National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: February 18, 2000

In reply refer to: M-00-5

Various Amphibious Passenger Vessel Operators, Manufacturers, and/or Refurbishers
(See Attached List)

Nationwide, more than 250 amphibious vessels are in passenger service. Of these, 26 are LARC[1] or Alvis Stalwart[2] amphibious vessels; the rest are DUKWs. Approximately 30 companies operate amphibious passenger vessels in 16 States and the District of Columbia. The National Transportation Safety Board estimates that, in the United States, amphibious excursion vessels carry more than 1 million passengers each year.

Shortly before noon on Saturday, May 1, 1999, the amphibious excursion boat[3] *Miss Majestic* entered Lake Hamilton near Hot Springs, Arkansas, on a regular excursion tour of the area. On board were 20 passengers and 1 operator. According to the operator, several minutes after entering the water, the vessel listed to port and then sank rapidly by the stern. The vessel sank below the surface of the water, taking the passengers and the operator with it. The vessel sank in 60 feet of water, and 13 of the 20 passengers, including 3 children, lost their lives.

According to testimony from the survivors, the *Miss Majestic* had been in the lake only 5 to 7 minutes when its stern became awash; within a minute thereafter, the vessel was swamped with water coming over the stern, and it sank. The *Miss Majestic* sank so rapidly that only seven passengers and the operator were able to escape from the vessel and swim to the surface, where they were rescued by pleasure boaters in the area.

[1] *LARC* is an acronym for Lighter Amphibious Resupply Cargo, vessels built for the U.S. military between 1962 and 1968. A typical Coast Guard-inspected LARC weighs 5 tons, is 35 feet long and 9 feet wide, and carries 32 passengers.

[2] The Alvis Stalwart is a British version of the military amphibious transport. It entered military service in the United Kingdom in the mid-1960s. As designed, it is 20 feet and 10 inches long and 8 feet and 7 inches wide. It accommodates 49 passengers.

[3] The vessel was a restored U.S. Army DUKW, an amphibious supply vehicle designed to travel up to 50 miles per hour on land and 6 miles per hour in water. *DUKW* is a U.S. Army acronym in which *D* stands for the model year, 1942, *U* stands for amphibious, *K* stands for front wheel drive, and *W* stands for rear wheel drive. More than 21,000 of these vehicles were manufactured during World War II, starting in 1942. As designed, they were 31 feet long and 8 feet wide and carried two drivers and 5,000 pounds of cargo (see *War Department Technical Manual TM9-802, February 23, 1945*). No reference was made to passenger capacity or accommodations, although DUKWs are known to have been used during World War II to land troops.

The survivors' time estimate of 5 to 7 minutes agrees with the Safety Board's estimates, which are based on the vessel's average speed and the distance that it traveled between the entrance ramp and the location of the sinking. DUKWs, such as the *Miss Majestic*, normally trim by the stern when waterborne, resulting in an aft freeboard of as little as 8 to 12 inches, depending on the number, weight, and distribution of the passengers.

The Safety Board made calculations to simulate the *Miss Majestic* accident, in which the boot on the aft end of the aft driveshaft housing had completely slipped off the housing. A detached boot allows water to enter the hull through the annular space between the 3-inch-diameter driveshaft and the 4-7/8-inch-diameter housing. The Safety Board estimated that the minimum rate of water inflow was about 170 gallons per minute (gpm), which was enough to eliminate the vessel's freeboard at the stern and sink the vessel in about 7 minutes. To verify the accuracy of its estimates, the Safety Board contracted a recognized naval architectural firm to perform detailed calculations. The firm's preliminary calculations confirmed that a vessel such as the *Miss Majestic* that was carrying 20 passengers would sink from uncontrolled flooding in as little as about 6 minutes.

As originally designed, a DUKW is equipped with a dewatering pump that is chain-driven from the propeller shaft and powered by the DUKW's propulsion engine. Operation of the pump, therefore, depends on the reliable operation of the vessel's propulsion system, as well as the reliable operation of the pump itself. The *Miss Majestic*'s dewatering pump was found to be inoperable, despite witness reports that it had functioned only 2 days earlier. Reliance upon an active system, such as a dewatering pump, requires assured reliability. However, even with meticulous maintenance and regular testing, reliability can never be guaranteed. Any shortcomings in maintenance, whether the result of inadequate training or experience, improper or ineffective procedures, failure to identify a problem, use of poor technique, or other causes, can render the active system useless.

