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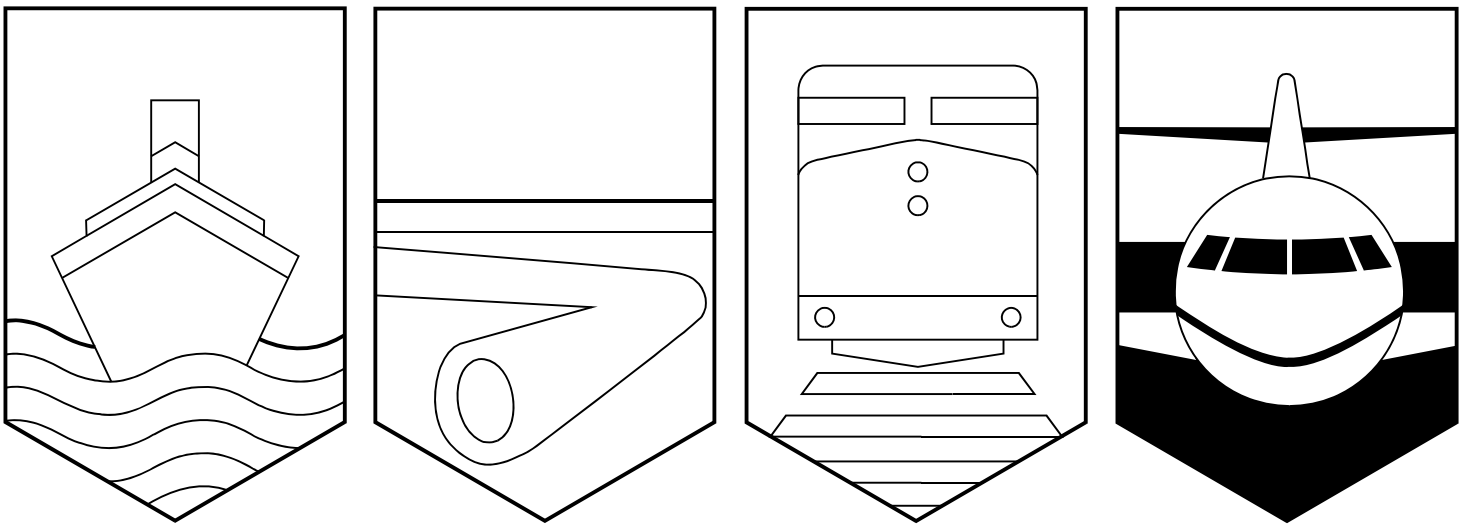

AVIATION OCCURRENCE REPORT

RUNWAY EXCURSION

AIR BC
BRITISH AEROSPACE BAE 146-200 C-FBAB
TERRACE, BRITISH COLUMBIA
21 JANUARY 1994

REPORT NUMBER A94P0016

Canada

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Aviation Occurrence Report

Runway Excursion

Air BC
British Aerospace BAe 146-200 C-FBAB
Terrace, British Columbia
21 January 1994

Report Number A94P0016

Synopsis

The crew conducted a circling approach to runway 15 at Terrace, British Columbia. The aircraft touched down on the runway at a measured distance of 1,650 feet from the threshold, continued down the runway, and went off the departure end of the runway at about 25 knots. The aircraft came to rest approximately 315 feet from the end of the paved surface. There was no damage to the aircraft; none of the passengers or crew members was injured.

