AVIATION OCCURRENCE REPORT
A98C0173

RUNWAY OVERRUN

WASAYA AIRWAYS LTD.
BAe 748-2A (HS-748-2A) C-GTAD
KASABONIKA, ONTARIO
06 AUGUST 1998

Aviation Occurrence Report

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Synopsis

Wasaya Airways Ltd. Flight 804, a Hawker Siddeley 748-2A, serial number 1750, landed at Kasabonika, Ontario, on a freight flight from Pickle Lake, Ontario. During the landing roll, the aircraft could not be stopped and overran the runway by about 450 feet. The captain, the first officer and one of the freight handlers suffered minor injuries; the other freight handler was not injured. The aircraft was destroyed.

The Board determined that the aircraft was landed at a point from which it could not be stopped under the prevailing conditions. Contributing to the occurrence were the lack of immediate propeller ground fine pitch and the choice of runway 03 as the landing runway. A possible contributing factor was the inappropriate information in the then-current runway analysis manual.

Ce rapport est également disponible en français.

Table of Contents

1.0 Factual Information

1.1 History of the Flight

The Hawker-Siddeley 748-2A operated by Wasaya Airways Ltd. (Wasaya) departed Pickle Lake, Ontario, at 1500 central daylight time (CDT)[1] on a 35-minute scheduled freight flight to Kasabonika, Ontario. The flight was the third flight of the day and followed two previous freight flights, to Wunnumin Lake and Webequie, respectively. The same crew, consisting of a captain, first officer, and two freight handlers, operated the aircraft on all three flights. The accident flight was uneventful during the departure from Pickle Lake, and during the en route portion of the flight. The captain and the first officer reported that, after landing, they both applied the aircraft's wheel brakes to the extent possible. The aircraft overran the remaining runway, the turn-around area and entered the overrun area. The aircraft came to rest upright in soft ground, in an area of sapling trees, about 500 feet north of the runway end markers.

1.2 Injuries to Persons

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

The captain, first officer, and a freight handler suffered minor cuts and bruises from contact with the interior of the aircraft and cargo items.

1.3 Damage to Aircraft

The aircraft's port wing struck uneven ground in the overrun area, breaking the spar near the outboard end of the flaps. All propeller blades were bent back; the port propeller hub was damaged internally. The fuselage was broken both forward and aft of the wing carry-through section. The forward fuselage break allowed the fuselage to move to starboard, and it entered the plane of the starboard propeller. The propeller cut into the fuselage in the forward cargo area. The main landing gear was severely damaged by impact with rocks. The nose landing gear was broken from its mounts by impact with rocks and was detached and separated from the aircraft. The lower front fuselage and lower cockpit floor were damaged by impact with rocks, and the cockpit floor was pushed up, deforming the centre console and jamming the engine controls. The deformation of the cockpit floor in the area of the rudder pedals trapped the captain's feet and prevented him from leaving the cockpit for a period of about five minutes after the aircraft came to rest.

1.4 Other Damage

[1] All times are CDT (Coordinated Universal Time minus five hours) unless otherwise noted.

The starboard propeller damaged some of the cargo and severed some cargo tie-down straps. The severed straps allowed some of the cargo to shift. Some of the vegetation in the overrun area was damaged, and a small amount of fuel spilled from the broken port wing.

1.5 Personnel Information

	Captain	First Officer
Age	51	26
Pilot Licence	ATPL	ATPL
Medical Expiry Date	31 Dec 1998	31 Jan 1999
Total Flying Hours	20 600	3 000
Hours on Type	6 000	500
Hours Last 90 Days	238	204
Hours on Type Last 90 Days	238	204
Hours on Duty Prior to Occurrence	6	6
Hours off Duty Prior to Work Period	12	12

The captain's records indicated that the day of the accident was his 10th consecutive day at work following 14 days off. The captain's average time on duty during those 10 days was
11.5 hours per day. He reported that he was not fatigued and was feeling fine. The day of the accident was the first officer's second day back at work after a period of two days off, and he too reported that he was feeling well at the time of the occurrence. Both the captain and the first officer had landed HS-748 aircraft at Kasabonika many times and were familiar with the area. There was no indication that physiological factors affected the performance of either of the crew members.

