Transportation
Safety Board
of Canada

Bureau de la sécurité
des transports
du Canada

AVIATION INVESTIGATION REPORT
A16Q0119

Loss of control and collision with terrain

Cessna U206F, C-FWBQ
Kuashkuapishiu Lake, Quebec
143 nm N of Baie-Comeau, Quebec
25 September 2016

Canada

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Summary

The privately operated Cessna U206F floatplane (registration C-FWBQ, serial number U20602785) was flying under visual flight rules from Kuashkuapishiu Lake, Quebec, to Ra-Ma Lake, Quebec, near the Manicouagan Reservoir, Quebec, with the pilot and 2 passengers aboard. After taking off at around 1400 Eastern Daylight Time, the aircraft began a climbing turn to the left while it was at the north end of the lake. A few moments later, the aircraft quickly banked to the right, lost altitude, struck the ground, and immediately caught fire. The fire consumed almost the entire cabin. The pilot was seriously injured, and the 2 passengers were fatally injured. No emergency locator transmitter signal was received.

Le présent rapport est également disponible en français.

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1.0 Factual information

1.1 History of the flight

The day before the accident, the pilot flew from Gatineau Airport, Quebec, with 1 passenger aboard, to Kuashkuapishiu Lake, Quebec, where his hunting and fishing camp was located. The privately operated Cessna U206F floatplane (registration C-FWBQ, serial number U20602785) stopped at the airport in Trois-Rivières, Quebec, to refuel and take on a second passenger. After dropping off the 2 passengers at Kuashkuapishiu Lake, the pilot made 3 more flights between Kuashkuapishiu Lake and Louise Lake, Quebec, to transport luggage and freight and to pick up 2 other passengers, who had arrived at Louise Lake by car, and bring them to Kuashkuapishiu Lake. The aircraft was refuelled twice between flights.

The pilot made a return flight to Louise Lake on the morning of the accident. The fuel transaction record from Louise Lake indicates that the pilot obtained 278 litres of aviation fuel at 1217 Eastern Daylight Time.[1] After returning to Kuashkuapishiu Lake, the pilot made pre-flight preparations to fly to Ra-Ma Lake, Quebec, with 2 passengers. The aircraft was loaded with food supplies, a 20-pound propane gas cylinder, 3 firearms, ammunition, an outboard motor and fuel, and luggage. One passenger was in the right-hand seat next to the pilot, and the other passenger was in the seat behind the pilot. The pilot gave a safety briefing that included a description of the seat belts, emergency exits, and lifejackets.

At around 1400, the aircraft, equipped with Wipaire 4000A amphibious floats, left the dock and taxied over the water toward the south end of the lake. After warming up the engine, the pilot selected 20° of flap, raised the water rudders, turned the aircraft into the wind, and applied full throttle. The aircraft then began its takeoff run northwards and became airborne mid-course, about 1600 feet from the starting point. The aircraft began a climbing turn to the left when it reached the north end of the lake. The aircraft was then lower than the surrounding terrain, the elevation of which was 228 feet higher than the elevation of the lake (Figure 1).

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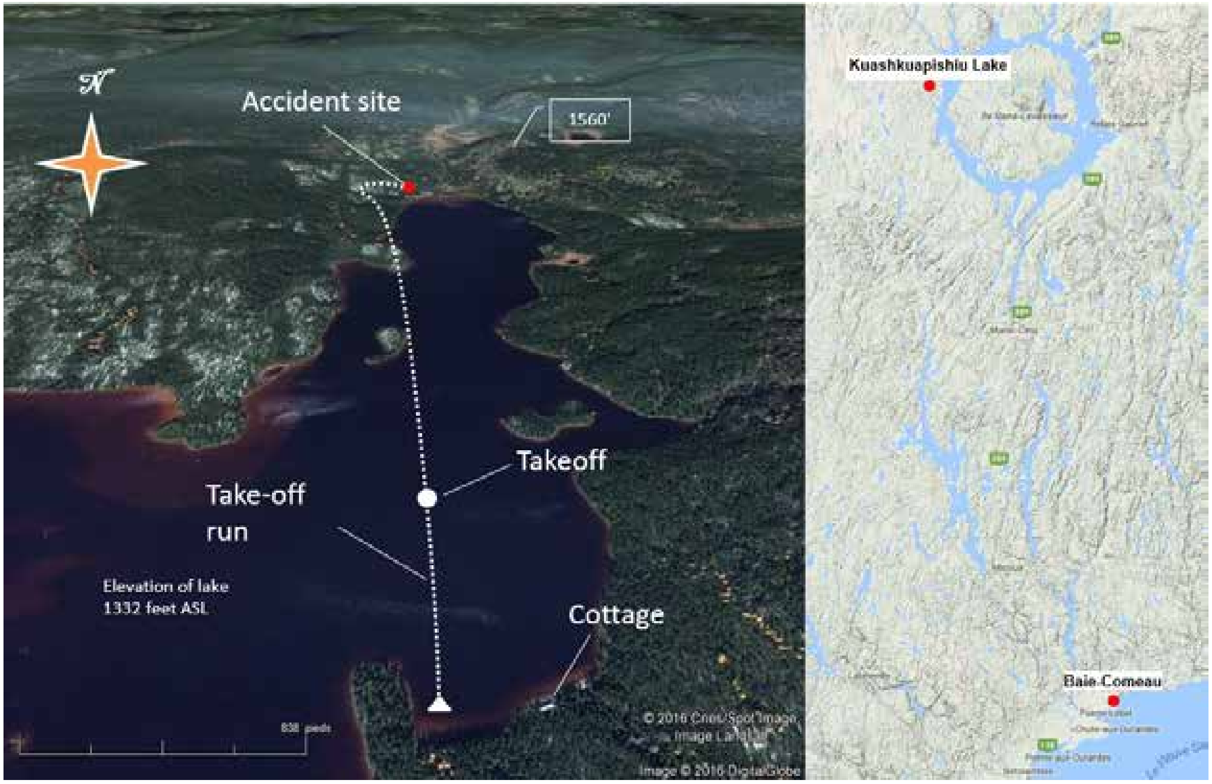
[1] All times are Eastern Daylight Time (Coordinated Universal Time minus 4 hours).

Figure 1. Trajectory of the aircraft during takeoff at Kuashkuapishiu Lake (51° 31′01.12 N, 069° 12′03.47 W) (Source: Google Earth, with TSB annotations)



A few moments later, the engine stopped and the pilot felt a reduction in the response to elevator and aileron control input, and at the same time noticed a 20-knot reduction in airspeed. The pilot decided to return to Kuashkuapishiu Lake and began a right turn by applying the right rudder pedal. The stall warning alarm then began sounding. The right wing dropped, and the aircraft nosedived.

The pilot pushed the control yoke forward. The aircraft lost altitude and crashed into a forested area a few metres from the lake tributary (51°30′58.95″ N, 069°12′2.92″ W). An intense fire broke out immediately upon impact. Only the pilot, whose clothes were on fire, was able to escape from the wreckage and dive into the river.

No emergency locator transmitter (ELT) signal was received by the COSPAS-SARSAT satellite system, and no other aircraft in the area reported receiving an ELT signal. The post-impact fire completely destroyed the cabin of the aircraft.

Two eyewitnesses at the cottage observed the takeoff and the column of smoke that appeared after the aircraft descended out of sight behind the tree tops. They rushed to the scene of the crash to provide assistance.

Back at the cottage with the survivor, one of the eyewitnesses provided first aid and used a satellite phone to request assistance. A helicopter from the private ambulance service Airmedic arrived at the Kuashkuapishiu Lake cottage at around 1835 with 2 nurses to administer first aid. The Joint Rescue Coordination Centre (JRCC) Halifax deployed a

Cormorant helicopter. At around 2100, the survivor and the nurses were winched aboard the Cormorant and taken to the hospital in Sept-Îles.

1.2 Injuries to persons

The pilot was seriously injured, and the 2 passengers were fatally injured.

1.3 Damage to aircraft

The aircraft was substantially damaged after colliding with trees and the terrain. The cabin was destroyed by the post-impact fire.

1.4 Other damage

Approximately 105 litres (165 pounds) of fuel and as much as 11 litres of engine oil were spilled and consumed by the post-impact fire.

1.5 Personnel information

Table 1. Personnel information

Pilot licence	Private pilot licence
Medical certificate expiry date	01 April 2017
Total flying hours	2500
Flight hours on type	260

The pilot held the necessary licence and qualifications for the flight, in accordance with existing regulations. The pilot obtained his private pilot licence in June 2001, acquired a float endorsement in October 2011, and passed an in-flight test to renew his instrument rating in May 2015. The information gathered during the investigation indicates that the pilot met the recency requirements set out in Subpart 1 of Part IV of the *Canadian Aviation Regulations* (CARs):

- He had been a pilot-in-command aboard an aircraft for 5 years preceding the flight.[2]
- He had successfully completed a recurrent training program in the 24 months preceding the flight.[3]
- He had completed at least 5 takeoffs and 5 landings in the 6 months preceding the flight.[4]

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[2] *Canadian Aviation Regulations*, paragraph 401.05(1)(a).

[3] Ibid., paragraph 401.05(2)(a).

[4] Ibid., clause 401.05(2)(b)(i)(A).

The pilot had made approximately 50 flights from Kuashkuapishiu Lake, including return flights to and from Ra-Ma Lake, on the aircraft in the year preceding the occurrence.

1.6 Aircraft information

1.6.1 General

Table 2. Aircraft information

Manufacturer	Cessna Aircraft Company
Type and model	Stationair U206F
Year of manufacture	1975
Serial number	U20602785
Certificate of airworthiness	Valid
Total airframe time	6963 hours (approximately)
Engine type (number)	Teledyne Continental IO-550-F (1)
Propeller or rotor type (number)	McCauley, model D3A34C401-C (1)
Maximum authorized takeoff weight	3800 pounds
Recommended fuel type(s)	100LL
Type of fuel used	100LL

The Cessna 206 was initially certified in the United States, in 1964, with a 285 hp engine and a 2-blade propeller. The U206F variant, certified in 1971, is equipped with a 3-blade propeller.