In contrast, a passive safety system requires no deliberate action or operation to deploy and generally facilitates fail-safe performance of the vessel. Some examples of passive safety systems that can prevent a vessel from sinking include compartmentalization with watertight bulkheads, installation of buoyant material inside the hull, and incorporation of buoyant sponsons exterior to the hull. Only the inherent reliability and fail-safe nature of a passive safety system ensure the level of dependability essential to safeguarding the lives of passengers. It is also noteworthy that no other U.S. Coast Guard-inspected vessels rely upon an active system to ensure their ability to remain afloat in the event of flooding.

The Safety Board has concerns about the risk of flooding and the vulnerability to sinking of all types of amphibious passenger vessels, including converted DUKWs, LARCs, and Alvis Stalwarts. Coast Guard data show that between March 6, 1991, and May 1, 1999, at least 18 amphibious passenger vessels had accidents and that six of the accidents resulted in some degree of flooding. Among the six was a July 2, 1994, accident involving the vessel *353 DUKW II*,[4] which sustained a seal clamp failure and subsequent flooding. The Safety Board has also learned of at least nine other incidents involving significant flooding that were not previously reported to

[4] USCG Accident Investigation Case No. MC94020663.

the Coast Guard. Any one of these flooding accidents or incidents (which included one report of a sinking) had the potential to escalate into a life-threatening situation.

Further, the Safety Board believes that amphibious vessels are involved in unique operations and have unique safety considerations. An amphibious vessel can be flooded through several mechanisms, including a failed driveshaft boot, a failed through-hull fitting, a missing plug, or a hull breached by grounding, collision, or allision. In addition, an amphibious vessel is subject to additional hull loadings and stresses not traditionally associated with conventional marine vessel operations. These hull loadings and stresses include highway and off-the-road travel, as well as stresses to the hull and appendages during repeated water entry and exit. Such operations can accelerate wear on the vessel's hull and loosen mechanical joints and connections, thereby compromising the watertight integrity of the hull.

The bottom of the hull of a DUKW has threaded plugs that are normally removed to provide access for maintenance. If any one of the plugs is inadvertently not replaced before the vessel returns to water, the vessel may flood; the flooding rate through a 4-inch plug is about 240 gpm. Consequently, a missing plug reduces a vessel's freeboard at the stern even more quickly than a failed boot does.

Because DUKWs have open interiors and a very low freeboard at the stern, they are vulnerable to rapid swamping and sinking. Once just the stern is immersed (freeboard reduced to zero), water quickly swamps the interior of the DUKW, causing it to sink rapidly by the stern. Survivors of the *Miss Majestic* accident confirmed that the vessel sank by the stern in less than a minute after the deck edge at the stern was submerged, leaving insufficient opportunity for passengers to escape before the vessel sank.

DUKWs are military vessels that were originally designed for combat use during World War II to carry two drivers and military cargo; they were not designed with commercial passenger safety or evacuation in mind. During restoration, the vessels are completely stripped, rebuilt, and equipped to carry passengers, but few changes to ensure the safety of those passengers in the event of flooding, are made. Amphibious vessels are vulnerable to rapid sinking because they lack reserve buoyancy; consequently, the Safety Board concludes that the potential exists for another life-threatening accident similar to the sinking of the *Miss Majestic*, unless the vulnerability to flooding and sinking is addressed.

Therefore, the Safety Board believes that operating companies and amphibious vessel manufacturers/refurbishers should make all existing and future amphibious vessels more survivable and stable so that they will not sink in the event of flooding. Operators and manufacturers/refurbishers can use various methods to increase the survivability of amphibious vessels in the event of flooding. For example, they can install transverse watertight bulkheads to achieve one-compartment subdivision. Alternately or in addition, they can install flotation materials in the hull to provide the reserve buoyancy that allows a vessel with passengers to remain afloat when flooded. There may be other methods of providing reserve buoyancy. The naval architectural firm that did stability calculations for the Safety Board found that it is both practical and cost effective to install watertight bulkheads and built-in flotation material, thus allowing a DUKW with a full complement of passengers and crew to remain afloat and upright even when a watertight compartment is flooded.

Other amphibious vessels, such as LARCs and Alvis Stalwarts, also do not have reserve buoyancy through watertight bulkheads, built-in flotation, or equivalent means. They are subject to the same operating environment and risks of flooding as are DUKWs. The Safety Board is confident that safety improvements, such as the installation of buoyant materials and watertight bulkheads or other means of providing reserve buoyancy on these amphibious vessels, could prevent them, as well, from sinking in the event of flooding.