1.6 Aircraft Information

1.6.1 Aircraft Data

Manufacturer	British Aerospace (Hawker Siddeley)
Type and Model	748 Series 2A
Year of Manufacture	1977
Serial Number	1750
Certificate of Airworthiness (Flight Permit)	Issued 19 October 1995
Total Airframe Time	12 310.9
Engine Type (number of)	Rolls-Royce turboprop (2)
Propeller/Rotor Type	Dowty Rotol variable/feathering
Maximum Allowable Take-off Weight	46 500 pounds
Recommended Fuel Type(s)	Jet A, Jet B, Aviation Kerosene or other Aviation Wide-Cut fuels
Fuel Type Used	Jet A

A review of the aircraft's maintenance records indicated that the aircraft was certified and maintained in accordance with existing regulations.

1.6.2 Aircraft Systems

The aircraft is equipped with three systems which contribute to deceleration after landing: the brakes, the propellers, and the flaps.

The hydraulic brake system provides hydraulic fluid to each of the main wheel brake systems, with pressure from hydraulic pumps attached to the engines. The brake system is controlled by a brake control valve and is operated by pressure from toe pedals attached to the rudder bars. An anti-skid system is fitted to each of the four main wheels and operates to release brake pressure to a main wheel when it senses that the wheel has slowed sufficiently to induce a skid.

The aircraft is equipped with four-blade Dowty Rotol constant-speed, full-feathering propellers. The propeller control system incorporates a flight fine pitch stop (FFPS), which is designed to prevent the pitch of the propeller blades from reducing below 18 degrees in flight. The FFPS is removable for ground operation. A single FFPS lever, mounted on the aircraft's centre console, activates electrical solenoids in each propeller control unit, which remove the stop to allow the pitch of the propellers to reduce to zero degrees (ground fine pitch). The aircraft flight manual (AFM) recommends removal of the FFPS immediately on touchdown in order to maximize aerodynamic drag from the propellers and thereby aid in the deceleration of the aircraft. The design of the propeller does not incorporate a reverse pitch system. The FFPS system incorporates a warning horn, which is activated five seconds after the touchdown if the FFPS lever has not been withdrawn.

The aircraft is equipped with slotted Fowler-type flaps. The trailing edges of the flaps are fitted with a tab section which lowers with the "Land" flap selection. The purpose of the tab is to increase drag during the final stages of landing. Examination of the aircraft after the occurrence revealed that the flaps were set to the "Land" position, and the tab section was extended.

1.7 Meteorological Information

No official weather information is available for Kasabonika. The area forecast for the Favourable Lake, Pickle Lake, Severn River regions, issued on 06 August 1998 for the period of the aircraft's arrival in Kasabonika, indicated that the area was in a light westerly to south-westerly flow, and that the airmass was moist and convectively unstable. An observation taken by the Trout Lake automated weather observation system at 1500 recorded the wind as 180 degrees true at two knots, visibility one and five-eights statute miles, a few clouds at 4 300 feet above ground level (agl), the temperature 30 degrees Celsius, dewpoint 15 degrees Celsius, and the altimeter setting 30.16 inches. The observation at 1600 recorded the wind as 180 degrees at two knots, visibility two and one-half statute miles, a few clouds at 3 500 feet agl, temperature 30 degrees Celsius, dewpoint 15 degrees, and the altimeter setting 30.14 inches. Witnesses in the airport area reported that they perceived the wind to be light.

1.8 Aids to Navigation

The Kasabonika area is served by a non-directional beacon, identifier YAQ, located at the airport. The accident aircraft was equipped with a global positioning system (GPS) receiver. The flight crew used the GPS during the approach for distance information, in order to judge the appropriate position for the start of the descent, and to check for variations in ground speed resulting from winds. The crew reported that, from their observations of the GPS information, they believed that there were no significant winds on final approach.

