there were no signals that could be set to stop the train. Only radio could be used to contact the crew, and the radios on the

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locomotive units were not equipped to operate on CV's frequencies. The train crew had small 5-watt portable radios with an effective range of 1 to 3 miles under optimum conditions, but the radios were not likely to receive a transmission unless they were close to one of the base stations, which were 25 miles or more apart. A measure of the ineffectiveness of the portable radios as replacements for the long-range radios on the locomotive units was the failure of the dispatcher to hear the extra brakeman's repeated calls for help over his portable radio, although the brakeman was about 2 miles away from the base station at Essex Junction. Fortunately, a citizen alerted the Essex Police almost immediately after the derailment and the rescue effort was not delayed.

Train No. 60 did not have a locomotive radio which would transmit and receive over the CV frequencies because Amtrak's motive power dispatcher permitted the train to leave New Haven without one. There was a proper radio in fully serviceable condition at New Haven, but it was locked up in the radio shop. There was adequate time to correct the situation, but this was not done. CV was informed of the radio deficiency by Amtrak, and the train had been frequently accepted by CV without a proper radio in the past. There were no rules or regulations prohibiting this, but given the high degree to which CV relies on radio communication in its operations, the Safety Board believes this was a matter of poor judgment on the parts of both Amtrak and CV. Necessary steps were promptly taken after the accident to assure that such a situation would not occur again, but Amtrak should make certain that similar deficiencies do not occur elsewhere in operations that involve running its trains over several different railroads with different radio frequencies.

Even if the locomotive radio on train No. 60 had been equipped to function on the CV frequencies, it would not have been possible for the enginemen to communicate with the dispatcher because the locomotive battery boxes were destroyed when the locomotive units derailed. The location of the batteries under the frame of the locomotive units, which is peculiar to Amtrak's F40PH units, makes them highly vulnerable when a locomotive unit derails and the carbody separates from the trucks. Such separation also occurred in the July 7 accident, the Amtrak derailment at Connellsville, Pennsylvania, on May 28, 1984, and the derailment of Amtrak's California Zephyr due to a washout near Granby, Colorado, on April 16, 1985. 15/ At Granby, as at Essex Junction, it was necessary for an engineman to walk about a half mile to reach a telephone and report the accident. In the Connellsville accident, an engineman walked 2 1/2 miles to use the telephone in a private residence. In all three accidents, the locations were relatively remote. Sixteen persons were seriously injured in the Granby derailment; 23 persons were injured, 4 seriously, in the Connellsville accident. In this day of almost total reliance on radios for communications on the railroads, it is intolerable that help for the injured occupants of passenger trains is delayed because it is necessary for train crewmembers to walk to the nearest telephone. The Safety Board believes that reliable emergency power for radio usage or an ability for the radio to broadcast an emergency message in the event of a serious accident is essential on Amtrak locomotives.

The Safety Board has long been interested in the application of radio use to railroad operations. Safety Recommendations have been issued to the FRA addressing the need for radios to be required equipment on trains, the need for compatibility of radios

15/ Railroad Accident/Incident Summary Reports--"Derailment of Amtrak Passenger Train, The California Zephyr, near Granby, Colorado, April 16, 1985" (NTSB/RAR-85/01/SUM) between railroad properties, and the need for standards governing the use of radios in the industry. Recommendations also have been issued to various individual properties on the same issues.

Since 1976, the Safety Board has issued to the FRA three safety recommendations on the use of operable radios onboard trains, as follows:

> R-76-8
>
> Require that trains be equipped with operable radios and that railroad management provide guidelines for their use in normal service and in emergency situations.
>
> R-79-73
>
> Establish regulations that would require all trains operating on a main track to be equipped with an operable radio.
>
> R-81-81
>
> Initiate rulemaking to require trains which operate on common trackage to have compatible radio equipment which will permit emergency communication.

All three recommendations are being held in an "Open--Unacceptable Action" status. It is interesting to note that, while over the past 10 years the FRA has not acted to resolve this issue, concern has been expressed at the highest levels. During the National Transportation Safety Board's National Accident Investigation Symposium held in Washington, D.C., July 30 - August 1, 1984, the FRA Administrator stated:

> There were two things that I found imponderable before coming to FRA. One was the difficulty in reaching an agreement among all of the parties that would address in a fair way the alcohol and drug issue.
>
> The second imponderable was why we have been unable to develop a consistent program of radio communication in the railroad industry. Having addressed the first problem, we do intend to move to address the second, and we are going to begin proceedings that deal with the issue of communication, radio communication among railroad operating vehicles.

The Safety Board appreciates the concern expressed by the FRA Administrator over a year ago and urges the FRA to move swiftly in its efforts to address the use of radios and radio communication standards to improve operational safety in the railroad industry. To underscore the Board's concern for this issue, Safety Recommendations R-76-8, R-79-73 and R-81-81 have been placed in a "Closed--Unacceptable Action/Superseded" status and a new recommendation is included in this report that covers the general issue of radios in railroad transportation safety.