The Board determined that the crew flew a landing pattern in a narrow valley under marginal weather conditions that dictated an unstabilized approach to the slippery and contaminated runway. The result was a longer-than-normal landing and landing roll. Contributing to the occurrence were a tailwind component, inaccurate James Brake Index (JBI) tables, crew decision making, and the company's use of landing performance tables different from those produced by the aircraft manufacturer for contaminated runways.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 History of the Flight

The British Aerospace BAe 146-200 aircraft, operated by Air BC as flight ABL597, was on a scheduled instrument flight rules (IFR)[1] flight from Vancouver, British Columbia, to Terrace, British Columbia. On board were two pilots, two cabin attendants, and 12 passengers. Prior to the approach into Terrace, the pilots briefed for the localizer/non-directional beacon (LOC/NDB C) approach to Terrace, circling for landing on runway 33 or runway 15. They flew the approach and broke out of cloud about 500 feet above ground level[2] (agl) to the northeast of the airport. They then decided to fly the left-hand circling approach for runway 15 as they did not have the required visual reference to land on runway 33. Due to the poor weather conditions, the crew had to manoeuvre the aircraft around low cloud during short final, but they followed the visual signal provided by the precision approach path indicator (PAPI) lights and established the aircraft on slope before landing.

The aircraft touched down on runway 15 about 1,650 feet from the threshold, as measured by airport personnel; it continued down the runway and went off the end at about 25 knots. The aircraft rolled into the overrun area, and came to rest approximately 315 feet from the end of the paved surface, with its nose 39 feet to the right of the extended centre line. The heading of the aircraft at rest was 154 degrees magnetic, 7 degrees right of runway orientation. There was no damage to the aircraft and none of the passengers or crew was injured. The passengers and crew deplaned the aircraft through the forward airstair door and were driven to the airport terminal by bus within about half an hour of the occurrence.

The incident took place at latitude 54°27'59"N and longitude 128°34'39"W at approximately 0835 Pacific standard time (PST)[3] during the hours of daylight.

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1 See Glossary for all abbreviations and acronyms.

2 Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.

3 All times are PST (Coordinated Universal Time [UTC] minus eight hours) unless otherwise stated.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	-	-	-	-
Minor/None	4	12	-	16
Total	4	12	-	16

1.3 Damage to Aircraft

The aircraft was not damaged.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

	Pilot-in-command	Co-pilot
Age	41	29
Pilot Licence	ATPL	ATPL
Medical Expiry Date	10 Feb 94	01 Jan 95
Total Flying Hours	12,152	8,450
Hours on Type	2,463	2,730
Hours Last 90 Days	127	230
Hours on Type Last 90 Days	127	230
Hours on Duty Prior to Occurrence	3	3
Hours Off Duty Prior to Work Period	18	72

The flight crew were certified and qualified for the flight in accordance with existing regulations.

1.6 Aircraft Information

Manufacturer	British Aerospace
Type	BAe 146-200
Year of Manufacture	1988
Serial Number	E2090
Certificate of Airworthiness (Flight Permit)	Valid
Total Airframe Time	13,674 hr
Engine Type (number of)	Lycoming ALF-502R-5 (4)
Propeller/Rotor Type (number of)	N/A
Maximum Allowable Take-off Weight	93,000 lb
Recommended Fuel Type(s)	Jet A, Jet B
Fuel Type Used	Jet B

The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The weight and centre of gravity were within the prescribed limits.

The aircraft was equipped with anti-skid brakes. The aircraft was not equipped with thrust reversers, nor was it required to be by certification standards. The aircraft's main landing gear track is 15 feet 6 inches wide.

The aircraft was examined after the occurrence, and no damage, unserviceability, or faults were found that might have contributed to the occurrence. The brakes functioned normally; the main gear tires were examined and there was no evidence of scalloping or scorching such as would be caused by hydroplaning.

1.7 Meteorological Information

The terminal forecast for Terrace from 0300 to 1500 was scattered cloud 500 feet agl, broken ceiling 2,000 feet agl, visibility four miles in light snow, wind from 360 degrees True at 20 knots gusting to 30 knots, occasional broken ceiling 500 feet agl, overcast 2,000 feet agl, visibility one mile in light freezing drizzle and fog.

The weather at the Terrace airport at 0800, 35 minutes before the occurrence, was overcast ceiling

measured 500 feet agl, visibility two and one-half miles in light freezing drizzle, light snow and very light ice pellets, temperature minus two degrees Celsius, dew point minus three degrees Celsius, wind from 010 degrees True at seven knots, altimeter setting 29.94 inches of mercury.