1.9 Aerodrome Information

The Kasabonika airport is a certified aerodrome, operated by the Province of Ontario.
Runway 03/21 is 100 feet wide and is comprised of a firm clay base under a patchy one-inch thick layer of loose gravel. The Canada Flight Supplement (CFS) lists the runway slope as
1.18 per cent. A survey completed in 1997 for the operator indicated that the runway is
3 527 feet long, with an overall elevation decrease of 41 feet (a down-slope of 1.16 per cent) from the threshold to the end of runway 03. The slope of the runway is not uniform. The slope for the first 1 469 feet of runway 03 is a down-slope of 1.07 per cent. The slope for the remaining
2 057 feet is a down-slope of 1.28 per cent. Transport Canada Aerodrome Standards and Recommended Practices, TP312, recommends that the transition from one slope to another be accomplished by a curved surface with a rate of change not exceeding 0.2 per cent per
30 metres. There is no sharp transition point in the slope of the runway; the down-slope increases gradually from the threshold of runway 03 to the area past the end of the runway.

A 200-foot gravel turn-around area is located past the lights marking the end of runway 03. The area north of this turn-around area is comprised of a relatively even gravel and clay ground in the first 100 feet; the ground then transitions to a steep drop-off area containing a number of large rocks. The difference in elevation from the runway end markers to the aircraft's final position was 21.3 feet (a down-slope of 4.26 per cent).

A windsock and a precision approach path indicator (PAPI) were located near the approach end of runway 03. The PAPI is designed to project a series of lights to provide pilots with visual indications of the desired approach slope to a runway. The first officer reported that he did not see the lights in the PAPI, and believed it to be unserviceable. The captain did not recall the status of the PAPI. The airport foreman checked the runway lights periodically and was not aware of any unserviceabilities in the airport equipment at the time of the occurrence. The PAPI system does not operate continuously. It, along with the runway and taxiway light system, is operated by aircraft radio control of aerodrome lighting (ARCAL). There was no indication that either the captain or the first officer activated the ARCAL system for the approach into Kasabonika; the crew used visual cues to determine the correct approach angle. A down-sloping runway presents different visual cues as to approach angle, as compared to a level runway, which can lead aircraft crew to position their aircraft higher on approach than the desired approach angle.

1.10 Communications

The first officer made several aerodrome traffic advisories at the top of the descent and again during the approach. There was no other air traffic in the area which influenced the choice of runway or affected the approach to runway 03. The airspace in the Kasabonika area is not controlled, and no clearances are required for operation into the Kasabonika airport.

1.11 Flight Recorders

The aircraft was equipped with a Plessey 650 flight data recorder (FDR) and a Fairchild (Loral) A100 cockpit voice recorder (CVR). Both units were recovered undamaged from the aircraft after the occurrence and were sent to the TSB Engineering Laboratory for analysis.

1.12 Wreckage and Impact Information

The aircraft's nose landing gear was torn off. The port wing was broken at the outboard flap position. The fuselage was broken ahead of and behind the wing area. As the aircraft descended the steeply-inclined portion of the overrun area, the forward fuselage shifted to starboard in relation to the rest of the aircraft, and the starboard propeller blades struck and penetrated the fuselage. The main fuselage of the aircraft came to rest on a heading of 355 degrees magnetic; the forward fuselage/cockpit portion was headed 020 degrees.

The hydraulic brake control valve and the anti-skid wheel braking system were examined at the TSB Engineering Laboratory. The brake control valve was found to be undamaged and functional. One of the wheel's anti-skid system was found to have damage consistent with the impact forces sustained by the aircraft in the occurrence, but internal examination revealed no apparent pre-existing defect. Tests of the anti-skid system on the three other wheels indicated that they functioned normally.

Damage to the aircraft prevented a full functional testing of the FFPS system. However, examination of the propeller control units at the TSB Engineering Laboratory indicated that the ground fine pitch solenoids were capable of normal operation. A field examination of the FFPS wiring and microswitch systems did not reveal any defects. There were no tests available to indicate when the FFPS lever was withdrawn, or whether it was selected to ground fine,
re-entered the flight fine position, and then was re-selected to ground fine.

Both main wheel brake component systems were removed from the site and examined at a maintenance facility in Thunder Bay, Ontario. No defects were noted in the brake components, and both of the brake rotors exhibited blueing discolouration consistent with heavy brake application and energy transfer.

1.13 Medical Information

There was no information which indicated that either the pilot or the first officer was affected by a pre-existing medical condition which affected his performance during the occurrence.

1.14 Fire

There was no indication of fire.