Therefore, the National Transportation Safety Board recommends that operators and manufacturers/refurbishers of amphibious passenger vessels:

> Without delay, alter your amphibious passenger vessels to provide reserve buoyancy through passive means, such as watertight compartmentalization, built-in flotation, or equivalent measures, so that they will remain afloat and upright in the event of flooding, even when carrying a full complement of passengers and crew. (M-00-5)

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any actions taken as a result of its safety recommendations and would appreciate a response from you within 90 days regarding action taken or contemplated with respect to the recommendation in this letter. Please refer to Safety Recommendation M-00-5 in your reply. If you need additional information, you may call (202) 314-6450.

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

Original Signed

By: Jim Hall
Chairman

List of Addressees

	Company	Address	POC
	Aqua Traks, Inc.	459 Old Military Road Lake Placid, NY 12946	Andre Karl, President
	Austin Ducks	1605 W. 5th Street Austin TX 78703	Paul Mauhler, President
	Boston Duck Tours	790 Boylston Street Boston, MA 02199	Andy Wilson, President
	Buffalo Point	PO Box 160471 Clearfield, UT 84016	Gary Hamblin, President
	Cape Cod Duck Mobile	P.O. Box 2453 Hyannis, MA 02601	John Britton, President
	Chattanooga Ducks	201 W. Fifth Street Chattanooga, TN 37402	William Toussaint, President
	Chicago Duck Corporation	1413 Redeker Lane Des Plaines, IL 60016	Hank LaBarbara, President
	Chicago Duck Tours/ Chicago Trolley Tours	1709 South Prairie Chicago, IL 60616	Rob Pierson, Chief of Operations
	Cool Stuff Tours C.A.M.I. LLC	31 Hawkes Road P.O. Box 1703 Bluffton, SC 29910	John Giljam, President
	DC Duck Tours Old Town Trolley	Old Town Trolley Tours 2640 Reed Street NE Washington DC 20018	David Cohen, General Manager
	Dells Duck Tours	1550 Wisconsin Dells Pkwy Wisconsin Dells, WI 53965-8446	George C. Field, President
	DUCKS Amphibious Renovations & Sales	104 Somerset Court Hot Springs, AR 71913	Jack I. Myers, President
	Just Ducky Tours	40-1A Oakville Court Pittsburgh, PA15220	Michael Cohen, President
	Land and Sea Tours	2070 S. Orange Blossom Trail Apopka, FL 32703	Frank Serafine, President
	Lowcountry Duck Tours	757 Condon Drive Charleston, SC 29412	Stacey Bull, General Manager
	Maui Duck Tours	P.O. Box 10367 Lahaina, Maui, Hawaii 96761	Lloyd Perry, President
	Metro Ducks, Dayton, OH c/o Chicago Duck Corporation	1413 Redeker Lane Des Plaines, IL 60016	Hank LaBarbara, President
	Moby Duck Tours (Public Access Tours)	75 Essex Avenue Gloucester, MA 01930	Jim Dominick, President
	Naples Land & Sea Tours	1160 First Avenue South Naples, FL 34102	Steve Alander, President
	National Park Duck Tours	418 Central Avenue Hot Springs, AR 71901	Don Roberts, President

Operator	Address	POC
Original Wisconsin Ducks	1890 Wisconsin Dells Pkwy., P.O. Box 117 Wisconsin Dells, WI 53965-0117	Dan Gavinski, President
Outfitters Kauai	2827A Poipu Road PO Box 1149 Poipu Beach, HI 96756	Rick Haviland, President
Ozark Mountain Ducks	1838 W. Hwy 76 PO Box 6458 Branson, MO 65616	Rick Warren, President
Peter Pan Bus Tours	1776 Main Street P.O. Box 1776 Springfield, MA 01102-1776	Peter L. Picknelly, Chairman
Plymouth Amphibious Tours (Splashdown Tours)	Captain John Boats 117 Standish Ave Plymouth, MA 02360	Stanley Tazaris, President
Ride the Ducks	2320 W. Hwy 76 Branson, MO 65616	Bob McDowell, President
Ride the Ducks of Seattle	709 John St. Seattle, WA 98109	Brien Tracey, Co-owner
South Padre Water Sports / Breakaway Cruises	P.O. Box 2460 South Padre Island, TX 78597	Daniel Bryant, President
Sterling Equipment	62 Nay St. East Boston, MA 02128	Larry Corbiel, President
White & Yellow Ducks	406 Central Avenue Hot Springs, AR 71901	Don Bridges, President