Just before landing, the FSS reported to the crew that the surface wind was from 350 degrees magnetic at five knots.

The weather at 0842, seven minutes after the occurrence, was broken ceiling measured 500 feet agl, overcast 1,200 feet agl, visibility three miles in very light freezing drizzle and light ice pellets, wind from 020 degrees True at six knots.

1.8 Crew Estimation of Landing Field Length

Before landing, the crew referred to charts in the Air BC BAe 146 *Quick Reference Handbook* to estimate the required landing field length. They used the "Landing Field Length - Dry Paved Runway" chart to calculate the landing field length for a dry runway, taking the existing tailwind into consideration. The resultant distance was then entered into the "Landing Distance Required Corrected For JBI 60% Factor" chart. This chart revealed that a runway length of 4,750 feet was required to land with a James Brake Index (JBI) of 0.25, and that the aircraft could land on the Terrace runway with a JBI reading as low as 0.20. These figures assumed the touchdown point to be a maximum of 1,000 feet beyond the runway threshold. Based on this information, the pilots were confident that the aircraft could land and stop safely on the 6,000-foot Terrace runway.

1.9 Approach and Landing

The Air BC BAe 146 *Pilot's Handbook* defines a "Stabilized Approach" as stabilized airspeed, stabilized sink rate, and a constant profile. The BAe 146 Operations Manual indicates that it is essential to arrive over the threshold at V_{REF} 33 with the thrust levers coming back to flight idle, aiming to touch down about 1,000 feet into the runway at about V_{REF} 33 - 7 knots. The aircraft landed about 1,650 feet beyond the runway threshold, which is about 650 feet beyond the ideal touchdown point. The co-pilot assessed that a stabilized approach to runway 15 at Terrace is difficult, due to the confined space and the high terrain, especially in poor weather.

The pilots intended to land into wind, on runway 33, which would have required a small left turn from the approach track, if the runway environment had been acquired prior to the missed approach point (MAP). They had also briefed for a circling approach to runway 15 in the event they were unable to land on runway 33.

When the aircraft arrived at the missed approach point, the weather conditions did not permit a landing on runway 33, so the pilots continued with the left circling pattern to runway 15. The co-pilot, who was flying the aircraft from the right-hand pilot's seat, lost sight of the runway during the circling procedure. The captain did not take control of the aircraft; however, he provided the co-pilot with directions to the final approach path. Flight data recorder (FDR) information reveals that the aircraft passed through the runway centre line during the turn from base leg to final approach, and that bank angles up to 24 degrees were required to manoeuvre the aircraft around the low cloud on final approach.

The pilots reported that the aircraft was established on the PAPI glide slope before landing. The airbrake was deployed before touchdown, which is normal procedure.

The aircraft touched down on the centre line of the runway at about 108 knots, at a point measured 1,650 feet beyond the runway threshold. The spoilers were deployed at touchdown. The co-pilot applied the brakes immediately after touchdown; however, they were not effective. The captain realized that the aircraft was not decelerating as expected so he shut down the two outboard engines. The aircraft ran off the end of the runway at about 25 knots. There was about 6 inches of soft snow on the runway overrun, and the aircraft occupants reported experiencing only a slight bump as the aircraft left the runway. Some passengers reported hearing a sound during the landing roll that was identified as the anti-lock brake system cycling on and off.

1.10 Crew Decisions

When the crew decided to continue for a left-hand circling procedure to runway 15, the co-pilot continued to fly the approach. However, because the runway was to his left and below his cross-cockpit line of sight, he could not judge the turn required to align the aircraft with the final approach path and was forced to rely on the captain's directions. It is not unusual for the pilot with a clear view of the runway during a circling procedure to take control and land the aircraft.

Additionally, during the last stages of the approach, the captain, on three occasions, expressed his doubts about the landing, and suggested that they go around, but he did not insist. The co-pilot expressed doubts about being able to see the runway again if they attempted another approach and continued with the approach and landing.