The owner's manual[5] describes, among other things, the normal operations, the emergency procedures, and the limitations and performance parameters of the Cessna Stationair, certified as model U206F. For the purposes of brevity and clarity, this report will use the term "flight manual" to refer to this document.

A supplement to the owner's manual[6] contains information for Cessna Stationairs equipped with floats or skis that is not found in the flight manual. For the purposes of brevity and clarity, this report will use the term "floats supplement" to refer to this document.

The aircraft was imported into Canada in November 2010 by its previous owner. The pilot/owner of the aircraft at the time of the accident had acquired it in July 2015. The aircraft underwent an annual inspection pursuant to CARs 625.86 and appendices B and C of CARs Chapter 625, on 20 April 2016, and oil changes were performed on 06 July and 15 September 2016. All of this work was carried out by a certified aircraft maintenance engineer.

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[5] Cessna Aircraft Company, *Cessna U206F Stationair 1975 Owner's Manual* (1984).

[6] Cessna Aircraft Company, *1975 Cessna Stationair and Turbo Stationair Floatplane Skiplane Owner's Manual Supplement*.

The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The journey logbook was on board the aircraft and was destroyed in the post-impact fire. The information gathered during the investigation indicated that the aircraft had accumulated 6855 hours of flight time as at 31 December 2015.

The technical logbooks, which were not on board the aircraft at the time of the accident, contain no entries later than 19 February 2015, and no document was found to indicate the certification of the aircraft's maintenance work or time in service. The investigation determined that the annual inspection had been performed in the spring of 2016.

The aircraft maintenance engineer was not required to keep a copy of the certifications; however, the regulations[7] require the aircraft owner to transcribe technical entries in the journey logbook into the appropriate technical logbooks for the airframe, engine, and propeller within 30 days after completion of the maintenance work. Because the journey logbook was not found and the technical logbooks were not up to date, it is estimated that the aircraft had accumulated approximately 6963 hours of flight time at the time of the accident.

1.6.2 Cessna U206F stall characteristics

According to the flight manual, the characteristics of a stall are typical, and a stall warning horn sounds an audible alarm when the aircraft speed is between 5 and 10 mph above stalling speed, regardless of the aircraft's configuration. According to the Wipaire Inc. pilot user manual, the aircraft can lose up to 250 feet of altitude during recovery actions to prevent a stall.[8] For the purposes of brevity and clarity, this report will use the term "Wipaire supplement" to refer to this document.

1.6.3 Weight and balance

The aircraft's weight and balance were calculated using the weight of its occupants, the estimated quantity of fuel on board,[9] and the weight of the luggage. The weight of the aircraft was estimated to be approximately 3700 pounds at the time of the crash, or 100 pounds below the maximum allowable weight.[10] According to calculations, the centre of gravity was within the centre of gravity range.

1.6.4 Takeoff performance

Performance tables enable pilots to anticipate aircraft performance under various conditions. Depending on the manufacturer, these tables are published in various formats and are based

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[7] *Canadian Aviation Regulations*, subsection 605.96(1).

[8] Wipaire Inc., *Pilot's Operating Handbook Supplement* (20 July 1995), p. 23.

[9] Based on the gathered information, the aircraft tanks contained 28 U.S. gallons of 100LL fuel.

[10] According to the Wipaire supplement (STC SA1483GL), the maximum allowed weight for amphibious operation of the aircraft was 3800 pounds.

on different variables. The tables published in the flight manual for the occurrence aircraft provide the takeoff distance and rate of climb for aircraft with a maximum gross weight of 3600 pounds. However, the tables in the floats supplement to the flight manual provide information (the takeoff distance, the total distance required to clear a 50-foot obstacle, and the climb rate) for aircraft with a maximum gross weight of 3500 pounds (Appendix A).

In the atmospheric conditions at the time of the occurrence flight, the tables in the floats supplement indicate that the takeoff run on the water with 20° of flap by an aircraft weighing 3500 pounds should have been 1124 feet.[11]

Because the table in the floats supplement does not provide data for an aircraft weighing more than 3500 pounds, a linear extrapolation was made to discover the takeoff run on the water for a 3700-pound aircraft[12] also with 20° of flap and in the same atmospheric conditions. It was estimated to be 1320 feet.

The observed takeoff run on the water during the occurrence flight was approximately 1600 feet. The aircraft had not yet reached 200 feet AGL when it was approximately 7000 feet from the point where the takeoff run had commenced.

According to the performance tables, under the atmospheric conditions present in this occurrence, an aircraft weighing 3500 pounds with 0° flap should have had a climb rate of 826 feet per minute. According to the extrapolation, an aircraft weighing 3700 pounds with the same amount of flap should have had a climb rate of 713 feet per minute.

Using the distance of the takeoff run on the water and the altitude reached by the aircraft at the end of the lake, it was calculated that the actual climb rate with 20° of flap was 230 feet per minute after the takeoff from the surface of the water.

In the absence of flight data, the investigation was unable to determine why the climb rate after takeoff was less than one third of the extrapolated climb rate.

1.6.5 Emergency locator transmitter

The aircraft was fitted with an Ameri-King Corporation (Ameri-King) automatic fixed emergency locator transmitter (ELT), model AK-451 (serial number 0528A) transmitting on 406 MHz and 121.5 MHz. A review of the aircraft's records indicated that the ELT was installed on 26 April 2013.

On 28 December 2015, the U.S. Federal Aviation Administration (FAA) issued an emergency cease-and-desist order to Ameri-King prohibiting the manufacture, sale, and distribution of all products for aircraft certified under its jurisdiction.

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[11] The climb rate indicated on the table assumes a 0° flap takeoff. The occurrence aircraft had 20° of flap.

[12] This was the estimated weight of the aircraft at takeoff.

On 01 March 2016, the FAA published an unapproved parts notification[13] that could affect Ameri-King products such as model AK-451 ELTs. The FAA found that Ameri-King had manufactured, repaired, sold, and distributed aircraft instruments and parts that did not comply with approved designs. Furthermore, the FAA was not confident that parts and components produced by Ameri-King before 28 December 2015 had been produced in accordance with approved design data.

The unapproved parts notification warned that all products manufactured or distributed after the emergency cease-and-desist order was issued were not FAA-approved. The FAA recommended removing these parts if they had been installed.

On 10 May 2016, Transport Canada (TC) issued a Civil Aviation Safety Alert (CASA)[14] stating that the FAA had issued Unapproved Parts Notification UPN 2016-2013NM460018 and that the CASA could be consulted online.

CASAs are available on the TC website and are emailed to aircraft owners who have subscribed to the mailing list. The owner of the aircraft at the time of the occurrence stated that he had not received any emails about Ameri-King products and was not sure whether he was on the CASA mailing list for this aircraft.

The ELT was not found in the charred aircraft debris. Because the ELT is made almost entirely of plastic, it is highly likely that it was completely destroyed in the heat generated by the fire. No ELT signal was received[15] by the COSPAS-SARSAT system, and no signal was heard or reported by other aircraft during searches.[16] It was not possible to determine why the ELT was not able to transmit a signal after the impact.

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[13] Unapproved Parts Notification (UPN) 2016-2013NM460018.

[14] Transport Canada, Civil Aviation Safety Alert (CASA) 2016-05.

[15] ELT signals are captured by the satellite-based search and rescue monitoring system of the Joint Rescue Coordination Centre.

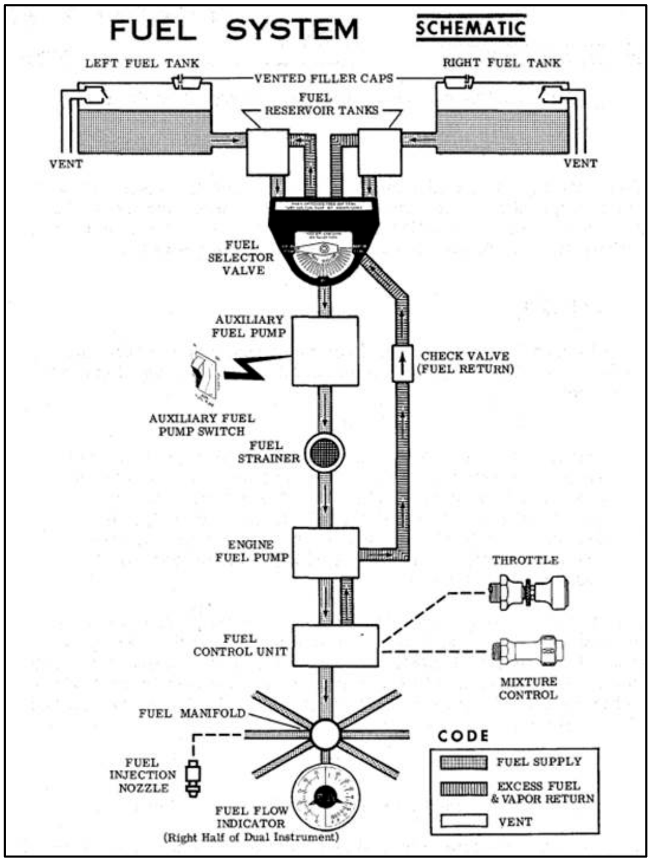
[16] Moreover, no functional test signal was received.

1.6.6 *Fuel system*

The flight manual states that

> Fuel is supplied to the engine from two tanks, one in each wing [Figure 2]. […] Fuel from each wing flows through a fuel reservoir tank [located under the cabin floor] to the fuel selector valve. Depending upon the setting of the selector valve, fuel from the left or right tank flows through a by-pass in the electric auxiliary fuel pump (when it is not operating) and fuel strainer to the engine-driven fuel pump. From here, fuel is distributed to the engine cylinders via a fuel control unit and manifold.
>
> NOTE
>
> Fuel cannot be used from both fuel tanks simultaneously.[17]

Figure 2. Fuel circuit schematic (Source: *1975 Cessna Stationair Owner's Manual*)



According to the manufacturer, sudden failure of an engine-driven fuel pump would result in the engine shutting down almost immediately.