Survival Aspects

Out of necessity, all six CV train crewmembers were located in the forward part of the train when it derailed. As a result, this accident had the potential of resulting in all of the crewmembers being entrapped or otherwise incapacitated. Had the lead locomotive unit fallen into the void in the embankment, instead of crossing it, it probably would have been crushed by the following unit and cars. In all likelihood, the enginemen would have been trapped in the wreckage. If fire had broken out from the ruptured locomotive fuel tanks, it is doubtful that the enginemen would have survived. As it was, the engineer was rendered unconscious, and he was unable to play any meaningful role in the postaccident response. Although the fireman extricated himself from the locomotive unit and went to summons help, he was shaken up and had difficulty seeing. After returning to the accident site, the fireman was physically unable to assist in the rescue operations.

Of the trainmen, only the extra brakeman escaped injury or entrapment, and then only barely. He was passing between the two forward coaches to begin detraining passengers when the train went into emergency, and he had just enough time to get into the rearward coach before the train derailed and the coaches parted. Had the extra brakeman still been in the vestibules, he, too, might have been incapacited. The baggagemaster was trapped in the bedroom/roomette car, but because he had been trained, he was able to tell rescuers how to remove the car's windows.

Because of the time of day, most of the Amtrak service employees also were in the forward cars. Several were preparing breakfast in the food service car. Others were on duty or resting in the sleeping cars. One Amtrak sleeping car attendant was killed in the slumbercoach. Other Amtrak employees were trapped or injured and were unable to assist in the postaccident rescue effort.

Most of the passengers were able to evacuate the train without great difficulty. Those who were trapped and had to be extricated were in the two sleeping cars. The worst case scenario was the slumbercoach which had fallen into the void and had its forward half crushed by cars that came to rest on top of it. The single roomettes in this car, which were comparatively small and cramped to begin with, were compressed into each other. Three passengers in these compartments and the car's attendant were killed by compression or blunt impact injuries to the head or chest. All the other occupants of the small roomette compartments were injured, and 10 of these persons were extricated only by lengthy and arduous exertions of well-equipped rescuers. None of those trapped could have freed themselves from the wreckage. Had fire broken out, none would have survived. Even though the body of the slumbercoach was built of stainless steel and had numerous interior compartment walls, it could not be expected to completely withstand the impacts produced by a 55-ton car and a 69-ton car falling on it. Had the car been of less substantial construction, more of the passengers onboard would have been fatally injured.

The effects of rapid deceleration and derailment in producing injuries to persons in the coaches and food service cars paralleled that noted in previous Amtrak train accidents that the Safety Board has investigated. Seats were rotated, seat mounts were torn loose, and cushions were detached from sheetmetal headrest supports. Many passengers sustained facial and head injuries when they were pitched from their seats; others were injured when struck by unrestrained baggage that was thrown from open overhead luggage racks. Persons in the food service cars were injured by unsecured equipment, such as microwave ovens and food containers, which were thrown from the counter areas. Some sleeping car and coach passengers were lacerated when they were thrown into ordinary glass mirrors that shattered as a result.

In its report of the investigation of a 1983 Amtrak derailment at Wilmington, Illinois, 16/ the Safety Board issued Safety Recommendation R-84-40 on November 29, 1984, which recommended that Amtrak:

16/ Railroad/Highway Accident Report--"Collision of Amtrak Passenger Train No. 301 on Illinois Central Gulf Railroad with MMS Terminals, Inc., Delivery Truck, Wilmington, Illinois, July 28, 1983" (NTSB/RHR-84/02).

> Correct the identified design deficiencies in the interior features of existing and new passenger cars, which can cause injuries in accidents, including the baggage retention capabilities of overhead luggage racks, inadequately secured seats, and inadequately secured equipment in food service cars.

Safety Recommendation R-84-40 was reiterated on February 4, 1985, in the Safety Board's report of the investigation of an Amtrak derailment at Woodlawn, Texas, on November 12, 1983. 17/

Amtrak responded to Safety Recommendation R-84-40 on March 13, 1985, reporting that as its coaches were overhauled the locking devices intended to prevent seat rotation would be modified to include a positive locking feature that would prevent undesired rotation. Additionally, Amtrak reported that it was replacing complete car sets of seat frames with a design equipped with a step latch with positive locking device that prevents the seat from falling away from the coach wall, as well as undesired seat rotation. In addition, Amtrak will equip all newly constructed coaches with the improved seat frames.

Regarding the problem of unsecured baggage in overhead racks, Amtrak responded that it has designed a web-type retention device to be applied to the racks of a new prototype sleeping car it has ordered. This and other baggage retention devices are to be evaluated for potential application on a new prototype coach. However, Amtrak reported that it does not plan to retrofit existing cars with baggage retention devices. As for unsecured equipment in food service cars, Amtrak advised that it will enhance securement of microwave and convection ovens by adding an extra steel bar across the top of the ovens to prevent displacement under extreme shock. The modification was being implemented as food service cars undergo overhaul and 120-day maintenance programs.

On July 29, 1985, the Safety Board informed Amtrak that it was pleased that Amtrak was working to eliminate design inadequacies in its coach seats and oven securement in food service cars, but was keeping Safety Recommendation R-84-40 in an "Open--Unacceptable Action" status inasmuch as Amtrak did not plan to retrofit the overhead luggage racks in its existing cars with retention devices. In this regard, the Board cited an Amtrak derailment at Queens, New York, on July 23, 1984, 18/ in which passengers were struck by loose baggage dislodged from overhead racks.

