National Transportation Safety Board

Office of Marine Safety

Washington, D.C. 20594

Group Chairman's Factual Report

Engineering/IIC Group

Stretch Duck 7

DCA18MM028

March 30, 2020

Contents

1. Accident Information

Vessel:	*Stretch Duck 7*
Accident Number*:*	DCA18MM028
Date:	July 19, 2018
Time:	1908 Central Daylight Savings Time (GMT-5)
Location:	Table Rock Lake, Stone County, Missouri
	36°35.236' N 093°19.113' W
Accident type:	Sinking with loss of life
Complement:	31 total (2 crew, 29 passengers)

2. IIC / Engineering Group

Chairman:	Brian Young, Office of Marine Safety
	National Transportation Safety Board (NTSB)
Members:	**Party Coordinators**
	CAPT Wayne Arguin, U.S. Coast Guard
	LT George Knowles, Missouri State Highway Patrol (MSHP)
	Frank English, Ripley Entertainment Inc.
	Lora Wilson, National Weather Service / NOAA

3. Accident summary

About 1908 local time on July 19, 2018, the 33-foot-long amphibious passenger vessel *Stretch Duck 7*, part of a fleet of vessels operated by Ride The Ducks Branson, sank during a storm, with heavy winds that developed rapidly on Table Rock Lake near Branson, Missouri. Of the 31 persons aboard, 17 fatalities resulted. Prior to the accident, the National Weather Service had issued a severe thunderstorm warning for the area advising of wind gusts of 60 mph. The manager-on-duty advised the captain and driver before departing the shoreside boarding facility to complete the lake portion of the tour before the land tour (which normally occurred first) due to the approaching weather. About 5 minutes after the vessel entered the water, the leading edge of a "derecho" passed through the area generating reported 3- to 5-foot waves and strong winds, with the highest wind gust recorded at 73 mph. The captain changed course, shortening the usual tour around an island, and attempted to exit the lake. However, during the effort to reach land, the vessel took on water and foundered approximately 250 feet away from the exit ramp near the stern of the *Showboat Branson Belle*, a moored paddle wheeler. Personnel from several fire, emergency medical services, and law enforcement agencies, along with the paddle wheeler crew and passengers, rescued and triaged 14 passengers, seven of whom were transported to local hospitals. Loss of the vessel was estimated at $184,000.

4. Investigation

The NTSB was the lead federal agency in this safety investigation. The NTSB launched a full team of investigators to Branson, Missouri on July 20, 2018. The US Coast Guard, Missouri State Highway Patrol, National Weather Service, and Ride The Ducks Branson were named as parties to the investigation. While on scene, investigators interviewed passengers from the *Stretch Duck 7*, crew members from other duck boats, crewmembers from the *Showboat Branson Belle*, and first responders from the Branson area. In addition, investigators documented the vessel's characteristics and damage, and they retrieved and reviewed recorded data from the vessel's DVR (digital video recorder). Investigators returned to Branson August 21-23 to participate in the post casualty examination and surveys of lifesaving equipment, bilge pumping systems, and alarm systems. The Coast Guard established a separate Marine Board of Investigation to determine causal factors and develop recommended safety measures, but as of the date of this report, has not been scheduled.

5. Company Information

Ride The Ducks was founded in Branson, Missouri in 1977 and owned by Bob McDowell. Ride The Ducks agreed to provide vehicles to Boston Duck Tours in 1994 and Ride The Ducks of Seattle in 1997. In 1996, Ride The Ducks subsidiary, Amphibious Vehicle Manufacturing (AVM) received USCG approval for the patented "stretch duck." Ride The Ducks was acquired by Herschend Family Entertainment Corporation in 2005.