1.15 Survival Aspects

Both the captain and the first officer were wearing the installed lap belts and shoulder harnesses. One freight handler was seated in the forward-facing crew seat and was wearing the installed lap belt and shoulder harness. The second freight handler occupied a rear-facing crew seat in the forward cargo area, which is equipped with a lap belt and a shoulder harness. He had reportedly occupied this seat and had worn the lap belt and shoulder harness during the take-off at Pickle Lake. During the flight, the second freight handler left his seat and sat on a pallet of cargo next to his seat, in the forward cargo area, in order to gain a better view. He was at that position during the landing at Kasabonika and sustained some facial cuts and bruises, mostly from contact with cargo items which shifted during the accident sequence. Some cargo items shifted and struck the crew seat where the second freight handler had been sitting.

1.16 Tests and Research

Not Applicable

1.17 Approach and Landing Information

On arrival in the Kasabonika area, the captain, who was the pilot-flying (PF), decided to approach and land on runway 03, and called for the pre-descent check. The captain selected runway 03 as the landing runway rather than runway 21, as it was more closely aligned with the flight path from Pickle Lake, which would simplify the approach. The first officer, who was the pilot-not-flying (PNF), called out the checklist items, which included a check of the status of the brakes and the hydraulic system. The captain and first officer reported that they checked the brakes and the hydraulic system and noted that the applied brake pressure and the system hydraulic pressure cycled and returned to normal, in accordance with the aircraft manufacturer's specifications.

During the descent, the captain believed that the aircraft was high, relative to the normal descent angle, and he completed several S-turns to lose altitude. The S-turns were completed about three miles from the threshold. On final approach, the captain and first officer both believed the aircraft to be slightly under the desired descent angle and the captain added power to slow the descent.

The captain brought the power levers to idle over the threshold. The aircraft touched down briefly at a point 1 273 feet from the threshold of the runway, rose briefly, and landed again at a point 1 469 feet from the

threshold. The crew members perceived the aircraft's braking after touchdown to be less effective than normal, despite the application of brake pressure by both crew members. The captain reported that he pulled the FFPS lever to the "STOP WITHDRAWN" position at the time of the first touchdown. After the aircraft traversed the 2 057 feet to the runway end markers, the captain steered the aircraft slightly to starboard. The aircraft then passed through the 200-foot gravel turn-around area, and entered the overrun area. The captain stated that he normally landed aircraft much closer to the threshold than he did during the occurrence flight, and that the aircraft floated farther down the runway on this occasion, for reasons which he was not able to explain. The FDR indicates that airspeed over the threshold may have been slightly above the target speed of 94 knots. Excess airspeed can contribute to "float," if the aircraft is held off the runway. Both tailwind and down-sloping runway conditions have the effect of increasing the runway distance consumed during the round-out and touchdown portion of the landing procedure.

Examination of the CVR revealed sounds which are consistent with the sounds of a landing. About five seconds after the landing sounds, the sound of a warning horn consistent with the FFPS warning was heard. The warning continued for a period of two seconds, and then stopped. Neither the captain nor the first officer recalled hearing the warning horn, nor could they explain why the horn would have activated. Both the captain and the first officer reported that their attention was concentrated on events outside the cockpit during the landing sequence.

1.18 Aircraft Weight

The aircraft weight limitations established by the manufacturer are as follows:

maximum gross take-off weight:.....46 500 pounds
maximum (structural) landing weight: .....43 000 pounds
maximum zero fuel weight:.....38 500 pounds

In addition, the aircraft may, for a particular take-off, be weight-limited for reasons of runway length, altitude, and temperature (WAT). The crew determined that, for the take-off from Pickle Lake, the WAT limit was 43 870 pounds. The crew also determined that the lowest, and therefore operative, weight limitation was the maximum zero fuel weight limit of 38 500 pounds plus the aircraft's take-off fuel load of 5 000 pounds, for a maximum allowable take-off weight of 43 500 pounds. The flight departed with a cargo load of 12 500 pounds, at a gross weight of 43 484 pounds. The fuel burn en route to Kasabonika was 1 200 pounds; the aircraft's landing weight was 42 284 pounds.

The aircraft's longitudinal and lateral centres of gravity were within the prescribed limits.

1.19 Aircraft Landing Performance

To provide company pilots with a performance reference for various airports, Wasaya contracted with Automated Systems in Aircraft Performance Inc. (ASAP) for the preparation of a runway analysis manual. ASAP advised that the material in the manual, prepared for the HS-748-2A, was derived from the performance information contained in the AFM. The manual in use at the time of the occurrence is dated 01 June 1998. The pages of the manual listing landing limit weights are dated 13 November 1997.