In the Amtrak derailment at Connellsville, Pennsylvania, coach passengers reported to Safety Board investigators that personal belongings and baggage "were flying everywhere." One woman was struck repeatedly and was literally buried under suitcases that fell from an overhead rack. Passengers reported that timely evacuation of the coaches was difficult because the aisles were full of fallen luggage. Considering the range of options that could be employed to effectively modify the existing luggage racks, the Safety Board believes that Amtrak should reconsider its position and move energetically to eliminate this common cause of injuries to coach passengers in derailments. Similarly, the use of shatterproof glass in mirrors would prevent serious

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17/ Railroad Accident Report--"Derailment of Amtrak Train No. 21 (The Eagle) on the Missouri Pacific Railroad, Woodlawn, Texas, November 12, 1983" (NTSB/RAR-85/01).

18/ Railroad Accident Report—"Head-on Collision of National Railroad Passenger Corporation (Amtrak) Passenger Trains Nos. 151 and 168, Astoria, Queens, New York, New York, July 23, 1984" (NTSB/RAR-85/09).

injuries to passengers in sleeping car compartments and coach lounges. Amtrak also should investigate measures to prevent the exposure of headrest frames as a result of cushion displacement on its Heritage class coaches, as well as its other coach cars.

Based on the findings in these latest accidents, the Safety Board is placing Safety Recommendation R-84-40 in a "Closed--Unacceptable Action/Superseded" status and is issuing new recommendations that Amtrak take action to correct the luggage retention problem as well as the non-shatterproof mirrors and seat cushion displacement problems.

Response to the Emergency

The extra brakemen was the only train crewmember who was able to evacuate passengers from the train and to provide for their care before the first emergency forces reached the site. He was assisted by those Amtrak onboard attendants who were not seriously injured in the accident. The training Central Vermont and Amtrak had provided to the brakeman, the train attendants, and local rescue forces was a positive factor in the effective manner in which their efforts were directed.

Although hampered and complicated by the inaccessibility of the accident site and the necessity of constructing an access road, the enormous rescue effort was initiated quickly and was executed in a smooth and highly efficient manner. Nearly 300 persons had to be located and cared for, a task complicated by the relatively large number of persons who were trapped and had to be extricated under very difficult conditions. However, the rescue forces were well-trained and equipped. Because the accident occurred on a Saturday, rather than on a weekday, many volunteer rescuers were at home and able to immediately respond to the emergency. Another fortunate coincidence was the nearby assembly of National Guardsmen who were readying helicopters, trucks, and other equipment for their annual summer maneuvers. The early on-scene appearance of State officials to direct the overall response effort resulted in the prompt diversion of the Guard to the accident site. This provided sorely-needed manpower and equipment essential to the quick construction of the access road and the fast evacuation of critically-injured persons to hospitals.

The area mass disaster plan was a remarkable model of good planning, and its smooth and successful implementation was marked by a total absence of confusion and a minimum of problems. The more seriously injured were selectively transported to the hospital that was best prepared to care for them. Hospitals put their disaster plans into effect and these worked effectively since the hospital personnel had been repeatedly drilled under simulated disaster conditions. Given the difficulties imposed by the limited access to and from the accident site, the ability of the nearby IBM dispensary to provide quick out-patient treatment to many persons was yet another fortunate circumstance. This eliminated the need to transport those with minor injuries the relatively long distance to the hospitals, and it reduced the burden on available transport, the access road, and the facilities and staff of the hospitals.

Control of access to the site by responding police agencies was a vital factor in the success of the rescue operation. Had the State Police not quickly and effectively set up a command post and restricted access to those persons and vehicles which were needed at the site, the narrow access road would have quickly become totally congested. This would have seriously impeded the evacuation effort and would have delayed needed vehicles and equipment from reaching the accident site. Moreover, the site would have become overcrowded with people and vehicles that were not needed there.

CONCLUSIONS

Findings

1. The severe rains that fell east of Essex Junction on the night of July 6-7, 1984, were inconsistent with the normal rainfall history of the area. The amount of rain that fell may have been twice the 100-year record rainfall for the area.

2. The Central Vermont mainline was well-constructed and maintained. The culvert that carried Redman Creek under the railroad was probably intact and unobstructed, and it was adequate to convey the runoff of normal rainstorms through the embankment.

3. The culvert and embankment were not seriously affected by runoff from the first two storms. Had the embankment been damaged, or had water been impounded behind it, the train crew would have observed this when they passed the location at 10:35 p.m.

4. The embankment may have become saturated by the heavy rains and some temporary impounding of water behind it. However, the catastrophic failure of the embankment probably resulted from the occurrence of a flash flood along the stream course sometime between 1 a.m. and 2 a.m. on July 7.

5. The flash flood resulted from the overtopping and blowing out of a series of beaver dams near the headwaters of Redman Creek. These dams were concealed from view, and their existence was unknown to Central Vermont and the public at large.

6. The Central Vermont dispatcher had no reason to expect that typically heavy rains would cause problems at the culvert or anywhere else. The railroad's line was not flood prone, the magnitude of the rainfall in the area was unreported, traincrews had not seen or reported damage or adverse conditions, and Redman Creek was an unlikely location for a flash flood.

7. Train No. 60 was operated by an alert crew that complied with the speed restrictions and rules. The crew did not encounter heavy rain or see standing water en route, and they had no reason to expect that the embankment had been breached.