In 2005, Amphibious Vehicle Manufacturing received USCG approval for the patented "truck duck." Herschend sold a majority interest in the company to an independent investor in 2012, and Ride The Ducks became an independent company. Chance Rides in Wichita took over this business from AVM in 2008 and built Truck Ducks until 2014. In 2014, Ride The Ducks opened in Guam, and in Mobile Alabama in 2016. The Branson operation was sold to Ripley Entertainment in December 2017. As of the date of this report, Ride The Ducks' fleet, operated by various companies around the United States, consisted of 95 vehicles, which carried over 1,500,000 passengers each year in 6 locations. The Branson operation, which was acquired by Ripley Entertainment, Inc. in December 2017, consisted of approximately 22 amphibious vessels that operated solely in the Branson, Missouri area.

6. Vessel Information

Stretch Duck 7, an amphibious vehicle, was originally built in 1944 by General Motors Corporation for the U.S. Government and based on a 2 ½ ton, six-wheel drive truck chassis, drive train, and engine. Over 21,500 of these vehicles were manufactured for military use, commonly referred to by their designation, DUKW, pronounced "Duck."[1]

Stretch Duck 7 was 33 feet long and 8 feet wide. During water operations with a full passenger load, the vessel's draft was about 5 feet with a freeboard of about 2 feet. The on-road drive arrangement had been modified from the original DUKW six-wheel drive (6 x 6) arrangement to a four-wheel drive (6 x 4) system. The hull and mechanical systems of *Stretch Duck 7* comprised of both new and rebuilt components installed on the chassis of a 1944-vintage DUKW. The hull comprised of 14-gauge side shell, 12-gauge bottom plating, and 10-gauge bow steel and was reinforced by interior framing and exterior reinforcement ribs.

[1]The acronym DUKW signifies: "D" indicated the first year of manufacture (1942), the "U" indicated a utility amphibious vehicle, the "K" indicated all-wheel drive, and the "W" indicated two powered rear axles.

The conversion and operation of these former military amphibious vessels for use in the tourism industry began in 1971, in Branson Missouri. *Stretch Duck 7* was acquired by Ozark Scenic Tours Inc. in 1982 and was modified in 1996 by increasing the overall length by 15 inches, moving the captain's station 18 inches forward for better visibility, and the hull was deepened in the stern area adding buoyancy. The vessel was inspected by the Coast Guard and issued a certificate of inspection as a small passenger vessel and land-based operation of the duck boats was regulated by the Federal Motor Carrier Safety Administration.

As part of RTDI's conversion, the majority of the vessel's hull and its systems were replaced including drive train, suspension, tires, wheels, axles, and wiring. According to RTDI's Fleet Operations Manager, these modifications improved maneuverability and visibility for the driver, increased reserve buoyancy, and reduced trim. Vessels modified in this manner were known as "stretch ducks" and the original design before stretching were referred to as "fleet ducks" or "original ducks." Later models of stretch ducks, known locally as "master jigs", were updated with completely new hulls, increased beam, and higher gunwales.[2] A total of 56 fleet ducks were updated and converted to stretch ducks or master jig ducks, in the time period from 1996 to 2005, by . In approximately 2005, AVM commenced building a newer version of the amphibious vessel known as "truck ducks". These vessels, built on an M35, 2 ½ ton truck chassis, were built with no original DUKW parts.[3] Chance Rides in Wichita took over this business from AVM in 2008 and built truck ducks until 2014.

[2] *Stretch Duck 54* was a Master Jig Duck.

[3] The M35 is 6x6 2.5-ton medium duty truck. It replaced the WWII CCKW "Deuce and a half" for the U.S. military which the DUKW is also based on.

Stretch Duck 7 vessel particulars

Vessel Name	*Stretch Duck 7*
Owner/Operator	Ripley Entertainment Inc. dba Ride The Ducks
Flag	United States
Type	Small passenger vessel
Built	1944
Official number	248292
State registration	MO 4463BK
Construction	Welded steel
AVM Hull number	35311427
Operator DOT number	609062
Draft	5 feet 2.375 inches
Length	33 feet
Engine	Chevrolet 427 gasoline
Horsepower	235
Beam	8 feet
Gross tonnage	4
Displacement	8 long tons

Propulsion System

Stretch Duck 7 was propelled on both land and water by a Chevrolet, 8-cylinder, 235-hp gasoline engine that was fitted in an engine compartment located forward of the captain's station. For land operation, the engine output shaft was connected to an automatic transmission. The transmission was connected to a single-speed transfer case that was connected to differentials at the forward and mid axles, which were then connected to the forward and middle driving wheels. For water operation, a separate output from the transfer case was connected to the propeller through a reduction gear and a propeller shaft. The operator had to engage and disengage the propeller manually before and after each waterborne operation. The three-bladed propeller had a diameter of 24 inches.