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[17] Cessna Aircraft Company, *1975 Cessna Stationair Owner's Manual* (1984), p. 2-1.

1.6.6.1 Auxiliary fuel pump

The flight manual states that "the auxiliary fuel pump switch is located on the left side of the instrument panel and is a yellow and red split-rocker type switch"[18] (Figure 3).

The right switch (yellow) is labelled START, and the ON position is used for various functions, including normal startup and continued engine operation if the engine-driven fuel pump fails.[19] If this pump fails, the auxiliary fuel pump provides sufficient capacity to allow the engine to operate during cruising, descent, landing, and taxiing.

The flight manual states that if the auxiliary fuel pump is running at the same time as the engine-driven fuel pump, the resulting air-fuel mixture will be too rich unless the pilot leans the mixture.[20] Therefore, the START switch must not be in the ON position during takeoff.

Figure 3. Auxiliary fuel pump switch (Source: Maurice Gunderson)

The flight manual also explains that

> The red left half of the switch is labelled EMERG, and its upper HI position is used in the event of an engine-driven fuel pump failure during take-off or high-power operation. […] Maximum fuel flow is produced when the left half of the switch is held in the spring-loaded HI position. In this position, an interlock within the switch automatically trips the right half of the switch to the ON position. When the spring-loaded left half of the switch is released, the right half will remain in the ON position until manually returned to the off position.[21]

1.6.7 Flight manual emergency procedures

Section III of the flight manual contains the emergency procedures, including a specific procedure for engine failure after takeoff, as well as several procedures for rough running or power loss, such as that caused by a failure of the engine-driven fuel pump.

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[18] Ibid., p. 2-3.

[19] Ibid.

[20] Ibid., pp. 2-3 to 2-4.

[21] Ibid., p. 2-4

1.6.7.1 Procedures for rough running or power loss

1.6.7.1.1 Failure of engine-driven fuel pump

The flight manual states that “failure of the engine-driven fuel pump will be evidenced by a sudden reduction in the fuel flow indication prior to a loss of power.”[22,23]

The manual also states that

> In the event of an engine-driven fuel pump failure during take-off, immediately hold the left half of the auxiliary fuel pump switch in the HI position until the aircraft is well clear of obstacles. Upon reaching a safe altitude, and reducing the power to a cruise setting, release the HI side of the switch. The ON position will then provide sufficient fuel flow to maintain engine operation while maneuvering for a landing.[24]

In this occurrence, to prevent the fuel-air mixture from becoming too rich, the auxiliary fuel pump was not running when the engine-driven fuel pump failed, because the use of the auxiliary fuel pump during takeoff was counter-indicated by Cessna.

1.6.7.2 Procedure to follow in the event of engine failure after takeoff

In the event of an engine failure after takeoff, the flight manual recommends “prompt lowering of the nose to maintain airspeed and establish a glide attitude.”[25] The manual also states that

- in most cases, the landing should be planned straight ahead and with only small changes in direction to avoid obstructions,[26] and
- altitude and airspeed are seldom sufficient to execute a 180° gliding turn necessary to return to the runway.[27]

The procedure for engine failure after takeoff (Figure 4) assumes that there is enough time to secure the fuel and ignition systems prior to touchdown.

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[22] Ibid., p. 3-8.

[23] The fuel flow meter is located on the right-hand side of the dashboard.

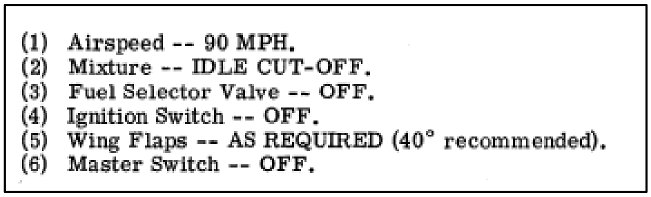
[24] Cessna Aircraft Company, *1975 Cessna Stationair Owner's Manual* (1984), p. 3-8.

[25] Ibid., p. 3-1.

[26] Ibid.

[27] Ibid.

Figure 4. Excerpt from flight manual: Procedure to follow in the event of an engine failure after takeoff (Source: *1975 Cessna Stationair Owner's Manual*)

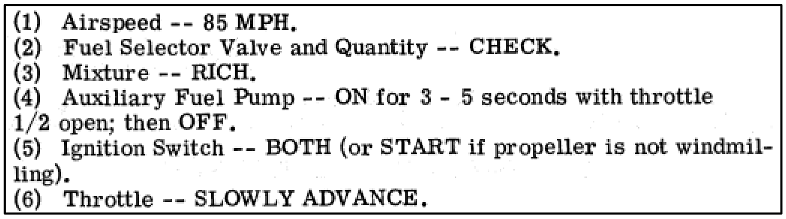


(1) Airspeed -- 90 MPH.
(2) Mixture -- IDLE CUT-OFF.
(3) Fuel Selector Valve -- OFF.
(4) Ignition Switch -- OFF.
(5) Wing Flaps -- AS REQUIRED (40° recommended).
(6) Master Switch -- OFF.

1.6.7.2.1 Procedure for in-flight engine failure

While gliding toward a suitable landing area, an effort should be made to identify the cause of the engine failure. If time permits, and an engine restart is feasible, the following procedure applies:[28]

Figure 5. Excerpt from flight manual: Procedure for in-flight engine failure (Source: *1975 Cessna Stationair Owner's Manual*)



(1) Airspeed -- 85 MPH.
(2) Fuel Selector Valve and Quantity -- CHECK.
(3) Mixture -- RICH.
(4) Auxiliary Fuel Pump -- ON for 3 - 5 seconds with throttle 1/2 open; then OFF.
(5) Ignition Switch -- BOTH (or START if propeller is not windmilling).
(6) Throttle -- SLOWLY ADVANCE.

1.6.7.2.2 Training

Managing an engine failure during takeoff on a single-engine aeroplane is critical because of the significant workload and the little time available before making an emergency landing.

Carrying out the procedure for dealing with engine failure after takeoff requires skills that are rarely put into practice, even in recurrent training. The pilot had carried out the procedure for dealing with engine failure only during in-flight training; however, for obvious safety reasons, the engine failure drills consisted of simulating the failure at altitude. Because the engine was not actually shut off, the pilot never had to carry out the entire procedure for dealing with in-flight engine failure. The pilot had also never practised the procedure for dealing with a failure of the engine-driven fuel pump during takeoff.

When an engine failure occurs immediately after takeoff, the pilot does not have time to look up the appropriate procedure before taking corrective measures. In this type of situation, the pilot needs to have a plan for dealing with the emergency. A flight over an area that is not suitable for a forced landing requires a detailed plan that carefully considers several factors, including terrain, altitude, the aircraft's glide ratio when gliding, and wind strength.

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[28] Ibid.

Developing this plan generally includes the minimum altitude at which a 180° turn would be attempted in order to return to the takeoff point after an engine failure.

In this occurrence, an examination of the terrain indicated that the only area clear of trees was about 1300 feet north of the accident site.

1.6.8 Aircraft modifications

1.6.8.1 General

The occurrence aircraft, built in 1975, included several modifications approved by supplemental type certificates (STCs).[29] Some STCs involve modifications to flight characteristics that can sometimes change the aircraft's operating limits. These new limits are added to the flight manual as supplemental aircraft flight manuals. The following subsections describe the various modifications made to the aircraft.

1.6.8.2 Modifications made to the aircraft in 1996 while it was registered in the United States

The aircraft had 4 modifications made while it was registered in the United States: a Horton Inc. short takeoff and landing (STOL) conversion kit; Wipaire Inc. wing extensions; a Teledyne Continental 300 hp engine and a McCauley 3-blade propeller; and Wipaire Inc. 4000A floats.

1.6.8.2.1 Horton short takeoff and landing conversion kit

In 1996, the occurrence aircraft was modified with a Horton STOL conversion kit in accordance with an approved STC.[30] The conversion kit had been authorized by Horton Inc. for installation on the aircraft.

This modification is intended to improve aircraft takeoff and landing performance by combining improved low-speed manoeuvrability and lower aerodynamic stall speeds. The components of the Horton STOL conversion kit that were installed on the aircraft included wing foil modifications that increased the leading edge profiles (to modify their aerodynamic profile), stall fences, and conical cambered wing tips.

1.6.8.2.2 Wipaire Inc. wing extensions

Wing extensions manufactured by Wipaire Inc. were installed on the aircraft in December 1996 under STC SA914NE. This modification extended each wing tip by 18 inches to increase the aircraft's rate of climb and stability while reducing its stalling speed and its takeoff and landing distances.

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[29] A supplemental type certificate allows the owner to make approved modifications to an aircraft. These modifications are often designed, manufactured and marketed by third-party enterprises, not the original manufacturer. In this report, "STC" also refers to an aircraft modification authorized under a supplemental type certificate for this aircraft.

[30] Supplemental Type Certificate STC SA990CE.

1.6.8.2.3 *Teledyne Continental 300-hp engine and McCauley 3-blade propeller*

A Teledyne Continental IO-550-F 300-hp engine and a McCauley 3-blade propeller were installed on the aircraft under STC SA1482GL to increase performance and attenuate sound levels.

1.6.8.2.4 *Wipaire Inc. 4000A floats*

Wipaire Inc. 4000A floats were installed in accordance with STC SA1483GL, such that the takeoff weight was increased to 3800 pounds. The Wipaire supplement contains, among other things, new normal procedures, emergency procedures, and new speed limits, including a never exceed speed (V_{ne}) reduced to 158 knots.[31] The supplement also states that the performance tables in the flight manual apply to this amphibious configuration.

1.6.8.3 *Modifications made to the aircraft in 2011 when it was imported into Canada*

The aircraft had 2 modifications made when it was imported into Canada: a Sierra Industries STOL conversion kit and Micro AeroDynamics Inc. vortex generators.