8. The fireman applied the train brakes in emergency when he first realized the embankment was breached. Although this did not materially reduce the train's speed, it did warn the extra brakeman in time for him to reach a place of safety. The extra brakeman was the only crewmember able to help evacuate and care for passengers after the accident.

9. Although the Burlington NWSO was only 4 to 5 miles west of the principal storm track, the personnel manning the office were unaware of the magnitude of the rain that fell there.

10. Burlington NWSO personnel monitored the storms on radar before and after the storms reached the area. However, they either did not detect the third intensive cell to pass along the main storm track, or they failed to appreciate its relevance to earlier storms along the same track.

11. The three special weather statements issued by Burlington NWSO and the general extension of a flood watch to western Vermont were broadcast over the NOAA weather radio. However, the value of the broadcasts was diminished because the National Weather Service did not require them to be preceded by the alarm tone. Users of weather radio receivers would have had to be monitoring them to have heard the broadcasts.

12. Some residents along the main storm track knew that rainfall had exceeded 5 inches before the third storm struck. Had Burlington NWSO been aware of this, it would have been justified in issuing a flash flood watch and warning, and the warning could have been more site specific.

13. Because of its equipment limitations and the fact that it serves a large territory, Burlington NWSO needs to develop a better system for gathering unofficial observations in order to adequately provide accurate weather information for surface transportation. The situation is probably similar in other areas.

14. Because extremely heavy rains had fallen in very short periods in mountainous areas along the storm track, there was clearly a threat of flash floods occurring in Vermont. However, Albany NSWO failed to upgrade its flood watch to a flash flood watch when it was extended to include Vermont.

15. Because Central Vermont lacked an effective weather detection and monitoring system and no longer had station and maintenance employees situated along its line, the dispatcher had only the train crews and an operator at White River Junction to rely on for adverse weather reports. Even if he had a NOAA weather radio receiver, he may not have been sufficiently alarmed by the 11:50 p.m. flood warning to have called out a track patrol.

16. Although Central Vermont was highly reliant on radio communication in its train operations, train No. 60 did not have a radio which would function on CV frequencies. Small portable radios given to train crewmembers were an inadequate substitute. Amtrak's motive power dispatcher should not have allowed the train to leave New Haven without the proper radio on the locomotive and the Central Vermont should not have accepted train No. 60 without a radio with a Central Vermont frequency.

17. Even if train No. 60 had the proper radio equipment, the engineman could not have used it to report the accident and call for help, because the locomotive battery boxes were destroyed. This accident and others demonstrated that the location of the batteries on some Amtrak locomotive units makes them prone to damage in a derailment.

18. Many passenger injuries would have been prevented or mitigated in severity if the cars had improved coach seat securement, luggage retention devices, better-secured food service equipment, and shatterproof mirror glass.

19. Training provided by Amtrak and Central Vermont to train crewmembers, Amtrak onboard service personnel, and local emergency forces aided in bringing about the effective and timely evacuation and extrication of passengers from the train.

20. The early on-scene appearance of Vermont State officials to direct the overall response effort, and the resultant application of the National Guard, the State Police, and other State resources to that effort were important elements in the outstanding response to the emergency.

21. Well conceived and successfully implemented mass disaster plans provided rapid handling and treatment of injured persons at local hospitals. The smoothness of the operation and lack of confusion were attributed to the repeated drilling of rescue forces and hospital personnel prior to the accident.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was a flash flood that destroyed the railroad support embankment over a small stream during a prolonged period of extraordinary heavy rainfall. The flash flood was precipitated by the heavy rains and the collapse of a series of beaver dams upstream of the embankment in heavily wooded locations that were unknown and were not reasonably detectable.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board made the following recommendations:

--to the National Railroad Passenger Corporation (Amtrak):

Eliminate the vulnerability of the battery boxes supplying power for radio usage and lighting on its locomotives in a derailment by relocating them in the carbody, above the underframe of the locomotive units. (Class II, Priority Action) (R-85-125)

Replace the existing mirrors in sleeping car compartments and coach lounges with shatterproof material. (Class II, Priority Action) (R-85-126)

Redesign and modify the coach and seatback cushions in the Heritage-class coaches to prevent their becoming dislodged when they are impacted from behind. (Class II, Priority Action) (R-85-127)

Develop and install effective retention devices on its overhead luggage racks to prevent the dislodging of luggage and other articles in a collision and/or derailment. (Class II, Priority Action) (R-85-128)

--to the Federal Railroad Administration:

Establish regulations that address the issues surrounding the use of radios for operational purposes on trains to include, but not be limited to, requirements for radios to be installed on trains; usage requirements for inter- and intra-train communications; usage requirements for dispatching and control operations; frequency compatibility requirements; and maintenance, inspection, and testing requirements. (Class II, Priority Action) (R-85-129)

--to the National Weather Service:

Solicit the voluntary submission of real-time severe weather observations from interested citizens and cooperative observers to provide a more complete overview of selected types of weather parameters at remote locations. (Class II, Priority Action) (R-85-130)

Evaluate the revision of the criteria for use of the tone alert signal with the National Oceanic and Atmospheric Administration Weather Radio to include special weather statements, flood watches, and other information which may be critical to surface transportation interests issued by National Weather Service Offices and Forecast Offices as information requiring a warning alarm when broadcast. (Class II, Priority Action) (R-85-131)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ JOHN K. LAUBER
Member

December 10, 1985

APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

Investigation

The National Transportation Safety Board was notified of the accident about 8:30 a.m., on July 7, 1984, and immediately dispatched an investigator from the New York Field Office to the scene. Other members of the investigative team were subsequently dispatched to the scene from Washington, D. C. Investigative groups were established for operations, mechanical, track and equipment, and survival factors.