The "Flaps 27 ½ Landing" page of the manual lists approach and landing climb limit weights of 42 580 pounds (with water methanol on) for 30 degrees Celsius for Kasabonika. The climb limit weights exceed 43 000

pounds for temperatures under 20 degrees Celsius. These weight limits were reportedly developed by ASAP to provide a climb performance margin in the event that the flight crew elects to conduct a missed approach. The approach and landing limits incorporate a temperature correction table and are not runway specific.

A second set of weight limits on the "Flaps 27 ½ Landing" page is entitled "Landing Runway Limit Weights." Separate limitations were developed for runway 03 and for runway 21. The limitation weight for both runways was listed as 43 000 pounds with zero wind. For both runways, the critical tailwind (the tailwind below which there is no change to the limitation weight) was stated to be seven knots, and the penalty for tailwinds in excess of the critical tailwind was to reduce the maximum weight by 390 pounds per knot of tailwind. ASAP personnel stated at that time that, for shorter runways such as Kasabonika, the effects of runway slope were insufficient to materially affect the limitation weights. There is no correction factor mentioned in the ASAP Landing Runway Limit Weights for the effects of temperature.

After the occurrence, Wasaya referred to the ASAP runway analysis manual as indicating that the aircraft could be operated into either runway at Kasabonika at 43 000 pounds landing weight.

On 24 August 1998, ASAP revised the runway analysis manual. The revised "Flaps 27 ½ Landing" page lists the maximum landing weights for both runway 03 and runway 21 as 43 000 pounds. The revised critical tailwind for runways 03 and 21 is listed as five knots and nine knots, respectively. The tailwind penalty for runway 03 is 1 210 pounds per knot, and the penalty for runway 21 is listed as 350 pounds per knot of tailwind. After the revision, ASAP has stated that it does not believe that the effect of runway slope is minimal on short runways.

The AFM contains a "Landing Distance Required" chart for flaps 27 ½ which accounts for variables in aircraft weight, aerodrome altitude, wind, and runway slope. The International Standard Atmosphere (ISA) temperature for the elevation of the runway is 13.8 degrees Celsius. The AFM states that corrections to the landing distance for temperature are not required by existing regulation. The AFM also states that landings with flaps 22 ½ must not be made with tailwind components at aircraft weights above 41 500 pounds.

The aircraft manufacturer was consulted as to the landing performance of the aircraft. The manufacturer calculated the landing distance required, from a threshold height of 50 feet, using the chart replicated in the AFM, which assumes a dry, paved runway and ISA conditions. The calculated landing distance required, taking into account the aircraft weight, runway elevation, and a runway down-slope of 1.28 per cent (the average slope for runway 03 from the landing point to the end) was 3 570 feet. The airborne segment of that distance comprises 1 330 feet, and the ground roll comprises 2 240 feet. The landing distance required is a "net" distance required to land from 50 feet. It is obtained by multiplying the measured "gross" stopping distances, obtained under ideal conditions during aircraft certification testing, by a safety factor of 1.67. Temperature is not a variable in the chart itself, but a temperature correction factor is mentioned in a note to the chart. The note states that operating regulations do not require account to be taken of variations in temperature from ISA; however, the effect of temperature is to increase the landing distance by 0.40 per cent for each degree Celsius by which the temperature exceeds the ISA temperature. In addition to temperature, several other factors affect landing distance, but are not specifically factored into performance charts. These include runway surface conditions other than dry pavement, aircraft component condition, and pilot technique. The manufacturer indicated that aircraft stopping distances will likely be longer on gravel surfaces than on the dry paved surfaces used in aircraft certification testing; however, no specific correction factor is available for hard dry gravel surfaces. The 1.67 safety factor is designed to compensate for real-world variations in temperature, runway surface, component condition and pilot technique.

A calculation based on the AFM data, a landing weight of 42 284 pounds and a slope of 1.16 per cent (the average slope for the entire runway) determined that the landing distance required was 3 510 feet under ISA conditions, and 3 735 feet when corrected for temperature. With a tailwind of two knots, the landing distance required was 3 650 feet, and 3 887 feet when corrected for temperature.