1.6.8.3.1 *Sierra Industries short takeoff and landing conversion kit*

This kit is also known as a Robertson STOL kit.

The aircraft was modified in 2011 by installing a flap–aileron interconnect under STC SA1513WE. This system allows a certain amount of downward aileron deflection when the flaps are deployed. The increased wing camber obtained by lowering the flaps increases lift under the wingtips. This modification is part of a STOL conversion kit made by Sierra Industries that normally includes increased wing foil leading edge profiles, stall fences, and a flap–aileron interconnect. However, similar stall fences and increased wing foil leading edge profiles had previously been installed on the aircraft in 1996 with the Horton conversion kit. As a result, only the Sierra flap–aileron interconnect taken from another aircraft was installed on the occurrence aircraft.

Installing the Sierra conversion kit requires disassembling the Horton kit components, then installing all of the Sierra kit components. However, only a partial installation was performed: the Horton kit components remained on the aircraft, and only the components of the Sierra Industries flap–aileron interconnect were installed on the aircraft.

The aircraft technical records do not indicate that the Sierra conversion kit was only partially installed; they suggest that a full installation was done.[32]

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[31] Wipaire Inc., *Pilot's Operating Handbook Supplement* (20 July 1995), p. 6.

[32] The person certifying the maintenance is responsible for ensuring that the modifications to the aircraft comply with the requirements of the STC.

1.6.8.3.2 Micro AeroDynamics Inc. vortex generators

Vortex generators manufactured by Micro AeroDynamics Inc. were installed on the wings, horizontal stabilizers, and fin under STC SA00887SE. Vortex generators are intended to improve control at low airspeeds and high angles of attack by controlling airflow over the wings, horizontal stabilizers, and fin.

1.6.9 Multiple modifications or multiple supplemental type certificates

The initial approval for each modification made under an STC is based on an evaluation for a standard certified aircraft with no modifications other than those stipulated in the STC.

Regulators approve STCs after testing a certified aircraft without any other modifications. Consequently, most TC and FAA-issued STCs include a compatibility statement which states, in part:

> Conditions: Prior to incorporating this modification, the installer shall establish that the interrelationship between this change and any other modification(s) incorporated will not adversely affect the airworthiness of the modified product.[33]

In addition to this statement, TC issued Airworthiness Notice B045, *Compatibility of Multiple Modifications*, in 1998, reminding owners, operators, and maintenance personnel that they must ensure that modifications will not affect the airworthiness of the modified product and that a new flight manual supplement may be required with the installation to prescribe the operating envelope.

STC holders do not typically test the aerodynamic interactions of multiple STCs on a single aircraft. The aerodynamic interactions on the occurrence aircraft were not known. For example, the pilot of the occurrence aircraft did not have access to any performance data or operating guidelines regarding the combined modifications made to the aircraft.

Some STCs give specific speed restrictions. However, the combination of installed STCs makes it difficult for pilots to identify the aircraft's actual speed limits. For example, the aircraft's pre-modification V_{ne} was 182 knots: the wing extension (STC SA914NE) reduced the V_{ne} to 165 knots, and the floats (STC SA1483GL) reduced it again to 158 knots. The stall characteristics of these modifications are unknown, as they have not been adequately evaluated in combination and such an evaluation has not been documented.

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[33] Transport Canada, Airworthiness Notice B045, *Compatibility of Multiple Modifications*, Edition 1 (15 May 1998); Federal Aviation Administration, Advisory Circular no. 20-188: Compatibility of Changes to Type Design Installed on Aircraft (09 December 2016).

1.6.9.1 Transportation Safety Board of Canada safety concern

Further to its investigation of the October 2013 aerodynamic stall and collision with terrain of a Cessna A185E,[34] the Transportation Safety Board of Canada (TSB) noted that TC currently requires the installer to evaluate all STC combinations and determine whether the combination of STCs maintains the aircraft's airworthiness.[35] However, there are no regulatory guidelines to determine the scope or extent of this evaluation or the manner in which it must be performed and documented.

Most light aircraft in Canada, including commercially operated light aircraft, are maintained by smaller approved maintenance organizations with limited capability for aerodynamic testing or engineering evaluations. As a result, the certification for compatibility and interaction between STCs is often made after only limited evaluation.

In conclusion, the Board issued the following safety concern:[36]

> The Board is concerned that, if multiple STCs are installed without adequate guidance on how to evaluate and document the effects on aircraft handling, pilots may lose control of the aircraft due to unknown aircraft performance.

1.6.9.2 National Transportation Safety Board recommendations concerning multiple supplemental type certificates on aircraft

Following the crash of 2 light aircraft[37] in which it was determined that multiple STCs had been a factor, the U.S. National Transportation Safety Board (NTSB) issued a Safety Recommendation Letter[38] stating the following:

> The NTSB concludes that, without specific guidance and/or a checklist to help the installer determine the interrelationship between STCs, the installer may not be able to ensure that an appropriate evaluation is performed. As these accidents show, multiple STCs installed on an aircraft can adversely affect each other and, ultimately, the performance and structure of the aircraft if their interaction is not evaluated properly. Therefore, the NTSB recommends that the FAA develop specific guidance and/or a checklist to help installers performing STC modifications determine the compatibility and interaction between a new STC and any previously installed STCs on the aircraft to ensure that the new STC will not adversely affect the aircraft's

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[34] TSB Aviation Investigation Report A13P0278.

[35] Transport Canada, Airworthiness Notice B045, *Compatibility of Multiple Modifications*, Edition 1 (15 May 1998).

[36] TSB Aviation Investigation Report A13P0278.

[37] United States National Transportation Safety Board, aviation accident reports ERA10FA140 and ERA10FA404.

[38] National Transportation Safety Board (NTSB) letter from Chairman Deborah A.P. Hersman, to Federal Aviation Administration Acting Administrator Michael P. Huerta (24 May 2012), Re.: NTSB safety recommendations A-12-021, A-12-022 and A-12-023.

> structural strength, performance, or flight characteristics. If the guidance and/or checklist indicate any adverse effects between the STCs, additional testing and/or an engineering evaluation should be performed before installing the new STC.

NTSB Recommendation A-12-022 states in part that:

> [The FAA should] instruct installers to document […] how the installer determined the compatibility and interaction between the new supplemental type certificate (STC) and previously installed STCs on the aircraft to show that the new STC will not adversely affect the aircraft's structural strength, performance, or flight characteristics.

In turn, the FAA responded that it was "developing policy and guidance to address STC compatibility concerns that include proposed actions for the installer, the STC applicant, the STC approval holder and the FAA (both engineering and airworthiness inspectors)."[39]

Furthermore, the FAA stated that its Aviation Rulemaking Committee was "considering recommendations for possible regulatory changes to implement more effective STC compatibility assessment procedures."[40]

On 09 December 2016, the FAA published Advisory Circular 20-188[41] to provide guidance to aircraft owners and STC installers on determining the compatibility of changes to type design installed on aircraft. The advisory circular lists potentially non-compatible installations, guidelines for owners and operators, and the installer's responsibilities. It also indicates how to resolve conflicts between non-compatible installations.

A review of the aircraft's technical records did not indicate that the installed modifications had undergone a compatibility assessment by the installer. Despite the above-mentioned conditions, TC does not require proof that this assessment has been done.

1.7 Meteorological information

There is no weather station at Kuashkuapishiu Lake. However, according to information from graphic area forecasts (GFA) (Appendix C), aerodrome forecasts (TAF) and aviation routine weather reports (METAR), weather conditions in the area of the flight at the time of the accident were favourable for a visual flight. The temperature at Kuashkuapishiu Lake was around 10 °C, winds were from the north at 10 to 20 knots, and the altimeter setting was approximately 30.05 inches of mercury.

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[39] Federal Aviation Administration Acting Administrator Michael P. Huerta, to National Transportation Safety Board (13 December 2013); Re.: NTSB Safety Recommendations A-12-021, A-12-022 and A-12-023.

[40] Ibid.

[41] Federal Aviation Administration, Advisory Circular (AC) 20-188: Compatibility of Changes to Type Design Installed on Aircraft (09 December 2016).

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Information on Kuashkuapishiu Lake

Kuashkuapishiu Lake (51°29′43″ N, 069°12′20″ W) is located immediately to the west of Manicouagan Reservoir. The lake is oriented on a north/south heading and is 2.25 nautical miles (nm) in length and approximately 0.3 nm wide. The lake is 1332 feet above sea level (ASL). The mouth of the lake is bordered on either side by mountains to the north with an elevation of around 1560 feet ASL.

The pilot's fishing camp was located midway along the lake on the eastern shore. Tidal flats prevented floatplanes from taxiing southward from the cottage. For this reason, the pilot could land and take off only on the northern part of the lake, which permitted a takeoff distance of around 7000 feet.

1.11 Flight recorders

The aircraft was not equipped with a flight recorder (flight data recorder or cockpit voice recorder), and existing regulations did not require one. The aircraft was equipped with a fixed global positioning system (GPS) and portable GPS device, which might have provided some information useful to the investigation. However, the 2 GPS devices were consumed by the post-impact fire.

1.12 Wreckage and impact information

1.12.1 General

The aircraft crashed 350 feet from the north end of Kuashkuapishiu Lake, in an area sparsely covered with short spruce trees and where the ground is covered in lichen. The elevation of the accident site was 1330 feet ASL. The aircraft struck the trees in a nose-down attitude of at least 20° in a steep right bank curve and struck the ground 75 feet away. There was no indication that objects or occupants were ejected or projected from the cabin.

Given the extent of the fire damage, inspection of the aircraft on site was limited and was focused on the engine, empennage, and wings.

1.12.2 *Engine examination*

Following the accident, the engine was sent to the TSB Engineering Laboratory in Ottawa for disassembly and examination. No abnormalities were found on the engine. However, disassembly of the engine-driven fuel pump revealed that the coupling shaft between the pump and the engine was sheared. No other sign of failure that might have contributed to the accident was found. No indication of engine or propeller rotation was observed.