Hearing

The Safety Board convened a 2-day public hearing as part of its investigation of this accident on September 13, 1984, at St. Albans, Vermont. Parties to the hearing included Central Vermont Railway, Inc., the National Railroad Passenger Corporation (Amtrak), the State of Vermont, the United Transportation Union, the Federal Railroad Administration, and the National Weather Service. Testimony was taken from 13 witnesses, and 38 exhibits were entered into the record.

APPENDIX B

TRAIN CREWMEMBER INFORMATION

Conductor Vernon Harrison Church

Conductor Vernon Harrison Church, 60, was employed as a brakeman by the Central Vermont Railway on December 7, 1946, and was promoted to conductor on April 18, 1952. He last passed examination on the operating rules in April 1982, and passed the mandatory CV physical examination in August 1982. Mr. Church had been cautioned and had received record discipline on four occasions for his responsibility in connection with minor accidents and rule infractions. He had never been suspended or discharged from service, and his record had been clear since July 7, 1982. Mr. Church attended a special Amtrak emergency procedure and equipment orientation course on May 15, 1984.

Engineer George Edward Gay

Engineer George Edward Gay, 60, was employed as an extra section laborer by the Central Vermont on September 1, 1942. He was made a sectionman on June 19, 1950, and a locomotive fireman on July 4, 1950. On January 9, 1958, Mr. Gay was promoted to locomotive engineer. He last passed examination on the operating rules in April 1984, and he passed the mandatory CV physical examination in August 1982. Mr. Gay, had been assessed record discipline in the form of demerits on three occasions for his responsibility in connection with minor derailments. In October 1981, he was suspended for 7 days following a derailment of cars in an industrial track. His record had been clear since that time.

Fireman Jeffrey Lloyd Howard

Fireman Jeffrey Lloyd Howard, 31, was employed as a sectionman by Central Vermont on July 22, 1974. He was made a machine operator on February 2, 1976, a crane operator on January 30, 1978, and a brakeman on August 11, 1978. He was promoted to conductor on July 25, 1982, and on March 2, 1983, he transferred to the position of locomotive fireman and entered CV's engineer training program. Mr. Howard completed a formal 8-week training course at the Canadian National Railways locomotive engineers' training school at Gimli, Manitoba, in May 1983. The course included 8 days of instruction and examination on the operating rules, and 7 weeks of other training with periodic examination on the mechanical, air brake, and operational aspects, as well as the operation of locomotive simulators. Following his formal training, Mr. Howard completed 8 weeks of on-the-job training on CV, successively embracing 1 week of yard operation, 1 week of local freight train operation, 4 weeks of through freight train operation, and 2 weeks of passenger train operation. He was promoted to locomotive engineer on July 6, 1983. Mr. Howard last passed examination on the operating rules in April 1984, and he passed the mandatory CV physical examination in August 1983. While employed as a crane operator in 1978, Mr. Howard was suspended for 15 days for his responsibility in the derailment and overturning of a crane. The only other entry in his service record was a meritorious award for discovering and reporting a broken rail in 1980.

Brakeman Gilbert Paul Goulette

Brakeman Gilbert Paul Goulette, 54, was employed as a brakeman by the Central Vermont on April 2, 1947. He was not promoted. Mr. Goulette had last passed examination on the operating rules in October 1982, and he had last passed the CV physical examination in August 1982. Mr. Goulette had received record discipline for rules infractions and minor derailments on five occasions, and in 1956 he was suspended for 30 days for his responsibility in a train collision. His record had been clear since January 5, 1969.