Canadian Aviation Regulation (CAR) 705.56 prohibits the dispatch of an aircraft where the aircraft weight at landing exceeds the weight specified for the destination runway length, taking into account pressure altitude and temperature. Temperature variation is incorporated into the net stopping distances. A calculation indicated that the gross stopping distance, corrected for temperature, would not exceed the landing distance available.

CAR 705.60 prohibits the dispatch of aircraft where the weight at landing will not allow a full stop landing within 70 per cent of the landing distance available. Because the landing distance required, using average runway slope, was 3 510 feet under ISA conditions, the landing distance available was 3 527 feet.

1.20 Organizational and Management Information

Pilots at Wasaya report to the chief pilot, who reports to the director of flight operations. Ultimate corporate authority resides in the president. The company had delegated authority from Transport Canada to conduct certain pilot proficiency checks (PPC) of its personnel. The occurrence captain had passed a check PPC for the HS-748 in 1996 and, at the time of the occurrence, held delegated authority to conduct proficiency checks on the Cessna 208 type.

1.21 Useful or Effective Investigation Techniques

Examination of the runway surface indicated that small stones had been pulled from the hard clay runway surface by the aircraft's tires during the landing roll. Examination of the tires revealed the presence of small stones of a size which corresponded to scratches in the tire marks left by the landing aircraft during the landing roll and longitudinal striations on the tire surfaces, which also corresponded in size to the small stones embedded in the runway surface. Abrasion of the runway surface indicates braking action approaching the limits of tire traction on the gravel runway.

2.0 Analysis

2.1 Approach and Landing Limit Weights

The approach climb limit weight of 42 580 pounds found in the ASAP runway analysis manual exceeded the aircraft's calculated landing weight, 42 284 pounds, which indicates that the aircraft's overshoot performance should not have been compromised. However, the fact that the flight crew's weight and balance sheet lists a maximum landing weight of 43 000 pounds indicates that this approach and landing climb weight limit was not observed during flight planning. Wasaya's belief that the runway analysis manual indicated that the aircraft could be operated into either runway at Kasabonika at 43 000 pounds was true only for temperatures under 20 degrees Celsius, and not at the ambient temperature of 30 degrees at the time of the accident.

The ASAP runway analysis manual in effect at the time of the accident listed the same landing runway limit weights for both runways 03 and 21, because ASAP believed that the effect of runway slope was minimal on short runways. The AFM landing distance required chart does incorporate slope as a factor, and the changes to the ASAP manual after the occurrence indicate that slope was taken into account in the revision. The landing runway limit weights that were in effect at the time of the accident did not assist the operator or the flight crew to appreciate the effects of wind during landings at Kasabonika.

2.2 Descent Profile

No clearances are required by the crew for the descent into the Kasabonika airport; the point at which the descent is commenced, the descent profile, and the approach speeds are determined by the crew. The crew did not activate the PAPI. Although the crew was experienced in operations into Kasabonika, the fact the aircraft was initially high on approach and then was low enough to require additional power indicates that reference to an operating PAPI might have assisted the crew in placing the aircraft on the optimal descent angle. The down-slope of runway 03 provided misleading visual cues to the crew on approach and may have made it more difficult for them to fly the aircraft on the optimal descent angle.

2.3 Kasabonika Runway

The Kasabonika runway slope is described as a single figure in the CFS, although the runway slope is not constant but increases steadily from the south to the north end of the runway and into the overrun. Because of this increasing slope, the first and most-level portion of runway 03 will be over-flown by landing aircraft, which makes it unlikely that the runway slope angle listed in the CFS can be realized in practice by landing aircraft. The increasing down-slope on runway 03 tends to amplify the effect of any condition which results in a touchdown point further down on the runway, in that the remaining runway will be both shorter and more-steeply inclined. The increasing down-slope of the runway carried into the overrun area, whose down-slope exceeding four per cent further increased the distance required to stop the accident aircraft.

2.4 Wind

Although the winds were reported to be light at Kasabonika, the revised runway analysis manual indicates that the effects of tailwinds on runway 03 landings are significant. The winds in the area were southerly, and it is possible that a small southerly tailwind component could have affected the aircraft as it was landing on runway 03.