1.12.3 *Engine-driven fuel pump examination*

Examination of the engine-driven fuel pump was unable to determine the cause of the sheared coupling shaft. However, examination of the area where the coupling shaft sheared indicated that the shear occurred while the engine was running at high speed, rendering it instantly inoperative and cutting off the engine's fuel supply. The pump had been overhauled on 15 October 2009 by a certified maintenance organization and had logged around 253 hours in service since its installation.

1.12.4 *Auxiliary electric fuel pump examination*

Although the auxiliary fuel pump showed normal wear and was free of obstructions and debris, the significant fire damage after the impact made it impossible to confirm whether the pump was capable of operating immediately before the accident.

1.12.5 *Fuel tank selector*

Examination of the fuel tank selector revealed no abnormalities. The valve was set to the left tank position.

1.12.6 *Propeller examination*

The 3-blade propeller (McCauley D3A34C401-C) was coupled to the engine. An examination of the propeller at the accident site and at the TSB Engineering Laboratory did not reveal any signs of rotation at impact. The blade that was perpendicular to the top of the engine was not bent or twisted. The 2 other blades were bent backward and showed no sign of torsion (Figure 6). There were no further indications of propeller rotation observed on the trees or ground.

The examination of the propeller did not reveal any anomalies that could have indicated abnormal performance.

Figure 6. View of engine and propeller

1.12.7 Wing examination

The 2 wings were separated from the cabin. The right wing was resting slightly to the rear of the empennage and to the right of the cabin. The left wing lay in front of the engine and to the right of the cabin. The tanks had ruptured when the wings first became dislocated and separated from the aircraft. The flaps were at 20°, in accordance with the manufacturer's recommendations for takeoff.

1.12.8 Examination of floats

The 2 floats were almost entirely destroyed by the fire.

1.12.9 Instruments

The instrument panel had melted under the intense heat from the fire; it was therefore not possible to determine the status and operational capabilities of on-board systems and components, nor of the position of controls, switches and indicators. Examination of the flight instruments was limited by the extent of the damage caused by the force of the impact with the ground and the post-impact fire. Because of the condition of the instruments, it was not possible to determine what indications were displayed at the time of the impact.

1.12.10 Flight controls

The flight control circuits in the cabin were damaged by the force of the impact and by the post-impact fire. However, it was possible to establish the continuity of the elevator and rudder controls and of almost all the flap and aileron controls. The investigation did not reveal any anomalies that may have hindered the normal operation of the flight control system.

1.12.11 Safety harnesses

Examination of the wreckage did not reveal the state of the safety harness attachment and adjustment points.

1.13 Medical and pathological information

There is no indication that the pilot's capacities were reduced due to physiological factors.

1.14 Fire

1.14.1 General

After hitting the ground, the aircraft caught fire and the cabin was destroyed by the post-impact fire. Because there were no witnesses, and because of the destructive nature of the fire, it was not possible to determine the fire's source and means of propagation. Potential ignition sources included fuel coming into contact with hot engine parts or an electric arc. The aircraft was carrying a 20-pound gas cylinder in the cabin, which was permitted under Part 12, section 12.10 of the *Transportation of Dangerous Goods Regulations*.[42]

1.14.2 Previously identified post-impact fire issues

Previous TSB aviation investigation reports, as well as the 2006 Aviation Safety Issues Investigation Report SII A05-01, *Post-impact fires resulting from small-aircraft accidents*, have documented the risks to aviation safety posed by post-crash fires. These reports note that there are a large number of small aircraft already in service, and the defences against post-impact fires in impact-survivable accidents involving these aircraft are and will remain inadequate unless countermeasures are introduced to reduce the risk.

The most effective ways to prevent post-impact fires in accidents involving existing small aircraft are to eliminate potential ignition sources, such as hot items, high-temperature electrical arcing and friction sparking; and to prevent fuel spillage by preserving fuel system integrity in survivable crash conditions. Technology that is known to reduce the incidence of post-impact fires by preventing ignition and containing fuel in crash conditions may be selectively retrofitted to existing small aircraft, including helicopters certified before 1994. Therefore, in Recommendation A06-10, issued on 29 August 2006, the Board recommended that:

> To reduce the number of post-impact fires in impact-survivable accidents involving existing production aircraft weighing less than 5700 kg, Transport Canada, the Federal Aviation Administration, and other foreign regulators conduct risk assessments to determine the feasibility of retrofitting aircraft with the following:
>
> - selected technology to eliminate hot items as a potential ignition source;
> - technology designed to inert the battery and electrical systems at impact to eliminate high-temperature electrical arcing as a potential ignition source;
> - protective or sacrificial insulating materials in locations that are vulnerable to friction heating and sparking during accidents to eliminate friction sparking as a potential ignition source; and
> - selected fuel system crashworthiness components that retain fuel.

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[42] Consolidation of *Transportation of Dangerous Goods Regulations* including amendment SOR/2016-95.

TSB Recommendation A06-10

In its response dated January 2017, TC stated that it did not agree with the recommendation and had no further planned activities to address the risks identified in Recommendation A06-10.

The Board believes that the risks identified in Recommendation A06-10 have not decreased and remain significant. Since January 2015, there have been 4 survivable aircraft accidents in Canada that resulted in post-impact fires, in which occupants suffered injuries ranging from minor to fatal (2 minor injuries, 2 serious injuries and 2 fatalities).[43] There has been no direct action taken or proposed by TC that will reduce or eliminate the deficiency identified in Recommendation A06-10.

Therefore, the response to Recommendation A06-10 is assessed as **Unsatisfactory**.

A similar study was conducted in the United States by the NTSB[44] in 1980 and led to NTSB Safety Recommendations A-80-90 to A-80-95. Four of these 6 recommendations are now listed as "Closed – Unacceptable Action." The only recommendation listed as "Closed – Acceptable Action" is A-80-094, which states:

> The NTSB recommends that the Federal Aviation Administration: Assess the feasibility of requiring the installation of selected crash resistant fuel system components, made available in kit form from manufacturers, in existing general aviation aircraft on a retrofit basis and promulgate appropriate regulations.[45]

The FAA started the rulemaking process to introduce standards for fuel fittings; however, the process was later stopped, based on the results of a cost-benefit analysis.

1.15 *Survival aspects*

Because of the extensive damage caused by the fire, TSB investigators were unable to determine the extent of deformation of the livable space following the aircraft's collision with trees and the ground. The pilot, who was seated on the left side, did not sustain any fractures as a result of the accident and was able to escape from the aircraft despite the severity of his burns. Because the aircraft struck the ground during a right turn, the right side of the fuselage was subjected to more abrupt acceleration than the left side.

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[43] TSB aviation occurrences A15C0102, A15P0147, A16O0079, and A16Q0119.

[44] National Transportation Safety Board, Special Study Report NTSB-AAS-80-2: *General Aviation Accidents: Postcrash Fires and How to Prevent or Control Them* (1980).

[45] National Transportation Safety Board, Safety Recommendation A-80-094.

1.16 Tests and research

1.16.1 TSB laboratory reports

The TSB completed the following laboratory reports in support of this investigation:

- LP261/2016 – Propulsion System Analysis
- LP292/2016 – Fuel Selector Valve Analysis
- LP293/2016 – Fuel Pump Analysis
- LP294/2016 – Horizontal Situation Indicator Analysis
- LP295/2016 – Stormscope Analysis

1.17 Organizational and management information

Not applicable.

1.18 Additional information

1.18.1 Slow flying

According to the TC *Flight Instructor Guide – Aeroplane*, "Slow flight is defined as flight in the speed range from below the speed for maximum endurance[46] to just above the stall speed."[47] When the aircraft is in slow flight just above the stall speed, the pilot will normally have the sensation of sloppy controls and diminished response to control movements. Therefore, an inadvertent entry into slow flight is an almost certain indication of an approaching stall.

1.18.1.1 Slow flight turns

Because the aircraft is flying close to its stall speed, a rotation around the vertical axis (yaw) will result in one wing leading and one wing trailing. The trailing wing may result in the critical angle of attack being exceeded and cause an incipient spin (autorotation). Given the slow response of ailerons during slow flight, yaw control is important to prevent wing stall.

1.18.2 Stall

An aerodynamic stall is defined as "an aerodynamic loss of lift caused by exceeding the aeroplane wing's critical angle of attack."[48] The general procedure for recovering from a stall is as follows:

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[46] Maximum endurance is the minimum power required to maintain altitude. Source: Transport Canada, TP 975, *Flight Instructor Guide – Aeroplane* (revised in September 2004).

[47] Transport Canada, TP 975, *Flight Instructor Guide – Aeroplane* (revised September 2004).

[48] Transport Canada, Advisory Circular (AC) 700-031: Prevention and Recovery from Aeroplane Stalls (08 November 2013).

1. Apply forward pressure on elevator control to reduce the angle of attack.
2. Set power/thrust as required.
3. Apply only enough rudder as necessary to control sideslip.
4. Apply aileron input to level the wings.
5. Establish a flight path away from terrain and complete the recovery.

1.18.2.1 Stall at takeoff

All aircraft go through a vulnerable period of low speed and low altitude during takeoff. A sudden reduction in engine power during this period could quickly reduce the gap between the climb speed and the stall speed if the pilot does not react immediately to reduce the aircraft's attitude and maintain glide speed.

1.19 Useful or effective investigation techniques

Not applicable.

2.0 Analysis

The aircraft was operating in favourable flight conditions and there is no indication that weather conditions could have caused this occurrence. The pilot was qualified to conduct the flight in accordance with existing regulations.

An analysis of the aircraft's maintenance logs raised some concerns with regard to multiple modifications made to the aircraft since it was first manufactured. However, examination of the wreckage and various components did not reveal any signs of airframe failure, flight control problems, abnormal flap operation, or in-flight fire. Examination of the propeller did not reveal any signs of rotation at the time of the impact, and examination of the engine revealed that the coupling shaft of the engine-driven fuel pump had sheared soon after takeoff while the engine was running at high speed, cutting off the engine's fuel supply and shutting it off suddenly.