A conventional (automotive style) power-assisted hydraulic steering system was used to steer the *Stretch Duck 7* on the road. On the water, steering was accomplished by a mechanical linkage (a push-pull cable) from the steering column to the rudder tiller at the stern. In the event

of an on-water steering failure, the vehicle was equipped with a redundant steering cable that could be connected manually to the tiller and operated with a hand crank.

The engine was cooled by a conventional (automotive style) closed and pressurized cooling system using a mixture of water and ethylene glycol (antifreeze). The mixture was cooled by passing it through both a traditional air-cooled radiator and a water-cooled heat exchanger called a keel cooler mounted on the exterior of the vessel, below the waterline.

Engine Ventilation System

The radiator was mounted at the front of the engine. Air flow across the radiator was generated by an engine-driven axial-flow fan and could be supplemented by air entering through the partially open engine compartment cover (hood). The engine compartment cover (hood) was hinged on the aft side and could be remotely closed by pulling a handle below the steering wheel in the captain's station.

Top: Engine compartment cover (hood) in closed position. Bottom: Forward ventilation grating of *Stretch Duck 7* with spring loaded damper in closed position.

Another ventilation opening forward of the hood allowed air to enter forward of the radiator. This hatch consisted of an approximately 3-square foot opening with an expanded-metal grating and a spring-loaded hinged plate which was held upwards with spring tension when closed. After passing across the radiator, the air was directed to port and starboard plenums on either side of the engine bay before exiting to the atmosphere through 28-inch wide by 7.5-inch high screened openings on both port and starboard sides, outboard of the captain's station just forward of the passenger cabin. The dampers on both sides of the vessel, the engine compartment hood, and the damper on the bow were approved by the U.S. Coast Guard and satisfied applicable regulatory requirements and were designed to be manually closed in the event of an engine fire from individual levers in the captain's station, as a means to assist in fire suppression. Closing the side dampers and engine compartment hood could also limit water ingress. When asked if the engine would continue to run after dampers were closed, the fleet operations manager stated that it wasn't a "great idea to continue under normal operation like that." And that "it would run for a while, but eventually you're going to start to experience some overheat, probably."

Starboard side engine cooling air exhaust grating on *Stretch Duck 7*.

Forward Air Intake Hatch: Original Design and Installation

According to the fleet operations manager who began working at Ride the Ducks International, LLC (RTDI) in the early 1990s, the smaller forward hatch on all fleet DUKWs and stretch ducks was designed with a wire mesh grate over the hatch, without any damper to enable closure, thus allowing air to freely flow into the engine space at all times. In approximately 1998 to 1999, the Coast Guard determined that the ventilation system did not meet the requirements for fire suppression, because there was no means of closure (i.e. damper) in the event of an engine fire. In response, the current forward hatch ventilation closure design, approved by the Coast Guard, was subsequently installed on the *Stretch Duck 7* and other fleet/stretch ducks. The damper on *Stretch Duck 7* was 27 ¾ inches wide by 15 ¼ inches long and had a 3/8-inch raised lip around three sides. The damper was held closed (upward) by three spring loaded hinges which were attached to the underside of the grating's frame. The damper was held in the open position (downward) with a latch which was connected to a cable that was directly linked to the engine compartment hood closing device. When an operator pulled the handle to close the engine compartment hood, (as the captain of *Stretch Duck 7* did on the evening of the accident), the damper in the forward hatch would also close at the same time. This arrangement on the stretch ducks allowed for the damper to be kept in the open position during normal operation (allowing for additional engine ventilation/cooling) and closed for fire suppression in the event of an engine fire.