2.5 Deceleration

Although the crew members perceived the aircraft's braking after touchdown to be less effective than normal, examination of the aircraft after the occurrence revealed that the brakes had absorbed considerable energy, and the tires had approached the limits of adhesion on the surface available. The captain reported selecting the propellers to the ground fine position on touchdown. However, the activation of the FFPS ground warning indicates that the propellers did not attain their ground fine position until about five seconds after touchdown. No mechanical or electrical anomalies were found that would indicate a fault in the FFPS system, and it is therefore likely that the propellers did not attain their ground fine position until five seconds after touchdown. Because the aircraft's centre console was disrupted during the occurrence and the flight crew's attention was mostly focussed outside the cockpit, there was insufficient information to determine whether the FFPS lever was selected late to the ground fine position, or whether it was selected initially to the ground fine position and then re-entered to the flight fine position and was then re-selected.

2.6 Landing Distance Required

Landing distance calculations indicated that, at the aircraft's landing weight and the average slope for runway 03 at Kasabonika, the landing distance required under ISA conditions was 3 510 feet, within the available runway length of 3 527 feet. When the landing distance required was calculated with the runway slope for the portion of runway remaining at the aircraft landing point, the required landing distance under ISA conditions exceeded the runway length at Kasabonika. When the landing distance required was calculated with the two-knot tailwind which prevailed at the nearest weather observation station and was forecast in the area forecast, the landing distance required exceeded the distance available. When a temperature correction was applied to any of the three scenarios described above, the landing distance required exceeded the distance available. Although the AFM does not require such a temperature correction to be made, the corrected landing distance indicates that the high ambient temperature on the day of the accident consumed part of the 1.67 safety factor built into the manufacturer's landing performance charts.

Because temperature variation is incorporated into the AFM net performance figures, and the gross stopping distance plus a temperature correction factor would still be within the landing distance available, the requirements of CAR 705.56 were met.

Because the landing distance available was 3 527 feet, and the landing distance required was 3 527 feet, the aircraft weight on landing did not allow it to stop within 70 per cent of the landing distance available, and therefore the requirements of CAR 705.60 were not met. The ASAP runway analysis manual did not take into account the requirements of CAR 705.60.

The aircraft's touchdown point, at 1 469 feet from the threshold of runway 03, was slightly farther down the runway than the factored landing distance point assumed by the manufacturer in calculating the aircraft's landing distance required. The selection of runway 03 as the landing runway, and the late touchdown point,

placed the aircraft in a position where the distance required exceeded the runway distance remaining, under ISA conditions. Although the manufacturer's calculated landing distance required included a 1.67 safety factor, that safety factor was consumed by the combined effects of the long landing, high ambient temperature, gravel-surfaced runway, possible tailwind, and probable momentary lack of propeller braking.

3.0 Conclusions

3.1 Findings

1. Records indicate that the captain and the first officer were certified and qualified for the flight in accordance with existing regulations.

2. Maintenance records indicate that the aircraft was certified and maintained in accordance with existing regulations.

3. There was no indication that physiological factors affected the performance of either of the crew members.

4. The ASAP runway analysis manual did not take into account the requirements of CAR 705.60, or assist the operator or the flight crew to appreciate the effects of wind during landings at Kasabonika.

5. The approach and landing climb limit weights in the ASAP runway analysis manual were not observed during the flight planning of the operation.

6. The aircraft weight at landing did not allow it to stop within 70 per cent of the landing distance available; therefore, the requirements of CAR 705.60 were not met.

7. The crew did not use the PAPI during the approach.

8. The slope of runway 03 is not constant but increases steadily from the south to the north end of the runway and into the overrun.

9. The aircraft landed at a point 1 469 feet from the threshold; the remaining 2 057 feet had a down-slope of 1.28 per cent.

10. The aircraft's propellers probably did not attain ground fine pitch position until about five seconds after landing.

11. The calculated landing distance required, without correction for temperature, including the average runway slope and the 1.67 safety factor, was within the runway length available.

12. The safety factor was consumed and exceeded by the combined effects of the long landing, high ambient temperature, gravel-surfaced runway, increasing runway slope, possible tailwind component, and probable momentary lack of propeller braking.