Brakeman Randall Earl Heald

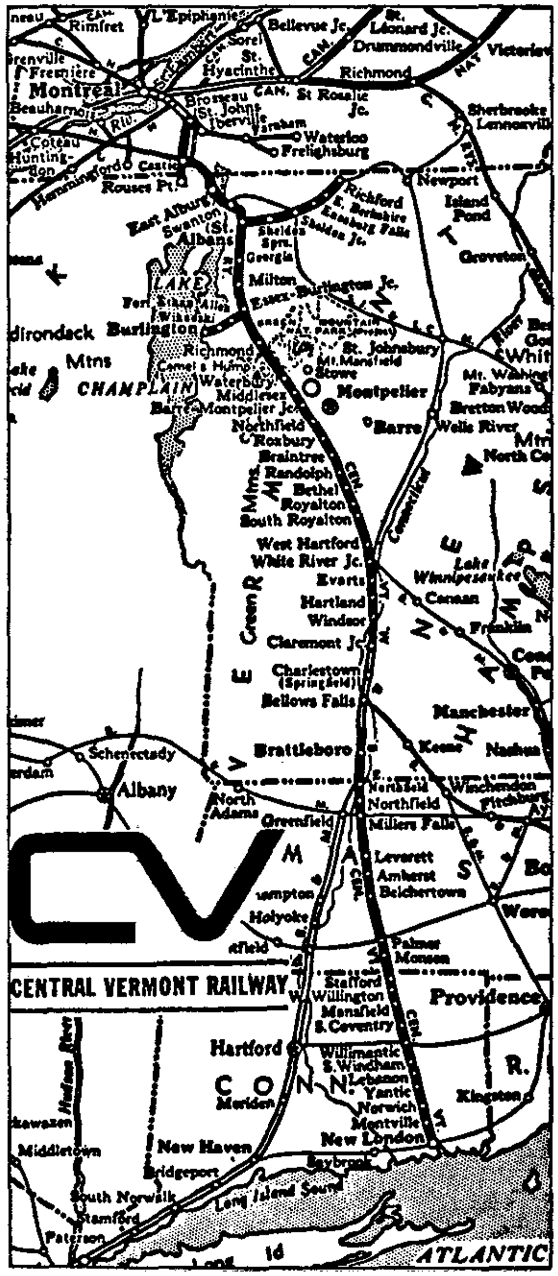
Brakeman Randall Earl Heald, 26, was employed as a stores department laborer by Central Vermont on July 3, 1978. He was made a brakeman on August 12, 1978, and he was promoted to conductor on May 4, 1983. Mr. Heald last passed examination on the operating rules in April 1983, and he passed the mandatory physical examination in August 1982. Mr. Heald attended a special Amtrak emergency procedure and equipment orientation course on May 15, 1984. He had received record discipline in the form of demerits on four occasions for missing calls to duty. His record was clear since June 22, 1981.

Brakeman Harold George Lemay

Brakeman Harold George Lemay, 59, who was working as baggagemaster on train No. 60, was employed as a brakeman by Central Vermont on March 29, 1947. He was not a conductor. Mr. Lemay had last passed examination on the operating rules in October 1982, and he had passed the mandatory physical examination in August 1982. His service record indicates he received record discipline on four occasions for failure to compare time, once for missing a call, and twice for rules infractions. On January 5, 1969, he was suspended for 5 days for a rules infraction. Since that time, his record was clear. Mr. Lemay attended a special Amtrak emergency procedure and equipment orientation course on May 17, 1984.

APPENDIX C

EXCERPTS FROM CENTRAL VERMONT RAILWAY TIMETABLE NO. 8, APRIL, 24, 1983



CENTRAL VERMONT RAILWAY, INC.

NORTHERN AND SOUTHERN DIVISIONS

EMPLOYEES' OPERATING TIME TABLE

8

TAKING EFFECT SUNDAY, APRIL 24TH, 1983

SUPPLEMENT NO. 1 TO TIMETABLE NO. 8 EFFECTIVE AT 0100 EASTERN STANDARD TIME SUNDAY, OCTOBER 30, 1983 HAS BEEN APPLIED TO PAGES 22, 23 AND 29

SAFETY IS OF THE FIRST IMPORTANCE IN THE DISCHARGE OF DUTY.

P. C. LARSON	**R. L. RIXON**
GENERAL MANAGER	SUPERINTENDENT
ST ALBANS, VT.	ST ALBANS, VT

ROXBURY and SWANTON SUBDIVISIONS

Subdivision	STATIONS	Miles from Windsor	Yard Limits	NORTHWARD TRAINS FIRST CLASS 27 Psgr. Daily	NORTHWARD TRAINS SECOND CLASS 245 INTM Daily Ex Sun
Roxbury Subdivision	WHITE RIVER JCT CKWZ	14.8	↓	0417	0200
	17.4				
	SOUTH ROYALTON	32.2	17.4	0440	0222
	7.2				
	BETHEL P	39.4		..	0233
	6.4				
	RANDOLPH	45.8		0456	0242
	14.9				
	ROXBURY P	60.7		0512	0300
	15.8				
	MONTPELIER JCT PY	76.5		s0536	0319
	9.6				
	WATERBURY	86.1		s0550	0331
	7.3				
	BOLTON P	93.4		..	0340
	5.9				
	RICHMOND	99.3		.	0348
	9.2				
	ESSEX JCT. ....YZ (Jct with Winooski Sub)	108.3	106.5 / 108.8	s0618	0400
	10.8				
	MILTON	119.1		.	0414
	8.1				
	OAKLAND	127.4	130.1	0639	0424
	3.8				
	TOFC	131.2			0430
	0.9				
	V ST ALBANS CKWYZ	132.1	↑	s0647	
		Miles from St Albans			
Swanton Subdivision	ST ALBANS .. CKWYZ (Jct with Richford Sub)	0.0 / 0.4	↕	0657	
	1.1				
	NORTH JCT	1.5	2.6	0659	.
	4.1				
	FONDA	5.6			.
	3.9				
	SWANTON	9.5		0708	.
	6.6				
	EAST ALBURGH Z	15.6	14.5 / 16.8	0727	..
	2.4				
	ROGERS	18.0	23.8	0730	.
	7.4				
	CANTIC RYZ	25.4	↑	s0749	...
				27	245