Hatch Design Differences between *Stretch Duck 7* and *Stretch Duck 54*

Unlike the *Stretch Duck 7* which was a stretch duck version, the *Stretch Duck 54* was a master jig version. The master jig duck was designed with a wider beam and a higher bow deck than that of the fleet/original DUKWs or stretch ducks, which allowed for a greater volume of air to be drawn through the engine space. Through testing of the first master jig duck in approximately 2002, RTDI found that the additional cooling provided by the keel coolers and the additional volume of air provided by the newer hull design allowed for enhanced cooling/ventilation and eliminated the need for the forward hatch opening. Based on this testing, RTDI determined that this would support keeping the forward hatch closed at all times on the master jig design except when needed to access the space for maintenance, without the need for a spring-loaded damper.

Thus, the *Stretch Duck 7* had a forward hatch with a releasable, spring loaded damper, and *Stretch Duck 54* did not.

Damper Position on *Stretch Duck 7*

According to Ripley's Fleet Operations Manager, the stretch ducks generally had operated with the damper in the forward hatch in the open position to allow for additional ventilation. However, with the installation of the keel coolers on the *Stretch Duck 7*, Ripley's had been operating and testing the *Stretch Duck 7* throughout the 2018 season with the forward hatch damper in the closed position. Ripley's view was that the installation of the keel coolers likely provided sufficient cooling to the point where the damper in the forward hatch could remain closed at all times, and was exploring the feasibility of doing so longer term, similar to the design/operation of the master jig vessels using a solid cover over the forward hatch. On July 18, 2018, the forward hatch/damper of *Stretch Duck 7* was already in the closed position and would have remained so throughout the voyage.

Approximate Damper Opening Weight

Investigators sought to estimate the approximate weight required to overcome the spring tension and open the forward hatch downward from the closed position. A 3-lb. weight was placed in the center of the damper, and the damper remained closed. A 4-lb. weight was placed in the center of the damper, and the damper opened about ½-inch, and then the weight shifted down towards the opened side. Weights were then placed on the aft side of the damper, furthest from the hinges. With 2 lbs. of weight on the aft side, the damper remained closed. With 2.5 lbs. applied, the damper opened about 4.5 inches. With 3 lbs. applied to the aft side, the damper opened about 8.5 inches, and with 4 lbs. the damper opened wide.

Bilge System

Although *Stretch Duck 7* was classified as an open boat with no subdivision, the bilge wells around the axles and shaft tunnel created separate spaces where bilge water could accumulate. These areas were the engine compartment forward of the front axle, the midship section, and each side of the shaft tunnel aft of the rear axle. The vessel was equipped with a total of six bilge alarms located near the bottom of the various bilge compartments. The following four spaces contained one bilge alarm: the engine compartment forward of the axle; the sea chest; and the two aft

compartments on either of the shaft tunnel. In the midship section there were two alarms located near the bottom of those compartments, one on each side of the vessel. The structural configuration of the midship section of the vessel allowed for water to freely communicate between the port and starboard side of the vessel, while the sea chest remained watertight. The bilge alarms were float switches that were activated when the water level exceeded a pre-determined height.

The *Stretch Duck 7* was equipped with three, Coast Guard-approved Rule 2000 standard model bilge pumps. Two pumps were located on the hull bottom in each of the aft bilge wells, on either side of the propeller shaft tunnel, and one pump was located on the port side between the forward and aft wheel wells. The submersible-style, 12-volt electric pumps were manufactured by Xylem Inc. Installed adjacent to each bilge pump was a "Rule-a-Matic Plus" automatic float switch, which would activate the bilge pump when the water level in the bilge reached approximately ½ inch. The Rule 2000 pumps were also equipped with 1 1/8-inch diameter plastic discharge hoses which discharged at the gunwale, two on the port side of the passenger area, and one on the starboard side. Each pump also had a separate yellow indicating light on the dashboard at the captain's station that illuminated if the pump was in operation.