1.11 James Brake Index and Runway Condition Information

JBI is a measure of braking action on a runway surface, with 0.8 being the best value, and 0.0 being no braking action.

The JBI was measured with the prescribed Transport Canada (TC) decelerometer in an approved truck at intervals of approximately 1,000 feet, and approximately 30 feet either side of the runway centre line, all in accordance with standard procedures.

The equipment used to measure the JBI was examined and tested, and no fault was found. The method of measuring the JBI, and the qualifications of the workers who made the measurements were examined and were found to be in order.

Urea is a chemical applied to the runway surface to melt ice. It is applied from the centre of the runway outwards.

On the day of the occurrence, the runway clearing operation began shortly after 0600, with the airport crews sweeping the snow off the runway and applying urea. At 0620, runway 15 was reported to be 100 per cent ice-covered, with a JBI of 0.26.

The pilot of an MU-2, an aircraft with a wheelbase of slightly less than eight feet, landed on runway 33 at 0820, 15 minutes before the occurrence. He reported that the braking action was fair. He said that the runway surface was not slushy but wet with granularity, like wet pavement, and that the runway was wetter and clearer in the middle.

At 0828, seven minutes before the occurrence, the runway was reported as 100 per cent ice-covered, with a trace of slush in the centre 60 feet. The average JBI was 0.36 with readings of 0.24/0.29 at the south end of the runway. This information was relayed to the BAe 146 crew at 0829 by the Terrace Flight Service Station (FSS) as runway 100 per cent ice-covered, centre 60 feet trace of slush, JBI average 0.36 down to about 0.29 at the south end of the runway. The value of 0.24 was not included in the report to the flight.

At 0842, seven minutes after the occurrence, the average JBI was 0.35, with readings of 0.24 at the south end. The BAe 146 captain walked on the south end of runway 15 shortly after the occurrence, and noted that the runway surface at the centre was ice covered with water on it about 1/16 of an inch deep, and that the runway was very slippery.

1.12 Emergency Rescue Services (ERS) Response

The ERS crew responded immediately and reached the aircraft within a few minutes. As there was no fire, damage or injury, their services were not required, beyond facilitating the transfer of the passengers to the main terminal.

1.13 Aids to Navigation

All aids to navigation were operating normally.

1.14 Terrace Airport Information

Runway 15 at Terrace airport is asphalt, has a downslope of 0.28 per cent and is oriented 147 degrees magnetic. It is 6,000 feet long and 150 feet wide. The airport is located at the end of a valley and is surrounded on three sides by mountains rising to over 10,000 feet above sea level (asl), and the airport reference point elevation is 713 feet asl.

1.15 Air BC BAe 146 Performance Charts

The Air BC BAe 146 *Pilot's Handbook*, Appendix C-3, states that, when the runway is forecast or reported to be wet or slippery at the arrival airport, then the Factored Wet Landing Distance method applies (Dry Factored Distance plus 15 per cent), unless the estimated or actual JBI is less than 0.28. When the estimated or actual JBI is less than approximately 0.28, the Dry Factored Distance with a JBI correction should apply. This distance can never be less than the wet distance calculated above.

The Dry and Wet Runway Landing Field Length charts in the Air BC BAe 146 *Pilot's Handbook* and the *Quick Reference Handbook* used by the flight crew were prepared by British Aerospace, the manufacturer, and accepted by TC during the process of certifying the aircraft to operate in Canada in 1984. At that time, the regulations did not require consideration of landing field length on contaminated runways. The standard procedure in Canada for estimating landing field length on contaminated runways was to apply the factored Dry Runway figures to the JBI tables. The JBI table increased the Dry Runway figures to account for reduced braking efficiency on slippery runways.

The Dry Runway figures contain the "60 per cent factor," meaning that the aircraft's demonstrated landing distance was 60 per cent of the stated Landing Field Length distance, as was required by regulation. For example, if the landing distance for a Dry Runway Field Length is 5,000 feet, then the aircraft can stop in 60 per cent of this distance, or 3,000 feet. The remaining 2,000 feet is a safety margin to account for differences in pilot technique, and for less than ideal runway conditions.