See pages 24 to 29 inclusive for Roxbury and Swanton Subdivision footnotes

ROXBURY and SWANTON SUBDIVISIONS

STATIONS	Subdivision	Office Signals		Siding Car Capacity	Length of Siding in Feet	SOUTHWARD TRAINS FIRST CLASS 26 Psgr.	SOUTHWARD TRAINS SECOND CLASS 244 INTM
WHITE RIVER JCT CKWZ	Roxbury Subdivision	V	N	YARD	YARD	s2355	2130
17.4							
SOUTH ROYALTON				82	4894	2322	2108
7.2							
BETHEL P				66	3944	. .	2058
6.4							
RANDOLPH				72	4544	2306	2049
14.9							
ROXBURY P				83	4935	2250	2030
15.8							
MONTPELIER JCT PY		K	D	78	4672	s2230	2011
9.6							
WATERBURY				84	5038	s2215	1959
7.3							
BOLTON P				77	4630		1950
5.9							
RICHMOND				84	5012		1942
9.2							
ESSEX JCT. ... YZ (Jct with Winooski Sub)		S	X	66	3965	s2148	1930
10.8							
MILTON				71	4269	.	1916
8.1							
OAKLAND				84	5040	2128	1906
3.8							
TOFC							1900
0.9							
V ST ALBANS CKWYZ		N	S	YARD	YARD	2120	
ST. ALBANS. . CKWYZ (Jct with Richford Sub)	Swanton Subdivision	N	S	YARD	YARD	s2110	
1.1							
NORTH JCT						2101	
4.1							
FONDA						.	
3.9							
SWANTON.				75	4477	2052	
6.6							
EAST ALBURGH Z						2036	
2.4							
ROGERS				74	4417	2033	
7.4							
CANTIC RYZ		V	A			2020	
						Daily	Daily Ex. Sat.
						26	244

See pages 24 to 29 inclusive for Roxbury and Swanton Subdivision footnotes

ROXBURY SUBDIVISION FOOTNOTES Continued

2 GENERAL FOOTNOTES

2 1 Mileage 30.1 – Private crossing over Sharon compound track must be kept clear of cars

2 2 **Vermont Castings' Tracks at Randolph, Vt. MP 44 46 Derail is located 30 feet south of point of switch to track 369. All cars placed at this plant must be placed north of derail located on track 368 at top of the hill No cars are to be placed at any time south of derail**

2 3 MONTPELIER JCT – Connection with WACR is via south leg of wye track

2 4 ESSEX JCT – Train order signal governs movements on Roxbury Subdivision only **Siding is east of main track south of station**

2 5 Station Protection Signal 1309, located at Mileage 130 9 Dispatcher Italy Yard controls all movements Trains or engines stopped by this signal must not proceed until Approach Signal indication is received If stop signal indication continues for 5 minutes, Dispatcher must be contacted for instructions

2 6 Hy rail track units and motor car may operate on lineup regulations In such instances, at least two employees qualified as flagmen in the Uniform Code of Operating Rules must accompany the unit and trains must be cleared by at least fifteen minutes Track Car Operating Regulation 9 17 is modified accordingly

3 EQUIPMENT RESTRICTIONS

3 1 Heaviest car permitted – 263,000 lbs

4 SPEEDS

4 1

	Mileage	Pegr	INTM	Frt	Snow plows and flangers
		Miles per hour			
	14 8 to 132.1 zone	59	49	40	***35
	15 5 to 16 5	40	40		
	20 6 to 21 7	45	45		
	28 1 to 28 6	50			
	33 2 to 34 4	45	45		
	37 6 to 39 7	45	45	35	25
	56 9 to 57 2	50	45		
	62 1 to 62 5	50			
	73 8 to 75 3	50			
	76 6 to 76 8	45	45		
	79 3 to 81 1	50			
	89.3 to 90.4	45	45		
	107 7 to 108 7	20	20	20	20
	122 0 to 122 3	40	40		
*	131 2 to 132 1.	30	30		
**	132 0 Lake Street, St Albans until crossing occupied	15	15	15	15

***Not marked with advance speed restriction or restricting signs for departing movements**

****Not marked with advance speed restriction or restricting signs**

*****Not indicated on zone speed signs**

4 2 CONDITIONAL SPEEDS

Mileage	Miles per hour
83 2 Bridge on track 326	15
86 2 to 86 3 Trains handling tri level auto traffic	10

APPENDIX D

REPORTED RAINFALL READINGS
BURLINGTON-ESSEX JUNCTION AREA
July 6-7, 1984

KEY TO RAINFALL MAP

STORM TRACK

ROUTE OF AMTRAK NO. 60

(A) ACCIDENT SITE

(B) LOCATION OF BEAVER DAMS

(C) WASHOUTS ALONG NORTH WILLISTON ROAD

(D) WASHOUT OF STATE ROUTE 15

(E) ESSEX JUNCTION STATION

REPORTED RAINFALL READINGS

1. Shelburne - 3.75 in. 8 pm to Midnight in rain gauge
2. Shelburne - 2.2 in. overnight in gauge
3. Shelburne - 4.2 in. overnight in rain gauge
4. Shelburne Pond - 6.5 in. in gauge overnight. 10:30 pm to shortly after Midnight
5. Williston - 5.5 in. in rain gauge 6 pm to 10:30 pm
6. Williston - 4 in. in gauge 6:30 to 11 pm; 2.75 in. 11 pm to 7 am
7. Williston - 6 in. in gauge 6:30 to 11 pm; 0.25 in. 11 pm to 8 am
8. Richmond - 2.5 in. in tub overnight
9. Williston - 3.7 in. in gauge overnight
10. Williston - 5.5 in. rise in swimming pool overnight
11. Williston - 6 in. rise in swimming pool overnight
12. Williston - 5.6 in. in gauge; no heavy rain after 11 pm
13. Williston - 5.5 in. (full gauge) by Midnight; 1.75 in. between Midnight and 9 am. Rain started about 7:10 pm; lightning and thunder between 11-11:30 pm. Hard rain resumed about 1 am.
14. Williston - 8-3/8 in. in straight-sided bucket by 4:30 am. Noted heaviest rain at about 2 am.
15. Williston - 3.5 in. in gauge overnight. Light rain began about 7 pm, heavy rain fell between 9 and 10 pm