A bilge alarm system control box was located on the starboard side of the captain's station under the dashboard. It was labelled as "Highwater Box" and provided audible and visual indicators of the bilge alarm status. A red light was labelled for forward, mid-section, sea chest, and aft. There was an alarm buzzer, a test button, and a mute button. When any of the bilge floats were activated, the corresponding red light on the control console illuminated and the associated audible alarm sounded.

"Highwater Box" on the starboard side of the captain's station of the *Stretch Duck 7*

The original DUKW design included a high capacity bilge pump, driven by a chain off the tail shaft, known as a "Higgins Pump." With a capacity of about 250 gallons per minute (gpm) when the engine and propeller shaft were engaged at full throttle, the pumps were designed to ensure the DUKW's survivability in three-foot seas or surf and 15 mph winds according to NVIC 1-01.[4] The Higgins Pump only functioned if the engine was running and the propeller shaft was rotating; its pumping rate increased or decreased with propeller shaft rotation speed. Parts for Higgins Pumps eventually became increasingly difficult to obtain. To alleviate this problem, RTDI sought and obtained approval from the Coast Guard to remove the Higgins Pumps after enclosing all the through-hull penetrations in a single water tight sea chest.[5] Should a transmission shaft boot fail as it did in the *Miss Majestic* accident, only the sea chest would flood. The sea chest on *Stretch Duck 7* was measured after the vessel was recovered. The approximate measurements from fore to aft was 48 inches. The athwartships measurement was 33 inches and the depth was 27 inches. The sea chest was not exactly rectangular, and for volumetric calculation, it was noted that several components such as the transmission gear were installed within the sea chest. A bilge alarm was installed inside the sea chest of the *Stretch Duck 7*.

7. Post-Accident Tests

On Wednesday, July 25, 2018, the recovered *Stretch Duck 7* was inspected at a hanger by investigators and party members. The following systems were tested:

- Bilge pump operation
- Bilge pump auto activation and indication
- Bilge alarm system
- Engine compartment air shutoff system
- Steering system
- Propeller running indication

[4] See Section 8.4 of this report for discussion of NVIC 1-01.

[5] Sea chests on ships are larger penetrations in a ship's hull providing suction for systems such as cooling, fire, and ballast water instead of many smaller hull penetrations. The sea chest on a Stretch Duck is dry, enclosing hull penetrations for the two drive shafts, propeller shaft, and keel cooler.

Bilge system operation

Each bilge pump was operationally tested using an external 12-volt battery, supplied by Ride The Ducks, connected to the electrical wires locally at each pump. The pumps were tested in the field using existing bilge water that had accumulated during the sinking. Each of the pumps operated as expected, near capacity of their ratings. An owner-supplied battery was provided due to the assumption that the engine would not operate after being submerged.

Bilge pump automatic activation and indication

The battery was then connected to the automatic bilge-float activation function for each of the bilge pumps on the vessel. When the water level was raised to activate the bilge pump activation float switch, the pump automatically started in each case. When the level dropped below the activation level, the pumps automatically stopped in each of the cases. The external battery was then relocated to the engine compartment and connected to each bilge circuit to test the operation of the indicating lights on the dashboard console. In each of the three pump locations the yellow (amber) indicating lights were illuminated when the pumps were operational.

Bilge alarm system

The external battery power was connected to the bilge alarm system. Each bilge float was tested, and successfully registered on the panel with audio and red visible alarms. The four areas were: sea chest, mid-section, forward, and aft. The only issue was that the audible alarm was unable to be silenced.

Engine compartment air shutoff system

The closing system for the port and starboard air intake dampers was tested by pulling each lever at the driver's console to inboard. In both cases, the dampers shut closed. The vessel was found at the bottom of the lake with the side dampers in the open position, and the hood cover in the closed position. The forward hatch was also found with the damper in the closed position.

Steering system

The front end of the *Stretch Duck 7* was jacked up to raise the front wheels off the deck. The steering system was activated by hand operation and verified proper operation of the rudder.

Propeller running indication

The external battery was connected to the “prop running” indicating light properly illuminated each time the propeller shaft was engaged.