When the Dry Runway Field Length is modified in the JBI tables for reduced braking coefficients, the 40 per cent safety margin is already used up, hence the JBI table does not start until the JBI is 0.35 or less, that is, when the aircraft has already passed into the 40 per cent safety margin. The Landing Runway Field Length figures in the JBI tables, therefore, are minimum stopping distances with no safety margin. Stopping within these distances requires a "textbook landing," that is, an ideal approach path and touchdown, correct approach speed, and prompt application of maximum braking and lift dumping devices. Any piloting or performance factors that are less than ideal will result in a landing distance longer than that which appears in the JBI table.

The 60 per cent factor is not explained in the *Aeronautical Information Publication Canada* (AIP). During their training, Air BC BAe 146 pilots are not taught that the 60 per cent factor is not present in the JBI tables, and their training leads them to use the JBI figures as accurate predictions of aircraft landing performance on contaminated runways.

Air BC reports that, in its six years of experience operating the BAe 146 on contaminated runways, the aircraft has performed according to the landing and JBI charts. The company believes that the aircraft went off the end of the runway because the JBI at the centre of the runway was less than where it was measured 30 feet either side of the centre line.

1.16 JBI Tables

TSB Engineering Branch report LP 44/94, "Calculation of Stopping Distances on Contaminated Runways using James Brake Index (JBI)," concluded that:

1) The method used to measure JBI is reasonable.

2) The JBI table in the AIP Canada should contain a warning that the distances assume a textbook landing, and do not contain the safety margin of the 60 per cent factor.

3) The calculation of the JBI figures does not consider the reduction in braking efficiency at lower JBI values, and is non-conservative.

The JBI table was created in 1973; however, TC has no engineering data on record to validate the JBI figures. A 1993 TC study entitled "The Validity and Applicability of the James Brake Index to Aircraft Landing Performance" was conducted to substantiate the JBI figures. The report concluded that actual landing distances may be as much as 18 per cent greater than the JBI table figures, and that the 60 per cent safety factor is removed. At the time of the occurrence, no amendment had been made to the JBI information in the AIP.

The AIP, section AIR 1.6.4, states that JBIs are accurate only for packed snow or ice, and not for wet or slush-covered runways. It also notes that, while there has been insufficient flight test verification to warrant formal approval, the information should prove a useful guide to pilots in estimating aircraft performance under adverse runway conditions.

The explanation below Table B, "Landing Distance Required Corrected for JBI and 60% Factor," in section AIR 1.6.6 of the AIP states as follows:

> ...it is designed for aircraft where performance data contains the 60% factor required by regulation. The table does not contain information for JBI numbers above .4 because the 60% factor already applied to the flight manual data will cater to runway requirements for JBI numbers above .4.

Thus, although the safety margin of the 60 per cent factor is not present in the JBI table, this is not clearly stated in the AIP. There is no explanation or definition of the 60 per cent factor in the AIP. Discussions with users of the JBI tables indicate that not everyone was aware that the 60 per cent factor is not present.

The Air BC BAe 146 *Pilot's Handbook* warns pilots that charts and graphs are only part of the solution when calculating landing distances, and states that pilots should remain "situationally aware," which means they should consider other factors that influence landing on a wet or slippery runway. They are also warned of the importance of flying the approach on profile at the correct speed, so as not to consume valuable runway. It is also stated that all landing distances derived from the JBI tables are considered estimated distances and are only intended as a guide. There is no direction on how to use these estimated distances as a guide when calculating landing distances. There is no mention in this handbook that JBI figures are only valid for packed snow and ice, as stated in the AIP, or that the safety margin of the 60 per cent factor is gone. Certification is not predicated on the use of reverse thrust when calculating landing distances; but, in fact, most large category aircraft are equipped with thrust reversers, and pilots of these aircraft use them when landing. The use of reverse thrust during the landing phase represents an extra stopping performance margin on slippery runways which is not available to the BAe 146 aircraft.