The information obtained, such as the aircraft's trajectory in the trees, indicates that an aerodynamic stall occurred at the beginning of a right turn less than 200 feet above ground level (AGL).[49] Consequently, the analysis will look at the various modifications made to the aircraft, the takeoff, the low-altitude engine malfunction, and post-impact survival.

2.1 Aircraft modifications

Before the Sierra Industries short takeoff and landing (STOL) conversion kit (STC SA1513WE) was installed, stall fences and a similar wing foil modification that increased the leading edge profile had been installed with the Horton conversion kit. It appears that the Horton kit components were retained, and only the components of the Sierra Industries flap–aileron interconnect were installed. If components related to the aerodynamics of the aircraft are not installed precisely as instructed in the supplemental type certificate (STC), there is a risk that the installation will have an unexpected effect that might increase the potential for a loss of aircraft control.

2.1.1 Limitations of multiple modifications

Regulators approve STCs after they have tested a certified aircraft with no modifications. When a single aircraft undergoes multiple modifications under several STCs, testing is generally not carried out to verify the aerodynamic interactions among the modifications. The Board is has previously issued a safety concern about the absence of guidance on how to evaluate and document the effects of multiple modifications.

In the case of the occurrence aircraft, the stall characteristics of the 6 modifications are unknown, as they were not tested in flight in combination. In addition, some of the modifications reduced speed limits: one reduced the never-exceed speed (V_{ne}) from

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[49] The aircraft was lower than the surrounding mountaintops at the time of the malfunction.

182 knots to 165 knots, and another reduced it again to 158 knots. These reductions tend to indicate structural limits or undesired effects at high speed induced by each of these modifications. However, the combined effects of these modifications are unknown.

The pilot thus did not have information on the stall characteristics or on the interaction of speed limits with the multiple modifications made to the aircraft. If appropriate evaluations are not conducted after multiple modifications that change the aircraft's aerodynamic characteristics, there is a risk that the aircraft will produce unexpected flight or stall characteristics in the course of a routine flight when the pilot is not prepared to respond to them, increasing the possibility of loss of control.

2.1.2 Compatibility of multiple modifications made according to supplemental type certificates

Transport Canada (TC) requires the installer to ensure that modifications to the aircraft will not affect its airworthiness. However, TC does not require the installer to document how it established compatibility between the new STC and previously installed STCs.

The aircraft's technical records did not indicate that the installer had conducted a compatibility assessment of the modifications to the aircraft. Consequently, it was not possible to know how the aircraft would have performed with these modifications. If there is no requirement to document the method used to establish the compatibility of modifications with the existing modifications, there is a risk that a compatibility assessment will not be performed and later, in routine flight, the aircraft will produce unexpected flight characteristics, increasing the possibility of loss of control.

2.2 Takeoff

2.2.1 Calculation of takeoff performance

The aircraft was mounted on floats (STC SA1483GL) and equipped with a more powerful engine (STC SA1482GL), increasing the maximum gross weight to 3800 pounds.

The following takeoff performance information was available to the pilot:

- Flight manual (wheeled aircraft) for aircraft weighing up to 3600 pounds
- Floats supplement, for aircraft weighing up to 3500 pounds
- Wipaire supplement (Wipaire/STC SA1483GL/amphibious 3800 pounds), indicating that the flight manual data apply.

There are no tables for takeoffs at 3800 pounds, and the instructions in STC SA1483GL indicate that the data in the flight manual apply. For comparison purposes, a linear extrapolation was made to estimate an aircraft's takeoff performance at 3700 pounds, the estimated weight of the occurrence aircraft at takeoff.

Based on the atmospheric conditions at the time of takeoff,[50] the takeoff performance was compared as shown in Table 3.

Table 3. Comparative data of takeoff performance based on available data sources

Data source	Water takeoff (feet)	Rate of climb with flaps (feet per minute)
Floats supplement (3500 pounds)	1124	826
Linear extrapolation from the table in the floats supplement to the flight manual (3700 pounds)	1320	713
Observed takeoff performance	1600	230

In this case, it appears that the aircraft's actual takeoff run was some 21% greater than the extrapolated distance at 3700 pounds and 42% greater than the distance indicated in the floats supplement for an aircraft weighing 3500 pounds.

The investigation determined that the aircraft had not yet reached 200 feet AGL at a distance of around 7000 feet from the point where the takeoff run had commenced. This represents an actual climb rate of some 32% of the extrapolated rate for an aircraft weighing 3700 pounds, and some 28% of the rate indicated in the floats supplement for an aircraft weighing 3500 pounds. The exact reason for this difference could not be determined.

The actual performance of a light aircraft with an aging airframe and an engine with a certain amount of wear will be lower than the flight manual data. Therefore, it is to be expected that the climb rate with 20° of flap would be lower than the rate with 0° of flap, and that any deviation from the optimal climb speed would result in a reduction in the climb rate. A takeoff technique different from the one used to obtain the published data could also increase the actual distance of the takeoff run and the distance needed to clear a 50-foot obstacle.

In this occurrence, the pilot had to rely on an empirical or experimental method to estimate the takeoff distance, climb rate, and distance required to clear an obstacle. With all of these variables in play, it would be difficult to predict the aircraft's altitude at a given point during takeoff.

In the absence of performance tables representing the aircraft's weight, it is difficult to predict the aircraft's flight trajectory and evaluate its actual performance in comparison to its theoretical performance. If pilots do not have takeoff performance data for the modified aircraft, there is an increased risk that the required takeoff distance will exceed the takeoff area or that the aircraft will be unable to clear obstacles.

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[50] Temperature 10 °C, winds from the north at 10 knots, and altimeter around 30.05 inches of mercury.

2.3 Low-altitude engine malfunction

The information gathered during the investigation established that the aircraft experienced an engine shutdown during the initial climb after takeoff, at 200 feet AGL, an altitude lower than the neighbouring terrain.

It can be difficult to diagnose a failure of the engine-driven fuel pump, because the duration and characteristics of the symptoms vary depending on the type of failure. If the fuel pump's performance had deteriorated, the pilot would have observed a gradual reduction in engine speed and possible rough running of the engine. These symptoms would have provided noticeable audible and tactile indications that may have prompted the pilot to apply the procedure for failure of the engine-driven fuel pump. Instead, the shear in the pump coupling shaft resulted in the fuel supply being cut off immediately, in turn shutting off the engine.

2.3.1 Flight manual emergency procedures

The section of the flight manual on rough running or power loss contains a specific procedure to follow if the engine-driven fuel pump fails after takeoff. The procedure consists primarily of keeping the auxiliary fuel pump EMERG switch set to HI in order to keep the engine running until the aircraft has cleared all obstacles.

The procedure for dealing with an in-flight engine failure mentions starting the auxiliary fuel pump; however, the procedure for dealing with engine failure after takeoff does not. The after-takeoff procedure emphasizes maintaining control by lowering the nose promptly to maintain speed and by landing straight ahead. It also states that the engine, the fuel supply, the ignition, and the electrical supply should be shut off, if time permits. However, the auxiliary fuel pump needs to be used if the engine-driven fuel pump fails during takeoff.

If emergency procedures in the flight manual do not include relevant material contained in other procedures, there is a risk to the safety of flight if the crew is not able to take appropriate actions in time.

Because the procedure for dealing with engine failure after takeoff did not include elements from the procedure specific to failure of the engine-driven fuel pump during takeoff, the pilot did not have a routine practised during flight training to rely on.

In this occurrence, the pilot first had to maintain control of the aircraft and follow the procedure for dealing with engine failure after takeoff, at the same time remembering that there was another procedure to be used if the engine failure was caused by the engine-driven fuel pump failing. Because the engine failure occurred at low altitude, the pilot did not have time to identify the type of failure, recall the various relevant procedures, and take actions that could have restored engine power.

2.3.2 *Managing engine failure after takeoff*

The engine failure occurred at a key moment, when the aircraft was in the most vulnerable stage of the flight after takeoff, just as it was flying over a forest at low altitude after passing the north shore of the lake.

Considering how suddenly the engine failed, how low the aircraft was at the time, and the fact that the failure occurred during a phase of the flight when there were significant demands on the pilot's attention, the pilot had little time to evaluate the situation. Under these circumstances, it would have been vital for the pilot to have a plan or at least to have chosen the minimum altitude at which a 180° turn could be attempted in the event of an engine failure.

The engine failure probably took the pilot by surprise. Once the engine failed, the first measures to take were to stabilize the speed and put the aircraft into a glide while maintaining control of the aircraft as it proceeded to a landing site. Although it is to be expected that the pilot would take a few seconds to react to the engine failure, the aircraft's speed diminished sufficiently to cause the stall warning to sound. The element of surprise, combined with a nose-up trim position during takeoff, probably affected the pilot's reaction time with regard to lowering the nose in time to compensate for the loss of speed.

Because the aircraft had just taken off, its configuration, with flaps at 20°, generated a significant amount of drag due to the flap settings and downward aileron deflection.[51] The amount of drag was further increased by the floats and their fastening devices. In these conditions, the sudden loss of traction would require the control yoke to be pushed forward quickly in order to lower the nose and reduce the negative effects of drag on the aircraft's speed.

In the moments that followed the engine failure, the pilot noticed that the control yoke inputs on the ailerons and elevator had little effect on the aircraft's trajectory and that the stall warning horn was sounding. The pilot did not maintain glide speed, and the aircraft entered slow flight, just above the stall speed.

For obvious safety reasons, engine failure drills were carried out at altitude without completely shutting off the engine. Therefore, the pilot had never had to carry out the entire procedure for dealing with an in-flight engine failure and had never been exposed to the conditions present on the occurrence flight when the engine failed.

When the engine failed, the pilot had to make decisions and take action quickly without being able to rely on prior real-world experience. Given that the pilot's experience was limited to training simulations, it is likely that the pilot was not prepared to switch, in a fraction of a second, from a routine flight situation to an emergency situation that required

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[51] The flap–aileron interconnect allows the ailerons to be deflected downward when the flaps are deployed.

extreme availability and concentration. Even though the pilot had taken the training required by regulations, the pilot was not prepared to manage the emergency effectively.