3.2 Causes

The aircraft was landed at a point from which it could not be stopped under the prevailing conditions. Contributing to the occurrence were the lack of immediate propeller ground fine pitch and the choice of runway 03 as the landing runway. A possible contributing factor was the inappropriate information in the then-current runway analysis manual.

4.0 Safety Action

4.1 Action Taken

Transport Canada convened the Performance Standards Working Group in March 1998. The Working Group has a Gravel Runways sub-committee, which was tasked with examining issues related to gravel operations.

The aircraft operator issued a memo to its flight crews on 10 August 1998. The memo cautions crews about landing on down-sloping runways and instructs them to land on runway 21 at Kasabonika when winds are light.

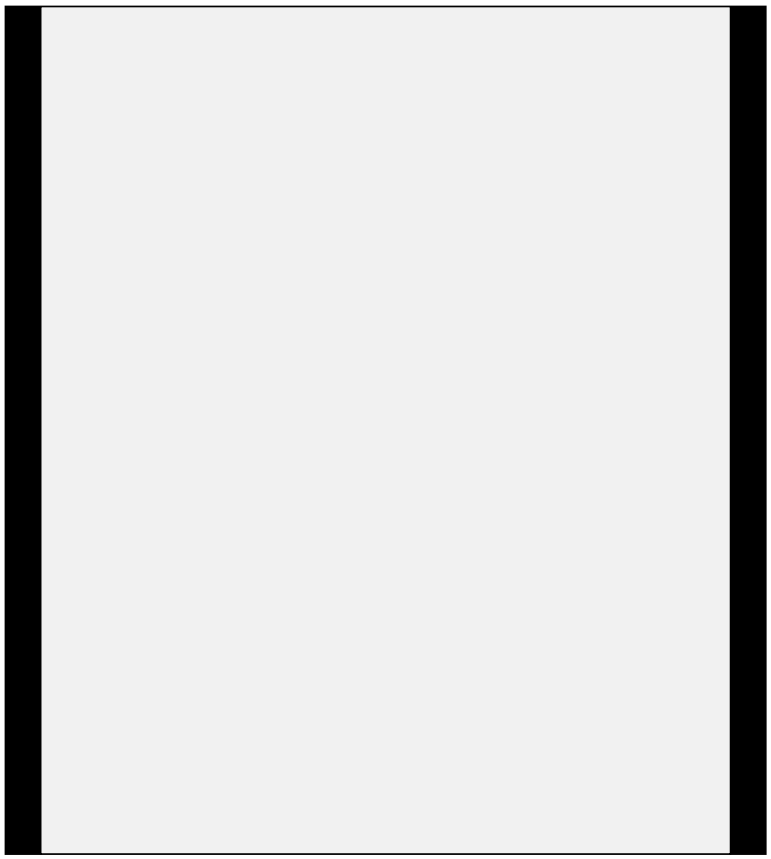
The ASAP runway analysis data, amended to incorporate the effects of runway slope, was distributed to Canadian operators of the HS-748 aircraft type on 24 August 1998.

In the fall of 1998, the airport operator began to re-grade the overrun area. The grade of the overrun area was smoothed to remove the sharp drop-off which existed in part of the overrun at the time of the accident. As well, a number of large boulders in that area were removed.

Transport Canada has taken steps to reconcile differences between the HS-748 AFM and the CARs.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 29 September 1999.

Appendix A - Runway and Ground Roll Diagram



Appendix B - List of Supporting Reports

The following TSB Engineering Branch Reports were completed:

LP 92/98 - FDR-CVR Analysis

LP 111/98 - Examination of Brake and Propeller System Components

Appendix C - Glossary

agl	above ground level
AFM	aircraft flight manual
ARCAL	aircraft radio control of aerodrome lighting
ASAP	Automated Systems in Aircraft Performance Inc.
ATPL	airline transport pilot licence
CAR	Canadian Aviation Regulation
CDT	central daylight time
CFS	Canada Flight Supplement
CVR	cockpit voice recorder
FDR	flight data recorder
FFPS	flight fine pitch stop
GPS	global positioning system
ISA	International Standard Atmosphere
PAPI	precision approach path indicator
PF	pilot-flying
PNF	pilot-not-flying
PPC	pilot proficiency check
TSB	Transportation Safety Board of Canada
Wasaya	Wasaya Airways Ltd.
WAT	weight-limited for reasons of runway length, altitude, and temperature