1.17 Information from the Manufacturer

British Aerospace (BAe), the manufacturer, was consulted regarding the occurrence. They stated that the JBI method of evaluating the BAe 146 performance on a slippery runway is not acceptable, and is totally inconsistent with the BAe figures. They refer to the BAe 146 *Manufacturer's Operations Manual* (MOM), section 9.10.11, "Handling Normal, Ice and Rain," which reveals that, given the circumstances on the day of the runway excursion, the aircraft would have required a ground roll of about 4,550 feet. When this distance is added to the 1,650 feet of runway overflown by the landing aircraft, a runway about 200 feet longer than the 6,000-foot Terrace runway was required. Furthermore, the landing distance required would have been increased by the tailwind component and the downslope of the runway.

The information in MOM section 9.10.11 is repeated in the BAe 146 *Aircraft Flight Manual* and was available to TC during the BAe 146 certification process; it was made available to Air BC in the fall of 1993. There is a disparity between the landing performance figures of Air BC and those of BAe.

1.18 Flight Recorders

There were two flight recorders installed on this aircraft at the time of the incident: the flight data recorder (FDR) and the cockpit voice recorder (CVR). Both units were removed from the aircraft, and the TSB retrieved and analyzed the data.

The FDR revealed that the aircraft was not in a stabilized approach before landing. The aircraft passed through the extended runway centre line as it turned onto final approach because the crew had to manoeuvre around low cloud, and angles of bank of up to 24 degrees were recorded when it was on short final. FDR data indicated that the aircraft touched down, left main gear first, 1,500 feet from the runway threshold[4], and the spoilers deployed at the 1,900-foot point. The captain shut down the

[4] Based on all of the information, however, it was concluded that the aircraft touched down at 1,650 feet.

outboard engines 4,200 feet from the threshold. The aircraft ran off the end of the runway at a speed of approximately 25 knots, about 42 seconds after touchdown.

The target final approach speed was 118 knots; the FDR indicated that the actual final approach speed was between 114 and 120 knots. The target flare speed was 113 knots; the FDR indicated that the actual flare speed was 117 knots. The target touchdown speed was 106 knots, and the FDR indicated that the actual touchdown speed was 108 knots.

The CVR contains an endless loop of tape which records, in this case, 33 minutes and 39 seconds of the most recent cockpit communications. Since the CVR had remained powered until the crew shut down the aircraft electrical power about 32 minutes after landing, only the last 1 minute and 39 seconds of this flight's communications remained for investigation purposes.

2.0 Analysis

2.1 Introduction

No mechanical discrepancies were found with the aircraft that would have contributed to the occurrence; the analysis will, therefore, focus on the combination of factors that led to the runway excursion.

2.2 The Approach and Landing

Had weather conditions not required the crew to manoeuvre around low cloud on short final, it is probable that the aircraft would have been on a stabilized approach. This would have enabled the co-pilot to land before 1,650 feet from the threshold, and he might have been able to stop the aircraft on the available runway.

The tailwind component present during the approach and landing contributed to the extended landing distance and additional ground run of the aircraft.

2.3 Crew Decisions

On breaking out of the cloud, the crew saw that a straight-in landing was not possible. They had briefed for this possibility, and elected to conduct a circling approach with a left turn to the other end of the runway. Several factors tended to de-stabilize the approach. The visual circling procedure had to be conducted with limited visibility in a confined area in freezing precipitation. The crew had to be mindful of the high terrain. There was a tailwind component, and the aircraft had to be manoeuvred around low cloud close to the runway threshold. The BAe 146 depends on brakes and lift dumping devices for deceleration. These may be less effective than reverse thrust in the high-speed early parts of a landing roll on a slippery surface.