2.3.3 *Attempt to make a 180° turn and loss of control*

Faced with the prospect of having to make a forced landing in the forest ahead, the pilot decided to make a 180° turn in order to perform a water landing on Kuashkuapishiu Lake. The decision to make a 180° turn at low altitude suggests incomplete planning before takeoff, because it is impossible to make a 180° turn when gliding below 200 feet AGL.

Given the sluggish response of the ailerons during slow flight, the pilot pressed the right rudder pedal to begin the 180° turn. The rotation around the vertical axis (yaw) resulted in the right wing's critical angle of attack being exceeded in an uncoordinated turn. The aerodynamic stall of the right wing resulted in an incipient spin (autorotation) to the right, which the pilot immediately stopped. However, the manoeuvre resulted in a sudden right turn and a steep descent. The pilot attempted a 180° turn at low altitude, and an aerodynamic stall ensued at too low an altitude for control to be regained before the aircraft struck the ground.

2.4 *Survival aspects*

The accident was survivable; the pilot, who was seated on the left-hand side, exited the aircraft alive. However, examination of the wreckage and analysis of the data collected was unable to determine whether the deaths of the 2 passengers sitting on the right could have been prevented.

2.4.1 *Post-impact fire*

Given the destructive nature of the fire, it was not possible to collect the physical evidence needed to support observations regarding the source of the fire, the fuel spill, or the propagation of the fire. It was therefore not possible to determine the influence of the propane gas cylinder that was on board. However, the transportation of the propane gas cylinder was permitted under the *Transportation of Dangerous Goods Regulations*.

2.4.2 *Emergency locator transmitter*

No emergency locator transmitter (ELT) was received by the COSPAS-SARSAT satellite system or heard or reported by other aircraft in the area during searches. The U.S. Federal Aviation Administration (FAA) has issued notices concerning the ELT model installed on board the aircraft, noting that it may have been manufactured, repaired, or sold with parts that did not comply with approved design standards. Although it was not possible to retrieve the ELT or determine why no signal was received after the impact, the fact remains that if aircraft in service carry emergency locator transmitters (ELTs) containing unapproved parts, the ELT may not work as intended in an accident, potentially delaying the arrival of search and rescue personnel and putting occupants at a higher risk of injury or death.

3.0 Findings

3.1 Findings as to causes and contributing factors

1. The coupling shaft of the engine-driven fuel pump sheared soon after takeoff while the engine was running at high speed, cutting off the engine's fuel supply and causing it to stop suddenly.
2. Because the engine failure occurred at low altitude, the pilot did not have time to identify the type of failure, recall the various relevant procedures, and take actions that could have restored engine power.
3. The pilot did not maintain glide speed, and the aircraft entered slow flight, just above the stall speed.
4. The pilot attempted a 180° turn at low altitude, and an aerodynamic stall ensued at too low an altitude for control to be regained before the aircraft struck the ground.

3.2 Findings as to risk

1. If components related to the aerodynamics of the aircraft are not installed precisely as instructed in the supplemental type certificate, there is a risk that the installation will have an unexpected effect that might increase the potential for a loss of aircraft control.
2. If appropriate evaluations are not conducted after multiple modifications that change the aircraft's aerodynamic characteristics, there is a risk that the aircraft will produce unexpected flight or stall characteristics in the course of a routine flight when the pilot is not prepared to respond to them, increasing the possibility of loss of control.
3. If there is no requirement to document the method used to establish the compatibility of modifications with the existing modifications, there is a risk that a compatibility assessment will not be performed and later, in routine flight, the aircraft will produce unexpected flight characteristics, increasing the possibility of loss of control.
4. If pilots do not have takeoff performance data for the modified aircraft, there is an increased risk that the required takeoff distance will exceed the takeoff area or that the aircraft will be unable to clear obstacles.
5. If emergency procedures in the flight manual do not include relevant material contained in other procedures, there is a risk to the safety of flight if the crew is not able to take appropriate actions in time.
6. If aircraft in service carry emergency locator transmitters (ELTs) containing unapproved parts, the ELT may not work as intended in an accident, potentially

delaying the arrival of search and rescue personnel and putting occupants at a higher risk of injury or death.

3.3 Other findings

1. The transportation of the propane gas cylinder was permitted under the *Transportation of Dangerous Goods Regulations*.

4.0 Safety action

4.1 Safety action taken

4.1.1 Transport Canada

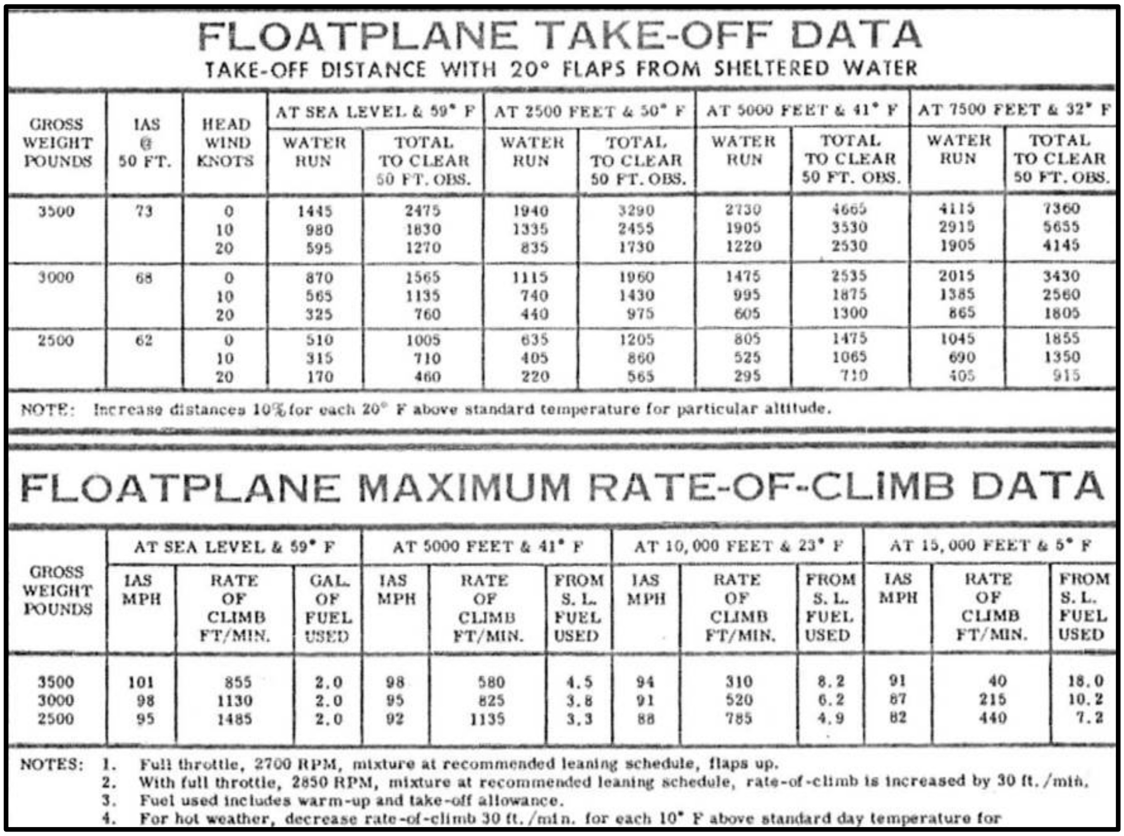
In August 2017, Transport Canada issued a Civil Aviation Safety Alert entitled "Unapproved Parts Alert: Unapproved Batteries Installed or Intended to be Installed on Ameri-King Corporation AK-451 Model Emergency Locator Transmitters." The alert, which covers the same model of emergency locator transmitter installed on the occurrence aircraft, targets unapproved batteries that are sourced directly from suppliers and that do not conform to the approved design of the emergency locator transmitter. The alert is available on the Transport Canada website.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 18 October 2017. It was officially released on 15 November 2017.

Visit the Transportation Safety Board of Canada's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

Appendices

Appendix A – Table of takeoff performance and climb rates



FLOATPLANE TAKE-OFF DATA

TAKE-OFF DISTANCE WITH 20° FLAPS FROM SHELTERED WATER

GROSS WEIGHT POUNDS	IAS @ 50 FT.	HEAD WIND KNOTS	AT SEA LEVEL & 59° F		AT 2500 FEET & 50° F		AT 5000 FEET & 41° F		AT 7500 FEET & 32° F	
			WATER RUN	TOTAL TO CLEAR 50 FT. OBS.	WATER RUN	TOTAL TO CLEAR 50 FT. OBS.	WATER RUN	TOTAL TO CLEAR 50 FT. OBS.	WATER RUN	TOTAL TO CLEAR 50 FT. OBS.
3500	73	0	1445	2475	1940	3290	2730	4665	4115	7360
		10	980	1830	1335	2455	1905	3530	2915	5655
		20	595	1270	835	1730	1220	2530	1905	4145
3000	68	0	870	1565	1115	1960	1475	2535	2015	3430
		10	565	1135	740	1430	995	1875	1385	2560
		20	325	760	440	975	605	1300	865	1805
2500	62	0	510	1005	635	1205	805	1475	1045	1855
		10	315	710	405	860	525	1065	690	1350
		20	170	460	220	565	295	710	405	915

NOTE: Increase distances 10% for each 20° F above standard temperature for particular altitude.