16 Essex Junction - Green Mountain Power Co. Winooski River Dam, Rainfall monitored every 2 hours. 6 pm to 8 pm, 0.07 in.; 8 pm to 10 pm, 1.8 in.; 10 pm to Midnight, 1.8 in.; Midnight to 8 a.m., 1.8 in.

17 South Burlington - National Weather Service; rainfall monitored every hour. 0.43 in., 7 pm to 8 pm; 0.18 in., 8 to 9 pm; 0.64 in., 9 to 10 pm; 0.11 in., 10 to 11 pm; trace, 11 pm to Midnight; 0.015, Midnight to 2 am; trace, 2 to 4 a.m.

18 South Burlington - 3.5 in. overnight in gauge

19 Essex Junction - 2.1 in. in gauge overnight. Observed very hard rain before and after 10:30 p.m.

20 Essex Junction - 2.55 in. in gauge overnight

21 Essex Junction - 10 in. in bucket overnight. Light rain began at 5 pm, hard rain began by 9:30 and continued to about Midnight.

22 Essex Junction - 1.9 in. in gauge overnight

23 Essex Junction - 4.5 in. in gauge overnight.

24 Essex Junction - 3.0 in. in gauge overnight

25 Essex Center - 3.7 in. in gauge overnight

26 Essex South - 5-1/4 in. coffee can full to overflowing overnight.

27 Essex South - 4.0 in. in gauge overnight. Heavy rain after 6 pm, very heavy shortly before 11 pm, stopped about 2 am.

28 Essex Center - 5.0 in. in gauge overnight

29 Essex Center - 5.0 in in gauge overnight

30 Essex Center - 2.25 in. in gauge overnight. Rain started about 9 pm.

31 Essex Center - 2.0 in. in gauge overnight.

32 Essex Center - 2.1 in. in gauge overnight

33 Jericho - 5.0 in. in gauge overnight. Rained heavily 7 pm to 1 am.

34 Jericho - 5 inch plus rise in swimming pool overnight.

35 Jericho - 3.5 in. in gauge overnight of which 0.5 inch fell during first half-hour (7 to 7:30 pm)

36 Jericho - 3.4 in. in gauge between 7 and 11 pm.

37 Underhill - 5.5 in., in gauge overnight. Gauge overflowed.

APPENDIX E

EXCERPTS FROM NATIONAL WEATHER SERVICE OPERATIONS MANUAL NOAA WEATHER RADIO (NWR) PROGRAM SEPTEMBER 26, 1980

Issue Date	Org Code
9-26-80	

NATIONAL WEATHER SERVICE
Operations Manual

Part	Chap
C	64

NOAA WEATHER RADIO (NWR) PROGRAM

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area is encouraged as part of any publicity of the local NWR facility. If possible this information should also be included in newspaper weather columns as a map or list of counties.

Routine programming should be curtailed or even suspended during warning situations. The extent to which this is done will depend on the nature of the event and the area affected. *All operations personnel should be skilled in procedures relating to the use of NWR in connection with potentially hazardous events.*

*4.3 Use of Warning Alarm. The following alarm tones are normally available in NWR transmitters:

Channel	Tone
1	1050 Hz
2	1200 Hz
3	1350 Hz
4	1500 Hz
5	1650 Hz

The 1050 Hz Warning tone will be used for the following watches and warnings on initial issuance and subsequently as appropriate:

	Watch	Warning
Tornado	yes#	yes
Severe Thunderstorm	yes#	yes
Flash Flood	yes#	yes
Hurricane	yes	yes
Tsunami	no	yes
Marine	n/a	yes
Winter Storm	no	yes
Blizzard/Severe Blizzard	n/a	yes
High Wind	n/a	yes
Dust Storm/Sandstorm	n/a	yes
Flood	n/a	yes
Enemy Attack	n/a	yes

#Note: If the alarm tone has been activated for a tornado, severe thunderstorm, or flash flood warning and a watch is issued for the same phenomenon within the next hour, use of the warning tone with the watch may not be necessary.

In addition, the warning tone may be used in conjuction with frost/freeze warning where approved by the regional headquarters. Except in very unusual circumstances, the warning tone should not be used for any statement related to the above phenomena which does not contain a watch or warning.

The 1050 Hz warning alarm may also be used, as appropriate, for localized warning situations not related to NWR programs where life and/or property are threatened and when requested by authorized officials. *The source of these messages should always be stated.* The basis for such use is covered by the agreements referred to in WSOM Chapter C-66. Examples of such use would be:

*U S GOVERNMENT PRINTING OFFICE: 1986-491-098:20072