The captain was faced with letting the co-pilot develop his judgement in challenging circumstances or controlling the aircraft himself. When the co-pilot lost sight of the runway because his view of it was blocked by his cross-cockpit line of sight, the captain would have been justified in taking control of the aircraft. Three times on the final approach, the captain suggested that they go around, but he left the decision with the co-pilot. The co-pilot expressed doubts about being able to see the runway again if they attempted another approach and continued with the approach and landing.

After the crew landed, they encountered unexpected conditions. The runway was more slippery than they had expected. In part, they relied too much on the JBI information provided to them and the pilot report from the MU-2. The JBI readings were taken on a track outside the wheel path of the aircraft on what was likely a less slippery surface. The MU-2 had a narrow track and might also have encountered different conditions than the landing BAe-146. In part, the published JBI information does not make clear that the normal landing distances safety factor is not present for the lower JBI readings. Neither does it express that reduced braking efficiency at lower JBI values makes the figures non-conservative.

There are cautionary words to make clear that JBI values are only for guidance. The BAe manufacturer's operating manual, if consulted, would have shown that remaining on the runway would have been problematic. The BAe information was made available to Air BC in 1993, and became a flight manual amendment.

In a situation where there is very little room for departure from the ideal landing profile, the effects of several factors increased the aircraft's landing roll to the extent that the aircraft overran the end of the runway. The crew could have and should have been aware of some of the effects, but they had no way of knowing about others, including the up to 18 per cent error in JBI readings and the reduction in the landing distance safety factor. The aircraft landed about 1,650 feet beyond the runway threshold, which is about 650 feet beyond the ideal touchdown point.

2.4 JBI Calculations

Because urea is spread on the runway centre area first, the centre of the runway might have been wetter than the surface 30 feet either side of the centre line, where the JBI was measured. The centre of the runway, where the BAe 146 landed, probably had a lower JBI than that reported. This would have caused the ineffective braking reported by the co-pilot.

Further, as JBI figures are only accurate for packed snow or ice, and not for wet or slush-covered runways, it was inappropriate for the pilots to rely on the JBI table to calculate the aircraft's stopping distance.

The JBI information published by TC in the AIP is for guidance only. The information is misleading as it does not give sufficient warning that the runway requirement figures for low JBI conditions have not been validated and contain inaccuracies of up to 18 per cent.

Although transport category aircraft such as the BAe 146 are given type approval which specifies that the aircraft shall be able to stop within 60 per cent of the intended landing field length, the use of the JBI table enables an operator to legally land on a contaminated runway where the JBI table predicts that the aircraft will require the full runway length, with no safety margin. Hence the 40 per cent safety margin is lost when it is most needed--that is, when the runway is contaminated and the stopping distance is unpredictable. Some pilots are not aware of this limitation regarding the JBI table and believe that the 60 per cent safety factor is still present.

2.5 BAe Contaminated Landing Performance Figures Compared to JBI Figures

The incident pilots relied unduly on the JBI figures, and did not realize that the safety margin of the 60 per cent factor had been removed, that the JBI figures were up to 18 per cent inaccurate, and that the JBI figures were estimates, to be used only as a guide.

Landing distance calculations using the figures in section 9.10.11 of the BAe 146 Operations Manual

(MOM) indicate that the aircraft would run off the end of the runway under the prevailing conditions; however, Air BC does not train, or require, its pilots to use the MOM performance charts to determine landing distances.

Landing distances predicted by both the MOM charts and the Air BC charts are longer than those predicted by the JBI tables; it was not possible, however, to determine the reason for this discrepancy, because the engineering data upon which the JBI table was based are not available.

3.0 Conclusions

3.1 Findings

1. The crew had to manoeuvre the aircraft around low cloud on short final to maintain visual contact with the runway.

2. The aircraft landed about 1,650 feet beyond the runway threshold, which is about 650 feet beyond the ideal touchdown point.