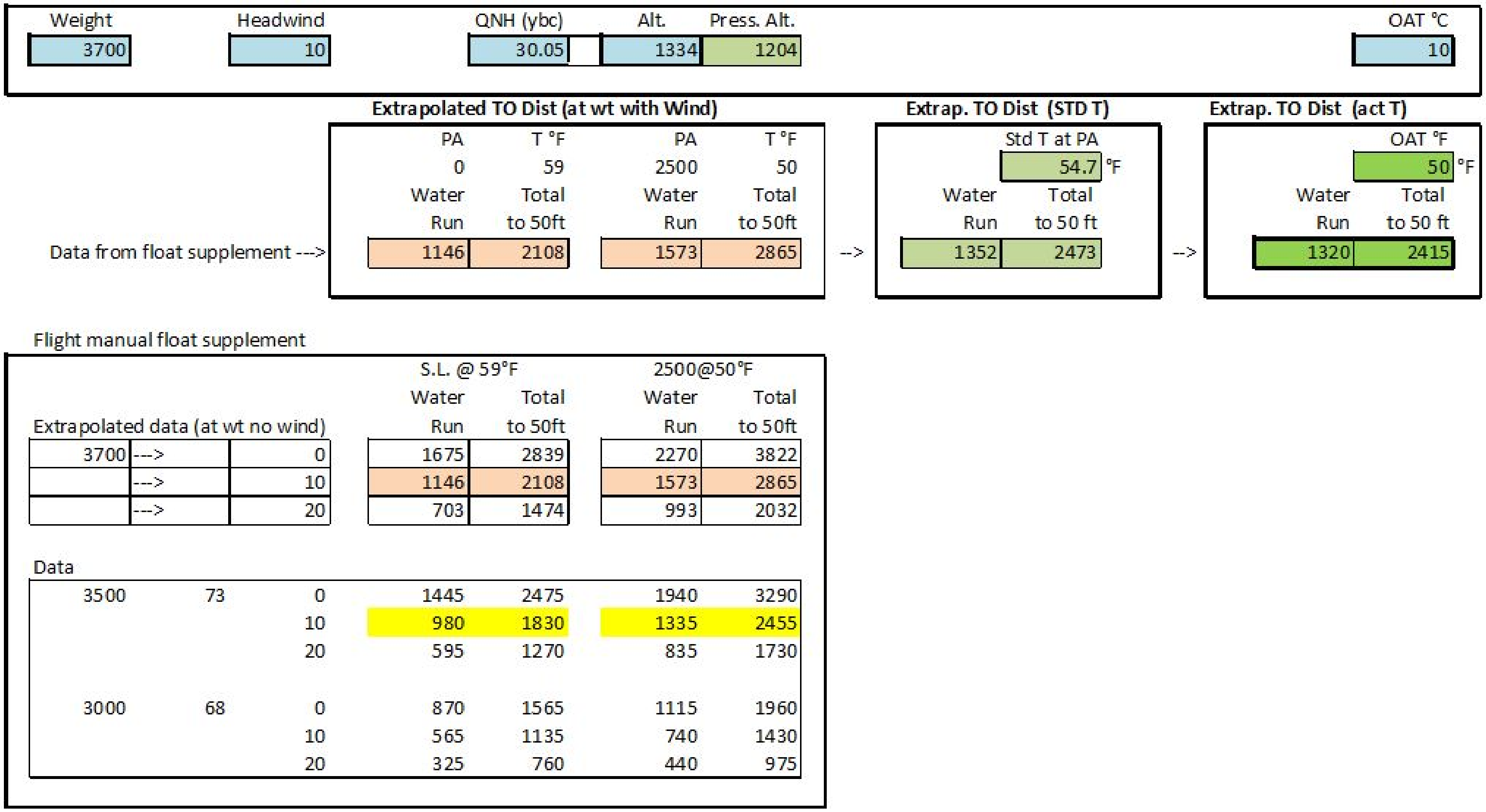
FLOATPLANE MAXIMUM RATE-OF-CLIMB DATA

GROSS WEIGHT POUNDS	AT SEA LEVEL & 59° F			AT 5000 FEET & 41° F			AT 10,000 FEET & 23° F			AT 15,000 FEET & 5° F		
	IAS MPH	RATE OF CLIMB FT/MIN.	GAL. OF FUEL USED	IAS MPH	RATE OF CLIMB FT/MIN.	FROM S. L. FUEL USED	IAS MPH	RATE OF CLIMB FT/MIN.	FROM S. L. FUEL USED	IAS MPH	RATE OF CLIMB FT/MIN.	FROM S. L. FUEL USED
3500	101	855	2.0	98	580	4.5	94	310	8.2	91	40	18.0
3000	98	1130	2.0	95	825	3.8	91	520	6.2	87	215	10.2
2500	95	1485	2.0	92	1135	3.3	88	785	4.9	82	440	7.2

NOTES:
1. Full throttle, 2700 RPM, mixture at recommended leaning schedule, flaps up.
2. With full throttle, 2850 RPM, mixture at recommended leaning schedule, rate-of-climb is increased by 30 ft./min.
3. Fuel used includes warm-up and take-off allowance.
4. For hot weather, decrease rate-of-climb 30 ft./min. for each 10° F above standard day temperature for

Source: Cessna Aircraft Company, *1975 Cessna Stationair and Turbo Stationair Floatplane Skiplane Owner's Manual Supplement*, p. 1-15

Appendix B – Calculation of takeoff performance



Weight	Headwind	QNH (ybc)	Alt.	Press. Alt.	OAT °C
3700	10	30.05	1334	1204	10

Extrapolated TO Dist (at wt with Wind)

	PA	T °F	PA	T °F
	0	59	2500	50
	Water Run	Total to 50ft	Water Run	Total to 50ft
Data from float supplement --->	1146	2108	1573	2865

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Extrap. TO Dist (STD T)

Std T at PA

54.7 °F

Water Run	Total to 50 ft
1352	2473

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Extrap. TO Dist (act T)

OAT °F

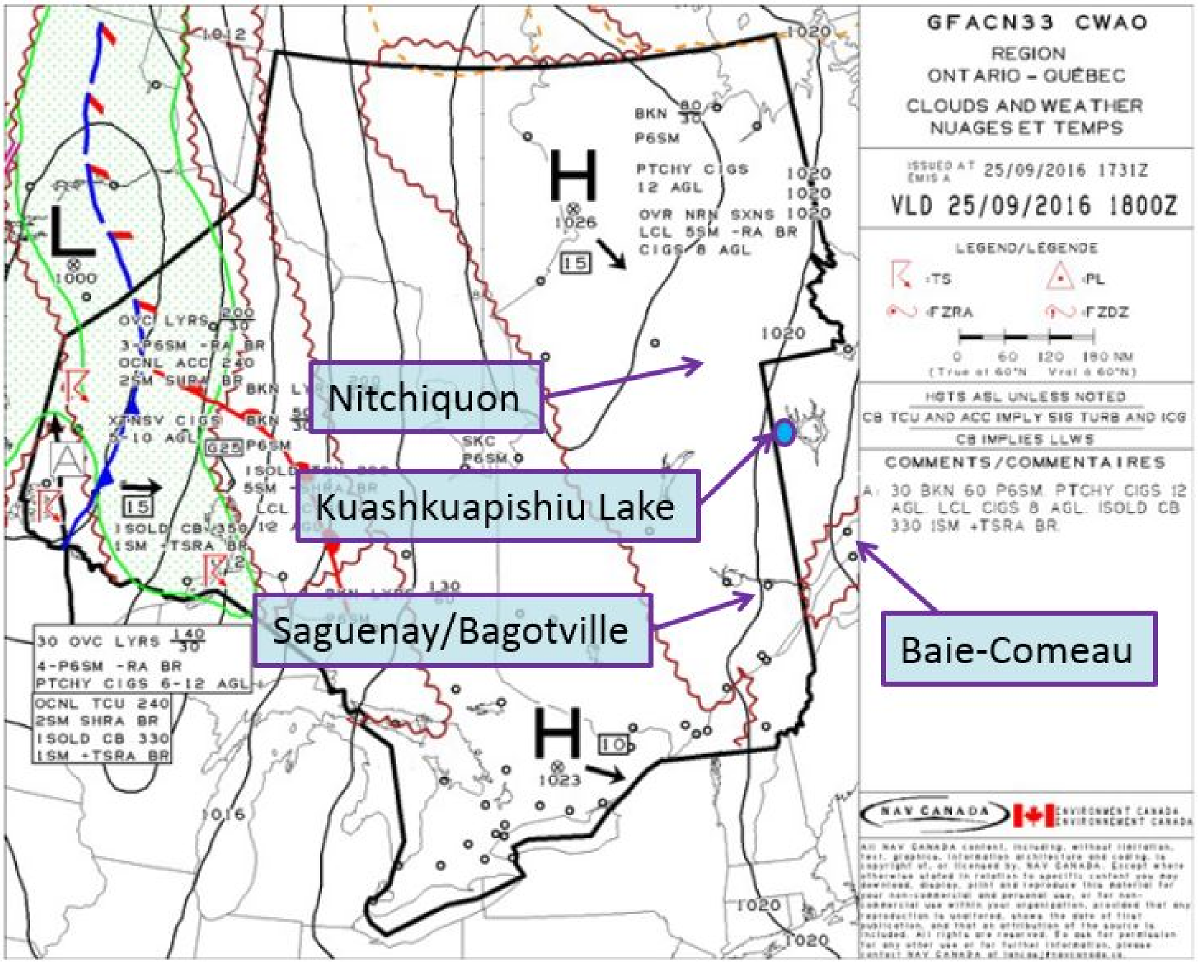
50 °F

Water Run	Total to 50 ft
1320	2415

Flight manual float supplement

			S.L. @ 59°F		2500@50°F	
			Water Run	Total to 50ft	Water Run	Total to 50ft
Extrapolated data (at wt no wind)						
3700	--->	0	1675	2839	2270	3822
	--->	10	1146	2108	1573	2865
	--->	20	703	1474	993	2032
Data						
3500	73	0	1445	2475	1940	3290
		10	980	1830	1335	2455
		20	595	1270	835	1730
3000	68	0	870	1565	1115	1960
		10	565	1135	740	1430
		20	325	760	440	975

Appendix C – Graphic area forecast (GFA) for the Ontario-Quebec region valid at the time of the occurrence



Source: Environment Canada, with TSB annotations.