3. The aircraft landed with a tailwind component on a downsloped runway.

4. The aircraft went off the end of the runway at a speed of approximately 25 knots.

5. There was low cloud, freezing precipitation, and a tailwind when the aircraft landed.

6. The captain suggested to the co-pilot that they go around, but the co-pilot expressed doubts about being able to see the runway again if they attempted another approach and continued with the approach and landing.

7. The 60 per cent factor is removed from the JBI table, and this is not clearly stated in the AIP.

8. The JBI readings sample only portions of the runway.

9. TC has no record to validate the JBI figures, and a recent TC study found that actual landing distances were as much as 18 per cent greater than the AIP values.

10. The crew relied unduly on the JBI table.

11. There was a discrepancy between the BAe 146 landing performance figures of BAe and those of Air BC.

12. The aircraft was serviced and maintained in accordance with existing directives. Its weight and balance were within limits and the centre of gravity was within the normal range.

13. The pilots were certificated and qualified for the flight in accordance with existing regulations.

14. The BAe 146 aircraft is not equipped with thrust reversers and relies on brakes and lift dumping devices which are less effective on slippery surfaces.

3.2 Causes

The crew flew a landing pattern in a narrow valley under marginal weather conditions that dictated an unstabilized approach to the slippery and contaminated runway. The result was a longer-than-normal landing and landing roll. Contributing to the occurrence were a tailwind component, inaccurate James Brake Index (JBI) tables, crew decision making, and the company's use of landing performance tables different from those produced by the aircraft manufacturer for contaminated runways.

4.0 Safety Action

4.1 Action Taken

4.1.1 JBI Tables

In light of this occurrence, the TSB sent an Aviation Safety Advisory (950056) to Transport Canada (TC) in April 1995. The Advisory highlighted the need for TC to re-evaluate the JBI tables and revise the information portrayed in the AIP accordingly. Additionally, it stated that TC might wish to consider interim action to inform the aviation community of the apparent shortcomings of the JBI tables.

Subsequent to the TSB Advisory, Air BC indicated other concerns regarding the use of landing distances based on JBI, namely the appropriateness of the runway locations where JBI measurements are taken, the need for JBI corrections for all possible runway conditions, and the possible adverse effect on stopping distances of melting due to urea application. The TSB forwarded these concerns to TC. In addition, a second Aviation Safety Advisory (960084) was sent to TC in August 1996 on the lack of an explicit indication that the JBI tables do not include the 60 per cent safety factor in the derived landing distances for contaminated runways.

TC has indicated that no changes will be made to the JBI tables until the results of a combined NASA/FAA/TC winter runway test program are available. TC also indicated that an Air Carrier Advisory Circular will be released on the issue of contaminated runways.

4.1.2 Operator Action

Air BC has indicated that, until the JBI data is validated, 20 per cent will be added to any required landing distance when using a JBI correction factor from the applicable table in the AIP.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail and W.A. Tadros, authorized the release of this report on 12 November 1996.

Appendix A - List of Supporting Reports

The following TSB Engineering Branch Laboratory reports were completed:

LP 10/94 - Flight Recorder Analysis;

LP 11/94 - Cockpit Voice Recorder/Air Traffic Control Tape Analysis; and

LP 44/94 - Calculation of Stopping Distances on Contaminated Runways using James Brake Index (JBI).

These reports are available upon request from the Transportation Safety Board of Canada.

Appendix B - Glossary

agl	above ground level
asl	above sea level
AIP	Aeronautical Information Publication (TP2300)
ATPL	Airline Transport Pilot Licence
BAe	British Aerospace
CVR	cockpit voice recorder
ERS	emergency rescue services
FDR	flight data recorder
FSS	Flight Service Station
hr	hour(s)
IFR	instrument flight rules
JBI	James Brake Index
lb	pound(s)
LOC	localizer navigation aid
MAP	missed approach point
MOM	Manufacturer's Operations Manual (for the BAe 146)
NDB	non-directional beacon
PAPI	precision approach path indicator
PST	Pacific standard time
TC	Transport Canada
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time (Zulu)
'	minute(s)
"	second(s)
°	degree(s)